Anglo-Chinese Junior College

JC 2 Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

PHYSICS **9749/01**

Paper 1 Multiple Choice

28 August 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your Name and Index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and circle your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\,\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	$T/^{o}C + 273.15$
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm\, \omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant.	λ	=	$\frac{\ln 2}{t_{1/2}}$

[Turn over

1 Anglo-Chinese Junior College's digital clock tower was restored in 2017.

What is its approximate height above the ground?

A 10 m **B** 30 m **C** 50 m **D** 100 m

2 Due to the random nature of radioactive decay, the count rate recorded by a Geiger-Muller tube is subject to statistical fluctuations. When the total count recorded from a source in a given time is *N*, the uncertainty is $\sqrt{N}$.

What is the number of counts taken to obtain a mean count rate precise to 0.1 %?

A 100

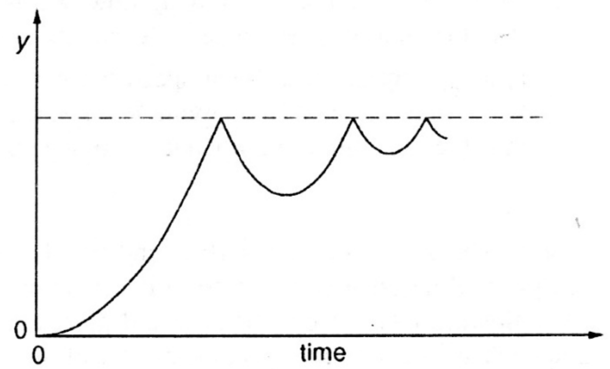
B 1000

C 10000

D 1000000

3 A ball is released from rest above a horizontal surface and bounces several times.

The graph shows the variation with time of quantity *y* for the ball.



What is quantity *y*?

A displacement from horizontal surface; taking upwards as positive

B displacement from horizontal surface; taking downwards as positive

C displacement from where ball is released; taking upwards as positive

D displacement from where ball is released; taking downwards as positive

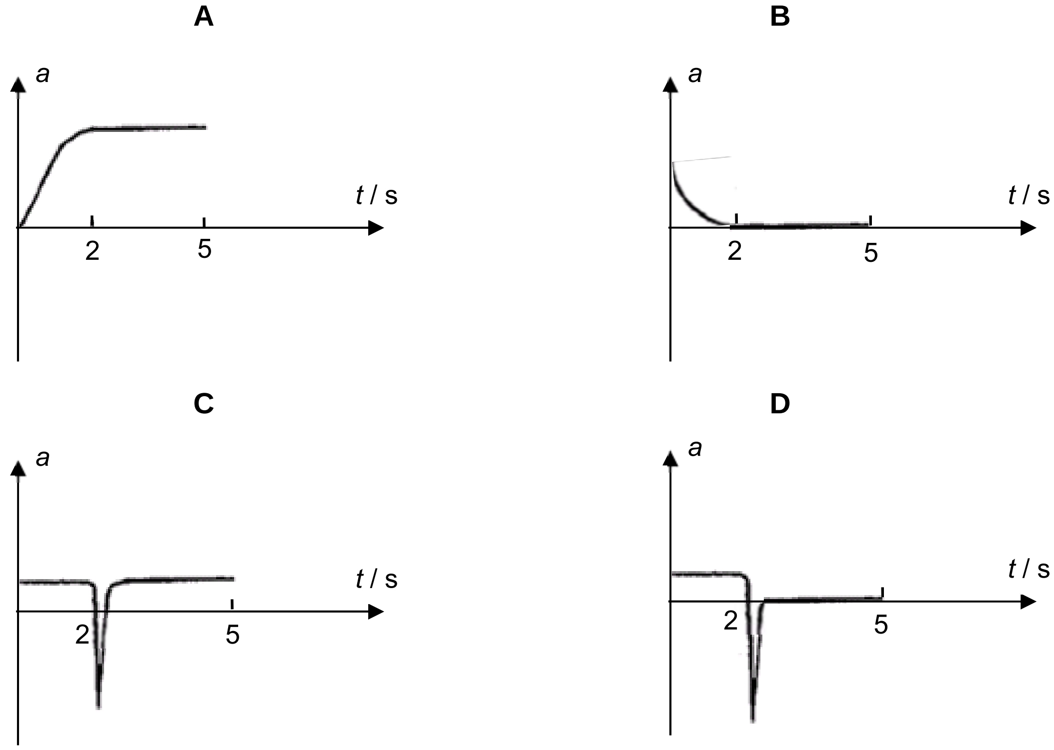
4 A student, standing on the platform of an MRT train station, notices that the first two carriages of an arriving train passes her in 2.00 s, and the next two carriages in another 2.40 s. The train is decelerating uniformly and each carriage is 20.0 m long.

What is the deceleration of the MRT train?

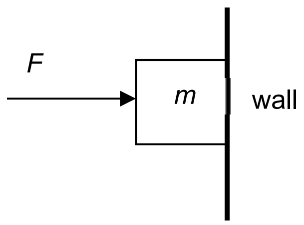
A 1.38 m s^{-2} **B** 1.52 m s^{-2} **C** 1.67 m s^{-2} **D** 3.33 m s^{-2}

5 A parachutist steps out from an aircraft, falls without air resistance for 2 s and then opens his parachute.

Which graph best represents the variation with time *t* of his vertical acceleration *a* during the first 5 s of his decent?



6 A block of mass *m* is held at rest by pushing it with a force *F* to prevent it from slipping.



What is the magnitude of the contact force exerted by the wall on the block?

A F

B mg

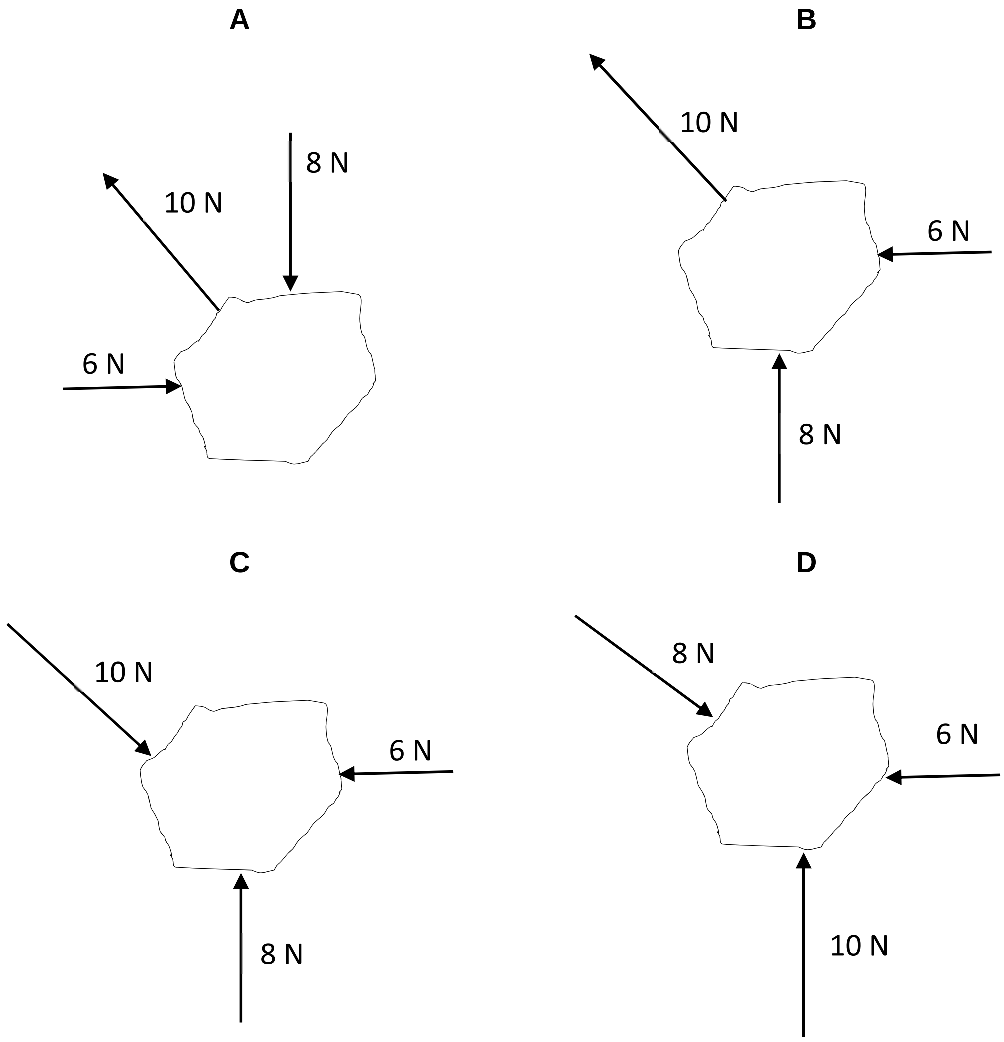
C $\sqrt{F^2-(mg)^2}$

D $\sqrt{F^2+(mg)^2}$

[Turn over

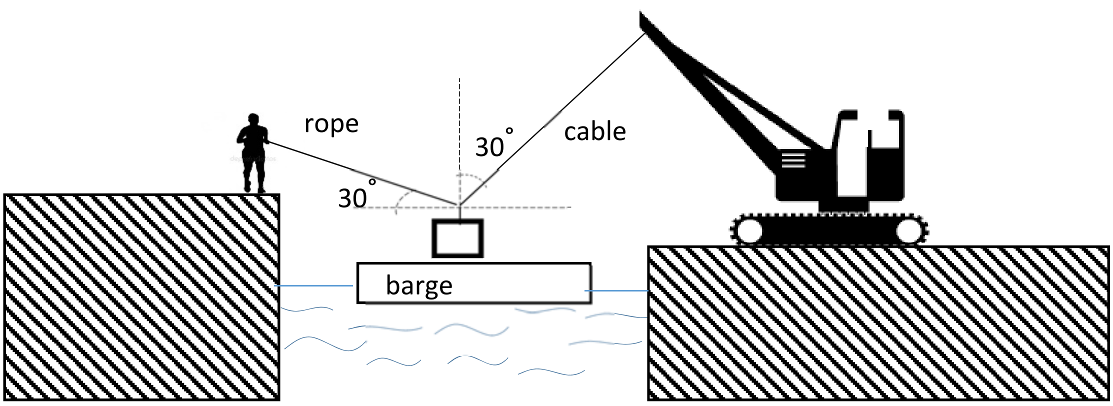
7 Three coplanar forces 10 N, 8 N and 6 N act on a flat object.

Which one of the following shows the flat object in equilibrium under the action of the forces?



8 A mini-crane is used to load a crate weighing 600 N onto a barge. The man uses a rope and applies a force of 300 N to the rope.

What is the tension in the cable from the crane?

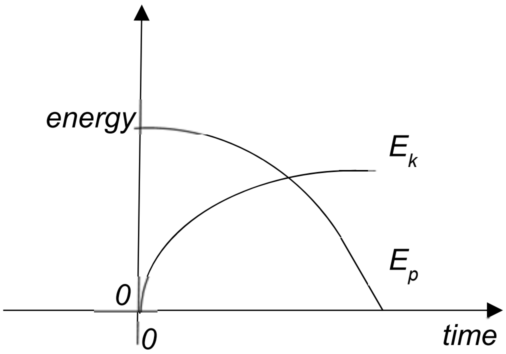


A 300 N **B** 520 N **C** 600 N **D** 690 N

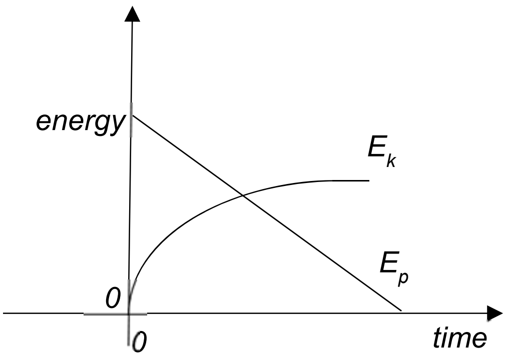
9 A steel ball is released at rest from the surface of oil in a tall cylinder so that it falls to the bottom of the cylinder.

Which graph shows variation with time of the gravitational potential energy, E_p and the kinetic energy, E_k of the ball?

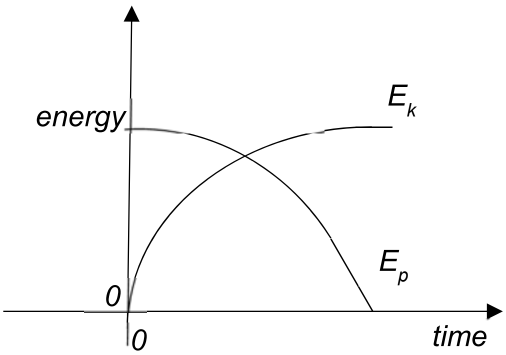
A



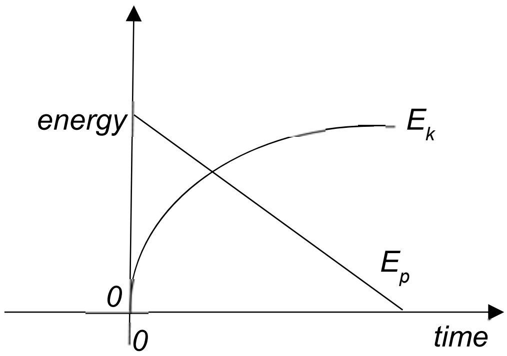
B



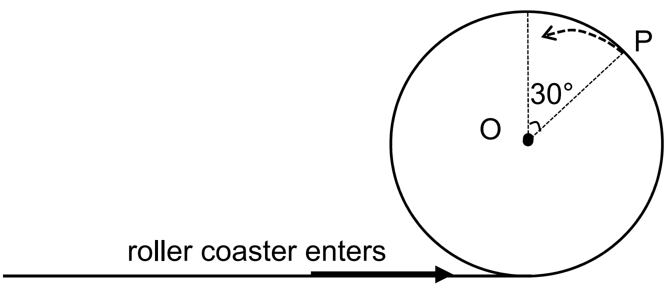
C



D



10 A toy roller coaster attempts a loop-a-loop. It enters the bottom of loop of radius 1.0 m with insufficient speed. It loses contact at the point P as shown. The line joining P and the centre of the loop O makes an angle 30° with the vertical.

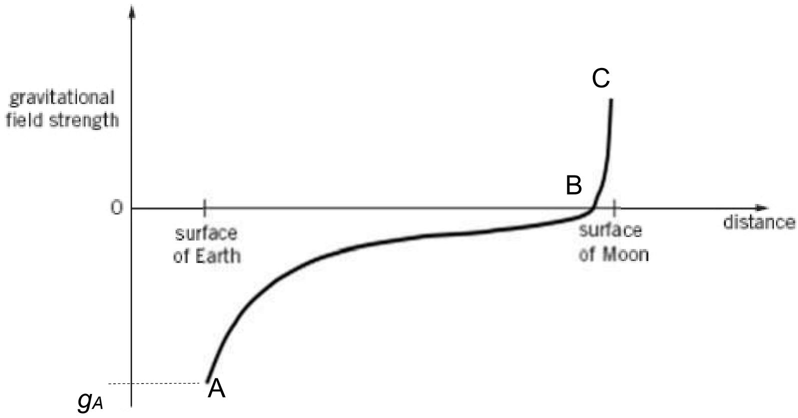


What is the speed at P which the roller coaster just loses contact with the loop?

A 0 m s^{-1} **B** 2.2 m s^{-1} **C** 2.9 m s^{-1} **D** 3.1 m s^{-1}

[Turn over

11 The diagram below shows the variation with distance between the surface of the Earth A and the surface of the Moon C of gravitational field strength. A mass *m* is at different positions between the Earth and Moon surface.



Which of the following statement is true?

A At A, mg_A gives the gravitational force due to Earth on *m* on Earth's surface.

B At B, the gravitational potential energy of *m* is maximum.

C At B, no force acts on mass *m*.

D At C, the gravitational potential energy of *m* is positive.

12 Escape velocity from a planet surface is the minimum speed needed for an object at the planet surface to be projected to leave the gravitational influence of the planet.

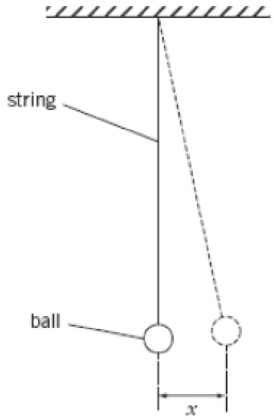
Given that:

$$\frac{\text{mass of Earth}}{\text{mass of Moon}} = 81, \quad \frac{\text{radius of Earth}}{\text{radius of Moon}} = 3.7$$

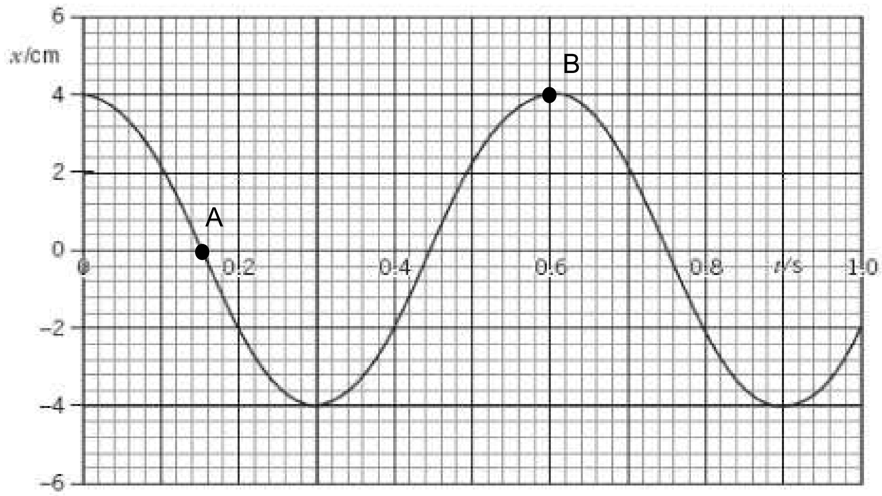
What is the ratio of $\dfrac{\text{escape velocity from Earth surface}}{\text{escape velocity from Moon surface}}$?

A 0.21 **B** 4.7 **C** 22 **D** 480

13 A small metal ball is suspended from a fixed point using a string as shown.



The ball is pulled a small distance to one side and then released. The variation with time *t* of the horizontal distance displacement *x* of the ball is shown below.



Which of the following statement is not true?

A At A, the kinetic energy of the ball is maximum.

B At A, the tension on the string is minimum.

C At B, the ball is instantaneously at rest.

D At B, the ball experiences the greatest restoring force.

14 An ideal gas is contained in a metal box. Which is not true?

A Increasing the temperature of the gas will increase the rate of collision of the gas molecules with the wall.

B Decreasing the internal energy of the gas will decrease the change of momentum of the gas molecules when it hit the walls.

C Increasing the dimensions of the box will increase the frequency of collision of the gas molecules with the walls.

D The speeds of the gas molecules are different but the pressure of the gas on the walls for the same temperature is constant.

[Turn over

15 Which property of a substance takes into account atmospheric pressure significantly?

A specific latent heat of fusion

B specific latent heat of vapourisation

C specific heat capacity of solid

D specific heat capacity of liquid

16 Two coherent waves from a double-slit meet on the screen to form an interference pattern.

What is the phase difference of the two waves at the second-order minima?

A 0 rad

B 3.14 rad

C 6.28 rad

D 9.42 rad

17 The following observations are recorded:

Intensity of unpolarised light = X
Intensity of polarised light after passing through first polaroid = Y
Intensity of polarised light after passing through second polaroid whose polarising axis is 30° to the first polaroid = Z

Which row give the correct intensity of X, Y and Z?

	X	Y	Z
A	I_o	I_o / 2	0.75 I_o
B	I_o	I_o	0.75 I_o
C	$2I_o$	I_o	0.75 I_o
D	$2I_o$	I_o / 2	0.375 I_o

18 Two blue dots of 5 mm diameter are projected on a screen. The distance between the two dots is 7 mm. A student who is facing the screen takes a few steps backwards and stops walking when she could just resolve the two dots.

The student wishes to still resolve the two dots by standing further back from the screen. What should she do?

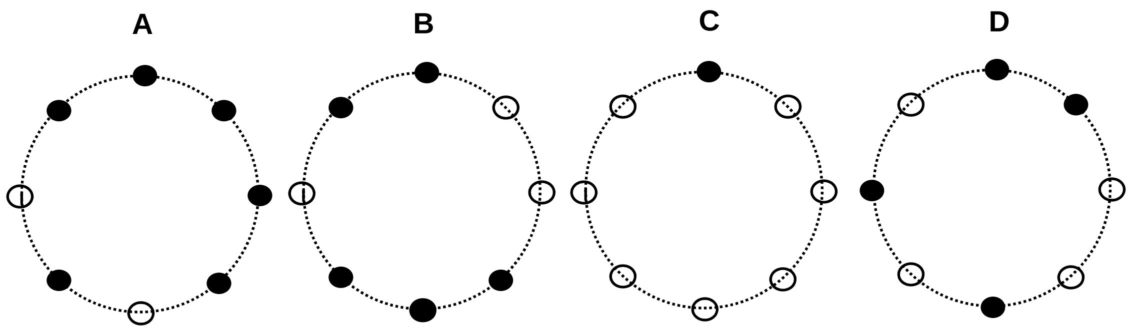
A darken the room to increase the size of the pupil of the eye.

B change the colour of the two dots from blue to red.

C make the blue dots slightly brighter.

D make the two dots closer.

19 A combination of eight electrons and protons are fixed in place and evenly spread along the circumference of circle as shown.

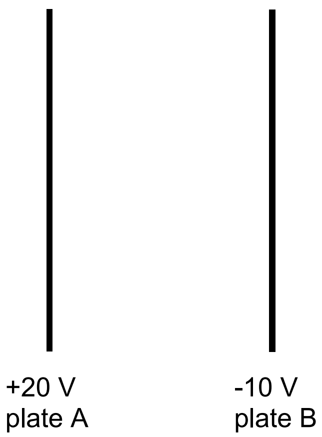


● - proton

○ - electron

Which of the above combinations has the smallest magnitude of resultant electric field strength at the centre of the circle?

20 Two long parallel plates spaced a distance 30 cm apart have electric potential of +20 V and –10 V respectively as shown.



Which statement is correct?

A At any point which is 20 cm to the right of plate A, work done by external agent per unit charge to bring a small positive test point charge from infinity to that point is non-zero.

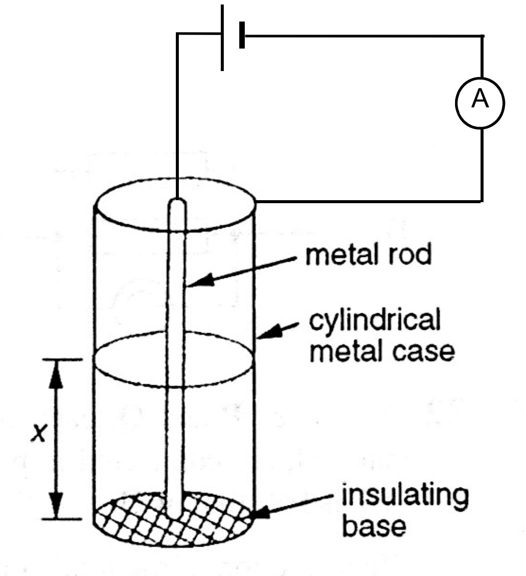
B The electric field strength within the two plates is 1 V m^{-1} and it is directed towards plate B.

C An electron placed at 10 cm to the left of plate B will gain 20 eV of electric potential energy when it reaches plate A.

D When the plates are connected to both ends of a resistor, the electric field strength within the two plates will become zero.

[Turn over

21 An electrical circuit is connected to a cylindrical metal case with an insulating base as shown. Conducting liquid fills the case to a depth of x.



How does the current I in the ammeter vary as x changes?

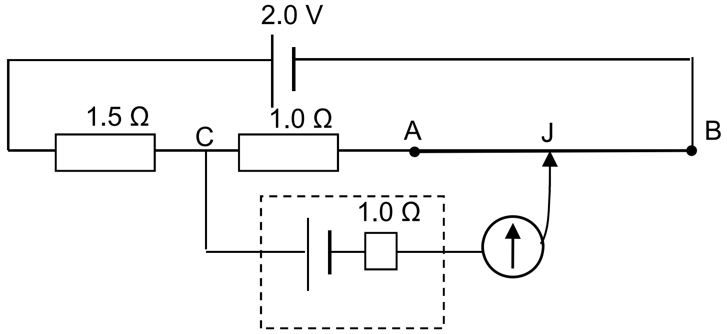
A $I \propto x$

B $I \propto x^2$

C $I \propto \frac{1}{x}$

D $I \propto \frac{1}{x^2}$

22 The diagram below shows a potentiometer circuit in which the wire AB is 100.0 cm long and has a resistance of 5.0 Ω. The e.m.f of the driver cell is 2.0 V and e.m.f of the cell with an internal resistance 1.0 Ω of connected between C and J is 1.5 V. At point J, there is no deflection in the galvanometer.

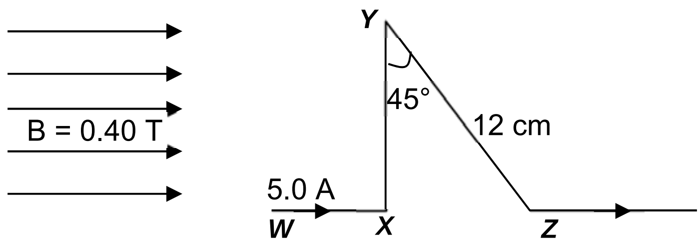


What is the balance length AJ?

A 7.5 cm **B** 20.0 cm **C** 80.0 cm **D** 92.5 cm

23 A current of 5.0 A is flowing in the wire as shown in the diagram below.

Given that the magnetic flux density is 0.40 T, what is the force on the portion YZ of the wire?



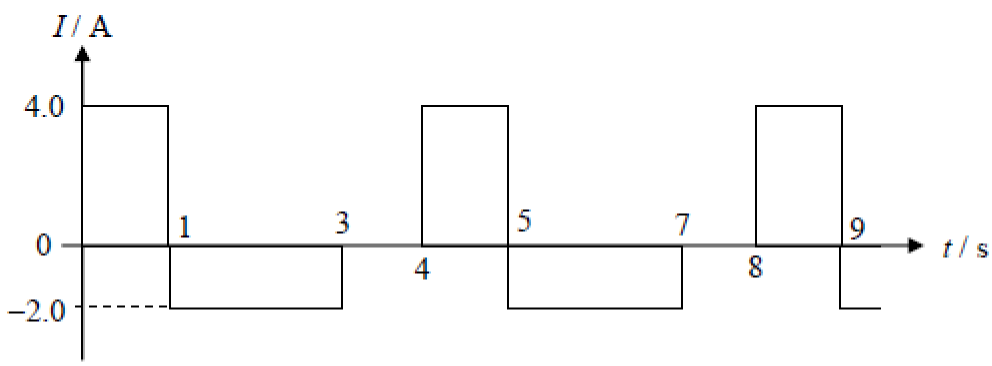
	Force	Direction
A	0.17 N	Into the page
B	0.17 N	Out of the page
C	0.24 N	Into the page
D	0.24 N	Out of the page

24 A particle X of charge $2q$ is moving in a uniform magnetic field of flux density B in a circle of radius r at a speed v. Another particle Y of charge q has the same mass as X and moves at the same speed as X.

What is the flux density required for Y to move in a circle which has half the radius of the circle moved by X?

A $\frac{B}{4}$ **B** $\frac{B}{2}$ **C** $2B$ **D** $4B$

25 An alternating current with a rectangular waveform as shown below flows through an 11 Ω resistor.

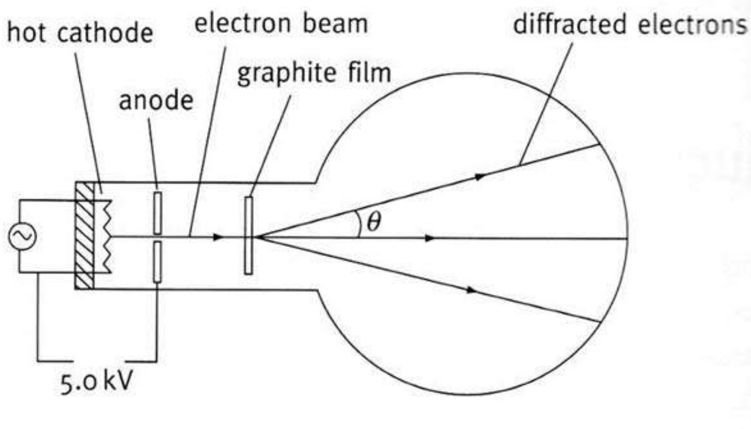


What is the average power dissipated by the resistor?

A 0 W **B** 44 W **C** 66 W **D** 88 W

[Turn over

26 A diagram shows a simplified setup of electron tube to demonstrate electron diffraction. The electrons are diffracted by angle θ. Diffraction rings appear on the screen.



The potential difference between the cathode and anode is increased from 5.0 kV to 10 kV.

Which of the following statement is false?

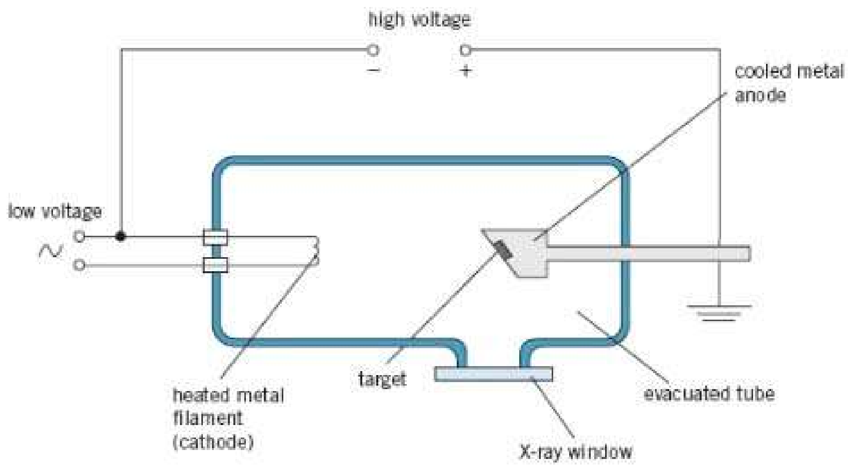
A The velocity of electrons hitting the graphite film increases.

B The diffracted angle θ decreases.

C The brightness of the central ring increases.

D The de Broglie wavelength of the electrons from the anode increases.

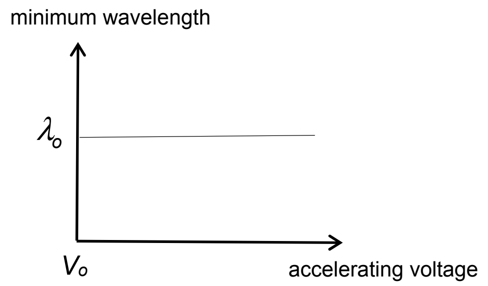
27 In an X-ray tube shown, the high voltage supply accelerates the electrons towards the target. X-rays with a range of wavelengths are emitted from the target.



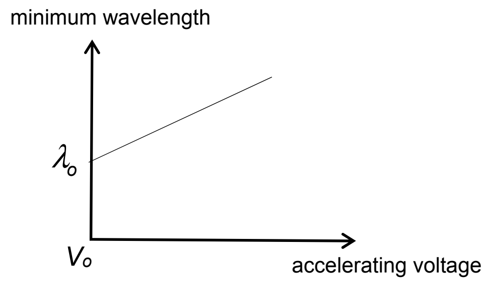
When the high voltage supply is V_o, the minimum wavelength of the x-ray emitted is λ_o.

Which of the following graph shows the variation with accelerating voltage of the minimum wavelength emitted?

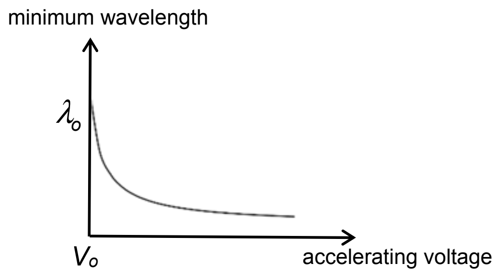
A



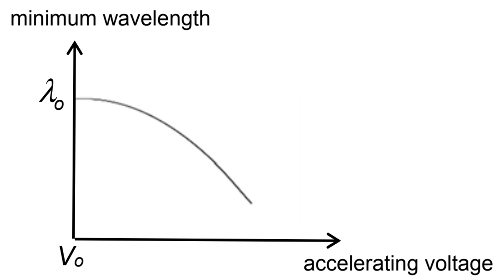
B



C



D



[Turn over

28 In a photoelectric emission experiment, ultra-violet radiation of 210 nm is incident on a piece of metal of surface area 2.0 cm ^{2}. A photocurrent of 2.1 μA is detected at the electrode.

If, on average, one electron is ejected for every 10^5 photons reaching the surface, what is the intensity of the ultra-violet radiation incident on the surface?

A 2.5×10^{-4} W m^{-2}

B 6.2×10^{-2} W m^{-2}

C 1.2 W m^{-2}

D 6.2×10^{3} W m^{-2}

29 Uranium – 238 $^{238}_{92}U$ undergoes a series of radioactive decay to form various daughter products. X is produced after Uranium – 238 emitted 4 α and 2 β decays.

What is the number of neutrons and protons in X?

	Neutron number	Proton number
A	136	86
B	136	94
C	222	86
D	222	94

30 After 100 days, 10 % of a radioactive sample of $^{232}_{90}Th$ has decayed.

How many half-lives have elapsed?

A 0.15 **B** 0.20 **C** 3.3 **D** 660

Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S 3 0 0 4	INDEX NUMBER	

PHYSICS **9749/04**

Paper 4 Practical

1 August 2018
2 hours 30 mins

Candidates answer on the Question Paper.
Additional Materials: as listed In the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use the appropriate units.

Give details of your practical shift and laboratory, where appropriate, in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiners' use only	
1	/ 11
2	/ 10
3	/ 22
4	/ 12
Total	/ 55

For Examiner's Use

1 In this experiment, you will investigate how the time of swing of masses depends on its distance from the pivot.

(a) **(i)** Measure the length l of the PVC tube.
Use the vernier caliper for this measurement.

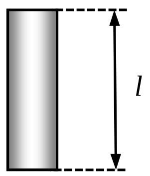


Fig. 1.1

l = …………………………….. [1]

(ii) Explain how you have made this measurement as accurate as possible.

…………………………………………………………………………………

…………………………………………………………………………………

……………………………………………………………………………….... [1]

(b) Set up the apparatus as shown in Fig. 1.2.

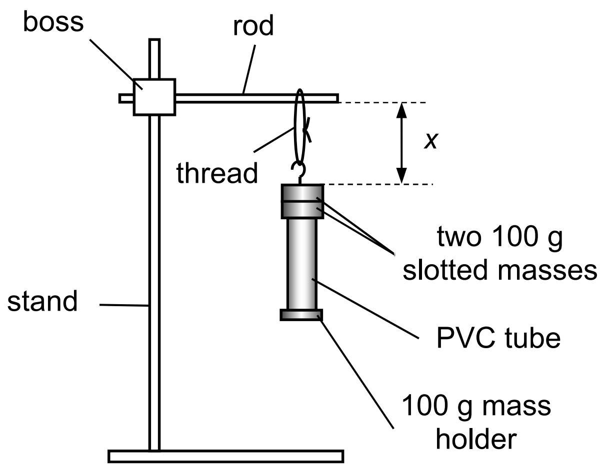


Fig. 1.2

For Examiner's Use

(i) Using the half-metre rule, measure the length x.

x = …………………………….. [1]

(ii) Estimate the percentage uncertainty in your value of x.

percentage uncertainty = …………………………….. [1]

(c) Displace the mass holder, as shown in Fig. 1.3. Ensure that the plane of oscillation is parallel to the rod on which the string pivots.

Release the tube.

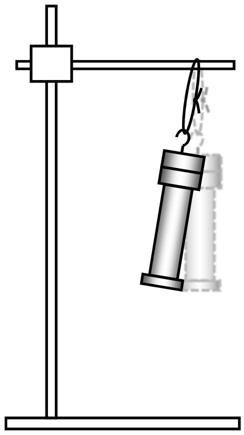


Fig. 1.3

Determine a value for the period of oscillation T.

T = …………………………….. [2]

[Turn over

For Examiner's Use

(d) Remove the PVC tube from the setup while keeping the two 100 g slotted masses on the mass holder as shown in Fig. 1.4.

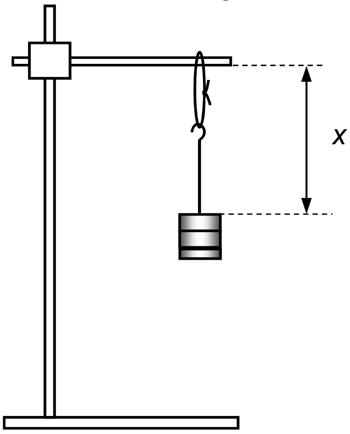


Fig. 1.4

(i) Using the value in **(a)(i)**, calculate x as shown in Fig. 1.4. Give your answer to an appropriate number of decimal places.

x = …………………………….. [1]

(ii) Repeat **(c)** to obtain a second value of T.

T = …………………………….. [1]

For Examiner's Use

(e) It is suggested that T and x are related by the equation

$$T^5 = k\,x$$

where k is a constant.

(i) Use your values from **(b)(i)**, **(c)** and **(d)** to determine two values for k. Give your values for k to an appropriate number of significant figures.

first value for k = ……………………………......

second value for k = …………………………………
[1]

(ii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your value in **(b)(ii)**.

……………………………………………………………………………….

……………………………………………………………………………….

……………………………………………………………………………….

……………………………………………………………………………….

…………………………………………………………………………… [2]

[Total: 11 marks]

For Examiner's Use

2 In this experiment you will investigate how the current flowing through a semiconductor diode varies as the potential difference across it and the temperature are changed.

(a) **(i)** Set up the circuit as shown in Fig. 2.1. The rheostat, 2 V cell and switch has been set up for you.

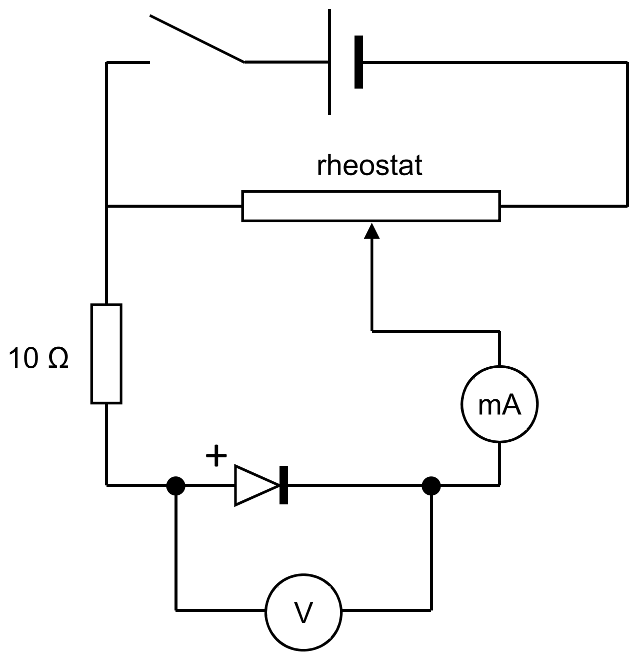


Fig. 2.1

(ii) Place one of the foam cups into the glass beaker. Use this to collect hot water from the water boiler.

(ii) Pour the hot water into the other foam cup until it is about a quarter filled.

(iii) Add some tap water until the temperature of the water is about 65 °C.

Record the temperature of the water *T*.

T = …………………………….. [1]

(b) **(i)** Place the diode in the water.

(ii) Close the switch.

For Examiner's Use

(iii) Adjust the rheostat such that the potential difference across the diode is 0.70 V.

Measure and record the current I flowing through the circuit.

I = ………………………….. [1]

(iv) Open the switch.

(c) **(i)** Pour away the hot water and fill the foam cup with tap water.

Record the temperature of the water, T.

T = ……………………………...

(ii) Repeat **(b)**.

I = ………………………….. [1]

[Turn over

For Examiner's Use

(d) When the experiment is conducted with constant temperature, current I is related to the potential difference V by the expression,

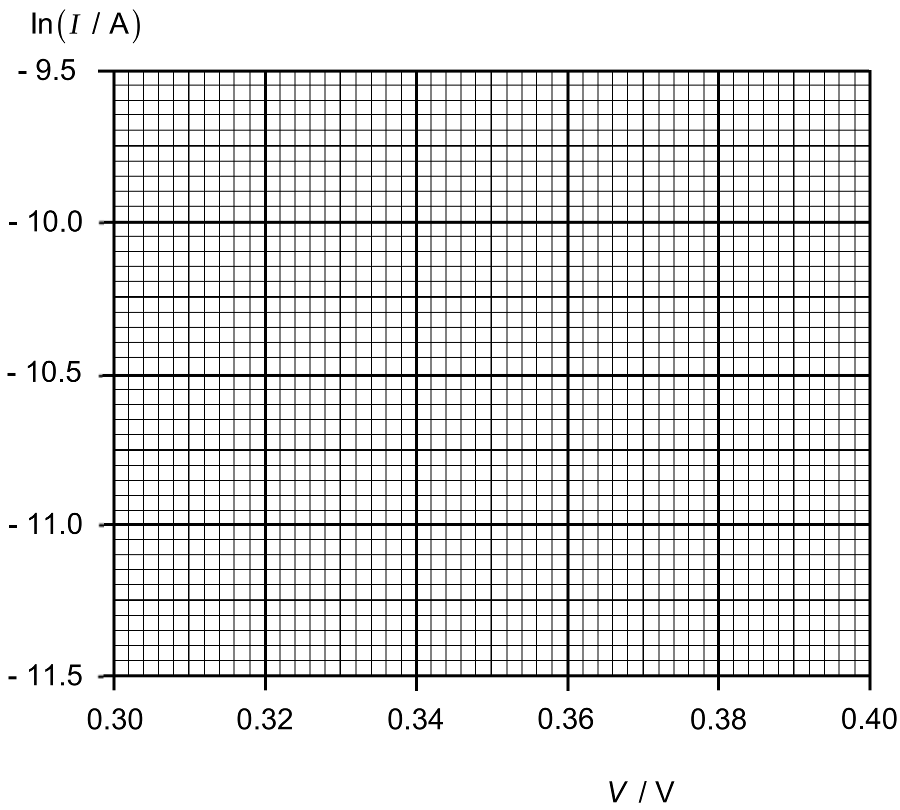
$$I = I_0 \exp\left\{\frac{eV}{kT}\right\}$$

where k is the Boltzmann constant (=1.38 x 10^{-23} J K^{-1}), e is the elementary charge, T is the temperature in kelvin, and I_0 is a constant.

The table shows the results from an experiment done with the diode kept at 60 °C.

V / V	I / x 10^{-6} A	ln(I / A)
0.31	10.3	- 11.48
0.33	17.4	- 10.96
0.34	22.3	- 10.71
0.35	27.7	- 10.49
0.36	37.6	- 10.19
0.37	47.1	- 9.96

(i) Plot the points on the grid and draw a straight line of best fit. [2]



For Examiner's Use

(ii) Determine the gradient and y-intercept of the line.

gradient = ...

y-intercept = ...

[3]

(iii) Determine the value I_0 and *e*.

I_0 = ...

e = ...

[1]

(iv) The experiment is repeated at a higher temperature.

Assuming that I_0 remains the same, sketch a new line in part **(d)(i)** that would represent this set of results. [1]

[Total: 10 marks]

[Turn over

For Examiner's Use

3 In this experiment, you will investigate the equilibrium of a rod supported by a spring.

(a) Measure and record the length l_0 of the unstretched spring, as shown in Fig. 3.1.

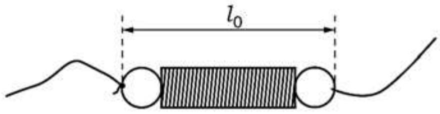


Fig. 3.1

l_0 = …………………………….. [1]

(b) Set up the apparatus as shown in Fig. 3.2.

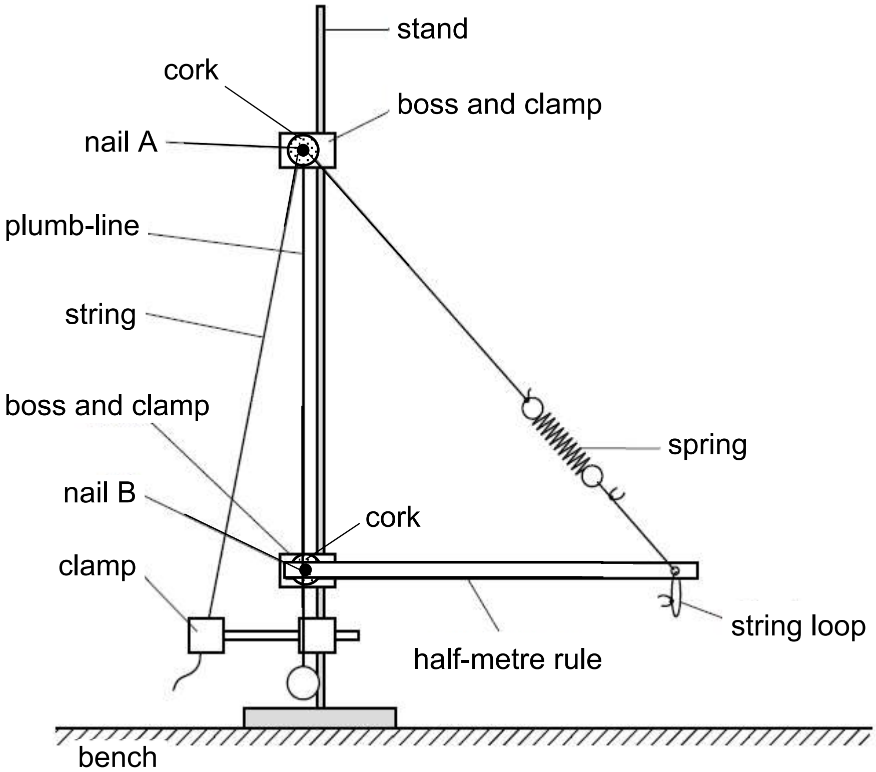


Fig. 3.2

The string loop, spring and string has been connected to one end of the half-metre rule. Nail B and a cork are already attached to the other end of the half-metre rule.

For Examiner's Use

(c) **(i)** Suspend the mass holder *M* from the string loop.

(ii) Adjust the string in the clamp such that the half-metre rule is horizontal again.

(iii) Use the plumb-line to ensure that nail B is vertically below nail A, as shown in Fig. 3.3.

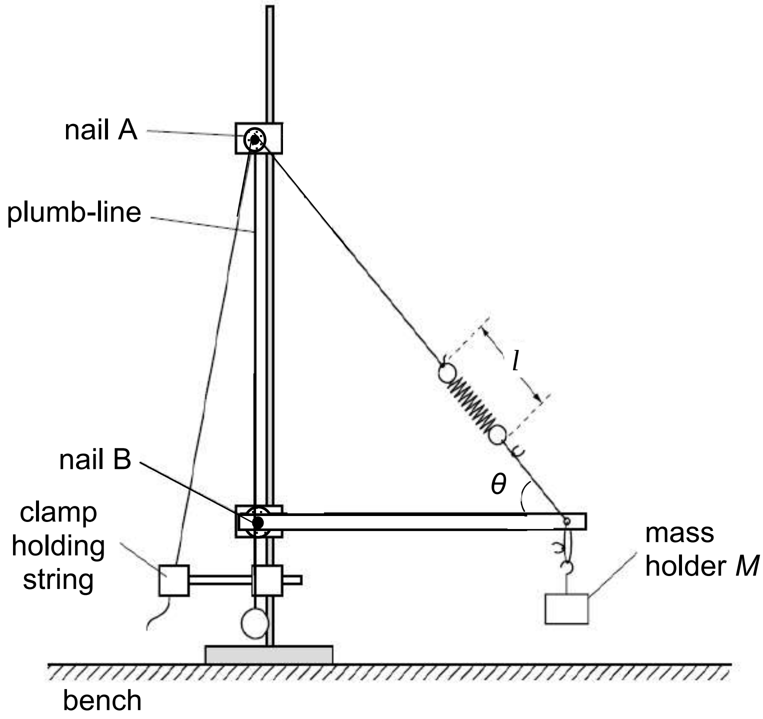


Fig. 3.3

(iv) Measure and record the angle θ between the half metre-rule and the string, and the length l of the spring.

θ = ……………………………………

l = ……………………………………

(v) Calculate *e* where $e = l - l_0$.

e = …………………………….. [1]

[Turn over

For Examiner's Use

(d) **(i)** Raise nail B by shifting the boss and repeat **(c)** to obtain further values of θ and *e*.

Include the values for $\tan\theta$.

[6]

(ii) Plot a graph of *e* against $\tan\theta$. Draw a curve through your points. [3]

(iii) Determine the gradient of the curve at θ = 30°.

gradient = ……………………………….. [2]

For Examiner's Use

[Turn over

For Examiner's Use

(e) **(i)** Suggest **two** significant sources of error in this experiment.

1 ………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

2 ………………………………………………………………………………………

………………………………………………………………………………………

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………………………………………………………………………………………

[2]

(ii) Suggest **two** improvements that could be made to the experiment to address the errors identified in **(e)(i)**. You may suggest the use of other apparatus or different procedure.

1 ………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

2 ………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

[2]

For Examiner's Use

(f) An engineer is designing a draw bridge that has a similar design to the set up in **(b)**, where a rope is used to support the bridge. The engineer has access to various materials and wants to determine the most suitable material for the rope.

Plan an investigation to determine which material can withstand the highest tension before breaking.

Your account should include:

- your experimental procedure
- details of the table of measurements with appropriate units
- how you would determine the highest tension before breaking.

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……………………………………………………………………………………….. [5]

[Total: 22 marks]

For Examiner's Use

4 Glass has a resistivity of the order of $10^{14}\ \Omega\ \text{m}$ which is very large.

A student wishes to investigate how the resistance of glass varies with its dimensions. It is suggested that the resistance R of the glass is related to its cross-sectional area A and its length l by the equation

$$R = k\,A^{x}\,l^{y}$$

where k, x and y are constants.

You are provided with sheets of glass of varying dimensions.

Design an experiment to determine the values of k, x and y.

You should draw a diagram showing the arrangement of your apparatus and you should pay particular attention to

(a) the procedure to be followed
(b) the control of variables
(c) how the data would be analysed
(d) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

For Examiner's Use

For Examiner's Use

……………………………………………………………………………………………………..

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……………………………………………………………………………………………….. [12]

[Total: 12 marks]

Anglo-Chinese Junior College

JC 2 Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S 3 0 0 4	INDEX NUMBER	

PHYSICS **9749/03**

Paper 3 Longer Structured Questions

23 August 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Name, Class and Index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiners' use only	
Section A	
1	/ 16
2	/ 12
3	/ 10
4	/ 8
5	/ 14
Total	/ 60
Section B	
6	/ 20
7	/ 20
Grand Total	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

For Examiner's Use

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p \Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature	T / K	=	T / °C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{x_o^2 - x^2}$
electric current	I	=	$A n v q$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{1/2}}$

[Turn over

For Examiner's Use

Section A

Answer **all** questions in the spaces provided.

1 **(a)** A soldier fires his semi-automatic rifle in a stationary position as shown in Fig. 1.1. Each bullet has a mass of 15 g and it leaves the gun with a velocity of 700 m s^{-1}.

Fig. 1.1

(i) If the rifle weighs 4.5 kg, calculate the velocity of the rifle when he fires a single shot.

velocity = ……………………… m s^{-1} [2]

(ii) If the soldier now fires 10 bullets horizontally in 2.0 s, calculate the average force exerted by the bullets on the rifle.

average force = ……………………… N [3]

For Examiner's Use

(b) Two balls X and Y having the same mass of 160 g collide head-on with each other as shown in Fig. 1.2.

Fig. 1.2

The graph in Fig. 1.3 shows the momentum of the balls before, during and after the collision.

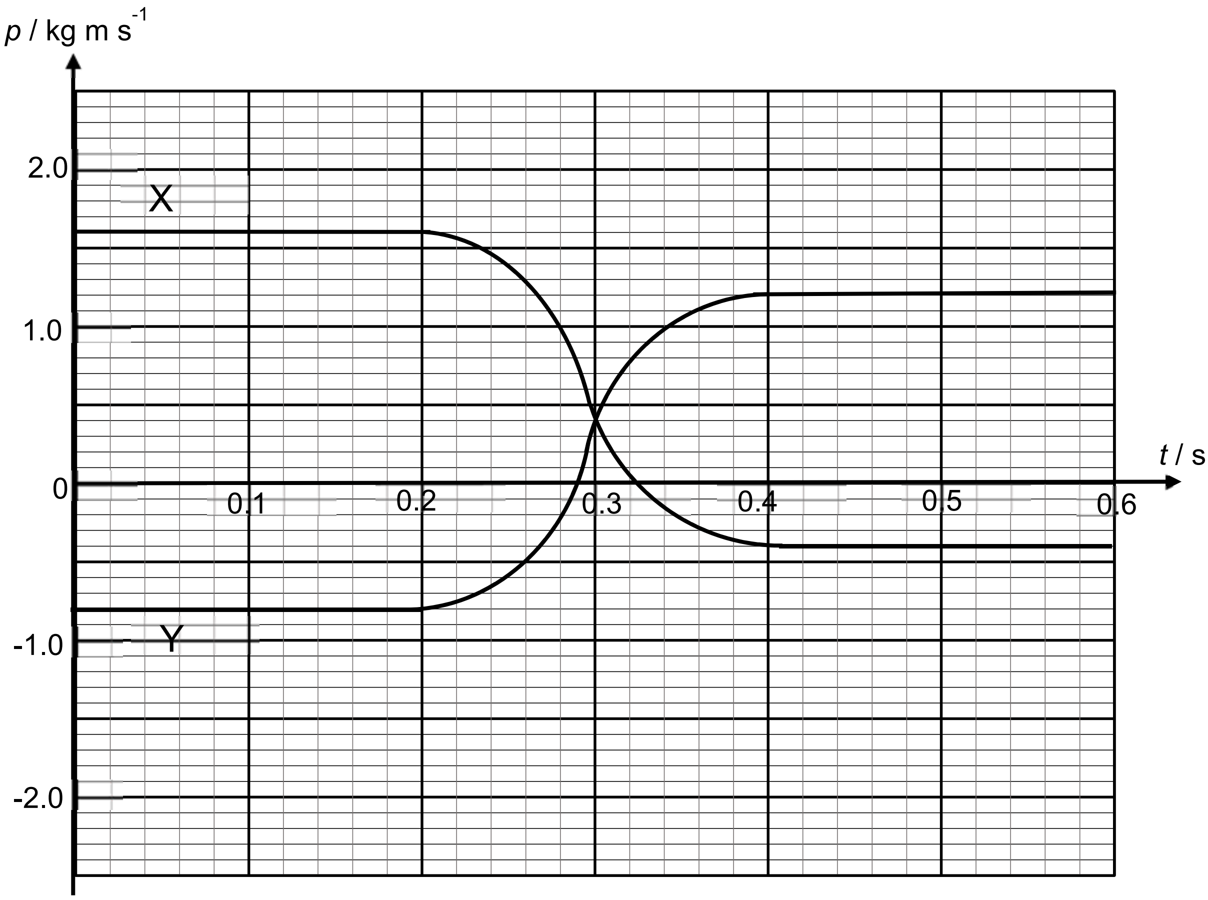

Fig. 1.3

(i) Show that the collision is inelastic.

[2]

[Turn over

For Examiner's Use

(ii) Calculate the impulse experienced by ball X due to the collision.

impulse = ………………………. N s [2]

(iii) Explain why both balls cannot lose all their kinetic energy at the same time during the collision.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………… [2]

For Examiner's Use

(c) Block B of mass 8.0 kg rests on a smooth 30° incline and is connected to block A of mass 12.0 kg via a frictionless pulley using an inextensible string as shown in Fig. 1.4. The blocks are released from rest and come to rest again momentarily when the spring is compressed by 1.2 m. The spring has a spring constant *k*.

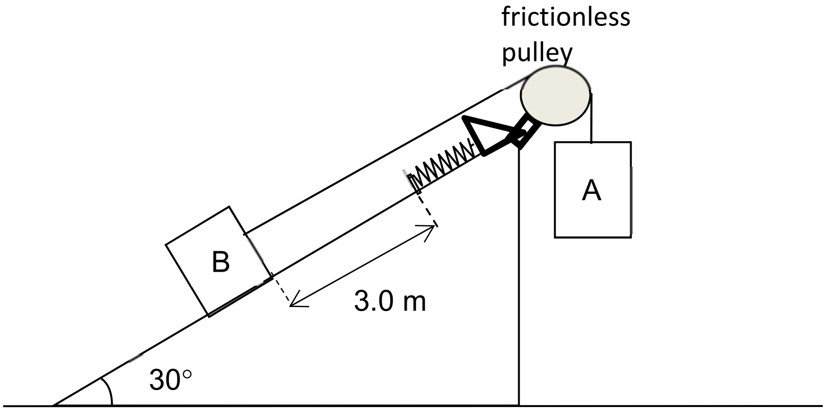

Fig. 1.4

(i) Describe the energy transformation from the time the blocks are released to the time when the blocks first come to rest.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

………………………………………………………………………………………… [3]

(ii) Calculate the value of *k.*

k = ………………………. N m^{-1} [2]

[Turn over

For Examiner's Use

2 A satellite of mass 1 200 kg is launched from the Earth's surface into a circular orbit at a height of 35 600 km directly above the equator. The radius of the Earth is 6 400 km.

Fig. 2.1 shows the variation with distance from Earth's centre *r* of gravitational potential *Φ* due to Earth.

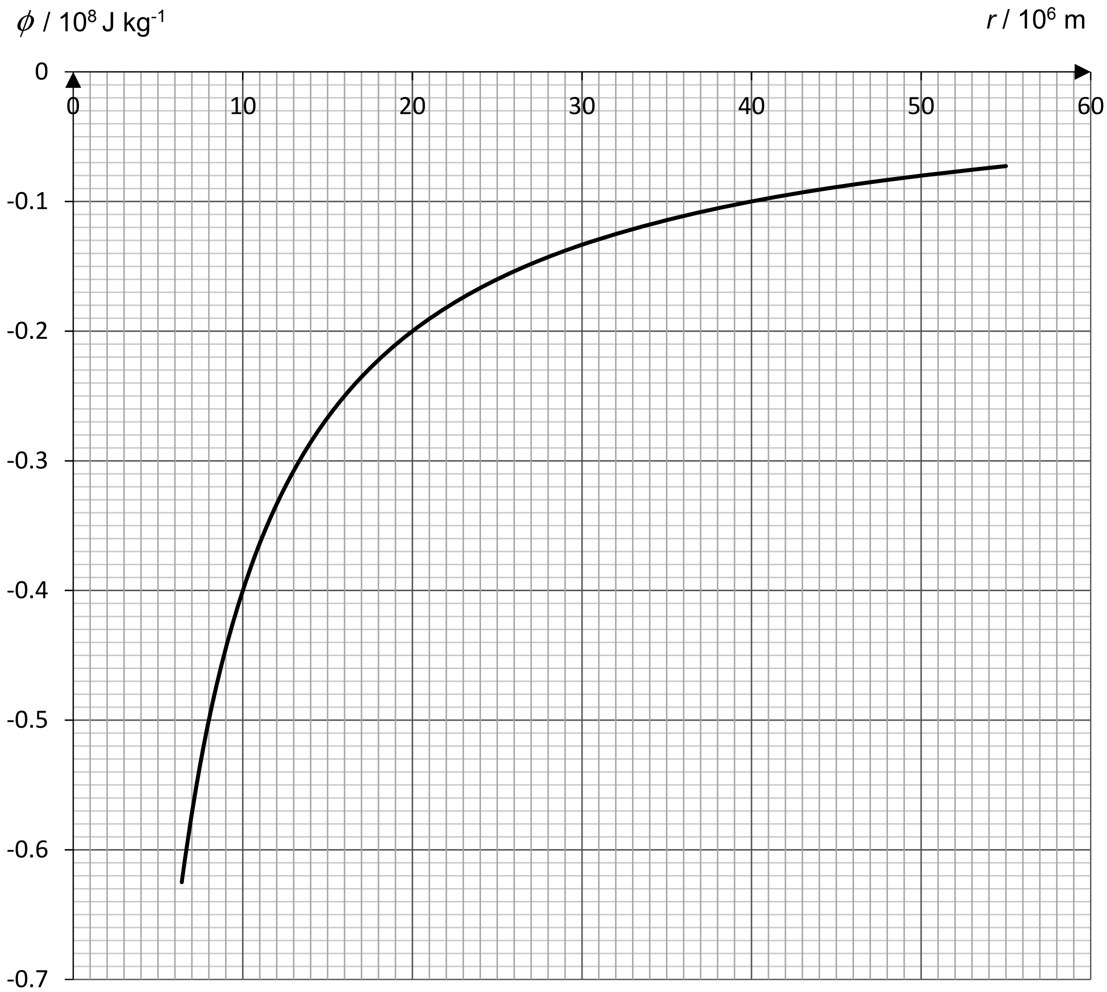

Fig. 2.1

(a) Explain why the gravitational potential graph is always negative.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

For Examiner's Use

(b) Using Fig. 2.1, show that the gravitational force acting on the satellite by the Earth when it is in orbit is about 270 N.

[3]

(c) Hence or otherwise, calculate the kinetic energy of the satellite when it is at the orbit.

kinetic energy = ……………………….. J [3]

For Examiner's Use

(d) Use Fig. 2.1 and your answer in **(c)** to determine the minimum amount of energy required to launch the satellite to the orbit. Assume that the kinetic energy of the satellite at the surface of Earth is 0 J.

energy = ……………………… J [3]

(e) The actual energy required to send the satellite to the orbit is different from the energy calculated in **(d)**.

Suggest a reason why.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

For Examiner's Use

3 **(a)** State what is meant by *internal energy* of a gas.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(b) 1.2×10^{-5} mol of ideal monoatomic gas is held in a container which allows heat to be freely exchanged between the gas, a regenerator and the surroundings. The regenerator acts as a type of heat storage that allows the gas to transfer heat to and from the regenerator as the gas cycles through the 4 states. The gas is made to undergo the following thermodynamic cycle as shown in Fig. 3.1.

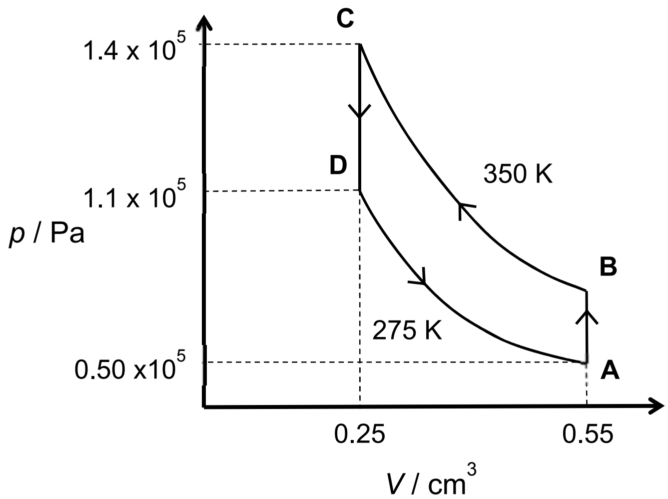

Fig. 3.1

A→B: the gas absorbs heat from the regenerator and its pressure increases.

B→C: the gas contracts isothermally at 350 K

C→D: the gas supplies heat to the regenerator and its pressure decreases

D→A: the gas expands isothermally at 275 K

For Examiner's Use

(i) Determine the pressure at B.

pressure at B = ……………………… Pa [2]

(ii) Show that the change in internal energy from C → D is -11.2 x 10^{-3} J.

[1]

(iii) Fig. 3.2 shows the energy changes for the transitions from A → B → C → D → A.

Complete the table. Show your working clearly.

	Heat supplied / x 10^{-3} J	work done on the gas / x 10^{-3} J	change in internal energy / x 10^{-3} J
A → B			
B → C		27.5	0
C → D			- 11.2
D → A		- 21.6	0

Fig 3.2

[3]

For Examiner's Use

(iv) The above cycle can be used to draw heat out from the surroundings by doing work on the gas. The coefficient of performance (COP) is a measure of how efficient this process is. The COP for such a system is defined as

$$\frac{Q_{in}}{W_{net}}$$

where Q_{in} is the heat energy absorbed by the gas from the surroundings and W_{net} is the **net** work done on the system for one cycle.

1. State which isothermal transition the gas absorbs heat energy from the surroundings.

……… → ……… [1]

2. Hence, determine the COP for this cycle.

COP = ………………………. [2]

[Turn over

For Examiner's Use

4 A mass damper can be used to stabilize a building during earthquakes. A mass-spring system shown in Fig 4.1 can be used to model a mass damper.

A 600 g mass is placed on a smooth surface and is attached horizontally to two unstretched identical springs X and Y with a spring constant of 20 N m^{-1}.

When the mass is displaced by 5.0 cm from its equilibrium position and released from rest as shown in Fig. 4.2, it undergoes simple harmonic motion.

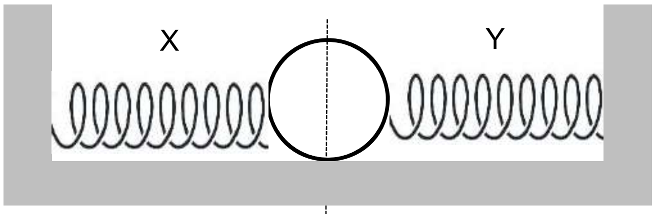

Fig. 4.1

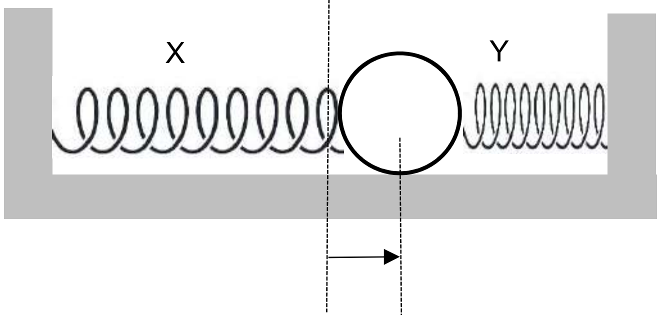

Fig. 4.2

(a) **(i)** Using energy consideration, calculate the maximum velocity of the mass.

maximum velocity = ……………………… m s^{-1} [3]

For Examiner's Use

(ii) Hence, determine the period of the oscillating spring-mass system.

period = ……………………… s [2]

(iii) Sketch on Fig 4.3 the variation with time *t* from the point of release of the mass

1. of the kinetic energy of the mass. Label this graph M.

2. of the elastic potential energy of spring Y. Label this graph S.

Show 1 complete oscillation. [2]

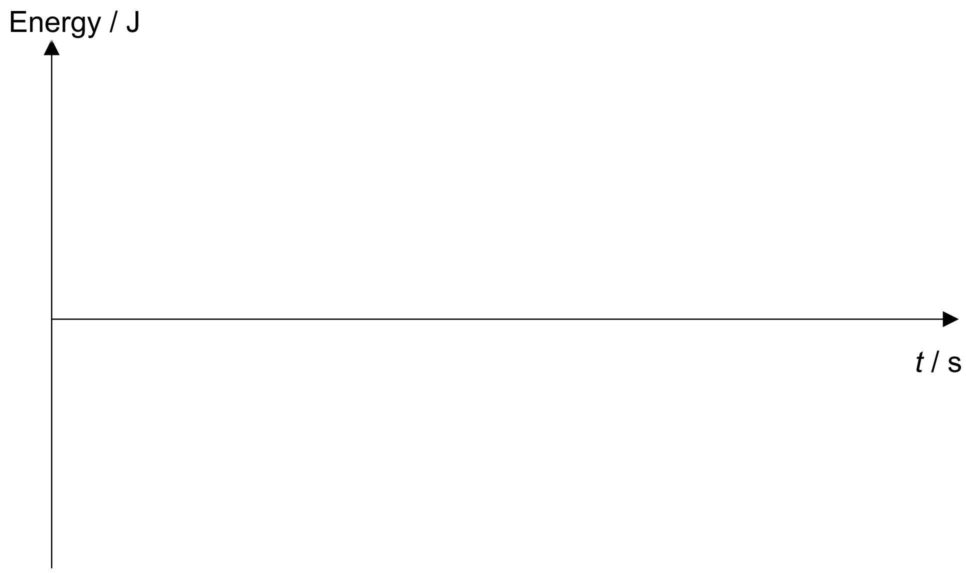

Fig. 4.3

(b) Suggest how the mass damper can help stabilize a building during an earthquake.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [1]

For Examiner's Use

5 **(a)** Fig. 5.1 shows a gold-leaf electroscope. The gold leaf is deflected because the electroscope is negatively-charged.

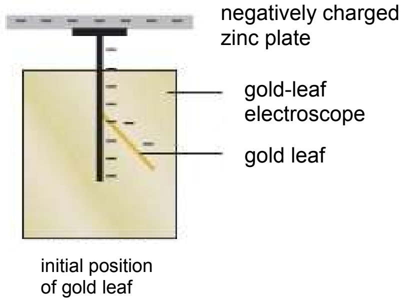

Fig. 5.1

(i) When red light is incident on the electroscope, the gold leaf remains deflected as shown in Fig. 5.2 a.

When ultra-violet radiation is incident on the electroscope, the gold leaf falls as shown in Fig. 5.2 b. This is due to a decrease in the negative charge of the gold leaf.

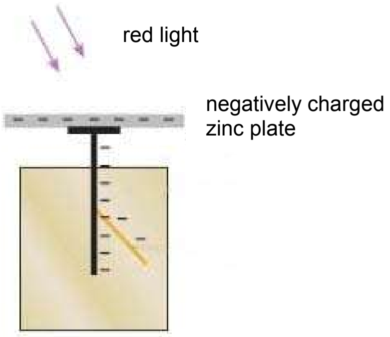

Fig. 5.2 a

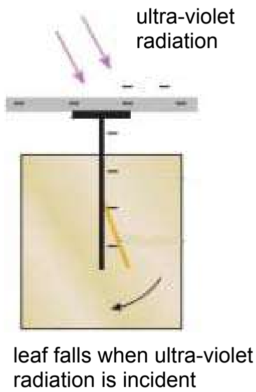

Fig. 5.2 b

Using Fig. 5.2 a and Fig. 5.2 b, explain how this is a demonstration of the photoelectric effect.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

For Examiner's Use

(ii) When the intensity of the red light that is incident on the electroscope in Fig. 5.2 a is increased, the deflection of the gold leaf remains the same.

Explain how this is an evidence for the particulate nature of electromagnetic radiation.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) X-rays are produced by bombarding electrons, accelerated through a high potential difference, on a metal target. A typical X-ray spectrum is shown in Fig. 5.3.

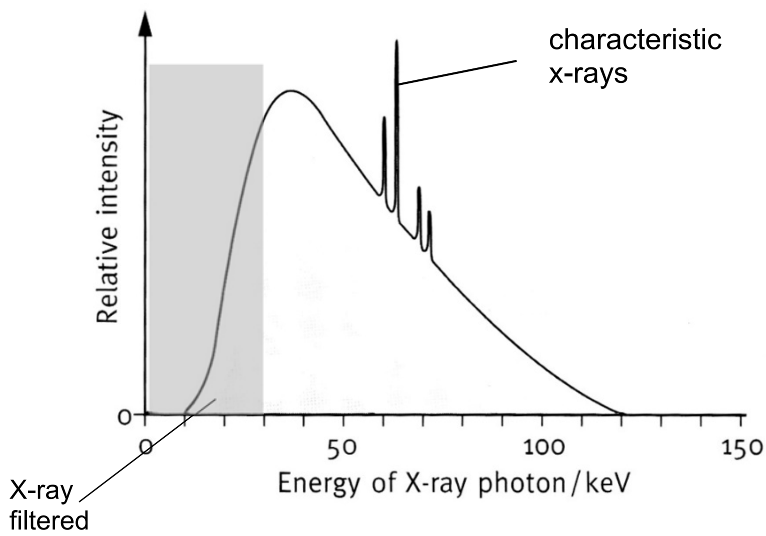

Fig. 5.3

(i) State the potential difference used to accelerate the electrons to produce the X-rays.

potential difference = ……………………… V [1]

(ii) Explain the mechanism by which the characteristic X-rays are produced.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………… [2]

(iii) Explain why characteristic X-rays produced are unique to the element used in the metal target.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………… [1]

(iv) X-rays can be used as a diagnostic tool. This is possible because different parts of our body absorb different amounts of X-ray. The lower energy X-rays are often filtered as shown in Fig. 5.3.

Suggest a reason why this is necessary.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………… [1]

For Examiner's Use

(c) An electron travelling at 1200 m s^{-1} passes through a slit of 24 μm as shown in Fig. 5.4.

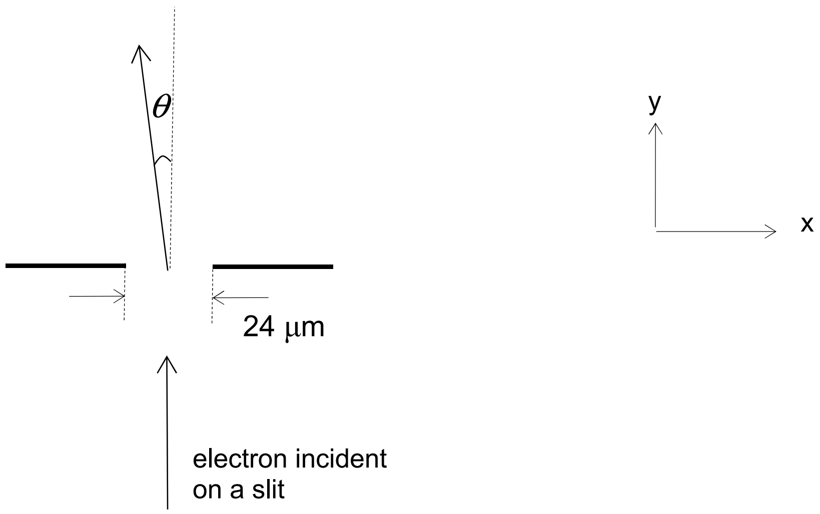

Fig. 5.4

(i) Calculate the minimum uncertainty of the momentum of the electron in the x-direction, Δp_x.

Δp_x= ……………………… kg m s^{-1} [2]

(ii) In an experiment where many electrons are put through the slit, it is observed that most electrons deviate from its original path within the angle θ as shown in Fig. 5.4 due to the uncertainty of the electrons' momentum.

Use your answer in **(c)(i)** or otherwise, calculate θ.

θ = ……………………… ° [3]

[Turn over

For Examiner's Use

Section B

Answer **one** question from this section.

6 (a) Define *electric field strength* at a point.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(b) (i) A long positively charged rod is placed at a distance from a stationary -2.0 μC point charge as shown in Fig. 6.1.

Sketch the electric field pattern between the rod and the point charge. [1]

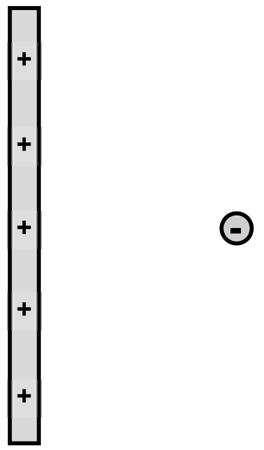

Fig. 6.1

(ii) A current I is passed through the rod and the charge moves at a speed of 1.5 cm s^{-1} as shown in Fig. 6.2. The charge experiences a magnetic field strength of 10 mT.

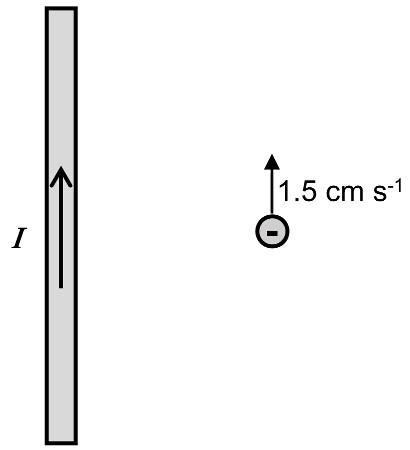

Fig. 6.2

For Examiner's Use

1. Calculate the magnitude of the force experienced by the charge due to the magnetic field of the rod.

force = ……………………… N [2]

2. The negative charge moves in a curved path to the right.

Explain this observation.

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……………………………………………………………………………………

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……………………………………………………………………………………

…………………………………………………………………………………… [2]

3. State and explain a modification that can be made to Fig. 6.2 such that the negative charge can be made to move parallel to the rod when the current I is still passing though the rod.

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……………………………………………………………………………………

…………………………………………………………………………………… [2]

[Turn over

For Examiner's Use

(iii) In a second experiment, the rod carrying a current of 4.0 mA is placed next to a horizontal flat coil of wire which is fixed in its position. The centre of the coil, P, is at a perpendicular distance of 20 cm from the rod as shown in Fig. 6.3.

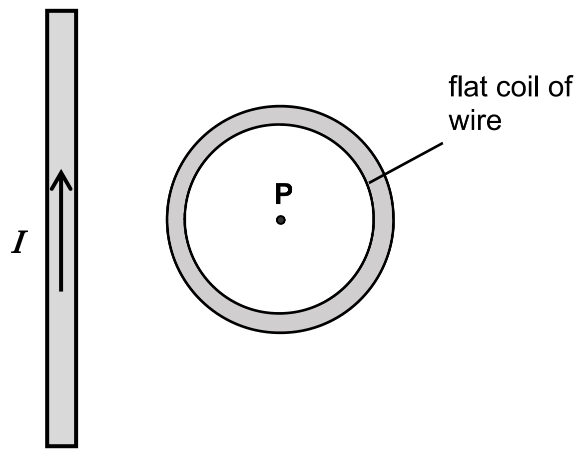

Fig. 6.3

1. Calculate the magnitude of the magnetic flux density at P.

magnetic flux density = ………………………. T [2]

2. A very small current now flows in the flat coil of wire in an anti-clockwise direction.

Without any further calculation, state and explain if the magnetic flux density at P will change compared to that obtained in **(b)(iii)1**.

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……………………………………………………………………………………

…………………………………………………………………………………… [2]

For Examiner's Use

3. State and explain the direction of the net force acting on the coil.

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……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(c) A circular coil is placed with its axis vertical and a bar magnet aligned with the axis of the coil, is held above the coil as shown in Fig. 6.4. The bar magnet is then dropped. A datalogger is connected to the coil and records the e.m.f. induced in the coil.

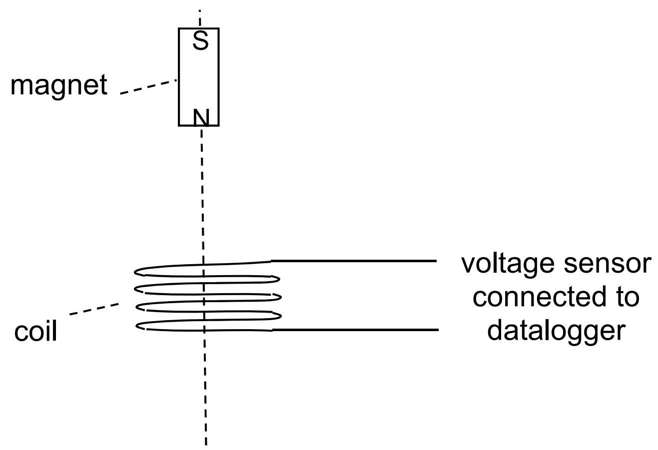

Fig. 6.4

Fig. 6.5 shows the variation with time of the e.m.f. induced as the magnet falls through the coil.

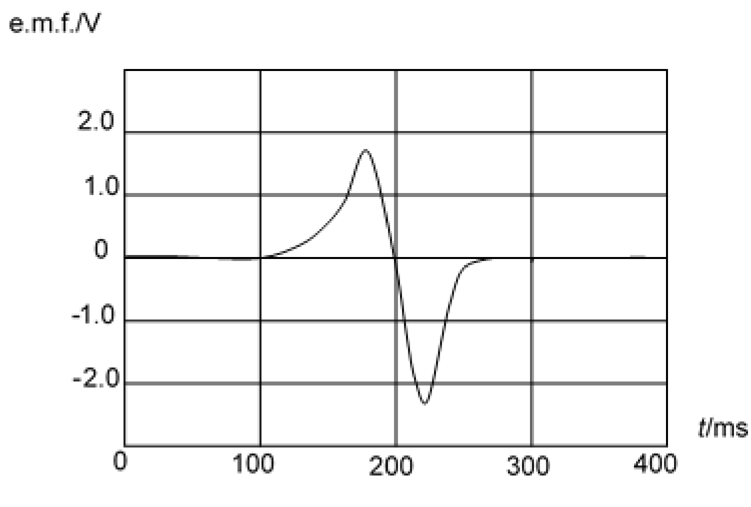

Fig. 6.5

[Turn over

For Examiner's Use

(i) State what the area under the graph between 200 ms and 270 ms represent.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Using the laws of electromagnetic induction, explain the shape of the graph obtained in Fig. 6.5.

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…………………………………………………………………………………………… [3]

(iii) The experiment is repeated with the magnet now dropped from a higher height.

State and explain how the graph in Fig. 6.5 will change.

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……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

For Examiner's Use

7 **(a)** Explain what is meant by the phase difference of two waves of the same frequency.

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…………………………………………………………………………………………………

………………………………………………………………………………………… [1]

(b) An experiment to investigate two-source interference using light waves is set up as shown in Fig. 7.1. Three slits S_0, S_1 and S_2 of equal width are used with a lamp that is attached with a red filter.

Fig. 7.1 (not to scale)

(i) For observable interference, suggest why slit S_o is needed when the light source used is a lamp.

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…………………………………………………………………………………………

………………………………………………………………………………… [2]

(ii) Draw on Fig. 7.1 lines to represent the rays of light from S_o to the point C on the screen which is equidistant to S_1 and S_2. [1]

(iii) State the path difference of the light reaching point C.

path difference = ……………………… [1]

For Examiner's Use

(iv) 1. The amplitude of the light at point C on the screen in Fig. 7.1 is ***A***.

State and explain the new amplitude at point C on the screen when a piece of polariser is placed in front of S_2.

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……………………………………………………………………………………

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……………………………………………………………………………………

…………………………………………………………………………………… [2]

2. Describe the changes to the interference pattern on the screen if the red filter in Fig. 7.1 is replaced with a blue filter.

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……………………………………………………………………………………

…………………………………………………………………………………… [2]

(c) (i) Explain the formation of a stationary wave.

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……………………………………………………………………………………

…………………………………………………………………………………… [2]

For Examiner's Use

(ii) A stationary wave is setup in a one end open tube using a speaker which is connected to a signal generator as shown in Fig. 7.2.

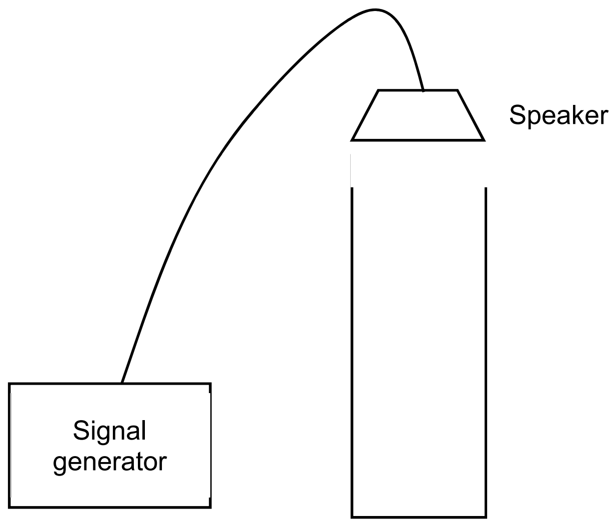

Fig. 7.2

The length of the tube is 90 cm long and the wavelength of the sound is 120 cm. A small microphone which senses pressure variation is placed in the tube to measure the frequency of the stationary wave formed.

The microphone is connected to a cathode-ray oscilloscope (c.r.o). When the microphone picks up the largest pressure variation, the waveform obtained on the c.r.o. is shown in Fig. 7.3.

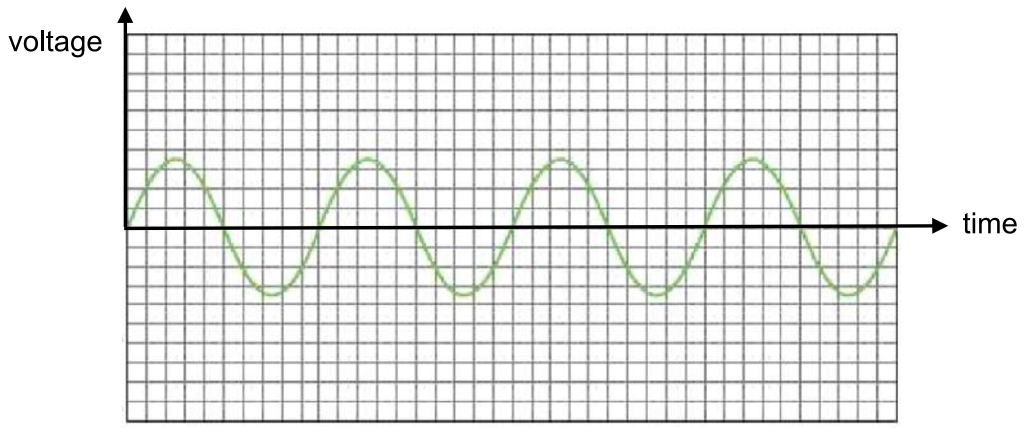

Fig. 7.3

For Examiner's Use

1. State and explain the distance in the tube from the open end for the microphone to be placed so that the waveform in Fig. 7.3 is obtained.

Include in your answer a diagram of the stationary wave setup in the air column of the tube. Label your diagram.

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....

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.... [3]

2. The wavelength of the sound from the speaker is increased to 330 cm. State and explain if a stationary wave can be formed.

....

....

....

....

.... [2]

For Examiner's Use

(d) A monochromatic laser is incident on a diffraction grating.

By drawing a suitable well-labelled diagram, describe how you would determine the wavelength of the laser light.

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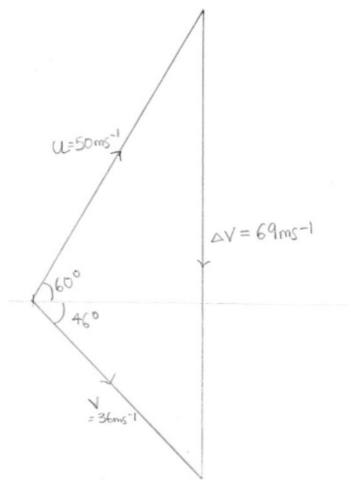
……………………………………………………………………………………………………

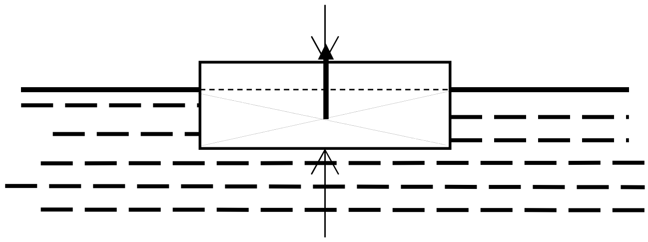
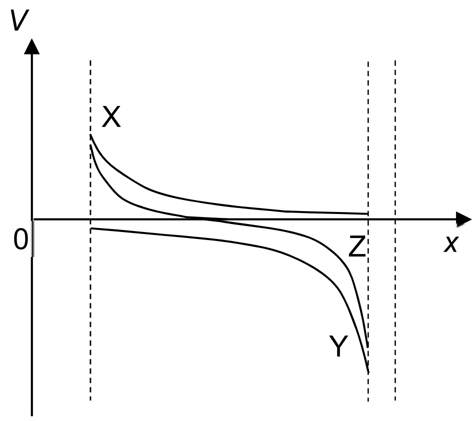
……………………………………………………………………………………………………

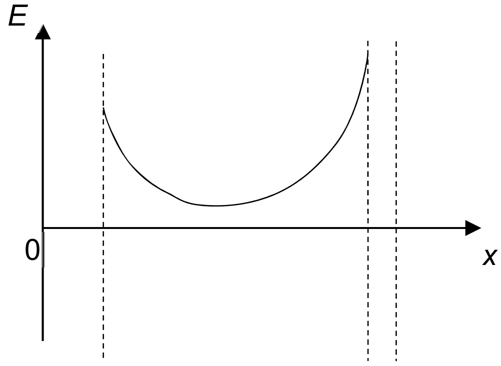
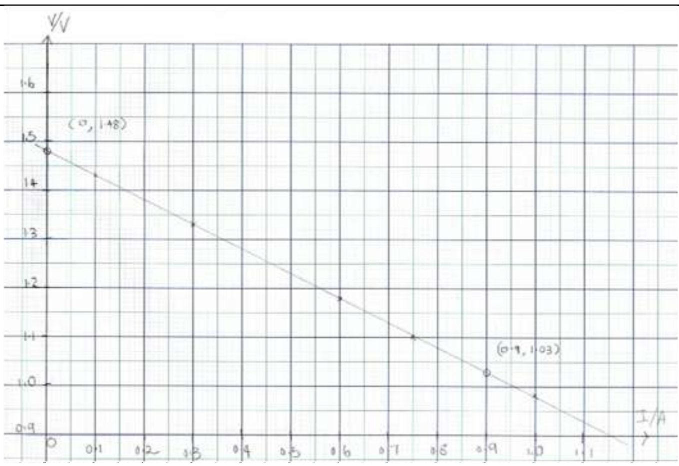
……………………………………………………………………………………………………

…………………………………………………………………………………………… [4]

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	**D**	**D**	**B**	**D**	**D**	**A**	**B**	**A**	**C**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	**B**	**B**	**C**	**B**	**D**	**C**	**A**	**D**	**D**
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	**D**	**B**	**D**	**C**	**D**	**C**	**D**	**A**	**A**

1	
(a)	Random errors: Above and below true value / no fixed pattern / different sign Systematic errors: Above or below true value / with a fixed pattern / same sign
	Random errors: Different magnitude / amount Systematic errors: Same magnitude / amount
(b)(i)	T = 1.41923 s
	$\pm\Delta T = \pm 0.01008$
	T = 1.42 ± 0.01 s
(b)(ii)	There is error due to human reaction time, large number of oscillations will reduce the effect of the (absolute) uncertainty on the calculation of *T*.
(b)(iii)	• Uneven radius of the Earth • Non-uniform density of the Earth (circulating magma current in the Earth core)
2	
(a)	$u_x = \dfrac{220}{8.8} = 25 \text{ m s}^{-1}$
	$u_y = 43.164 \text{ m s}^{-1}$
	$\tan\theta = \dfrac{43.164}{25}$ $\theta = 59.9^{\circ}\ (1dp)$
	$u = 50 \text{ m s}^{-1}\ (2sf)$
(b)(i)	*change in velocity*, Δv $= 69 \text{ m s}^{-1}\ (2sf)$
	
(b)(ii)	magnitude of v = (36 ± 2) m s^{-1} direction: (46 ± 2) °below horizontal

3	
(a)	Any object immersed in a fluid will experience an upthrust whose magnitude is equal to the weight of the fluid displaced by the object.
(b)(i)	Resultant force = upthrust
	= 1165.428 N = 1200 N (2sf)
(b)(ii)	 Correct point of origin and having magnitude equal to difference in length of the two arrows
(b)(iii)	By Principle of floatation, $\rho_{block} V_{block} g = \rho_{water} V_{disp} g$
	ρ_{block} = 730 kg m^{-3} (2sf)
(b)(iv)1	$r_{water}V_{block}g - r_{block}V_{block}g = r_{block}V_{block}a$
	a = 4.9 m s^{-2} (2sf)
(b)(iv)2	$s = \frac{1}{2}at^2$
	= 0.20 s (2sf)
(b)(iv)3	As block moves up, viscous drag acts on the block downwards,
	reducing the net force / acceleration upwards on the block. Time taken is longer.
4	
(a)(i) **(a)(ii)** **(a)(iii)**	
	Correct general shape for X and Y
	Show an understanding that the resultant potential is a **scalar** sum of the potential due to the individual charges.

(b)	
	U shaped graph
	Show an understanding that the resultant field strength is the **negative gradient** of the potential graph.
(c)	For charge to be stationary, net force = 0 $\lvert E_{+q}\rvert = \lvert E_{-2q}\rvert$
	Let the distance of the point from +*q* charge be *r*. $\dfrac{q}{4\pi\varepsilon_0 r^2} = \dfrac{2q}{4\pi\varepsilon_0 (d+r)^2}$
	r = 2.41 *d* (3sf)
5	
(a)(i)	current = $\dfrac{\text{total charge}}{\text{time}}$
	$= \dfrac{\text{n x A} \times L \text{ x } e}{\text{time}}$
	$= nAve$
(a)(ii)	$I = nAve,\ v \propto \dfrac{1}{n(\text{diameter})^2}$
	= 0.24 m s^{-1} (2sf)
(b)(i)	
	
	Since, $V = E - Ir$, $V = -rI + E$ intercept = *E* = 1.48 V
	gradient = $\dfrac{1.48-1.03}{0.00-0.90} = -0.50$
	r = 0.50 Ω

(b)(ii)	As temperature increases, resistance of thermistor decreases.
	The effective resistance of the circuit decreases. Current increases, causing terminal potential difference to decrease.
	Since $P = \frac{V^2}{R}$, power output of resistor R decreases.
6	
(a)	Nucleus is very small compared to atom.
	The nucleus is positively charged.
	Only a small proportion of *α*-particles approach close to the nucleus. Electrostatic repulsion gives a large deflection.
(b)(i)	A: nucleon number = 1; proton number = 1
	B: nucleon number = 3; proton number = 1
(b)(ii)	Slow moving nuclides would not have sufficient kinetic energy to overcome large/strong electrostatic repulsion between the two nuclides.
(b)(iii)	Mass defect = 0.00240 *u*
	Binding energy = 3.5856×10^{-13}
	Binding energy per nucleon = 1.7928×10^{-13} J
	= 1.1 MeV (2sf)
(c)(i)	Mean time taken for half the number of Sodium-24 present to decay / disintegrate.
(c)(ii)	$A = A_o e^{-\lambda t}$
	A = 1979.26187 disintegrations per minute Volume of blood = 1979.26187 / 0.50
	= 4000 cm^3 (2sf)
	OR $A = A_o e^{-\lambda t}$
	A_o = 3.03143 disintegrations per minute Volume of blood = 12000 / 3.03143
	= 4000 cm^3 (2sf)
(c)(iii)	Short half-life of Sodium-24 makes it suitable for use as it does not stay in the body for a long period of time.
7	
(a)	• Lower emission of greenhouse gases • Does not require petrol as fuel (use less non-renewable energy sources) • Quieter engines
(b)(i)	$a = v - u / t$ = 2.72166
	$s = v^2 - u^2 / 2a$ = 320 m (2 sf)
(b)(ii)1.	Units of C_d = Units of ($F_d / \rho v^2 A$) = 1

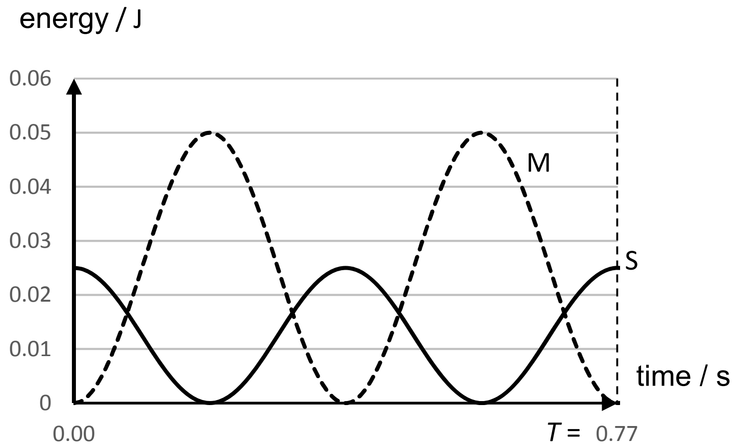
(b)(ii)2.	Power = *Fv*
	= 1000 W (2 sf)
(c)(i)	0.28
(c)(ii)	Kinetic energy of car to electrical energy of generator to (chemical) potential energy of battery
(c)(iii)	Increase in efficiency = (0.08 * 0.80 * 0.90)
	= 0.06 (1sf)
(d)(i)	Energy stored per unit mass of the battery
(d)(ii)	Mass of battery = (30 x 1000 / 140) / 48 x 4 1.1 kg (2sf)
(d)(iii)	Time = Energy / Power = 4.3 hours (2sf)
(d)(iv)1	69.86 %
(d)(iv)2	Point plotted to half smallest square
(d)(iv)3	Best-fit line drawn
(d)(iv)4	*P* = 77.75 - 78.25 %
(e)(i)	• Electric cars consume electricity in charging which produces CO_2 at the point of power generation • Production of components of car may produce CO_2
(e)(ii)	CO_2 emission in 1 charge = 0.4 x 30 x 1000 = 12000 g
	Emission rate = 12000 / 172 = 69.76744 g km^{-1} Band A1

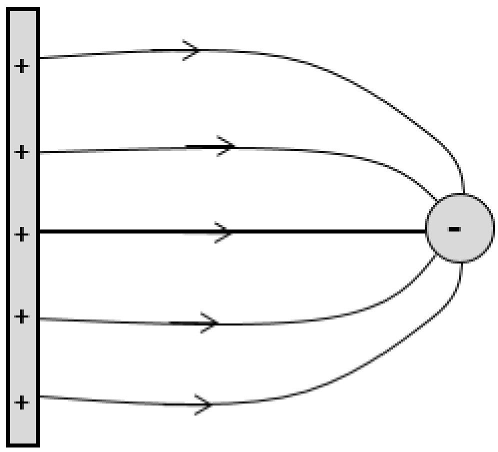
1	
(a)(i)	By Conservation of linear momentum, $0 = m_{Rifle} v_{recoil} + m_{bullet} v_{bullet}$
	v_{recoil} = -2.3 m s^{-1} (2 sf)
(a)(ii)	Change in momentum of 1 bullet = 0.015 (700 – 0)
	By N2L, Average force by rifle on bullets = $\frac{m(v_f - v_i)}{\Delta t}$
	= 52.5 N By N3L, Average force by bullets on rifle is equal and opposite to average force by rifle on bullets = -52.5 N
	Alternative Change in momentum of rifle = 10(4.5)(-2.33333 – 0)
	By N2L, Average force by bullets on rifle = $\frac{m(v_f - v_i)}{\Delta t}$
	= -52.5 N
(b)(i)	Initial KE = 10 J Final KE = 5 J
	Since initial KE is greater than final KE, collision is inelastic.
	Alternative Relative speed of approach = 15 m s^{-1} Relative speed of separation = 10 m s^{-1}
	Since relative speed of approach is not equal to relative speed of separation, the collision is inelastic.
(b)(ii)	Impulse = change in momentum
	= -2.0 N s
(b)(iii)	If KE is fully converted to other forms of energy at the same time during the collision, total / sum of momentum is zero.
	By conservation of momentum, since total / sum of initial momentum is not zero, this is not possible.
(c)(i)	From point of release of block B to the point of contact with spring: Net loss of GPE of blocks is converted to gain in KE of blocks.
	From point of contact with spring to point where net force on block B is zero: Net loss of GPE of blocks is converted to gain in KE of blocks and EPE of spring.
	From point where net force on block B is zero to point of maximum compression: Net loss of GPE and KE of blocks is converted to gain in EPE of spring.
(c)(ii)	Net loss in GPE = Gain in EPE
	k = 460 N m^{-1} (2 sf)

2	
(a)	Work done per unit mass by an external agent in bringing a small point test mass from infinity to a point near Earth is negative.
	Gravitational potential at infinity is zero. It is negative because gravitational force is always attractive.
(b)	Negative gradient of gravitational potential - distance graph gives gravitational field strength.
	Tangent drawn with 2 points read off
	$\frac{\left(-0.075-\left(-0.190\right)\right)\times 10^{8}}{\left(50-0\right)\times 10^{6}}=0.23\text{ N kg}^{-1}$ Gravitational force = 0.23 N kg^{-1} x 1200 kg = 276 N
(c)	Gravitational force provides centripetal force
	Centripetal force = $m\frac{v^2}{r}$ $\frac{1}{2}mv^2=\frac{\text{force}\times r}{2}$
	= 5.7 x 10^9 J (2sf)
(d)	Increase in GPE required = $\Delta\Phi$ x m (= 6.36 x 10^{10} J)
	Minimum energy required = Increase in GPE + KE at orbit
	= 6.93 x 10^{10} J (3 sf)
(e)	• Energy used to accelerate and decelerate the satellite to change direction of satellite • Energy to overcome resistive forces in Earth's atmosphere • Inefficiency in propulsion system • Energy required to launch satellite (due to rocket) • KE of satellite is not zero at Earth's surface due to Earth's rotation
3	
(a)	The internal energy of a body is the sum of the random distribution of all the potential and kinetic energies of the microscopic particles / atoms / molecules in the gas.
(b)(i)	Since B and C are at the same temperature, $P_C V_C = P_B V_B$
	$P_B = 6.36\times 10^4$ Pa
	Alternative Using Ideal gas law, $P_B V_B = nRT_B$
	$P_B = 6.35\times 10^4$ Pa

(b)(ii)	Applying Ideal gas equation, $\Delta U_{CD} = \frac{3}{2}nR\Delta T = \frac{3}{2}\Delta(PV) = \frac{3}{2}V(\Delta P)$
	$\Delta U_{CD} = -11.2\times10^{-3}$ J
(b)(iii)	Isovolumetric process: W = 0 J $W_{CD} = W_{AB} = 0$ J For a cyclic process, $\Delta U = 0$ $\Rightarrow \Delta U_{AB} = -\Delta U_{CD} = 11.2\times10^{-3}$ J Apply first law of thermodynamics $Q_{AB} = 11.2\times10^{-3}$ J; $Q_{BC} = -27.5\times10^{-3}$ J; $Q_{CD} = -11.2\times10^{-3}$ J; $Q_{DA} = 21.6\times10^{-3}$ J
(b)(iv)1.	D $\rightarrow$ A
(b)(iv)2.	$W_{net} = 27.5\times10^{-3} + (-21.6\times10^{-3})$
	$\text{COP} = \frac{21.6\times10^{-3}}{5.9\times10^{-3}}$ $= 3.7$ (2sf)
4	
(a)(i)	Maximum EPE stored in the 2 springs = $2\times\frac{1}{2}kx^2 = 0.050$ J
	When this is all transferred to KE $\frac{1}{2}mv_{max}^2 = 0.050$ J
	$v_{max} = 0.41$ m s^{-1} (2sf)
(a)(ii)	$v_{max} = \omega x_o$
	$T = 0.77$ s (2sf)

	heat supplied / x 10^{-3} J	work done on the gas / x 10^{-3} J	change in internal energy / x 10^{-3} J
A $\rightarrow$ B	11.2	0	11.2
B $\rightarrow$ C	- 27.5	27.5	0
C $\rightarrow$ D	-11.2	0	-11.2
D $\rightarrow$ A	21.6	- 21.6	0

(a)(iii)1. **(a)(iii)2.**	
	Correct M graph – $\sin^2$ and T or 0.77 shown
	Correct S graph – $\cos^2$ and ½ energy of M
(b)	During an earthquake, as the building sways, energy is transferred to the mass-spring system of the damper. Therefore, amplitude of oscillation of the building decreases, preventing structural damage.
5	
(a)(i)	Electrons are emitted from zinc when ultraviolet radiation is incident on it, discharging the gold leaf.
	Frequency of ultraviolet radiation, but not red light, exceeds threshold frequency of zinc.
(a)(ii)	Increasing intensity increases the number of photons incident per unit time.
	Energy of each photon doesn't change. Since electromagnetic radiation behave as particles which interact with electrons in a one-to-one manner, no electrons are emitted as energy of photon is still less than the work function of zinc.
(b)(i)	120 000 V
(b)(ii)	High energy electrons knock out the inner shell electrons from the metal target atoms. Electrons from higher energy level drops to lower energy level.
	The loss in energy of electrons is converted to X-ray photons of energy = energy difference between the two energy levels.
(b)(iii)	Different metal targets have their unique energy levels. Hence the differences are energy levels are unique.
(b)(iv)	Lower energy X-rays have insufficient energy to penetrate through the body. But they contribute to the overall dose in patients.
(c)(i)	Estimate uncertainty of position of x = 24 x 10^{-6} m
	$\Delta x \Delta p_x \geq h$ $\Delta p_x = \frac{6.63\times10^{-34}}{24\times10^{-6}}$ $= 2.8\times10^{-29}$ kg m s^{-1} (round up to 2sf)

(c)(ii)	$p_y = m_e v = 1.0932\times10^{-27}$ kg m s^{-1}
	$tan\,\theta = \frac{p_x}{p_y} = \frac{2.7625\times10^{-29}}{1.0932\times10^{-27}}$
	$\theta = 1.4°$ (1dp)
	Alternative Wavelength associated with the electrons $\lambda = \frac{h}{p_y} = 6.065\times10^{-7}$ m
	Using single slit diffraction formula, n = 1, b = 24 x 10^{-6} m $b\sin\theta = \lambda$
	$\theta = 1.448507° = 1.4°$ (1dp)
6	
(a)	Electric field strength at a point is the electric force experienced per unit charge on a small stationary positive point test charge placed at that point and is in direction of the electric force on a positive test charge at that point.
(b)(i)	
	Correct direction of E field E field stronger to the right Symmetrical field pattern At least 5 lines
(b)(ii)1.	$F = Bqv \sin 90°$
	= 3.0 x 10^{-10} N
(b)(ii)2.	Direction of magnetic field due to wire is into the page and current is downwards. Using FLHR, direction of magnetic force experienced by the charge is to the right.
	Force has a different direction from velocity of charge, hence path is curved.
(b)(ii)3.	Apply a uniform electric field to the right OR using parallel plates with positive plate at the left
	Net force on charge will be zero due to electric force which is opposite in direction but equal in magnitude to the magnetic force exerted by the rod.
	Alternative Apply a magnetic field out of page OR by placing another rod carrying current of the same magnitude and direction such that the charge lies exactly between the 2 rods
	Net force on charge will be zero due to magnetic force which is opposite in direction but equal in magnitude to the magnetic force exerted by the rod.

(b)(iii)1.	$B = \frac{\mu_o I}{2\pi r}$
	= 4.0 x 10^{-9} T
(b)(iii)2.	Using RHGR, magnetic field due to coil at P is out of the page while magnetic field due to rod at P is into the page.
	Hence resultant magnetic flux density at P is the vector sum of the magnetic field due to the coil and rod.
(b)(iii)3.	The part of the coil closer to the rod will experience a repulsive force / force to the right (current in opposite direction) while the opposite end of the coil will experience an attractive force / force to the left (current in the same direction)
	The repulsive force is stronger than the attractive force as the magnetic flux density decreases with distance from the rod, therefore the coil will experience a net force to the right.
(c)(i)	The area under the graph between 200 ms and 270 ms represents the loss in magnetic flux linkage experienced by the coil when the magnet is leaving the coil.
(c)(ii)	As the magnet approaches the coil, the coil experiences a change of magnetic flux linkage and emf is induced, reaching a maximum when the N-pole of the magnet reaches the coil.
	When the S-pole leaves the coil, rate of change of magnetic flux linkage is larger as speed increases due to acceleration, resulting in a higher induced emf.
	As the change in magnetic flux linkage is in the opposite direction when the magnet is entering and leaving the coil, with increasing flux when entering and decreasing flux when leaving, induced emf have opposite polarity.
(c)(iii)	Due to greater speed attained, there is a greater rate of change of magnetic flux linkage experienced by the coil.
	The two peaks will be higher as magnitude of induced emf increases.
	OR
	Due to greater speed attained and change in magnetic flux linkage remains unchanged.
	The time duration where there is an induced emf is shorter.
7	
(a)	Phase difference between two waves is the fraction of a cycle by which two waves are out of step with each other.
(b)(i)	Lamp is not a point source
	Single slit makes light from S_1 and S_2 coherent / light from lamp is not coherent
(b)(ii)	One line from S_0 to S_1 to C One line from S_0 to S_2 to C Arrows to indicate direction
(b)(iii)	Path difference = 0 m
(b)(iv)1.	Intensity at C due to S_2 is reduced
	Resultant amplitude at C is less than A since intensity is proportional to amplitude^2.
(b)(iv)2.	Fringe separation is smaller
	Contrast remains the same
(c)(i)	Two waves travelling in opposite directions meet/superpose
	Two waves have same speed and frequency/wavelength

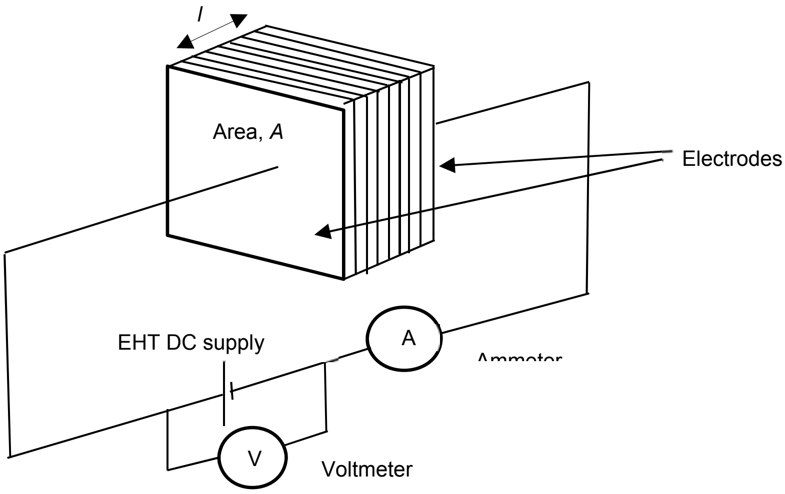
(c)(ii)1.	Correct stationary wave pattern: two nodes and two antinodes
	Pressure variation is maximum at the displacement node
	Microphone is placed 30 cm from the open end or at the closed end
(c)(ii)2.	Fundamental mode requires wavelength of 360 cm
	No stationary wave pattern can be formed
(d)	Diagram shows: Laser Grating Screen showing zero and first order bright fringe or other order fringes (can be markings on screen) Angle θ between zero and first order bright fringe
	d is slit separation or example calculation like 1 mm / 600 lines
	D is screen distance and x is distance from n = 0 to n = 1
	$\tan\theta = x / D$ To find λ, use $\lambda = d \sin\theta$

Question 1 – Oscillation	
(a)(i)	Zero error indicated and repeated readings To nearest 0.002 cm
(a)(ii)	Take repeated readings where the vernier calipers are positioned at different positions along the circumference of the tube and take average.
(b)(i)	Repeated readings To nearest 1 mm
(b)(ii)	$\Delta x \geq 2$ mm 1 sf
(c)	Measurement of t > 10 s (check **(d)(ii)** also) Repeated readings To nearest 0.01 s (check **(d)(ii)** also)
	n (no. of oscillations) indicated *T* correctly calculated 4 sf
(d)(i)	Correct calculation To nearest 0.1 cm 1 dp
(d)(ii)	*T* correctly calculated, and **more** than that in **(c)** (Measurement of t > 10 s, repeated readings, to nearest 0.01 s checked in **(c)**)
(e)(i)	Correct method for finding both value of *k* with units
(e)(ii)	Calculate % diff of *k*
	Must compare with **(b)(ii)**

Question 2 – Electrical Circuits / Thermodynamics	
(a)(iii)	To nearest 0.5 °C (Check **(c)(i)** also)
(b)(iii)	To nearest 0.1 mA (check **(c)(ii)** also)
(c)(ii)	Current measured to be **less** than that of **(b)(iii)** (To nearest 0.1 mA, checked in **(b)(iii)**)
(d)(i)	**All** points plotted correctly Work to an accuracy half of a small square
	Straight line of best fit drawn correctly
(d)(ii)	Linearizing equation – correctly identify the gradient and y-intercept in **(d)(ii)** or **(d)(iii)**
	Gradient – hypotenuse of the triangle must be greater than half the length of the drawn line Read-offs must be accurate to half a small square Correct units of V^{-1}
	y-intercept determined from $y = mx + c$ using a point on the line Must not have units
(d)(iii)	Values of *e* and I_0 calculated correctly with correct units
(d)(iv)	Line drawn with smaller gradient Line should not intercept original line

Question 3 – Mechanics (Equilibrium of Forces)	
(a)	To nearest 1 mm Check repeated readings for *l* and θ in table
(c)(v)	Correct calculation shown Correct units 1 or 2 dp if in cm
(d)(i)	Award 2 marks if candidate has successfully collected 6 or more sets of data (l, θ). Award 1 mark if candidate has successfully collected 5 sets of data (l, θ). Award 0 mark if candidate has successfully collected 4 or fewer sets of data (l, θ).
	Layout: column headings correctly shown with correctly presented units
	All measured values to correct precision θ to nearest ° l to nearest 0.1 cm
	Correct precision for each calculated value *e* to 1 or 2 dp in cm tan θ to 2 or 3 sf
	Correctly calculated values of calculated quantity
(d)(ii)	Sensible scales must be used. Awkard scales (e.g. 3:10) are not allowed. Scales must be chosen so that plotted points occupy half the graph grid in both x and y directions Axes must be labelled with the quantity which is being plotted. (allow ecf from **(d)(i)**)
	All observations must be plotted Work to an accuracy of half a small square
	Curve of best fit – judge by scatter of points about the candidate's line. There must be fair scatter of points either side of the line.
(d)(iii)	Tangent correctly drawn at tan (30°) = 0.57735
	Gradient – hypotenuse of the triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Correct unit shown.
(e)(i)	Relevant points (with appropriate elaboration) might include: • Difficult to ensure that the half-metre rule is horizontal • Shaky hands when holding the ruler / protractor to measure the length of spring / angle, affecting the measurement of *l* / θ. • Difficult to determine the end positions of the spring to accurately determine l, affecting the measurement of *l*.
(e)(ii)	Relevant points (with appropriate elaboration) might include: • Measure the height of the two ends of the metre rule from the table using a ruler. Ensure that they are at the same height so that the metre rule is horizontal. • Use another retort stand, boss and clamp to hold on to the protractor/ruler and position it in front of the set up to measure. • Attach pins to both ends of the spring so that a consistent position of the spring is used to measure the length throughout.

(f)	D1 – Diagram showing or description explaining how the experiment should be carried out. B1 – For each material of rope, load weights on the ruler until the rope breaks. A1 – Determine the tension in the rope as *mg*, where *m* is the mass hanging from the rope. Any 2 further details: F1 – Measure the mass of the load with an electronic balance or using specified standard slotted mass. F1 – Keep the length and/or diameter of the rope between the clamp and mass holder the same for the different materials. Measure with metre rule / vernier caliper / micrometer screw gauge to ensure they are the same. F1 – Once breaking point is achieved, repeat experiment with smaller increments of load to determine the breaking tension more accurately. F1 – Repeat the experiment for each material to find the average breaking tension of the rope.

Question 4 – Planning	
	Diagram 
	Labelled circuit diagram
	Basic Procedure
	Vary *l* and measure *R* while keeping *A* constant
	Vary *A* and measure *R* while keeping *l* constant
	Methods and Measurements
	Total thickness of glass, *l* measured using vernier calipers Method of determining area, *A* perpendicular to current flow (Measure length by breadth and multiply) using half meter rule (or 30-cm rule)
	Method of measuring resistance, *R* by use of ohmmeter or using potential difference / current ($R = V / I$)
	Controlled variables
	Temperature (of glass) kept constant by monitoring ambient temperature with a thermometer (or by doing experiment in an air-conditioned room)
	Analysis
	Linearise: $\ln R = x \ln(A) + \ln(kl^y)$ where x is the gradient and $\ln(kl^y)$ is the vertical intercept
	Describe linearising of the other equation if not mentioned earlier: $\ln R = y \ln(l) + \ln(kA^x)$ where y is the gradient and $\ln(kA^x)$ is the vertical intercept
	Explain how *k* is obtained using graphs related to both equations
	Further details
	Perform trials/tests to determine type of power supply required because resistance of glass is very high Or Perform trials to determine range of ammeter or ohmmeter because resistance of glass is very high Or Use glass sheets with small *l* and large *A* because the resistance of glass is very high
	Repeated readings of *V* and *I* or *R* if using ohmmeter to find average *R* to reduce random error

	Take many readings of thickness (of glass) at different locations and find average to account for non-uniformity in glass
	Good contact between circuit and glass using appropriate electrodes e.g. use of metal plates, foil, conducting putty
	Metal plates/foil/conducting putty to cover all of the cross-sectional area in use to ensure no exposed area of glass that is not connected to the circuit
	Method of securing circuit and glass e.g. with clamps, weights to ensure no/minimize air gaps between glass sheets and between electrodes and glass sheets
	Use clean / dry glass as impurities / moisture affect resistivity
	Safety
	Switch off before changing circuit / use rubber gloves due to use of EHT (extra high voltage) / prevent electric shock
	Wear thick gloves and protective footwear while handling glass in case of breakage

Name: ________________________________ (   )   PDG : _______ / 17

ANDERSON JUNIOR COLLEGE

2018 JC2 Preliminary Examination

PHYSICS Higher 2 9749/01

Paper 1 Multiple Choice **Tuesday 18 September 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

Write your name, class index number and PDG on the Answer Sheet in the spaces provided.
Shade and write your NRIC/FIN.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
The use of an approved scientific calculator is expected, where appropriate.

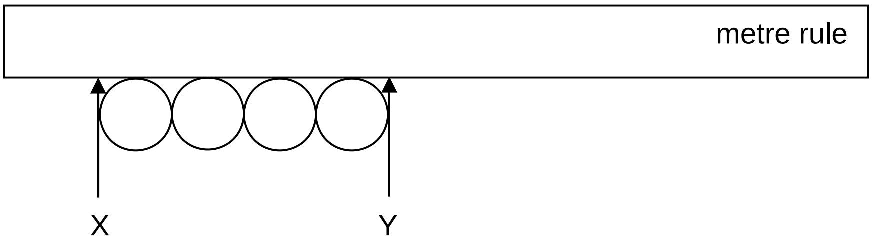
Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm \omega\sqrt{x_o^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 A student attempts to determine the radius of a steel ball by using a metre rule to measure four similar balls in a row.



The student estimates the position on the scale to be as follows:
X = (1.00 ± 0.05) cm
Y = (5.00 ± 0.05) cm

What is the radius of a steel ball together with its associated uncertainty?

A (0.50 ± 0.01) cm

B (0.50 ± 0.05) cm

C (0.5 ± 0.1) cm

D (1.0 ± 0.1) cm

2 A cannon at the top of a 30 m high hill fires a shell at an angle of 30° upwards from the horizontal with a speed of 50 m s^{-1}.

Taking air resistance to be negligible, what is the angle to the vertical at which the shell lands on level ground?

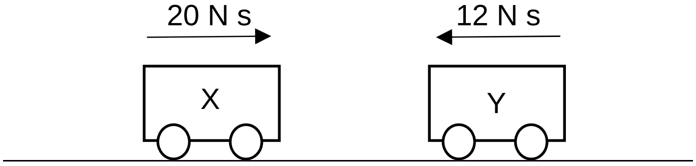
A 39° **B** 42° **C** 48° **D** 51°

3 A model helicopter of mass 5.0 kg rises with constant acceleration from rest to a height of 60 m in 10 s.

What is the upward force exerted on the model by the air?

A 3.0 N **B** 6.0 N **C** 43 N **D** 55 N

4 The given diagram shows the momentum of two trolleys, X and Y just before they collide. The collision reverses the direction of motion of both trolleys. Just after the collision, the momentum of Y is 12 N s.

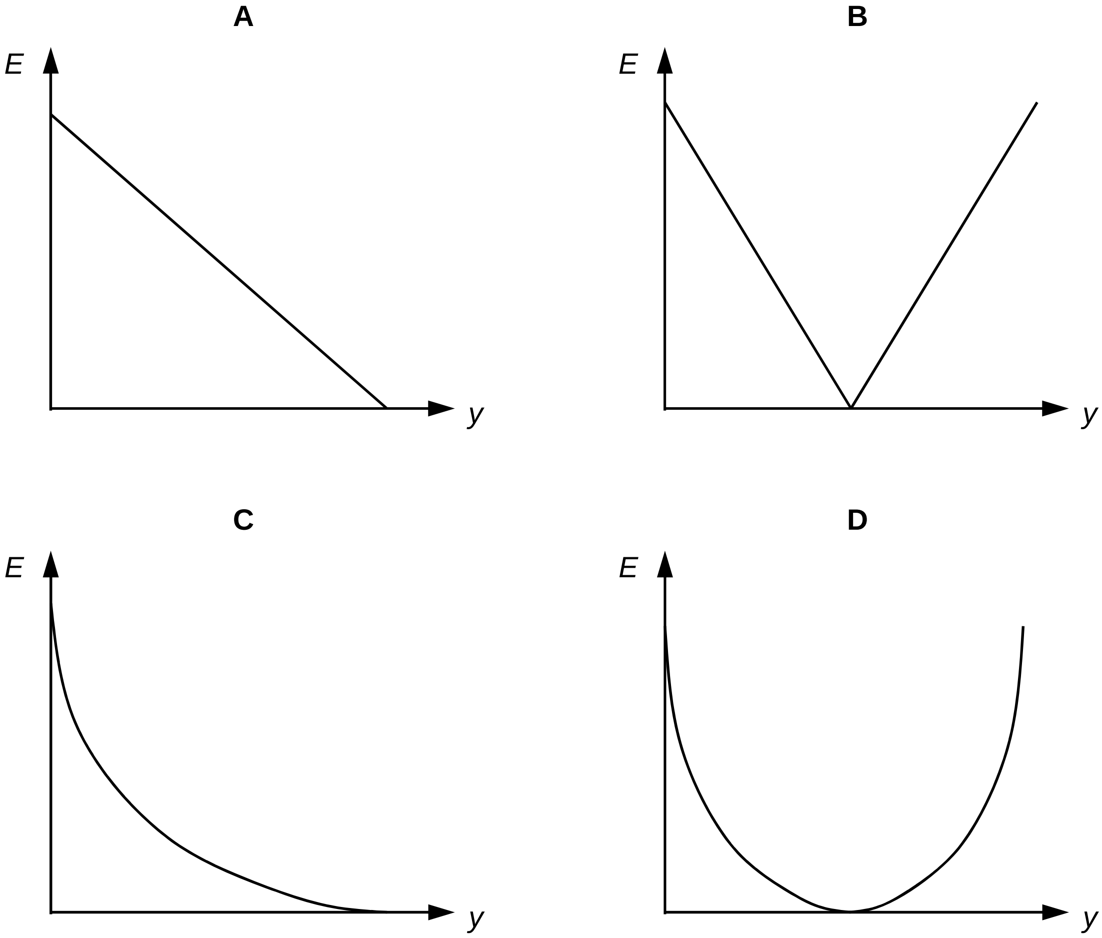


What is the magnitude of the corresponding momentum of X?

A 4 N s **B** 6 N s **C** 10 N s **D** 20 N s

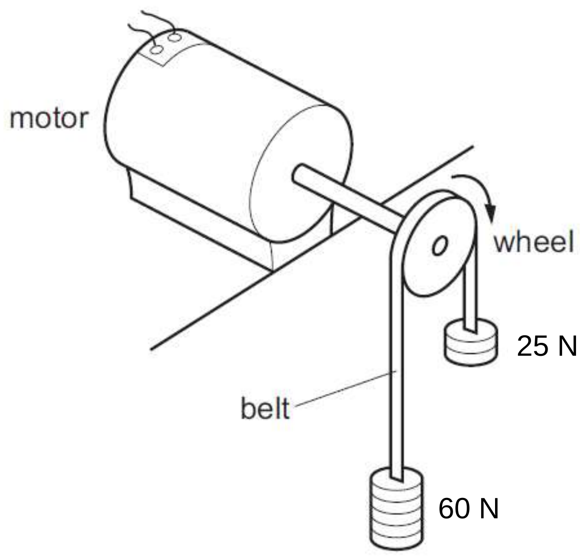
5 A man throws a ball vertically upwards. The ball reaches a maximum height, and then falls back into the man's hand. Air resistance may be assumed to be negligible.

Which graph shows how the kinetic energy *E* of the ball varies with the vertical displacement y?



6 The diagram shows an arrangement used to find the output power of an electric motor.

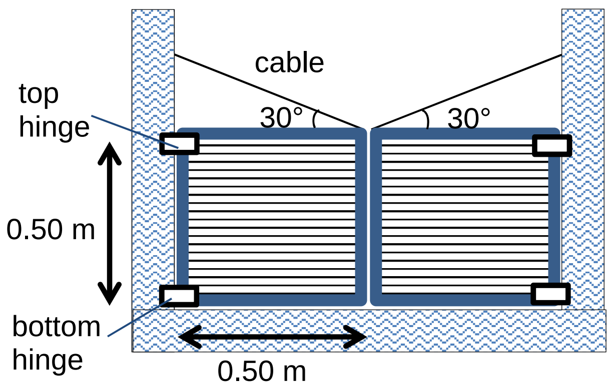
The wheel attached to the motor's axle has a diameter of 35 cm and the belt which passes over it is stationary when the weights have the values shown.



When the wheel is making 20 revolutions per second, what is the output power of the motor?

A 250 W **B** 770 W **C** 1300 W **D** 1900 W

7 A window is made up of 2 uniform panes. Each pane is 0.50 m wide and 0.50 m high, with hinges attached at the top and bottom as seen in the figure. A cable makes an angle of 30° with the top of the pane and has a tension of 150 N. The mass of one pane is 20 kg.



What is the magnitude and direction of the horizontal force exerted by the top hinge on the left pane?

A 107 N to the right **B** 107 N to the left **C** 130 N to the right **D** 130 N to the left

8 An electric scooter of mass 10 kg moves at a constant speed over a humpback bridge of radius of curvature 3 m.

What is maximum speed of the electric scooter such that it does not lose contact with the bridge?

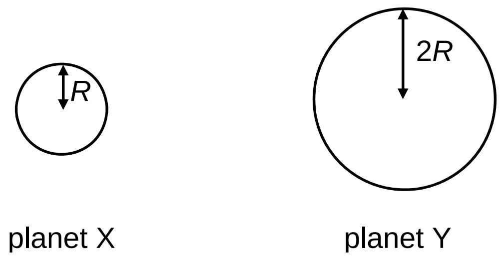
A 1.8 m s^{-1}

B 3.3 m s^{-1}

C 5.4 m s^{-1}

D 5.7 m s^{-1}

9 The diagram shows two planets X and Y, each of them is isolated in space.



Planet X and planet Y have the same mean density.
The radius of planet X is half that of planet Y.

What is the ratio of the gravitational field strength at the surface of planet X to the gravitational field strength at the surface of planet Y?

A 0.5 **B** 1.4 **C** 2.0 **D** 2.8

10 The mass of the Earth is 5.96 x 10^{24} kg and its mean radius is 6.37 x 10^{6} m. What is the escape velocity of a body which is at a height 1.0 x 10^{6} m above the Earth's surface?

A 7.34×10^{3} m s^{-1}

B 1.04×10^{4} m s^{-1}

C 1.11×10^{4} m s^{-1}

D 2.82×10^{4} m s^{-1}

11 Which statement explains why the thermodynamic temperature scale is considered more fundamental than the Celsius temperature scale?

A The thermodynamic temperature scale is determined using the triple point of water instead of ice point, which is more reproducible.

B The thermodynamic temperature scale is independent of the properties of materials.

C The thermodynamic temperature scale can measure a greater range of temperatures.

D The thermodynamic temperature scale is related to the random kinetic energy of the particles.

12 The first law of thermodynamics can be written as

$$q = \Delta U + w$$

where ΔU is the increase in internal energy.

Which of the following correctly represent what q and w stands for?

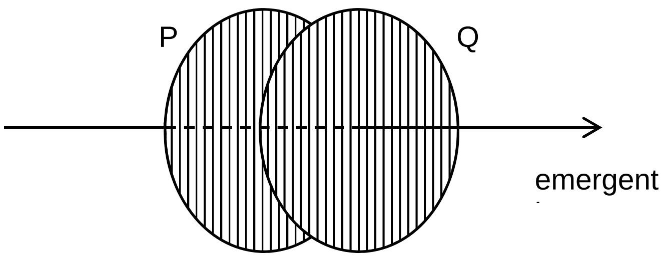
	q	w
A	thermal energy supplied to the system	work done on the system
B	thermal energy supplied to the system	work done by the system
C	thermal energy removed from the system	work done on the system
D	thermal energy removed from the system	work done by the system

13 An object of mass 40 g is oscillating with a frequency of 25 Hz.

What is the magnitude of the restoring force on the object when it is at a displacement of 2.5 mm from equilibrium?

A 16 N **B** 9.8 N **C** 4.0 N **D** 2.5 N

14 Two sheets of polaroid, P and Q, are placed so that their polarizing directions are parallel and vertical, as shown in the diagram. The amplitude of the emergent beam is A_0.



What is the smallest angle through which Q must be turned for the amplitude of the emergent beam to be reduced to ½ A_0?

A 30 ° **B** 45 ° **C** 60 ° **D** 90 °

15 Two progressive waves of frequency 300 Hz are superimposed to produce a stationary wave. The distance between the first node and the sixth node is 7.5 m. What is the speed of the progressive waves?

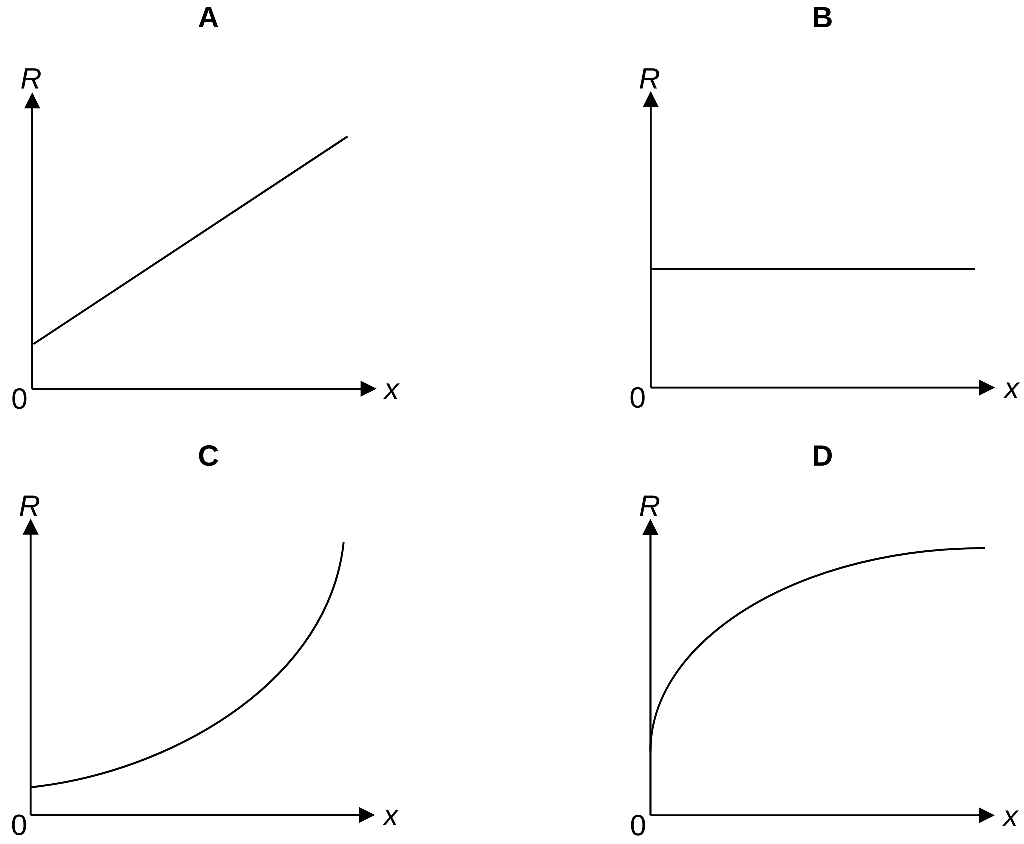
A 375 m s^{-1} **B** 450 m s^{-1} **C** 750 m s^{-1} **D** 900 m s^{-1}

16 A camera lens with a maximum aperture of 25 mm forms an image of an object 9.0 m away. If a monochromatic light of wavelength 500 nm is used, what is the minimum distance between two points on the object that are just resolved?

A 0.09 mm **B** 0.18 mm **C** 5.2 mm **D** 10 mm

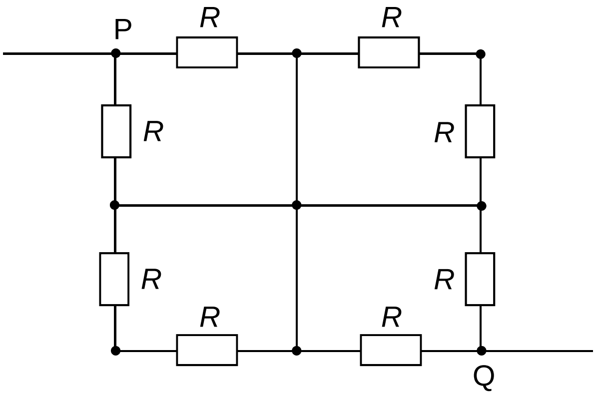
17 When a metal wire is stretched, it becomes longer.

Which graph best represents the variation with extension *x* of the resistance *R* of the wire?



18 Eight identical resistors, each of resistance *R*, are connected in a network as shown below.

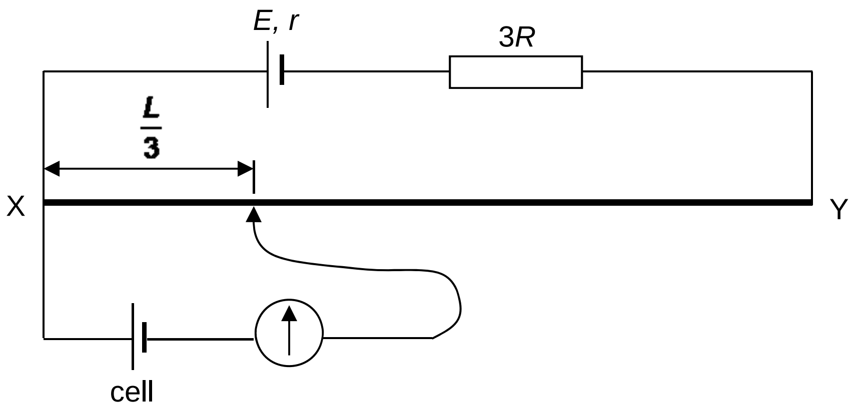
What is the effective resistance between the terminals P and Q?



A $\frac{R}{8}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

19 A potentiometer has a wire XY of length L and resistance R. It is powered by a battery of electromotive force (e.m.f.) E and internal resistance r in series with a resistor of resistance $3R$.

With a cell in the branch circuit, the null point is found to be $\frac{L}{3}$ from X, as shown below.

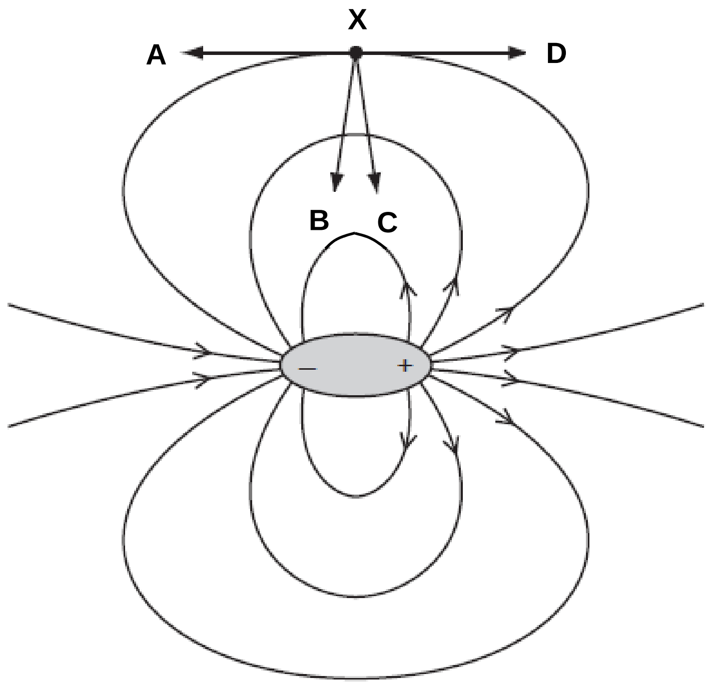


What is the e.m.f. of the cell?

A $\dfrac{E}{12}$ **B** $\dfrac{ER}{3(3R+r)}$ **C** $\dfrac{ER}{4R+r}$ **D** $\dfrac{ER}{3(4R+r)}$

20 An electric dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of an electric dipole is shown below.

What is the direction of the force that acts on an electron placed at point X?



21 A particle has a charge of 3 *e*. The particle remains at rest midway between a pair of horizontal, parallel plates having a separation of 15 mm. The potential difference between the plates is 660 V.

What is the weight of the particle?

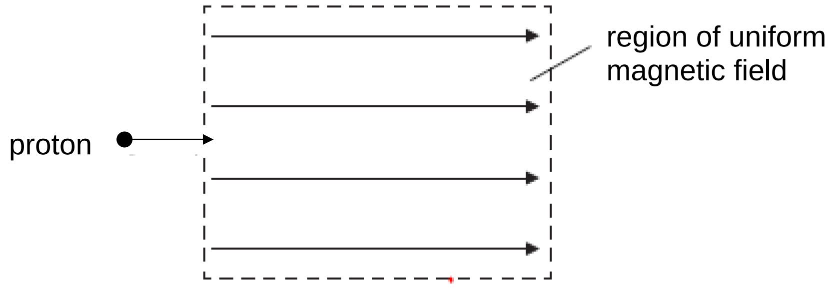
A 2.1×10^{-14} N

B 1.1×10^{-14} N

C 2.1×10^{-17} N

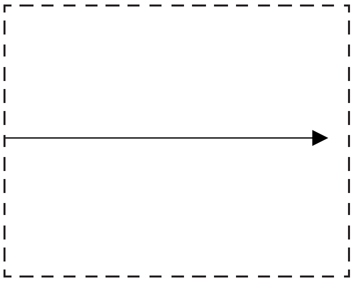
D 1.1×10^{-17} N

22 A proton enters a region of uniform magnetic field. The direction of the particle's velocity is parallel to the direction of the magnetic field as shown in the diagram below.

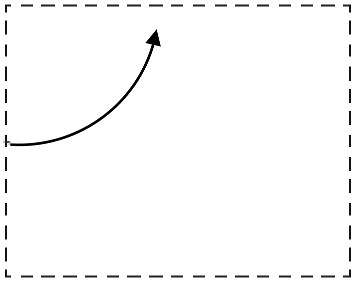


Which of the following diagrams correctly shows the path of the proton while in the region of magnetic field?

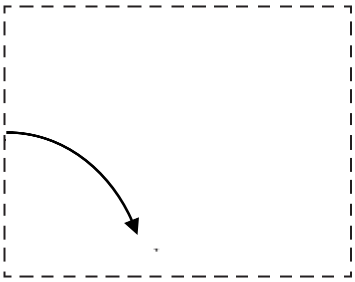
A



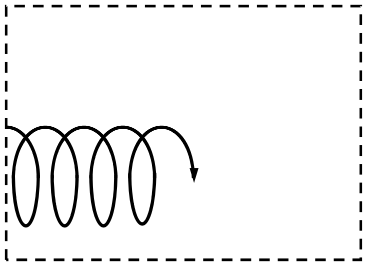
B



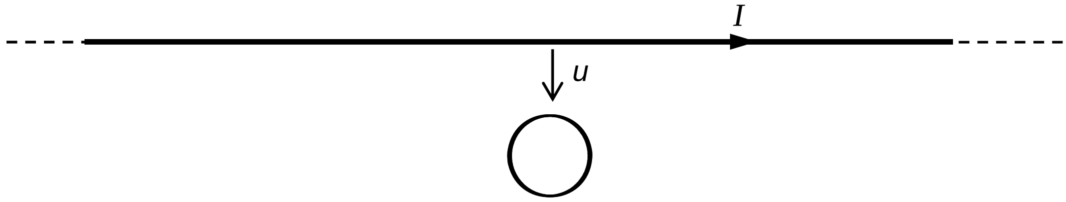
C



D



23 A long straight wire is in the plane of a flat short circuited coil. The straight wire carries a constant current I as shown and is moved at a constant speed *u* towards the flat coil.



Which statement describing the current in the flat coil is true?

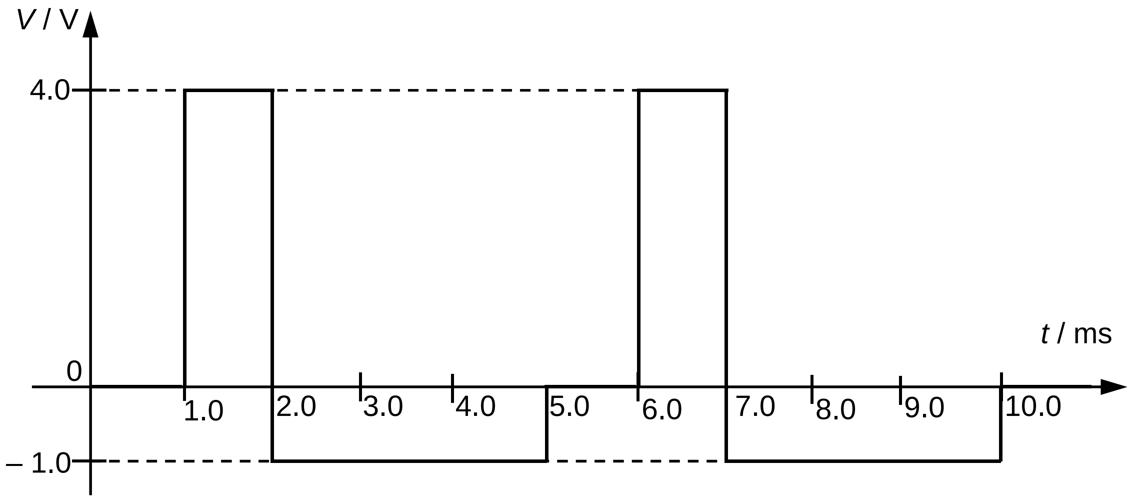
A The current is always zero.

B The current is always constant.

C The current is decreasing.

D The current is increasing.

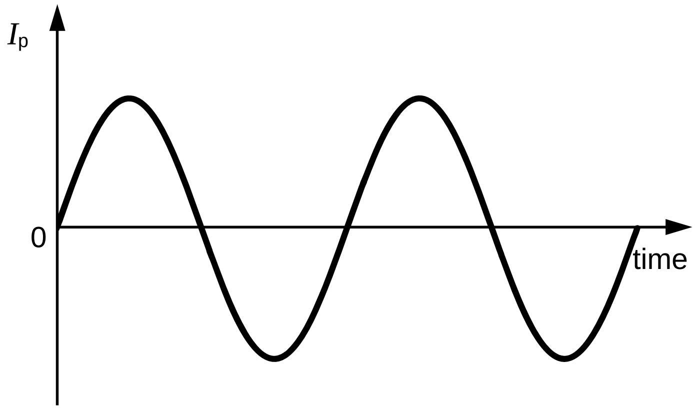
24 The variation with time *t* of the voltage *V* of an alternating source applied across a 2.0 Ω resistor is shown below.



What is the power dissipated in the resistor?

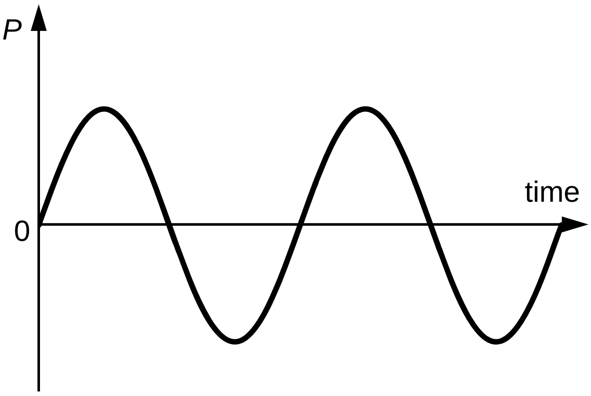
A 0.98 W **B** 1.5 W **C** 1.9 W **D** 2.4 W

25 The variation with time of an alternating current I_p connected to the primary coil of a transformer is as shown.

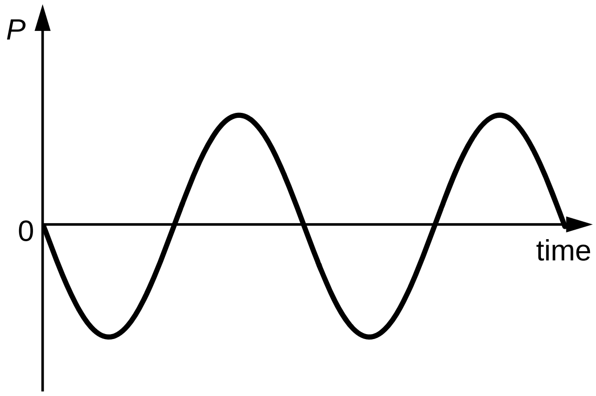


Which graph represents the variation with time of the power output, *P*, in a resistor connected across the secondary coil?

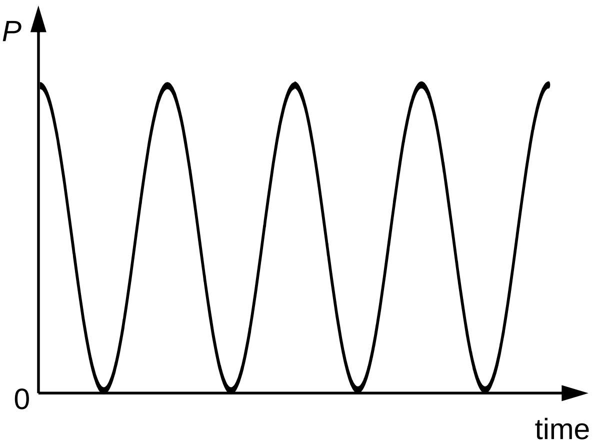
A



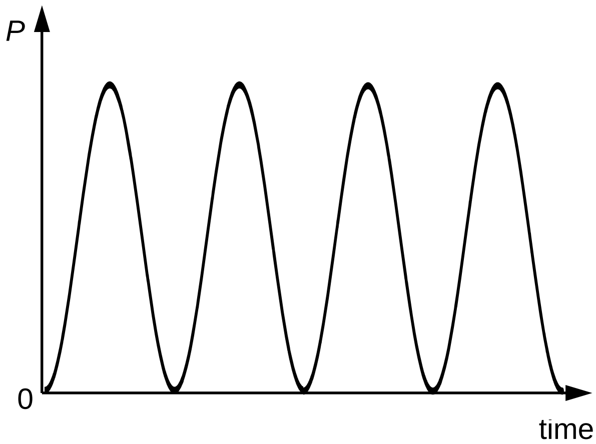
B



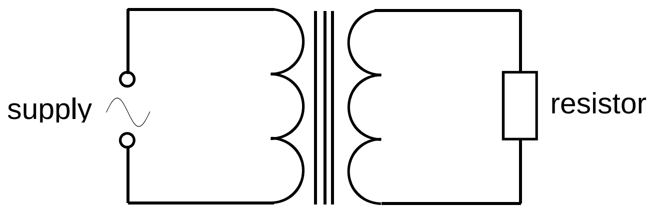
C



D



26 A 1:12 step-up ideal transformer is connect to a light bulb. The resistor dissipates heat at a rate of 36 W when the peak alternating voltage of the supply is 2.8 V.

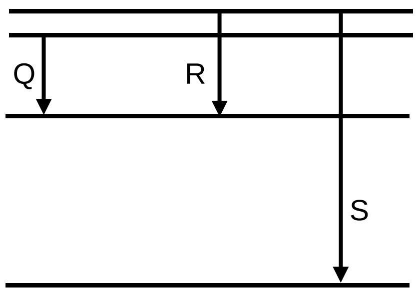


The peak alternating voltage of the supply is then changed to 1.4 V.

What is the root-mean-square current in the primary coil?

A 6.4 A **B** 9.1 A **C** 26 A **D** 36 A

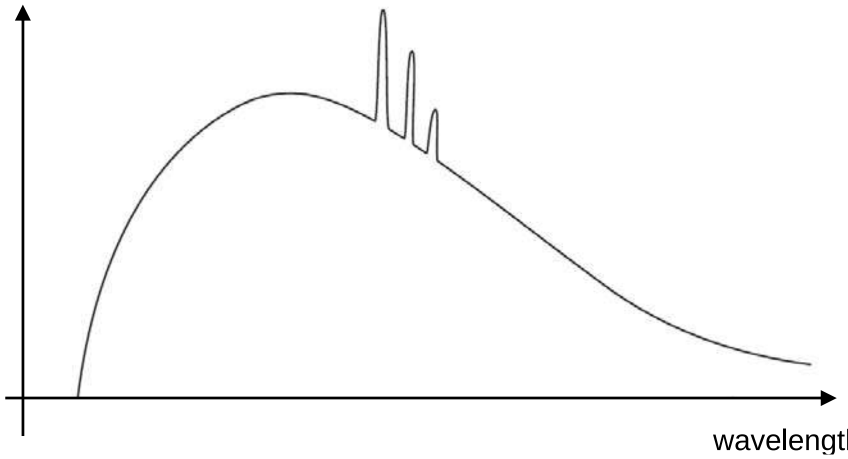
27 The diagram below shows some of the energy levels of an atom. The three transitions shown result in radiation of ultraviolet (UV), as well as green and yellow regions of the visible light spectrum.



Which one of the choices below correctly identifies the transitions?

	UV	green visible light	yellow visible light
A	S	R	Q
B	S	Q	R
C	Q	R	S
D	Q	S	R

28 The graph below shows a spectrum of X-ray radiation produced when high-speed electrons are incident on a metal target.



Which statement is the correct explanation for the formation of the characteristic peaks?

A Excitation of electrons in the metal target.

B De-excitation of electrons in the metal target.

C Excitation of electrons incident on the metal target.

D De-excitation of electrons incident on the metal target.

29 Which equation shows a radioactive decay that emits an alpha particle?

A $^{14}_{7}\text{N} + ^{1}_{1}\text{p} \rightarrow ^{11}_{6}\text{C} + \text{X}$

B $^{220}_{86}\text{Rn} \rightarrow ^{216}_{84}\text{Po} + \text{X}$

C $^{137}_{55}\text{Cs} \rightarrow ^{137}_{56}\text{Ba} + \text{X}$

D $^{60}_{28}\text{Ni} \rightarrow ^{60}_{28}\text{Ni} + \text{X}$

30 Which of the following statements concerning nuclear properties is true?

A The greater the binding energy of a nucleus, the more stable it is.

B If the total rest mass of the products of a reaction is greater than the total rest mass of the reactants, this reaction is impossible.

C When a stationary nucleus decays by emitting a γ photon, the daughter nucleus will move off in opposite direction to the γ photon.

D The half-life of a radioactive isotope can be changed by allowing the isotope to react chemically to produce a new compound.

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ANDERSON JUNIOR COLLEGE

2018 JC2 Preliminary Examination

PHYSICS   Higher 2   9749/02

Paper 2 Structured Questions   **Tuesday 11 September 2018**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs.
Do not use paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Paper 1 (30 marks)	
Paper 2 (80 marks)	
1	
2	
3	
4	
5	
6	
7	
Deduction	
P2 total (80 marks)	

This document consists of **21** printed pages and **1** blank page.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\varphi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{x_o^{\,2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 Ball A falls vertically in air from rest. The variation with time *t* of the distance *d* moved by the ball is shown in Fig. 1.1.

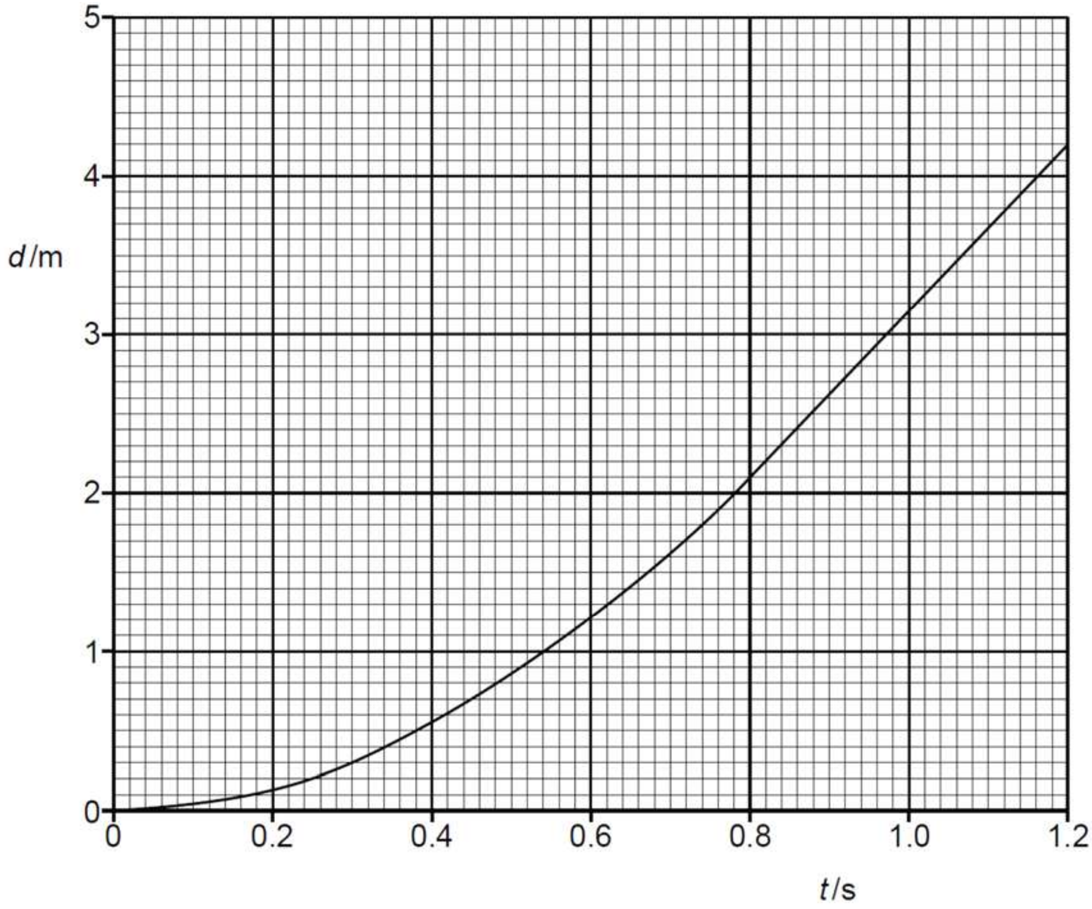

Fig. 1.1

(a) By reference to Fig. 1.1, explain how it can be deduced that air resistance is not negligible.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..[2]

(b) Use Fig. 1.1 to determine

(i) the speed of the ball at a time of 0.40 s after it has been released,

speed = ……………………………. m s^{-1} [2]

(ii) the average speed of the ball in the first 0.40 s after it has been released.

average speed = …………………………… m s^{-1} [1]

(c) Ball A is replaced by ball B which experiences negligible air resistance.

(i) Calculate the distance travelled by ball B after falling for 0.40 s from rest.

distance = ……………………………m [1]

(ii) On Fig. 1.1, sketch a graph to show the variation with time *t* of the distance *d* moved by ball B after falling from rest. Label the graph P. [3]

2 A circular disc of radius 11.8 cm is spinning about its centre O in a vertical plane at a rate of 100 revolutions per minute. A plasticine of mass 3.8 g is stuck to the edge of the disc at point P and the line OP is 45 ° from the vertical at the instant, as shown in Fig. 2.1.

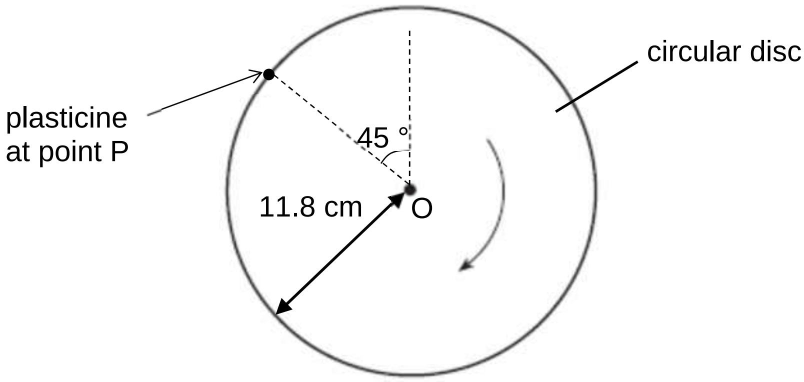

Fig. 2.1

(a) Show that the centripetal force acting on the plasticine is 0.049 N.

[3]

(b) On Fig. 2.2, the weight of the plasticine at P has been drawn. At this instant, the magnitude of the contact force by the disc on the plasticine is equal to the weight of the plasticine. Draw an arrow on Fig. 2.2 to show the contact force by the disc on the plasticine at P. Label this arrow C. [1]

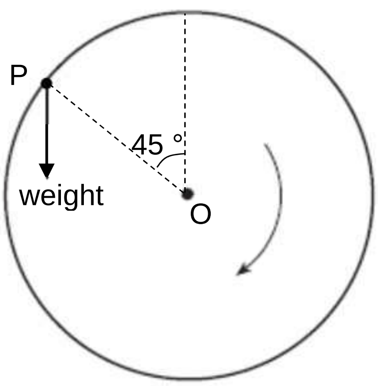

Fig. 2.2

(c) The angular velocity of the disc is increased gradually.

The maximum value of the contact force between the disc and plasticine is 0.23 N.

(i) Explain why the plasticine is most likely to first lose contact with the disc at the lowest point of the revolution.

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…………………………………………………………………………………………… [3]

(ii) Hence, determine the angular velocity when the plasticine first loses contact with the disc.

angular velocity = ………………………….. rad s^{-1} [2]

3 **(a)** **(i)** Explain the concept of *absolute zero* on the thermodynamic temperature scale.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(ii) Explain how empirical evidence leads to the concept of *absolute zero*.

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………………………………………………………………………………………… [3]

(b) Two insulated gas cylinders A and B are connected by a tube of negligible volume, as shown in Fig. 3.1.

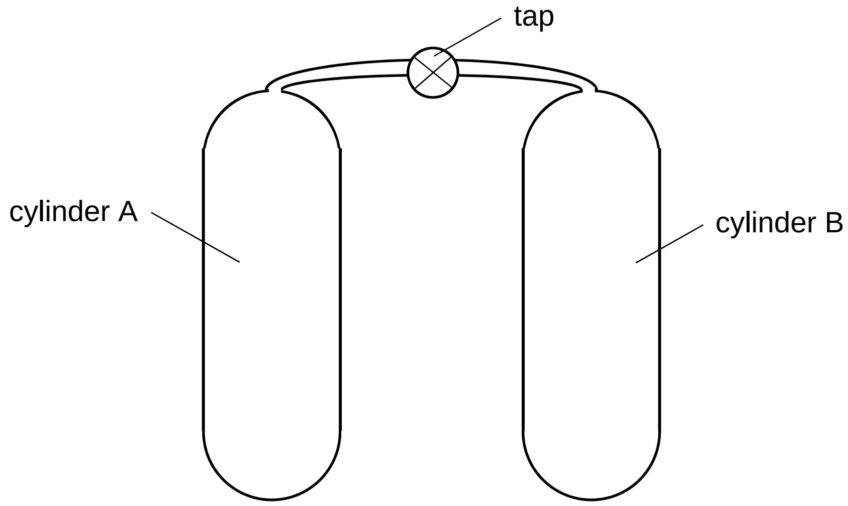

Fig. 3.1

Each cylinder has an internal volume of 2.0×10^{-2} m^3. Initially, the tap is closed and cylinder A contains 1.2 mol of an ideal gas at a temperature of 37 °C. Cylinder B contains the same ideal gas at pressure 1.2×10^5 Pa and temperature 37 °C

The tap is opened and some gas flows from cylinder A to cylinder B. Using the fact that the total amount of gas is constant, determine the final pressure of the gas in the cylinders.

pressure = …………………….. Pa [4]

4 **(a)** State, for an oscillating system, what is meant by

(i) natural frequency of vibration,

…………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) resonance.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) State and explain one situation where resonance is useful.

……………………………………………………………………………………………………

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……………………………………………………………………………………………………[2]

(c) A car component of mass 0.430 kg undergoes forced oscillation.

Fig. 4.1 shows how the amplitude of the oscillation varies with frequency.

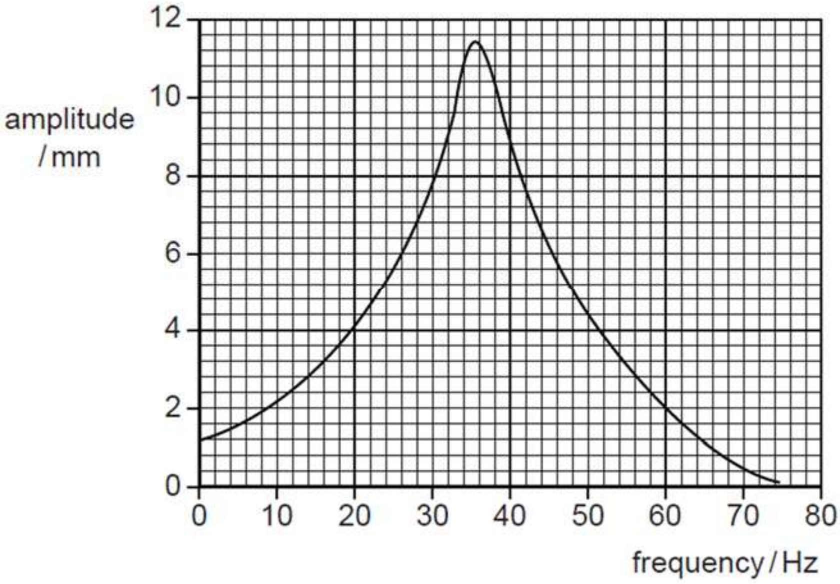

Fig. 4.1

(i) Calculate, for the component oscillating at the resonant frequency, the time interval between a maximum linear speed and the subsequent maximum linear acceleration.

time = …………………... s [3]

(ii) The component is now supported on a rubber mounting.

On Fig. 4.1, draw a line to show the variation with frequency of amplitude for the supported component. [2]

5 **(a)** Fig. 5.1 shows the variation with voltage V of the current I across a filament lamp rated 6.0 V, 1.5 W.

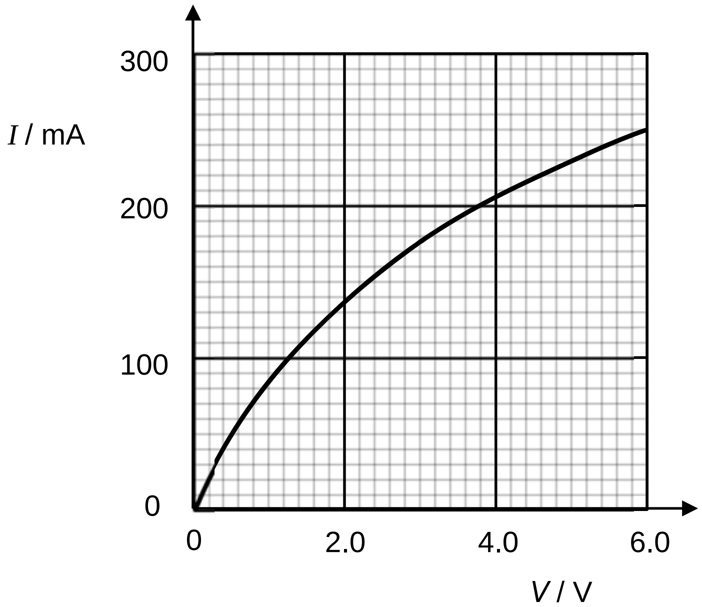

Fig. 5.1

(i) In microscopic terms, explain why the resistance of the filament lamp increases as V increases.

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……………………………………………………………………………………………[3]

(ii) On Fig. 5.1, draw a line to show the variation with V of I if the filament lamp is assumed to be ohmic. [1]

(iii) Use Fig. 5.1 to determine the change in resistance of the filament lamp when V increases from 4.0 V to 6.0 V.

change in resistance = …………………….. Ω [2]

(b) A student designs a circuit for a night light using the filament lamp in **(a)** and a light-dependent resistor (LDR), as shown in Fig. 5.2.

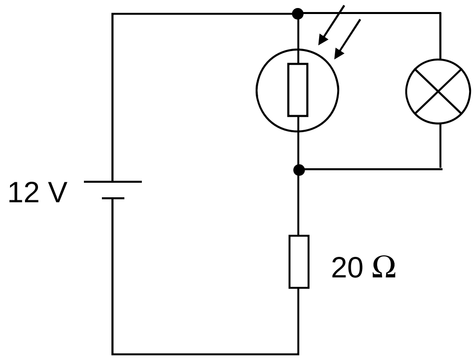

Fig. 5.2

The LDR has a resistance of 10 Ω in daylight and increases to 1000 Ω in the dark.

(i) Explain why the lamp will not operate at its rated power in daylight.

……………………………………………………………………………………...................

……………………………………………………………………………………….... [2]

(ii) Calculate the resistance of the LDR in order for the lamp to operate at its rated power of 1.5 W.

resistance = …………………. Ω [3]

6 (a) A sample of water is contaminated with radioactive iodine-131 ($^{131}_{53}\mathrm{I}$).
The activity of the iodine-131 in 1.0 kg of this water is 460 Bq.
The half-life of iodine-131 is 8.1 days.

(i) Calculate the number of iodine-131 atoms in 1.0 kg of this water.

number = ………………………………….. [2]

(ii) An amount of 1.0 mol of non-contaminated water has a mass of 18 g.

Calculate the ratio

$$\frac{\text{number of molecules of water in 1.0 kg of contaminated water}}{\text{number of atoms of iodine-131 in 1.0 kg of contaminated water}}$$

ratio = …………………………………. [2]

(iii) An acceptable limit for the activity of iodine-131 in water has been set as 170 Bq kg^{-1}.

Calculate the time, in days, for the activity of the contaminated water to be reduced to this acceptable level.

time = ………………………… days [2]

(b) A milk sample is to be tested for evidence of radioactive contamination with the radioactive nuclide strontium-90 (^{90}Sr), using a Geiger-Muller tube. The two stages involved in the decay of ^{90}Sr are described by the following two equations.

Stage 1: $^{90}_{38}\text{Sr} \rightarrow {}^{90}_{39}\text{Y} + \beta$

Stage 2: $^{90}_{39}\text{Y} \rightarrow {}^{90}_{40}\text{Zr} + \beta$

At each stage, a β-particle is emitted. At the end of stage 2, the product zirconium-90 (^{90}Zr) is stable.

(i) For stage 1, the emitted β-particles have a range of energies up to a maximum of 0.55 MeV. Use conservation laws to explain why this range of energies leads to the suggestion that another particle is emitted by the decaying strontium-90 nucleus together with the β-particle.

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………………………………………………………………………………………… [4]

(ii) Explain why it is difficult to measure the half-life of the beta decay of the strontium-90 experimentally.

…………………………………………………………………………………………..

………………………………………………………………………………………… [1]

7 Read the following article and then answer the questions that follow.

Shielding from nuclear radiation

Since the beginning of the industrial age, the burning of fossil fuels such as coal and petroleum has elevated the atmospheric CO_2 concentration to unprecedented levels. As a consequence, the global average surface temperature has increased and the earth has experienced the hottest years ever recorded. If we continue to consume fossil fuels at the same rate, the resulting temperature increase will have dramatic effects on global climate.

One measure to mitigate global warming is the use of renewable energy. Unfortunately, they are heavily dependent on the weather. Even as the technology for utilising renewable energy such as solar and wind improve, there are reliability issues, which present important challenges to be overcome before the world can turn "100 per cent renewables".

Nuclear fission reactors generate electricity without producing greenhouse emissions. However, these power plants can pose serious safety and security problems due to concerns over radioactivity. Dangers associated with exposure to radiation have been recognised for many years. As a result of these hazards, measures have been adopted to reduce exposure to radiation to as low a level as possible. One such measure is to shield individuals from radioactive sources using radiation absorbing materials.

Experiments have been carried out to investigate the effectiveness of materials as absorbers of γ-ray photons. One possible experiment is illustrated in Fig. 7.1.

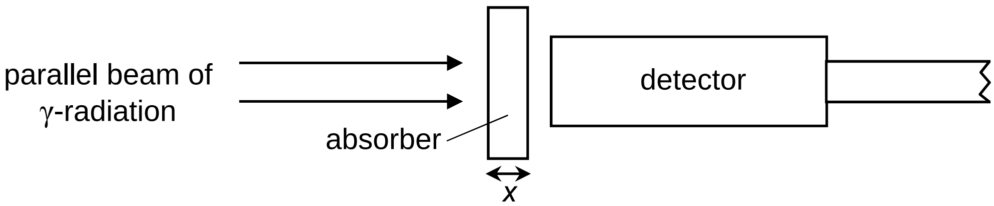

Fig. 7.1

The count-rate C_X of γ-ray photons is measured for various thickness x of the absorber, together with the count-rate C_0 for no absorber. Fig. 7.2 shows the variation with thickness x of the ratio C_X/C_0 for lead.

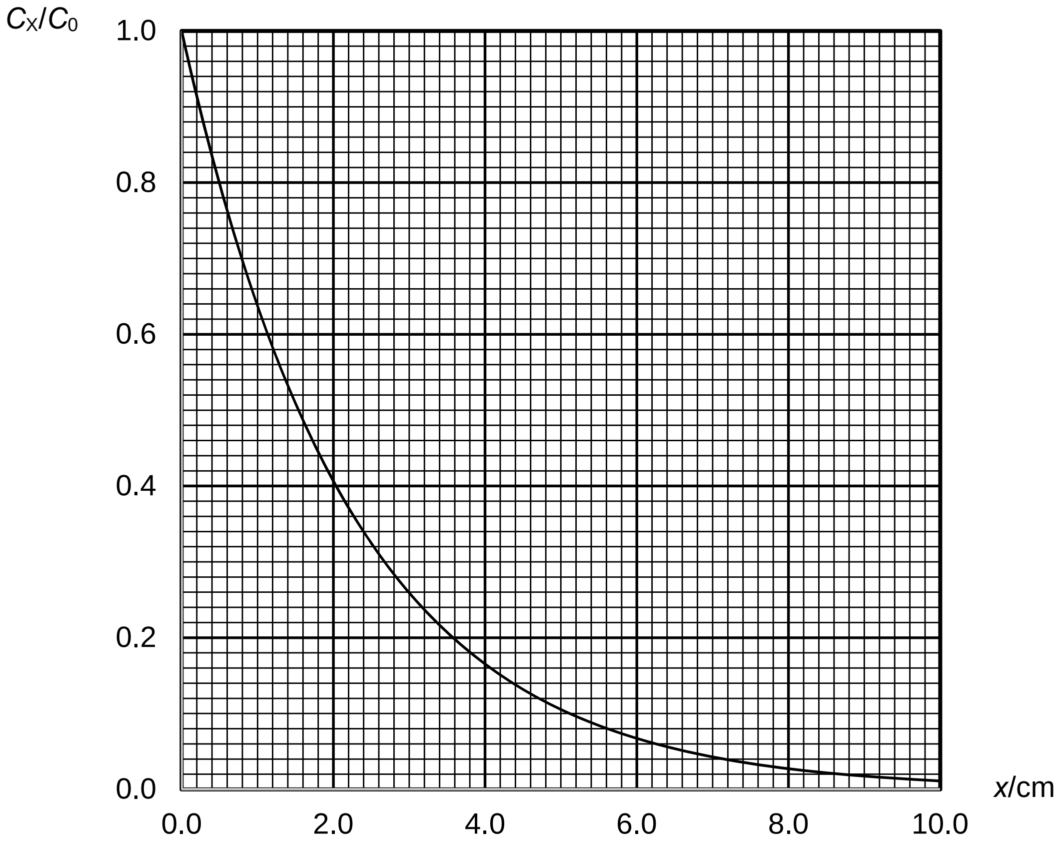

Fig. 7.2

(a) **(i)** By providing examples, briefly explain the reliability issues faced by renewable energy sources.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(ii) State what is meant by γ-radiation.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(iii) Suggest how exposure to γ-radiation could be dangerous.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(iv) Suggest why it is necessary to have a parallel beam of γ-radiation in this experiment.

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…………………………………………………………………………………………… [1]

(v) Use Fig. 7.2 to explain why complete shielding is not possible.

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…………………………………………………………………………………………… [1]

(b) Data from Fig. 7.2 are used to obtain values of ln (C_X/C_0). These are used to plot the graph of Fig. 7.3.

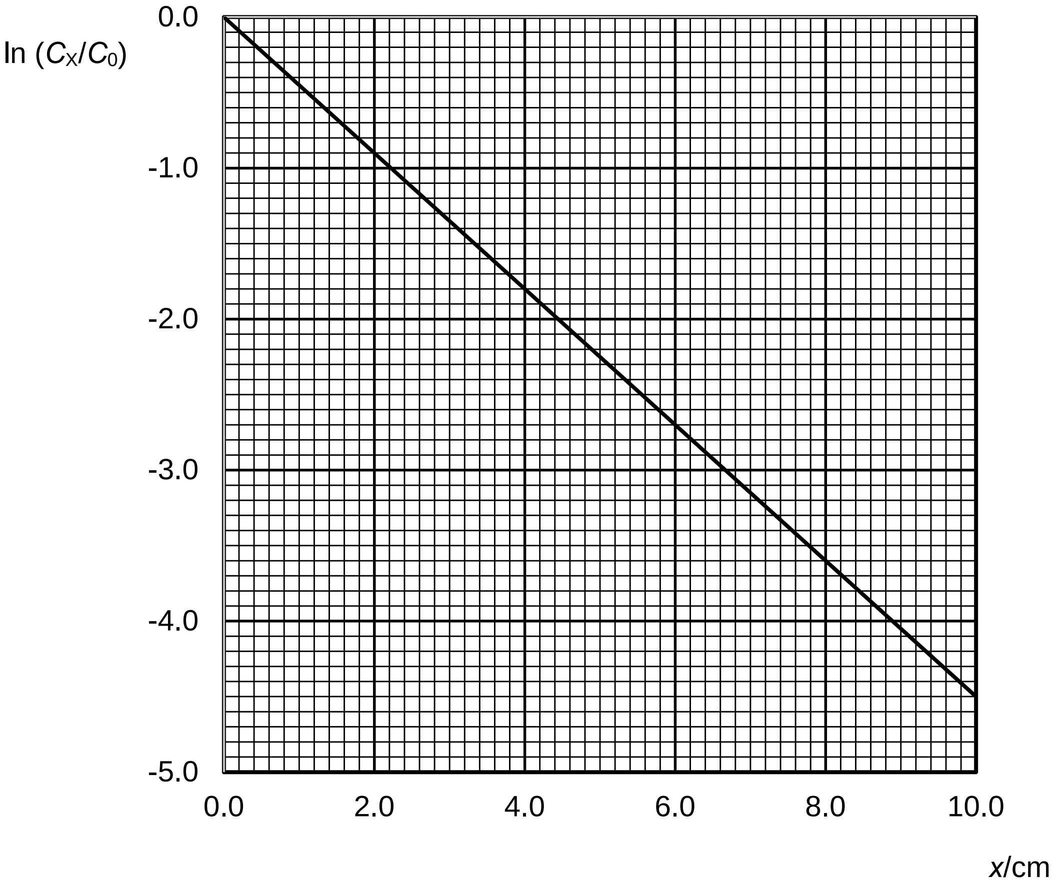

Fig. 7.3

(i) It is proposed that the count-rate C_X changes with the thickness x of the absorber according to an expression of the form

$$C_X = C_0 e^{-\mu x},$$

where μ is a constant.

Explain why the graph of Fig. 7.3 supports this proposal.

[3]

(ii) The constant μ is known as the linear absorption coefficient. Use Fig. 7.3 to calculate a value of μ for lead.

μ = …………………………….cm^{-1} [2]

(c) The linear absorption coefficient μ has been found to depend on photon energy and on the absorbing material itself. For γ-ray photons of one energy, μ is different for different materials.

In order to assess absorption of γ-ray photons in matter such that the material of the absorber does not have to be specified, a quantity known as the mass absorption coefficient μ_m is calculated. μ_m is given by the expression

$$\mu_m = \frac{\mu}{\rho},$$

where ρ is the density of the absorbing material.

Values of μ for 2.75 MeV photons and of ρ for different materials are given in Fig. 7.4.

material	μ / cm^{-1}	ρ / g cm^{-3}	μ_m / ……..
aluminium	0.095	2.70	0.035
tin	0.267	7.28	0.037
lead	……………..	11.3	……………

Fig. 7.4

On Fig. 7.4,

(i) give an appropriate unit for μ_m. [1]

(ii) use your answer to **(b)(ii)** to complete the table of values for lead. [1]

(d) Concrete is a common building material which is sometimes used for shielding. The density of concrete is 2.4×10^3 kg m^{-3}.

(i) Use the information given in Fig. 7.4 to calculate an average value for μ_m.

average value for μ_m = …………………………….[1]

(ii) Hence, show that the linear absorption coefficient μ for 2.75 MeV photons in concrete is approximately 0.09 cm^{-1}.

[2]

(iii) Calculate the approximate thickness of concrete which would provide the same level of shielding, for 2.75 MeV photons, as a thickness of 4.0 cm of lead.

thickness of concrete = …………………………….cm [2]

(iv) With reference to your answer in **(d)(iii)**, suggest why concrete may be used, in preference to lead, where radioactive sources of high activity are to be shielded.

1. ………………………………………………………………………………....................

……………………………………………………………………………………....................

2. ………………………………………………………………………………....................

……………………………………………………………………………………….... [2]

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ANDERSON JUNIOR COLLEGE

2018 JC2 Preliminary Examination

PHYSICS Higher 2 9749/03

Paper 3 Longer Structured Questions **Tuesday 13 September 2018**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
Deduction	
P3 Total (80 marks)	
Prelim Overall (100%)	

This document consists of **20** printed pages and **0** blank page.

[Turn Over

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
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unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\varphi = -\frac{Gm}{r}$
temperature	$T/\mathrm{K} = T/^{\circ}\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm \omega \sqrt{x_o^{\ 2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this section.

1 **(a)** Fig 1.1 shows two identical beakers. A wooden block is placed inside beaker B. In both beakers, the water level is filled to the brim. The two beakers are each placed on a top-pan balance.

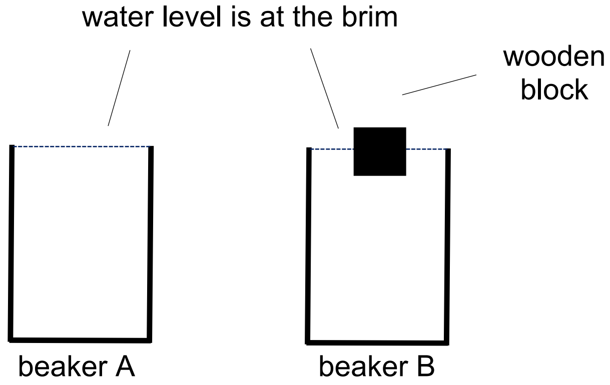

Fig. 1.1

Compare the top-pan balance readings for the two beakers.

Explain your answer.

....

....

....

.... [2]

(b) Fig.1.2 shows a beaker of water placed on a force sensor connected to a data-logger. A solid block is submerged in the water. A string is attached on one end to the ceiling, and the other end to the solid block.

The beaker and water have combined weight *P*. The solid block has weight *Q* and it displaces water of weight *R* when submerged. The tension in the string supporting the block is *T* and the contact force registered by the data-logger is *C*.

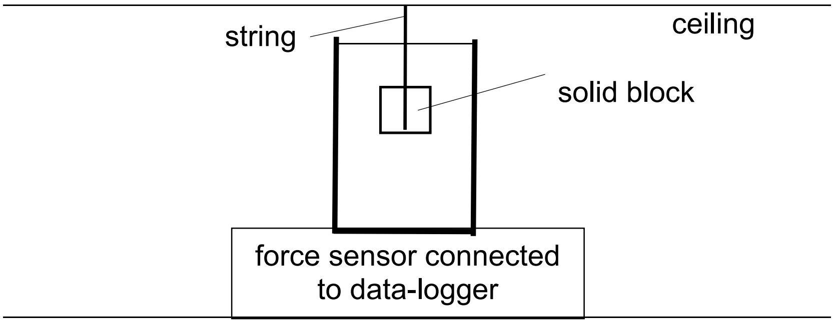

Fig. 1.2

(i) Draw a force diagram showing all the forces acting on

1. the solid block,

2. the system consisting of the solid block, beaker and water. (You may treat the system as a point object.)

[3]

(ii) Fig 1.3 shows a table of values for *P*, *Q* and *R*.

combined weight of beaker and water, *P*	3.00 N
weight of solid block, *Q*	1.13 N
weight of water displaced by solid block, *R*	0.20 N

Fig. 1.3

1. Calculate the reading registered on the data-logger.

reading = ……………………………N [2]

2. The string is now cut and the solid block falls and rests at the bottom of the beaker. Determine the change in the reading on the data-logger.

change in reading = ……………………………N [2]

2 The Earth may be considered to be a uniform sphere of radius 6.4×10^6 m and its mass is assumed to be concentrated at its centre.

(a) Show that the mass of the Earth is 6.0×10^{24} kg.

[1]

(b) A satellite of mass 650 kg is to be launched from the Equator and put into geostationary orbit.

(i) Determine the radius of the geostationary orbit.

radius = ……………………………. m [3]

(ii) Calculate the increase in gravitational potential energy of the satellite during its launch from the Earth's surface to the geostationary orbit.

increase in gravitational potential energy = ……………………………. J [2]

(c) Small resistive forces acting on the satellite cause the radius of its orbit to change. Explain why the kinetic energy of the satellite increases due to these resistive forces.

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……..........
[3] [1]

3 **(a)** State what is meant by *specific latent heat of vaporization*.

………..

………..

……………………………………………………………………………………………………...........[2]

(b) As water turns to steam, the intermolecular separation increases by ten times. The atmospheric pressure is 1.0×10^5 Pa, the density of water is 1000 kg m^{-3} and the specific latent heat of vaporization is 2300 J g^{-1}.

(i) The water molecules experience increase in internal energy when the water boils. State what is meant by *increase in internal energy*.

……………………………………………………………………………………….....................

…………………………………………………………………………………………….... [1]

(ii) Using the first law of thermodynamics, determine the change in internal energy ΔU when 1.0 kg of water completely boils off to become steam.

ΔU = ……………………..……… J [4]

(iii) The latent heat of vaporization is not equal to the increase in internal energy. Explain why they are different.

……………………………………………………………………………………….....................

…………………………………………………………………………………………….... [1]

4 The graph of a wave at time $t = 0$ is shown in Fig. 4.1. The wave is travelling to the left with a speed of 340 m s^{-1}.

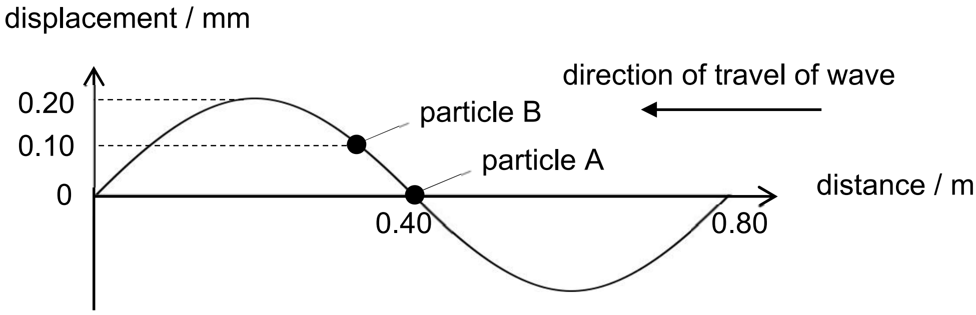

Fig. 4.1

(a) Calculate the frequency of the oscillation of particle A.

frequency = …………………………….. Hz [2]

(b) Show that the total energy E_T of the oscillation of particle A is given by

$$E_T = 2\pi^2 m f^2 a^2,$$

where a is the amplitude of vibration of particle A and m is the mass of particle A.

[2]

(c) The mass of particle A is 4.7×10^{-26} kg. Use the expression in **(ii)** to calculate the energy of the oscillations of particle A.

energy = ………………………………. J [2]

(d) Sketch on the axes of Fig. 4.2 the variation of displacement with time for particle A.

Fig. 4.2

[2]

(e) Calculate the phase angle between the two particles A and B.

phase angle = ……………………………. ° [2]

5 **(a)** State the *principle of superposition.*

……..

……..

……..

[2] [1]

(b) Fig. 5.1 shows the arrangement for viewing a visible interference pattern on a screen.

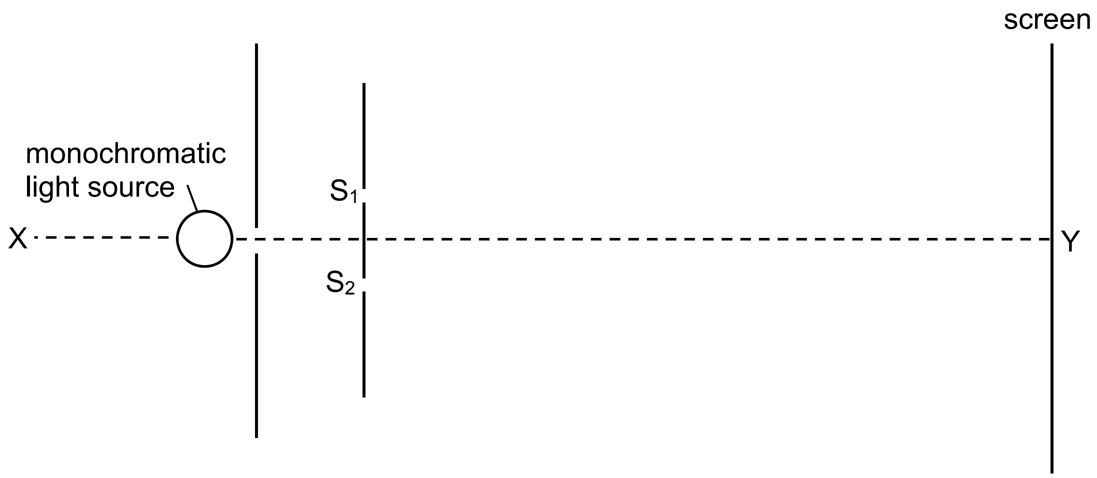

Fig. 5.1

In a darkened room, a double slit (S_1S_2) is placed in front of a narrow single slit situated in front of a monochromatic light source. Line XY is equidistant from S_1 and S_2.

(i) Explain why a single slit is used in Fig. 5.1.

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……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(ii) The point Y on the screen is directly opposite to the centre of the double slit. State and explain the nature of the interference that occurs at Y.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(iii) The distance between slits S_1 and S_2 is 0.60 mm. When the screen is placed 1.8 m from the slits, the distance between the two first-order bright fringes in the interference pattern formed on the screen is 4.0 mm. Calculate the wavelength of the light.

wavelength = ………………………… m [2]

(iv) Suggest changes to the appearance of the fringes when each of the following changes is made separately.

1. Moving the light source and single slit along the axis towards point X, further away from S_1S_2.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

2. Shifting the single slit a small distance downwards, closer to slit S_2.

……………………………………………………………………………………………

……………………………………………………………………………………………

.... [2]

6 A small coil is positioned so that its axis lies along the axis of a large bar magnet, as shown in Fig. 6.1.

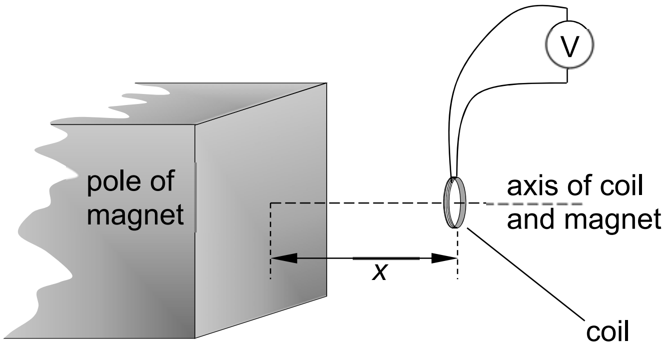

Fig. 6.1

The coil has a diameter of 5.3 mm and contains 180 turns of wire. The ends of the coil are connected to a voltmeter.

The average magnetic flux density *B* through the coil varies with the distance *x* between the face of the magnet and the plane of the coil as shown in Fig. 6.2.

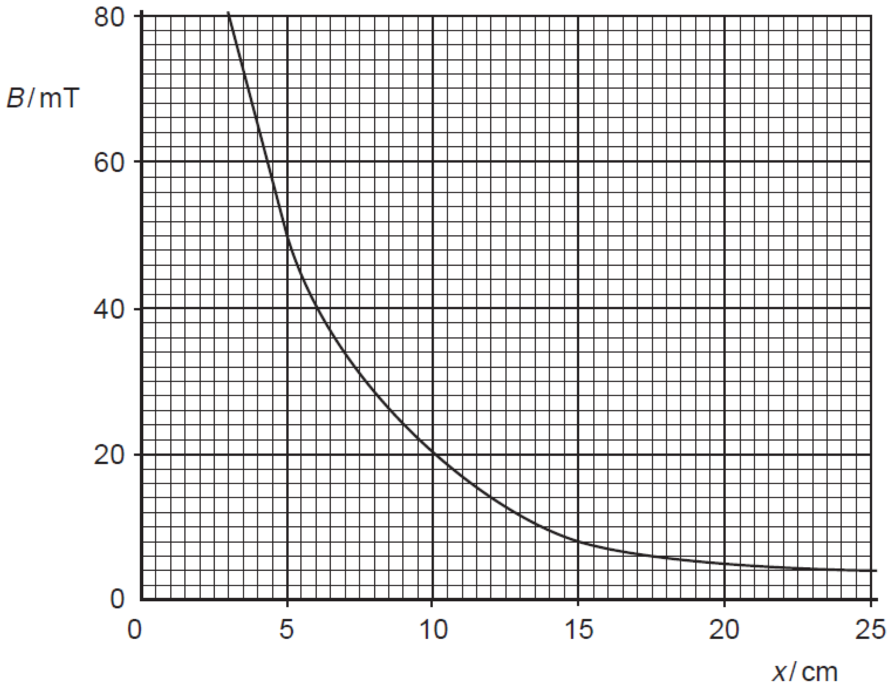

Fig. 6.2

(a) The coil is initially 5.0 cm from the face of the magnet. Show that the magnetic flux linkage of the coil is 2.0×10^{-4} Wb.

[3]

(b) The coil is then moved along the axis of the magnet so that the distance x changes from x = 5.0 cm to x = 20 cm in a time of 0.30 s. As the coil is being moved, a deflection is observed in the voltmeter.

(i) Determine the average electromotive force (e.m.f) induced in the coil.

e.m.f = …………………….... V [2]

(ii) State and explain the variation, if any, of the speed of the coil so that the induced e.m.f. remains constant during this movement.

………………………………………………………………………………………...................

………………………………………………………………………………………...................

………………………………………………………………………………………...................

……………………………………………………………………………………..……..... [2]

(c) The voltmeter is now replaced with a resistor and the coil is again moved away from the magnet as in **(b)**. As the coil is moved, thermal energy is transferred in the resistor. Use laws of electromagnetic induction to explain the origin of this thermal energy.

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…………………………………………………………………………………………………...

…………………………………………………………………………………………………. [4]

Section B

Answer **one** question in this section.

7 **(a)** Define electric field strength at a point.

....

....

.... [2]

(b) A small charged metal sphere is situated in an earthed metal box. Fig. 7.1 illustrates the electric field between the sphere and the metal box.

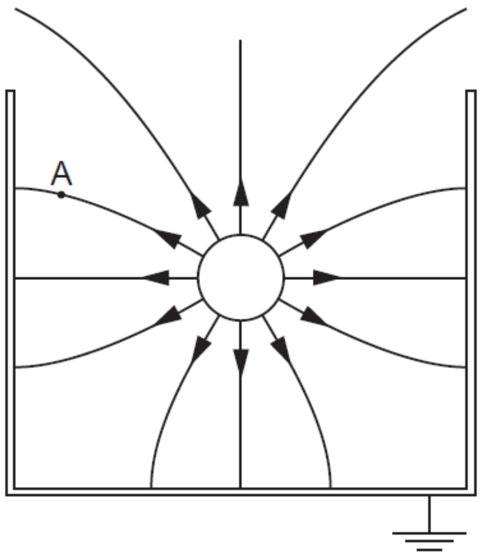

Fig. 7.1

(i) By reference to Fig. 7.1, state and explain

1. whether the sphere is positively or negatively charged,

....

....

.... [1]

2. why it appears as if the charge on the sphere is concentrated at the centre of the sphere.

....

.... [1]

(ii) On Fig. 7.1, draw an arrow to show the direction of the force on a stationary electron situated at point A. [1]

(iii) The radius *r* of the sphere is 2.4 cm. The magnitude of the charge *q* on the sphere is 0.76 nC.

1. Calculate a value for the magnitude of the electric potential *V* at the surface of the sphere.

electric potential = ……………………… V [2]

2. State the sign of the charge induced on the inside of the metal box. Hence explain whether the actual magnitude of the potential will be greater or smaller than the value calculated in **(iii) 1**.

....

....

....

.... [3]

(iv) Two electrons on the surface of the metal box are separated by a distance of 6.0 $\times 10^{-10}$ m. Determine the ratio

$$\frac{\text{electric force between the electrons}}{\text{weight of an electron}}$$

ratio = …………………………….. [2]

(v) A lead sphere is placed in a lead box, in a similar arrangement to that shown in Fig. 7.1. Explain why it is **not** possible for the gravitational field to have a similar shape to that of the electric field.

....

.... [1]

(c) A large horseshoe magnet produces a uniform magnetic field of flux density *B* between its poles. Outside the region of the poles, the flux density is zero.
The magnet is placed on a top-pan balance and the wire XY is situated between its poles, as shown in Fig. 7.2.

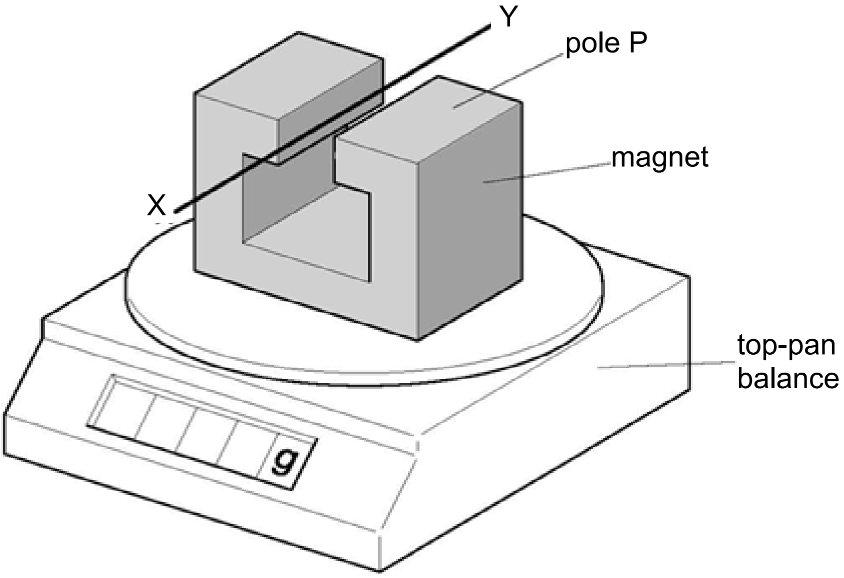

Fig. 7.2

The wire XY is horizontal and normal to the magnetic field. The length of wire between the poles is 4.4 cm.

A direct current of magnitude 2.6 A is passed through the wire in the direction from X to Y. The reading on the top-pan balance increases by 2.3 g.

(i) State and explain the polarity of the pole P of the magnet.

....

....

....

....

....

.... [3]

(ii) Calculate the magnetic flux density between the poles.

magnetic flux density = ……………………………...T [2]

(iii) A low frequency alternating current is now passed through the wire.
The root-mean-square (r.m.s.) value of the current is 2.6 A.

Describe quantitatively the variation of the reading seen on the balance.

………………………………………………………………………………….................

………………………………………………………………………………….................

………………………………………………………………………………….................

…………………………………………………………………………….…………..... [2]

8 **(a)** In the first decade of the 20th century Albert Einstein studied the photoelectric effect. The photoelectric current I for potential difference V between the photocathode and the anode was first measured. The experiment was then repeated using light of the same frequency but of different intensity.

The series of graphs of I for potential difference V produced were similar to those drawn in Fig 8.1.

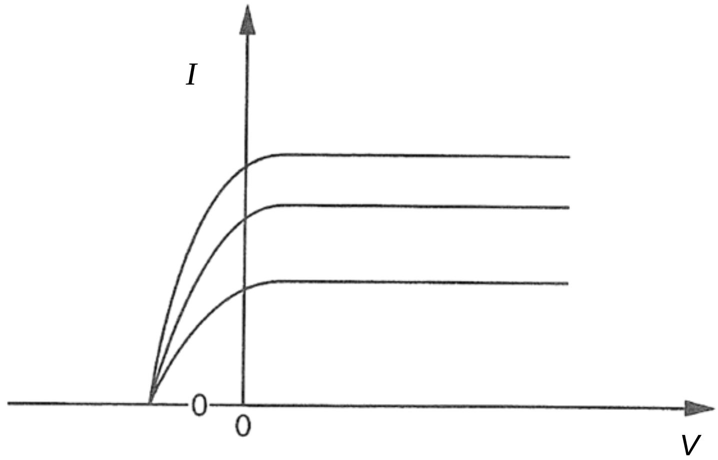

Fig. 8.1

State which feature of this graph could not be explained by Einstein using the wave theory of light.

....

....

.... [2]

(b) Fig. 8.2 shows a photocell using cesium as the photocathode. When the cesium surface is exposed to electromagnetic radiation, photoelectrons are ejected. The anode collects the photoelectrons and the sensitive ammeter indicates the presence of a tiny current.

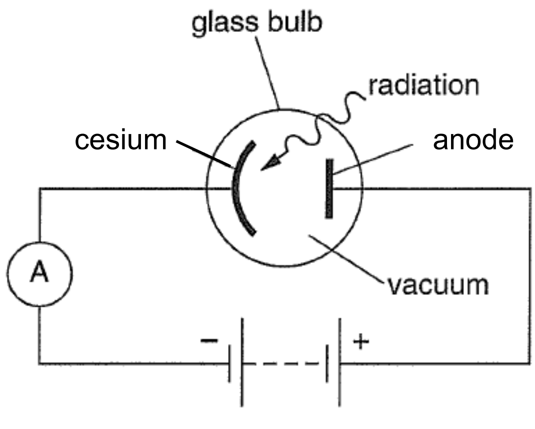

Fig. 8.2

(i) For a certain frequency and intensity of radiation, the ammeter shows a current of 1.2×10^{-7} A. Calculate the number of photoelectrons reaching the collector in 5.0 s.

number of photoelectrons = ……………………………. [2]

(ii) The work function energy of cesium is 2.2 eV and the incident radiation has frequency 7.0×10^{14} Hz. Calculate the maximum kinetic energy of the photoelectrons.

maximum kinetic energy = …………………………… J [2]

(iii) The intensity of the incident radiation is doubled but the wavelength is kept constant. State and explain the effect this has on each of the following

1. the maximum kinetic energy of the photoelectrons,

……………………………………………………………………………………...........

..……………………………………………………………………………………………

……………………………………………………………………………………………..

……………………………………………………………………………….………… [3]

2. the current in the photocell.

……………………………………………………………………………………...........

……………………………………………………………………………………...........

……………………………………………………………………………….………… [2]

(iv) Explain why, no current is detected by the ammeter when the cesium photocathode is replaced with zinc.

…………………………………………………………………………………………...........

…………………………………………………………………………………………...........

…………………………………………………………………………………………….. [2]

(c) Einstein's observation introduced the particulate nature of light waves.

(i) Describe an experiment that shows the wave nature of a particle.

…………………………………………………………………………………….................

…………………………………………………………………………………………………

…………………………………………………………………………………….................

…………………………………………………………………………………………… [2]

(ii) Calculate the de Broglie wavelength for a single electron which has a speed of 2.5 $\times 10^6$ m s^{-1}.

wavelength = …………………………… m [1]

(iii) State and explain whether electrons with speed of 2.5 $\times 10^6$ m s^{-1} are suitable to be used to study atomic structure of matter.

…………………………………………………………………………………………...........

……………………………………………………………………………………………… [1]

(iv) Neutrons can also be used to investigate the atomic structure of matter. Suggest and explain an advantage and a disadvantage in using neutrons.

advantage ……………………………………………………………………………….

……………………………………………………………………………………………......

……………………………………………………………………………………………......

disadvantage …...…………………………………………………………………...........

……………………………………………………………………………………………......

……………………………………………………………………………………………… [3]

Name: ______________________________ (   )   PDG: ______/ 17

ANDERSON JUNIOR COLLEGE

2018 JC2 Preliminary Examination

PHYSICS Higher 2 9749/04

Paper 4 Practical **Monday 20 August 2018**

2 hours 30 minutes

Candidates answer on the Question Paper.
Additional Materials: As listed on the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose mark if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
Paper 4 (55 marks)	
1	
2	
3	
4	
Total (55 marks)	

This document consists of **16** printed pages and **0** blank page.

1 In this experiment, you will investigate how the motion of a pendulum whose swing is interrupted depends on its length.

(a) (i) Lay the pendulum next to the rule and use the pen to make a mark on the string so that the distance *L* is 0.180 m, as shown in Fig. 1.1.

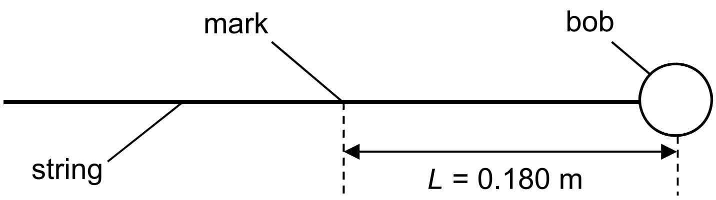

Fig. 1.1

(ii) Set up the apparatus, fixing the string in the split bung so that the string is just touching the wooden rod at the mark you have made.

Fig. 1.2 shows a side view and a front view of the apparatus.

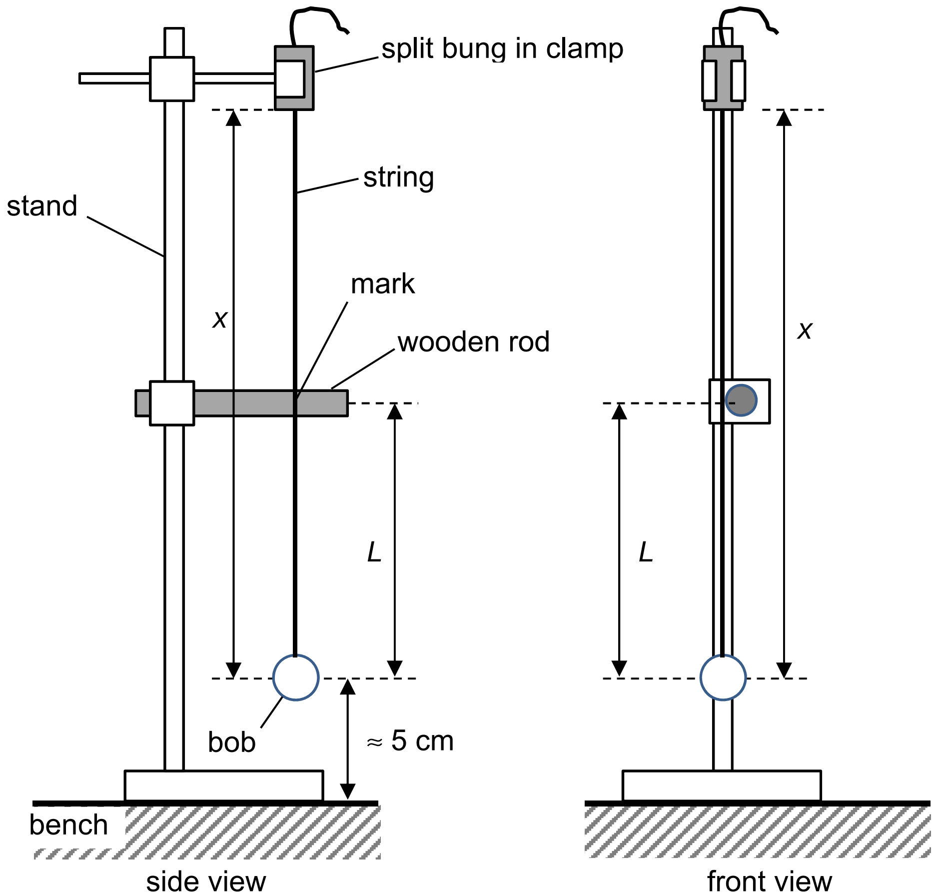

Fig. 1.2

The centre of the bob should be approximately 5 cm above the bench.

The distance *x* between the bottom of the bung and the centre of the bob should be approximately 55 cm.

The mark on the string should be level with the centre of the rod.

For Examiner's Use

(iii) Measure and record the distance *x*.

x = ……………………………

(b) (i) Move the bob sideways through a distance of approximately 5 cm, as shown in Fig. 1.3.

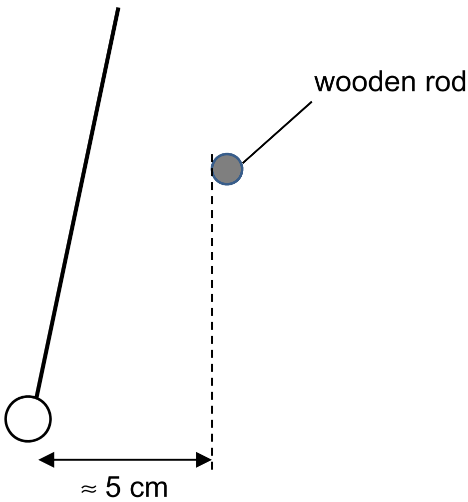

Fig. 1.3

(ii) Release the bob and watch its movement. The bob will move to the right and then to the left again completing a swing, as shown in Fig. 1.4. Let the pendulum swing to and fro, counting the number of swings.

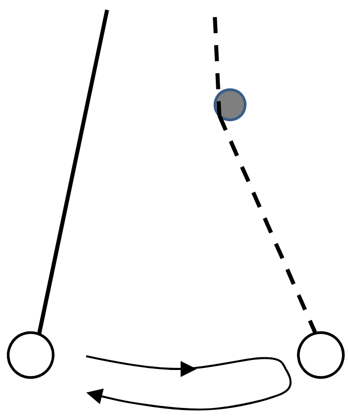

Fig.1.4

Determine an accurate value for the time *T* taken for one complete swing.

T = …………………………… [1]

For Examiner's Use

(c) Reduce the distance *x*. Keep *L* constant, by adjusting the height of the wooden rod if necessary. Repeat steps **(a)(iii)** and **(b)** to obtain further sets of readings for *x* and *T*.

[7]

(d) Theory suggests that *T* and *x* are related by the equation

$$T = P\sqrt{x} + Q$$

where *P* and *Q* are constants.

Plot a suitable graph to determine *P* and *Q*.

P = ……………………………………

Q = …………………………………… [4]

For Examiner's Use

[3]

For Examiner's Use

(e) An amusement park ride consists of a capsule attached to a mechanical arm that has two segments and swings just like the pendulum in this experiment. The total length of the two segments of the arm is limited by the height of the supporting structure. The engineer is required to find out the lower segment's length such that the set-up has a period that is 60% of the period of a simple pendulum. The length of the simple pendulum is the total length of the two segments of the arm.

Plan an investigation to find out the ratio $\frac{\text{length of lower segment of arm}}{\text{total length of arm}}$ to meet the above requirement.

Your account should include:

- your experimental procedure
- details of the table of measurements with appropriate units
- how you would find the required ratio.

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.... [4]

[Total: 19 marks]

For Examiner's Use

2 In this experiment, you will investigate the resistance of a wire coil.

(a) You have been provided with a coil as shown in Fig. 2.1.

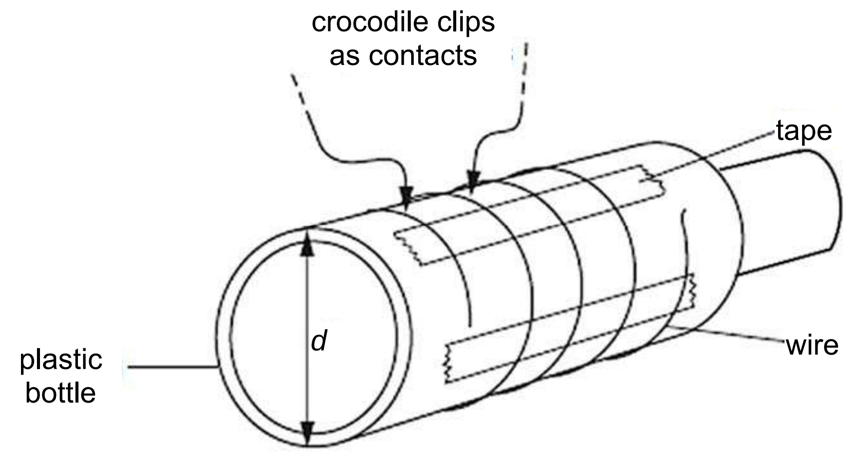


Fig. 2.1

(i) Measure and record the diameter *d* of the plastic bottle.

d = ……………………… [2]

(ii) Estimate the absolute uncertainty in your value of *d*.

uncertainty of *d* = ……………………… [1]

(iii) Estimate the length *x* of wire in a single turn.

x = ……………………… [1]

For Examiner's Use

(b) Set up the circuit as shown in Fig. 2.2, and hold the contacts against two positions on the coil.

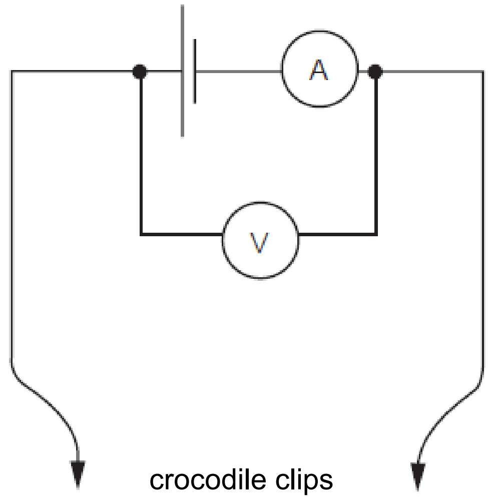


Fig. 2.2

(i) Measure and record the number *n* of turns between the contacts, voltage *V* and current *I*.

n = ………….………….

V = ………….………….

I = ……….………….. [1]

(ii) Determine the resistance *R* between the contacts.

R = ………….…………. [1]

(iii) The resistance per metre μ of the wire is given by

$$\mu = \frac{R}{xn}$$

Use your results to determine a value for μ.

μ = ………….…………. [2]

[Total: 8 marks]

For Examiner's Use

3 In this experiment, you will investigate the motion of two masses connected by a string passing over a pulley.

(a) **(i)** Set up the apparatus as shown in Fig. 3.1.

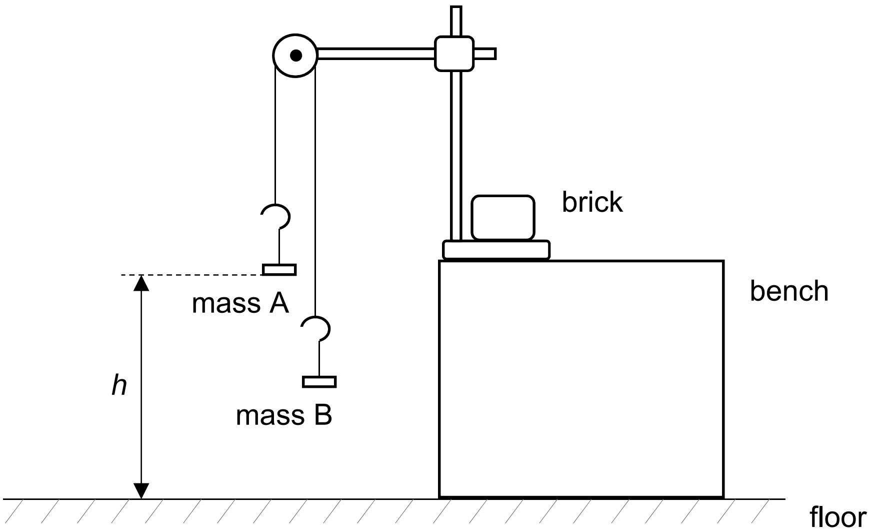


Fig. 3.1

Both the mass m_A of A and the mass m_B of B are equal to 150 g.

Adjust the apparatus so that the distance *h* between the bottom of mass A and the floor is about 1 m.

(ii) Measure and record *h*.

h = ……………………… [1]

(b) **(i)** Transfer 10 g from mass B to mass A.

(ii) State the difference in mass ($m_A – m_B$).

$m_A – m_B$ = ……………………… [1]

(iii) Release mass A from height *h* as recorded in **(a)(ii)** and determine the time *t* it takes to reach the floor.

t = ……………………… [1]

(iv) Estimate the percentage uncertainty in your value of *t*.

uncertainty of *t* = ……………………… [1]

[Turn Over

For Examiner's Use

(v) Transfer another 10 g from mass B to mass A and repeat **(b)(ii)** and **(b)(iii)**.

$m_A - m_B$ = ……………………….

t = ………………….. [1]

(c) It is suggested that $m_A - m_B = \frac{k}{t^2}$ where k is a constant.

(i) Use your values from **(b)(ii), (b)(iii)** and **(b)(v)** to determine two values for k.

Give your values for k to an appropriate number of significant figures.

first value for k = …………………………

second value for k = ………………………[2]

(ii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your value in **(b)(iv)**.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

…………………………………………………………………………………..... [1]

For Examiner's Use

(d) **(i)** Suggest two significant sources of error in this experiment.

1 …………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

2 …………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) Suggest two improvements that could be made to the experiment to address the errors identified in **(d)(i)**. You may suggest the use of other apparatus or a different procedure.

1 …………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

2 …………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

For Examiner's Use

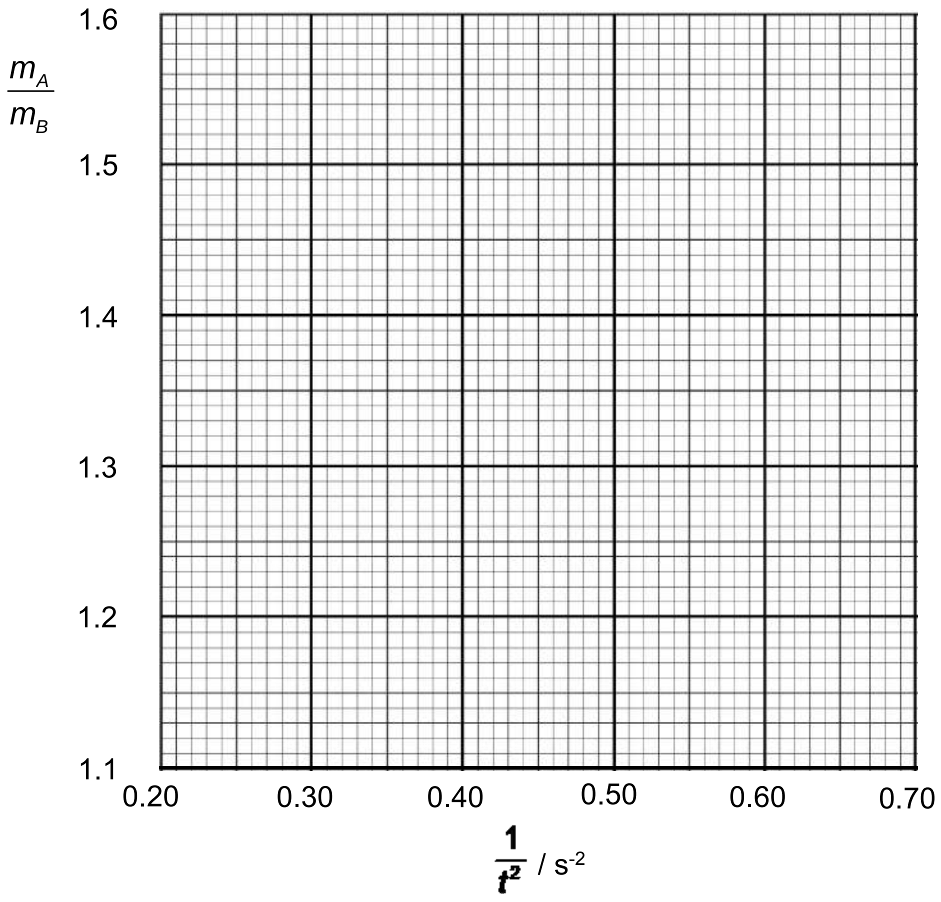
(e) The experiment in **(b)** is repeated with different ratio of the masses $\frac{m_A}{m_B}$.

The results are shown in the table.

Values of $\frac{1}{t^2}$ are included.

$\frac{m_A}{m_B}$	t / s	$\frac{1}{t^2}$ / s^{-2}
1.20	2.1	0.23
1.29	1.7	0.35
1.36	1.5	0.44
1.42	1.3	0.59
1.50	1.2	0.69

(i) Plot the points on the grid and draw the straight line of best fit.



[2]

(ii) Determine the y-intercept of the line.

y-intercept = ………………………… [2]

(iii) Use your answer in **(e)(ii)** to state whether $\frac{m_A}{m_B}$ is proportional to $\frac{1}{t^2}$.

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[Total: 17 marks]

For Examiner's Use

For Examiner's Use

4 A light-dependent resistor (LDR) is made of a high resistance semiconductor. In the dark, a LDR can have a resistance as high as several mega ohms (MΩ), while in the light, it can have a resistance as low as a few hundred ohms.

LDR can be placed in streetlights to control when the light is on. Ambient light falling on the LDR causes the streetlight to turn off. Thus energy is saved by ensuring the light is only on during hours of darkness.

(*adapted from Wikipedia*)

The resistance R of the LDR at a distance d from an intense light source is

$$R = kd^n$$

where k and n are constants.

You are provided with a high intensity lamp.

Design an experiment to determine the values of k and n.

You should draw a diagram to show the arrangement of your apparatus and you should pay particular attention to

(a) the equipment you would use
(b) the procedure to be followed
(c) how the constants k and n are determined
(d) the control of variables
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

For Examiner's Use

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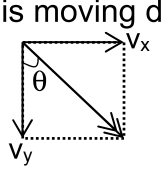
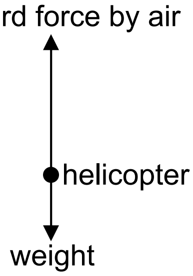
For Examiner's Use

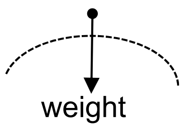
[11]

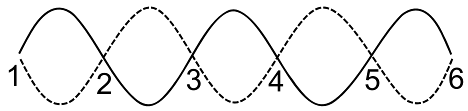
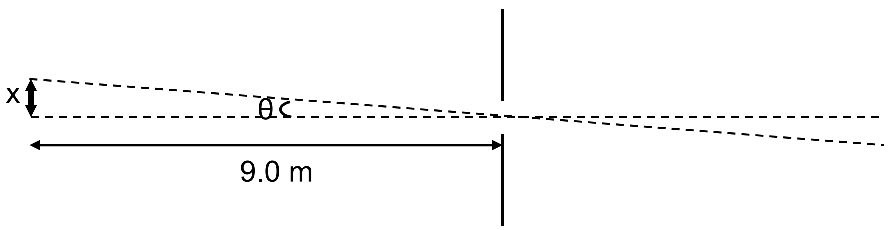
[Total: 11 marks]

2018 AJC JC2 H2 Physics Prelim Solutions
Paper 1 (30 marks)

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	D	D	A	A	B	A	C	A	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	B	D	C	D	B	C	C	D	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	A	D	C	C	B	A	B	B	C

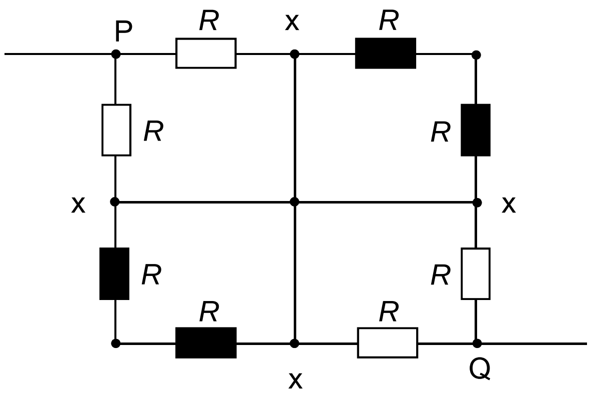
No	Answer & Solution
1	**Ans: A** Y-X = 4.0 cm, Δ(Y-X) = 0.1 cm r = 1/8 (Y-X) = 0.50 cm Δr = 1/8 Δ (Y-X) = 0.01 cm (1 s.f.) r = 0.50 ± 0.01 cm
2	**Ans: D** $v_x = u_x$ $v_y^2 = u_y^2 - 2gs$ $= (50\sin30°)^2 + 2(-9.81)(-30)$ $v_y = -34.8$ m s^{-1} The negative sign shows tthat the ball is moving downwards. $\theta = \tan^{-1} (v_x / v_y) = (50\cos30° / 34.8)$ $= 51.2°$ 
3	**Ans: D** Taking upward direction as positive, $s_y = 0 + \frac{1}{2} a_y t^2$ $a_y = \frac{2s_y}{t^2} = \frac{2 \times 60}{10^2}$ = 1.2 m s^{-2} Upward force – weight = ma Upward force = ma + weight = m (a + g) = 5.0 (1.2 + 9.81) = 55.05 N 
4	**Ans: A** Taking the direction to the right as positive, 20 + (–12) = 12 + ($-P_X$) P_X = 4 N s

5	**Ans: A** By Conservation of Energy, loss in KE = Gain in GPE. ➔ $\Delta E = \Delta mgh = mg\Delta h$ Hence E varies linearly with height, i.e. a straight line. Since y is vertical displacement, at maximum height (largest y value) E = 0. Hence the answer is A.
6	**Ans: B** When the motor is not spinning, the 60 N mass will move downwards as there is a net downward force of 35 N. Since the belt remains stationary when the motor is spinning, $P_{output} = F_{net} \times$ (distance moved per unit time) $= F_{net} \times (20\pi d)$ $= 35 \times (20 \times \pi \times 0.35) = 770$ W
7	**Ans: A** Assume that the horizontal force at the top hinge is to the right, Taking moment about bottom hinge, $(T \sin\theta)(d)+(T\cos\theta)(d) = (R_x)(d)+(W)(0.5d)$ $(150 \sin 30°)(0.5) + (150 \cos 30°)(0.5) = Rx(0.5) + (20)(9.81)(0.5)(0.5)$ $R_x = 107$ N to the right. (since the answer is positive)
8	**Ans : C** For max speed such that the scooter does not lose contact with bridge, weight of scooter provides centripetal force. $mg = mv^2/r$ $v = \sqrt{(gr)} = \sqrt{(3 \times 9.81)} = 5.4$ m s^{-1} 
9	**Ans : A** Gravitational field strength, $g = \frac{GM}{r^2}$ Since $M = \rho \times V = \rho \times \frac{4}{3}\pi r^3$, $g = \frac{\left(G \times \rho \times \frac{4}{3}\pi r^3\right)}{r^2} = \frac{4}{3}G\rho\pi r$, i.e. g is proportional to r. Therefore, $\frac{g_x}{g_r} = \frac{R}{2R} = 0.5$
10	**Ans : B** At a height of 1.0×10^6 m, distance from the centre of the Earth, $r = 1.0 \times 10^6 + 6.37 \times 10^6 = 7.37 \times 10^6$ m From Conservation of Energy, total energy at r = total energy at infinity = 0 $-\frac{GMm}{r} + \frac{1}{2}mv^2 = 0$ $v = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 5.96 \times 10^{24}}{7.37 \times 10^6}} = 1.04 \times 10^4 \text{ m s}^{-1}$

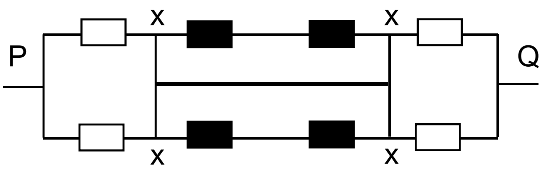
11	**Ans : B** By definition for thermodynamic temperature scale.
12	**Ans: B** $q = \Delta U + w$ $\Delta U = q - w$ compare with $\Delta U = Q + W$ (usual convention) W is work done by system
13	**Ans: D** For SHM, $a = -\omega^2 x$ Hence, magnitude of restoring force = ma = m [(2πf)^{2}x] = 0.040 x (2π x 25)^2 x 0.0025 = 2.47 N
14	**Ans: C** $A_0 \cos\theta = ½ A_0$ $\theta = 60°$
15	**Ans : D**  Distance between first and sixth node = 5 x λ / 2 = 7.5 m λ = 3.0 m From v = λf v = 3.0 x 300 = 900 m s^{-1}
16	**Ans : B**  Using Rayleigh's criterion, the minimum angle for image to be just resolved, $\sin\theta = \frac{\lambda}{b}$ $\sin\theta \approx \tan\theta$ $\frac{\lambda}{b} = \frac{x}{9.0}$ tan θ = x / 9.0 = 2.0 × 10^{-5} x = 1.8 × 10^{-4} = 0.18 mm
17	**Ans: C** $R = \frac{\rho L}{A}$ $R = \frac{\rho L}{\left(\frac{V}{L}\right)} = \frac{\rho L^2}{V} = \frac{\rho (L_0 + x)^2}{V}$ Note: For constant volume, R against x graph is quadratic.

18

Ans: C



The above circuit can be redrawn as:



No current passes through the resistors in black as all current will pass through the bold wire (zero resistance)
Resistance across PQ = $R/2 + R/2 = R$

19

Ans: D
Using potential divider concept,

e.m.f. of cell = p.d. across the balance length of wire $= E\left(\dfrac{\frac{1}{3}R}{r+3R+r}\right)$

$= \dfrac{ER}{3(4R+r)}$

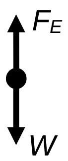
20

Ans : D

The direction of electric field line at a point indicates the direction of electric force on a positive test charge placed at the point. Since an electron is a negative charge, it will experience an electric force in the direction opposite to that of the electric field.

21

Ans : A



For uniform electric field, $E = \dfrac{V}{d}$

$F_E = qE$
$W = qE = q(V/d)$
$= (4.8 \times 10^{-19})(660)/(0.015)$
$= 2.1 \times 10^{-14}$ N

22

Ans : A

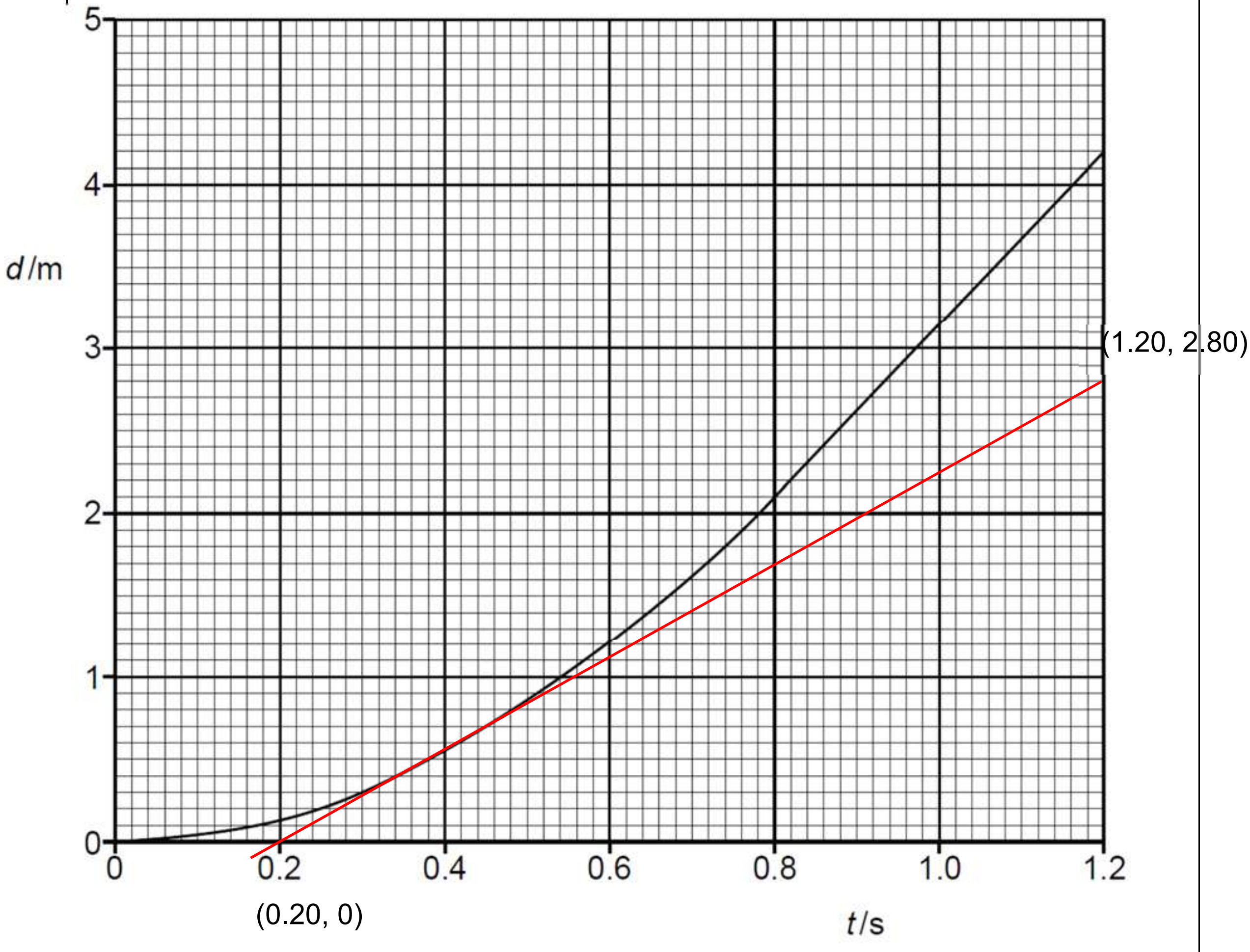
There is no magnetic force on the moving charge whose velocity is parallel to the direction of B-field.

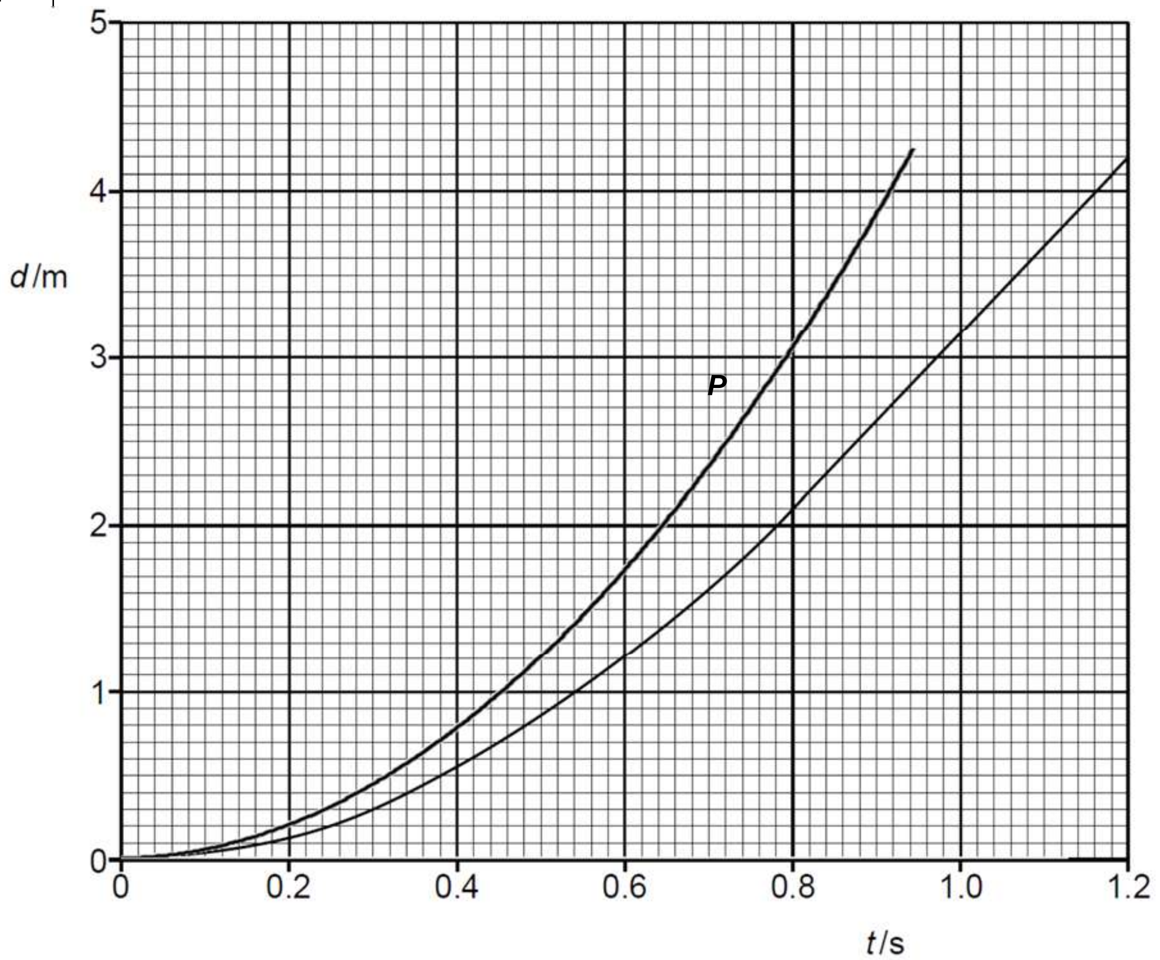
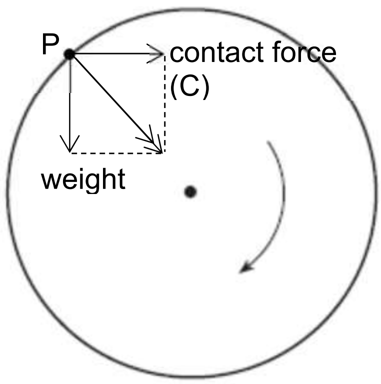
23	**Ans: D** As the long straight wire moves towards the flat coil, the magnetic flux density in the area enclosed by the coil increases. Since $B = \frac{\mu_0 I}{2\pi d}$, for each speed, magnetic flux density inside the coil increases at an increasing rate. This results in the increasing rate of change of magnetic flux linkage leading to increasing induced e.m.f. in the coil. Thus, current increases.
24	**Ans: C** To find r.m.s. value of V, we need to square the graph and find the average value of V^2 then find square root. $V_{r.m.s.} = \sqrt{\frac{(4^2 \times 1) + (1 \times 3)}{5}}$ = √(3.8) Power dissipated = $V_{r.m.s.}{}^2$ / R = 3.8 / 2.0 = 1.9 W
25	**Ans: C** Magnetic flux through the transformer follows the same sinusoidal function as that of the alternating supply current, i.e. sine curve. Since the induced e.m.f. in the secondary coil is proportional to the rate of change of magnetic flux through the coil (i.e. dΦ/dt), hence the voltage and current at the secondary coil will be a cosine curve. Since $P = I^2R = V^2/R$, the power-time graph will be a cosine-square curve.
26	**Ans: B** Using $P_0 = \frac{V_0{}^2}{R}$, Since the transformer is ideal, $P_{primary} = P_{secondary}$ For primary coil, $\frac{P_{o,initial}}{P_{o,final}} = \left(\frac{V_{0,initial}}{V_{o,final}}\right)^2 \rightarrow \frac{36 \times 2}{P_{o,final}} = \left(\frac{2.8}{1.4}\right)^2$ $P_{o,final}$ = 18 W $I_0 = \frac{P_0}{V_0} = \frac{18}{1.4} = 12.86$ A $I_{rms} = \frac{12.86}{\sqrt{2}} = 9.09$ A
27	**Ans : A** Energy of photon = $\frac{hc}{\lambda}$ Energy of photon S > energy of photon R > energy of photon Q λ of photon S < λ of photon R < λ of photon Q Thus S is ultraviolet, R is green and Q is yellow.

[Turn Over

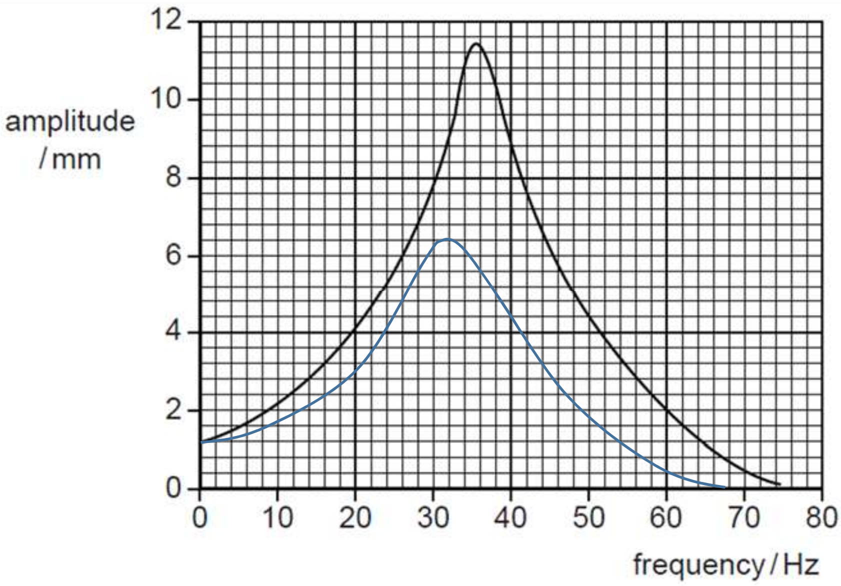
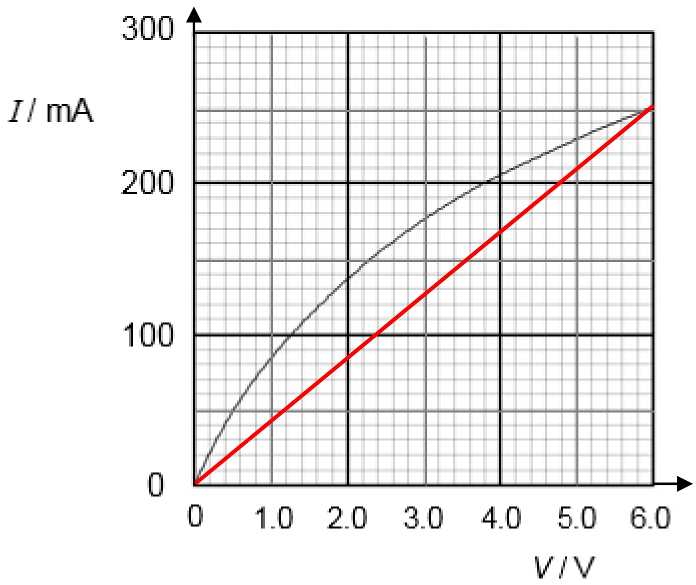
28	**Ans : B** Characteristic peaks are formed by de-excitation of electrons in the inner shells of metal metal target, i.e. when an electron from an outer shell falls to the inner shell to replace the displaced electron.
29	**Ans: B** An alpha particle is a helium nucleus. $^{220}_{86}Rn \rightarrow {}^{216}_{84}Po + {}^{4}_{2}He$ Option A is <u>NOT</u> a radioactive decay, since radioactive decay is spontaneous.
30	**Ans: C** A – The stability of the nucleus depends on the binding energy per nucleon, not the binding energy. B – The reaction can still occur provided energy is given to the reactants. D – The half-life of a radioactive isotope is a constant for a given radioactive isotope. C is correct because of the principle of conservation of momentum.

2018 AJC Prelim Physics H2P2 Solutions
Paper 2 (80 marks)

1a	The gradient of the graph is the speed or velocity, And it becomes constant (from approximately 0.8 s onwards)	B1 B1
1bi	 At t = 0.40 s, gradient = (2.80 – 0) / (1.20 – 0.20) = 2.8 So, speed = 2.8 ms^{-1} (allowed range is ± 0.1. if answer > ±0.1 but ≤ ±0.2, then award 1 mark)	 M1 A1
1bii	Average speed = 0.55 / 0.40 = 1.375 = 1.38 ms^{-1}	A1
1ci	Distance travelled = ½ at^2 = ½ (9.81) (0.40)^2 = 0.7848 = 0.78 m	B1

1cii	 Continuous curve line starting from zero, with increasing gradient Curve line is smooth, always above the given line, never vertical or straight Passes through (0.40, 0.80). Accuracy up to half small square	 M1 A1 A1
2a	ω = 2π (N/t) = 2π (100/60) = 10.472 rad s^{-1} F = $mr\omega^2$ = (3.8×10^{-3}) (0.118) (10.472) = 4.9172 = 4.9×10^{-2} N	 M1 M1 A1
2b	 Arrow C must be equal length to weight and perpendicular to weight.	A1

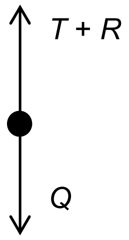
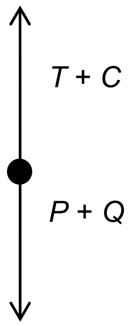
2ci	Direction of weight and contact force is opposite to each other Contact force is the largest (at the lowest point) Centripetal force is upwards Therefore, plasticine is most likely to first lose contact with the disc at the lowest point of the revolution.	M1 M1 M1 A0
2cii	At lowest point, $C_{max} - mg = mr\omega^2$ $0.23 - (3.8 \times 10^{-3})(9.81) = (3.8 \times 10^{-3})(0.118)\ \omega^2$ $\omega = 20.73 = 21$ rad s^{-1}	C1 A1
3ai	Temperature at which all substances have a <u>minimum</u> (internal/kinetic) energy.	B1
3aii	<u>Readings</u> from <u>constant-volume</u> gas thermometer (accept constant-pressure) are plotted on a pressure-temperature graph. By <u>extrapolating the graph</u>, the temperature at which pressure is zero is -273.15 °C. This temperature is the same (when experiment is repeated) for different gases OR this temperature does not depend on the property of any particular substance.	B1 B1 B1
3b	Before the tap is opened, for cylinder B, pV = nRT $(1.2 \times 10^5)(2.0 \times 10^{-2}) = n_B (8.31)(273.15 + 37)$ $n_B = 0.931$ mol (Cylinders are insulated, there is no heat exchange with their surroundings, Q = 0. Since total volume is fixed, W = 0. For a system consisting of the two cylinders, using 1st Law of Thermodynamics, this means $\Delta U = 0$, thus for ideal gas, this means $\Delta T = 0$) Final temperature is 37°C After tap is opened, using pV = nRT on for both cylinders $p(V_A + V_B) = (n_A + n_B)RT$ $p(2 \times 2.0 \times 10^{-2}) = (1.2 + 0.931)(8.31)(273.15 + 37)$ $p = 1.4 \times 10^5$ Pa	C1 C1 C1 A1
4ai	Frequency of the system when it is oscillation <u>freely</u>.	B1
4aii	When forced / driving frequency equals natural frequency of vibration, maximum amplitude of vibration of the oscillating body occurs.	B1 B1
4b	(What is vibrating) eg. vibration of quartz, (Why it is useful) eg. for accurate timing.	M1 A1
4ci	Resonant frequency = 35 Hz Period of oscillation, T = 1/35 = 0.028571 s Time interval = ¼ T = 0.00714 ≈ 0.0071 s	C1 C1 A1
4cii	Same starting point and all points are lower. The 2 graphs should not intersect except at the starting point. Peak at lower frequency, flatter	B1 B1

		
5ai	As *V* increases, power dissipation increases, which increases the temperature of the filament. The amplitude of vibration of lattice ions/atomic core increases, causing electrons to collide more frequently with the lattice ions/atomic core as they drift along the filament. This reduces the mean drift speed of the electrons. Hence resistance increases.	B1 B1 B1
5aii	 Straight line passing through origin and (6.0, 250)	B1
5aiii	$\text{change in resistance} = \dfrac{6.0}{0.250} - \dfrac{4.0}{0.205}$ $= 4.5\ \Omega$	C1 A1
5bi	The effective resistance of the LDR and lamp is less than 10 Ω in daylight. Using the potential divider principle, potential difference across the lamp (and LDR) will be less than 6 V (or less than 4 V).	B1 B1

5bii	$R_{lamp} = \frac{V^2}{P_{lamp}} = \frac{6.0^2}{1.5} = 24\ \Omega$ For V across lamp to be 6 V, $R_{effective}$ = 20 Ω $\frac{1}{R_{effective}} = \frac{1}{R_{LDR}} + \frac{1}{24}$ $\frac{1}{20} = \frac{1}{R_{LDR}} + \frac{1}{24}$ $R_{LDR} = 120\ \Omega$	C1 C1 A1
6ai	A = λN 460 = N × [ln 2 / (8.1 × 24 × 60 × 60)] N = 4.6 × 10^8	 M1 A1
6aii	Number of water molecules in 1.0 kg = (6.02 × 10^{23}) / 0.018 = 3.3× 10^{25} Ratio = (3.3× 10^{25}) / (4.6 × 10^8) = 7.2 × 10^{16}	C1 A1
6aiii	A = $A_0\, e^{-\lambda t}$ 170 = 460 exp [-(ln2t)/8.1] t = 11.6 days	 C1 A1
6bi	If there are no other particles, β-particle would always have same energy. Range of energies means range of speeds/momenta Using conservation of energy and momentum there must be another particle to share energy/momentum	B1 B1 M1 A1
6bii	The daughter nucleus yttrium-90 also undergoes beta decay. Thus, it is difficult to deduce whether a beta particle is due to the decay of strontium-90 or yttrium-90.	B1
7ai	1. Solar energy can be affected by cloud cover, OR is only present in the day. 2. Wind speeds can vary. 3. It is difficult to efficiently store excess energy generated for use at a later timing when the supply of energy falls. (any 2 of the above)	B1 B1
7aii	γ-radiation is high energy electromagnetic radiation OR photons emitted from radioactive decay of atomic nuclei.	B1 B1
7aiii	γ-radiation can penetrate the skin while its ionizing powers can cause damage to DNA / cells / organs.	B1 B1
7aiv	To ensure that all γ-radiation would travel the same distance *x* through the absorber.	A1
7av	The curve reaches an asymptote at the *x*-axis.	A1

7bi	$C_X / C_0 = e^{-\mu x}$, Taking ln on both sides, ln (C_X / C_0) = $-\mu x$ As Fig. 7.3 is a graph of ln (C_X / C_0) against x with a <u>straight line, negative gradient</u>, <u>passing through the origin,</u> it indicates a relationship $C_X / C_0 = e^{-\mu x}$.	 B1 B1 B1
7bii	gradient = $-\mu$ gradient = -4.5 / 10 = -0.45 Hence, μ = 0.45 cm^{-1}	 M1 A1
7ci	units of μ_m = units of μ / units of ρ = cm^{-1} / g cm^{-3} = g^{-1} cm^2	A1
7cii	For lead, μ = 0.45 cm^{-1} $\mu_m = \mu/\rho$ = 0.45 / 11.3 = 0.0398 = 0.040 cm^{-1}	A1
7di	average μ_m = (0.035 + 0.037 + 0.040) /3 = 0.037 cm^2 g^{-1}	A1
7dii	For concrete, $\mu = \mu_m \rho$ = 0.037 × 2.4 = 0.037 × 2.4 × 10^3 × 10^3 / 100^3 = 0.0888 = 0.09 cm^{-1}	 M1 M1 A0
7diii	$C_X / C_0 = e^{-\mu x}$, For same shielding effect, value of C_X / C_0 is the same. Hence, value of μx must be the same. $(\mu x)_{concrete} = (\mu x)_{lead}$ (0.09) x = (0.45) (4.0) x = 20 cm OR From Fig. 6.2, when x = 4.0 cm, C_X / C_0 = 0.16 Using $C_X / C_0 = e^{-\mu x}$, ln (C_X / C_0) = $-\mu x$ ln 0.16 = -0.09 x x = 20 cm	 C1 A1 C1 A1
7div	1. Concrete is cheaper OR more available than lead. 2. Concrete is a stronger material than lead OR Concrete is a better choice as a construction material than lead. 3. Lead is toxic compared to concrete.	B1 B1

2018 AJC H2 Prelim Solutions
Paper 3 (80 marks)

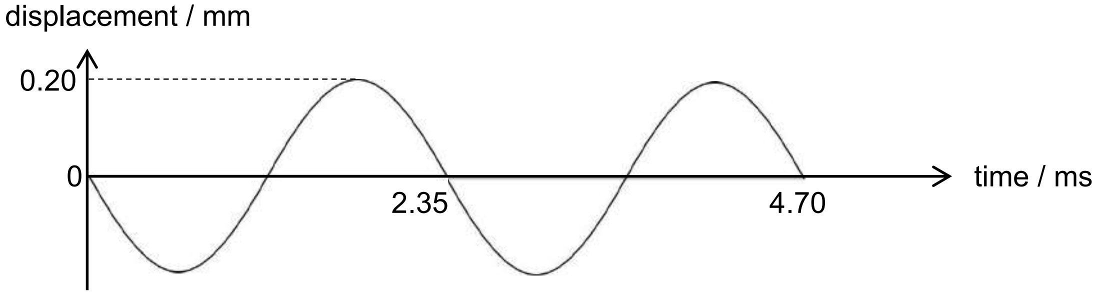
1a	The weight of displaced water is equal to the weight of the wooden block. The weights for both beakers are the same / the readings are the same	M1 A1
1b(i)1	 Arrows are equal in length with correct labels	 B1
1b(i)2	 Arrows are equal in length with correct labels Lengths of arrows are longer than in **1b(i)1**	 B1 B1
1b(ii)	$C = P + Q - T = P + Q - (Q - R) = P + R$ = 3.00 + 0.20 = 3.20 N	C1 A1
1b(iii)	Initial reading = 3.20 N Final reading = $P + Q$ = 3.00 – 1.13 = 4.13 N Change = 4.13 – 3.20 = 0.93 N	 C1 A1

2a	$g = GM / R^2$ $M = [9.81 \times (6.4 \times 10^6)^2] / 6.67 \times 10^{-11} = 6.02 \times 10^{24}$ $\approx 6.0 \times 10^{24}$ kg	 M1 A0
2b(i)	Gravitational force provides for centripetal force, $GM / r^2 = r\omega^2$ For geostationary satellite, $\omega = 2\pi / (24 \times 3600)$ Hence, $6.67 \times 10^{-11} \times 6.02 \times 10^{24} = r^3 \times \omega^2$ $r = 4.23 \times 10^7 \approx 4.2 \times 10^7$ m	B1 M1 A1

2b(ii)	Potential energy at Equator, $\Phi_e = -\frac{GMm}{R_e}$ Potential energy at geostationary orbit, $\Phi_o = -\frac{GMm}{R_o}$ Increase in potential energy $= \Phi_o - \Phi_e = -\frac{GMm}{R_o} - \left(-\frac{GMm}{R_e}\right) = GMm\left(\frac{1}{R_e} - \frac{1}{R_o}\right)$ $= 6.67\times10^{-11}\times6.02\times10^{24}\times650\left(\frac{1}{6.4\times10^{6}} - \frac{1}{4.23\times10^{7}}\right)$ $= 3.46 \times 10^{10} \approx 3.5 \times 10^{10}$ J	 C1 A1
2c	Total energy of the satellite will decrease (due to work done against resistive forces). Radius will decrease since total energy = -GMm/2r, so the kinetic energy will increase since KE = GMm/2r.	M1 M1 A1

3a	**Specific latent heat of vaporization** is the amount of thermal energy per unit mass required to change a substance from liquid to vapour without change of temperature.	B1 B1
3b(i)	Increase in potential energies of all the **water molecules** when the water boils.	B1
3b(ii)	$\Delta U = Q + W$ $Q = mL$ (positive because heat supplied) = 1000 x 2300 J $W = p\Delta V$ (negative because expansion) $= p\,(m/\rho) \times 10^3 = -1.0 \times 10^5 \times (1.0 / 1000) \times 10^3$ J $\Delta U = 1000 \times 2300 - 1.0 \times 10^5 \times (1.0 / 1000) \times 10^3$ J $= 2.2 \times 10^6$ J	 C1 C1 C1 A1
3b(iii)	Part of the heat supplied is used to do work against the atmosphere when water expands from liquid to vapour.	B1

4a	From Fig. 4.1, wavelength λ = 0.80 m Using $v = f\lambda$ $f = v / \lambda = 340 / 0.8 = 425$ Hz	C1 A1
4b	By COE, $E_T = \frac{1}{2} m v_{max}^2$ $v_{max} = a\omega = a\,2\pi f$ $\therefore E_T = 2\pi^2 m f^2 a^2$	B1 B1 A0
4c	$E_T = 2\pi^2 m f^2 a^2$ $= 2\pi^2 \times 4.7 \times 10^{-26} \times 425^2 \times (0.2 \times 10^{-3})^2$ $= 6.7 \times 10^{-27}$ J	 C1 A1

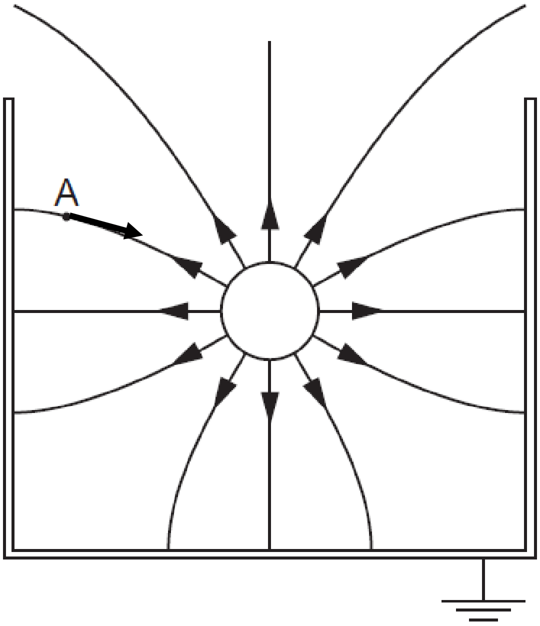
4d	 Sinusoidal wave with axes labelled (correct amplitude and period) Negative sine wave	B1 B1
4e	let θ be the phase angle between A and B. $0.10 = 0.20 \sin \theta$ $\theta = 30^\circ$	C1 A1

5a	When two waves meet at a point, the resultant displacement is equal to the vector sum of the individual displacements.	B1 B1
5b(i)	For observable interference pattern, the two sources must be coherent. At the single slit, the monochromatic light diffracts from a point source. At the double slit, the same diffracted wave reaches S_1 and S_2 (to create two coherent sources).	B1 B1 B1
5b(ii)	Since the path/phase difference is zero and the 2 waves arrive at Y in phase, constructive interference happens at Y.	M1 A1
5b(iii)	From $x = \lambda D / a$ $\lambda = ax / D$ $= (2.0 \times 10^{-3} \times 0.6 \times 10^{-3}) / 1.8$ $= 6.67 \times 10^{-7} \approx 6.7 \times 10^{-7}$ m	C1 A1
5biv1	the fringe separation will remain the same intensity of bright fringe decreases, while dark fringe remains dark OR less contrast between bright and dark fringes	B1 B1
5biv2	the zeroth order will shift away from Y towards the top of the page Fringe separation / intensity / contrast will remain the same	B1 B1

6a	From Fig. 6.2, magnetic flux density = 50 mT Magnetic flux linkage, $\Phi = NBA$ $= 180 \times 50 \times 10^{-3} \times \pi (5.3 \times 10^{-3} / 2)^2$ $= 1.9856 \times 10^{-4} = 2.0 \times 10^{-4}$ Wb Note: To get the answer mark, the calculated value must be written down before showing the answer to be that in the question.	M1 M1 A1

6b(i)	change in magnetic flux density ΔB = 5 – 50 = – 45 mT (from graph, accept positive value) average induced e.m.f. = $\Delta\Phi / \Delta t = \Delta NBA / \Delta t = NA\,\Delta B / \Delta t$ $= 180 \times \pi\,(5.3\times10^{-3}/2)^2 \times(-45\times10^{-3}) / 0.30$ $= -5.957\times10^{-4} = -6.0\times10^{-4}$ V Note: accept if answer is given as a positive value	C1 A1
6b(ii)	The change in magnetic flux linkage / magnetic flux / magnetic flux density decreases as distance increases. **OR** At constant speed, the rate of change of magnetic flux linkage / induced e.m.f. decreases as x increases. Hence to keep the e.m.f. constant, the speed must increase.	M1 A1
6c	As the coil moves, there is changing / decreasing flux linkage in the coil, leading to an induced e.m.f. Induced e.m.f. results in induced current which creates a magnetic field / flux in the coil that opposes the motion of the coil. As work is done / energy is needed to move the coil away from the magnet, (induced) current gives the heating effect (in the resistor) which comes from the work done. **OR** (last two points can be replaced by the following) Work done in moving the coil is converted to electrical energy. When induced current flows through resistor, electrical energy is converted to heat.	B1 B1 B1 B1 B1 B1

7a	Electric field strength is defined as the electric force per unit positive charge placed at a point in the electric field.	B2
7b(i)1	The sphere is positively charged because the sphere has a higher potential than the metal box which is earthed, at 0 V, based on the direction of the field lines. **OR** field lines pointing/directed away from the sphere	A0 M1
7b(i)2	The field lines are normal to the surface **OR** the lines appear to radiate from the centre of the sphere.	B1

7b(ii)	 Direction of the force is correct and tangent to the field and, origin at A.	B1
7biii1	$V = \dfrac{0.76 \times 10^{-9}}{4\pi\varepsilon(2.4 \times 10^{-2})}$ $= 2.847 \times 10^{2}$ V $\approx 2.85 \times 10^{2}$ V (OR 2.8×10^{2} V for 2sf)	C1 A1
7biii2	The sign is negative. The actual potential at the surface of the sphere is smaller because the actual potential is the scalar sum of the positive potential due to the charged metal sphere and the negative potentials due to the metal box.	B1 A1 M1
7b(iv)	Electric force $F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_o r^2}$ $= \dfrac{(1.60 \times 10^{-19})^2}{4\pi\varepsilon_o(6.0 \times 10^{-10})^2} = 6.39 \times 10^{-10}$ N Ratio $= \dfrac{6.39 \times 10^{-10}}{9.11 \times 10^{-31} \times 9.81}$ $= 7.15 \times 10^{19}$	C1 A1
7b(v)	The gravitational forces are always attractive. **OR** gravitational field lines must be directed towards both box and sphere.	B1
7c(i)	As seen from <u>the increased balance reading</u>, there is a <u>downward force on magnet</u> due to wire carrying current. By Newton's third law, there is an <u>upward force on wire</u> by magnet. By Fleming's left hand rule, pole P is a <u>**north**</u> pole.	M1 M1 A1
7c(ii)	By Newton's 2nd law, W – BIL = 0 $\Rightarrow$ W = BIL $2.3 \times 10^{-3} \times 9.81 = B \times 2.6 \times 4.4 \times 10^{-2}$ B = 0.20 T (g = 10, loses this mark)	C1 A1
7c(iii)	The reading will vary between 3.3 g above the original value (when there is no current) and 3.3 g below the original value. For marking: Correct peak value – 1m. Description of varying reading above and below the original value – 1m.	B2

8a	The value of V when I = 0 remains unchanged as intensity is varied. This value is the stopping potential.	B1 B1
8bi	$Q = It$ and $ne = It$ Hence $n = It / e = (1.2 \times 10^{-7} \times 5.0) / 1.6 \times 10^{-19}$ $n = 3.75 \times 10^{12} \approx 3.8 \times 10^{12}$	 C1 A1
8bii	Using Einstein's photoelectric equation : $hf = \Phi + KE_{max}$ $KE_{max} = hf - \Phi$ $= 6.63 \times 10^{-34} \times 7.0 \times 10^{14} - 2.2 \times 1.6 \times 10^{-19}$ $= 1.12 \times 10^{-19} \approx 1.1 \times 10^{-19}$ J	 C1 A1
8biii1	The energy of a photon is given by hc / λ, therefore the energy of each photon remains the same/constant (since λ is constant). For the same metal the work function remains the same, ,hence (from the photoelectric equation) the maximum kinetic energy remains the same/constant.	M1 M1 A1
8biii2	There are twice as many photons reaching the surface, hence the current in the photocell doubled	M1 A1
8biv	Zinc has work function larger than the photon energy, Hence no electrons ejected, so no photocurrent.	B1 B1
8ci	Fast-moving electrons pass through thin carbon/graphite Concentric diffraction rings are observed on the screen	B1 B1
8cii	From $\lambda = h/p = h/mv$ $= 6.63 \times 10^{-34} / (9.11 \times 10^{-31} \times 2.5 \times 10^{6})$ $= 2.91 \times 10^{-10} \approx 2.9 \times 10^{-10}$ m	 A1
8ciii	They are suitable as their wavelength is comparable to the atomic spacing.	B1
8civ	Neutrons have no charge (advantage or disadvantage) Advantage: Neutrons experience no electrical forces (when interacting with atoms) Disadvantage: Neutrons cannot be accelerated using an accelerating potential hence difficult to control their speeds. Neutrons production (require a nuclear reactor, and thus) is much more difficult than electron production	B1 B1 B1

2018 AJC Physics Prelim H2 P4 Solutions and Mark Scheme

1 (a) (iii) x = 55.0 cm

(b) (ii) Time t for 20 oscillations,

t_1 = 23.5 s

t_2 = 23.7 s

T = (23.5 + 23.7)/40 = 1.18 s

T = 1.18 s [1]

(c)

x/cm	No of oscillations N	Time for N oscillations		$T = (t_1 + t_2)/2N$ T / s	$\sqrt{x}$ / cm^{½}
		t_1 /s	t_2 /s		
55.0	20	23.5	23.7	1.18	7.42
50.0	20	22.5	22.3	1.12	7.07
45.0	20	22.0	21.9	1.10	6.71
40.0	20	21.4	21.3	1.07	6.32
35.0	20	20.8	20.8	1.04	5.92
30.0	25	24.7	24.8	0.990	5.48
25.0	25	23.6	23.3	0.938	5.00

[7]

(d) Plot a graph of T vs $\sqrt{x}$ where P is the gradient and Q is the y-intercept.

$$Gradient = \frac{1.152 - 0.944}{7.15 - 5.00}$$

= 0.0967

P = 0.0967 s cm$^{-½}$

Subst point (7.15, 1.152) into $y = mx + c$

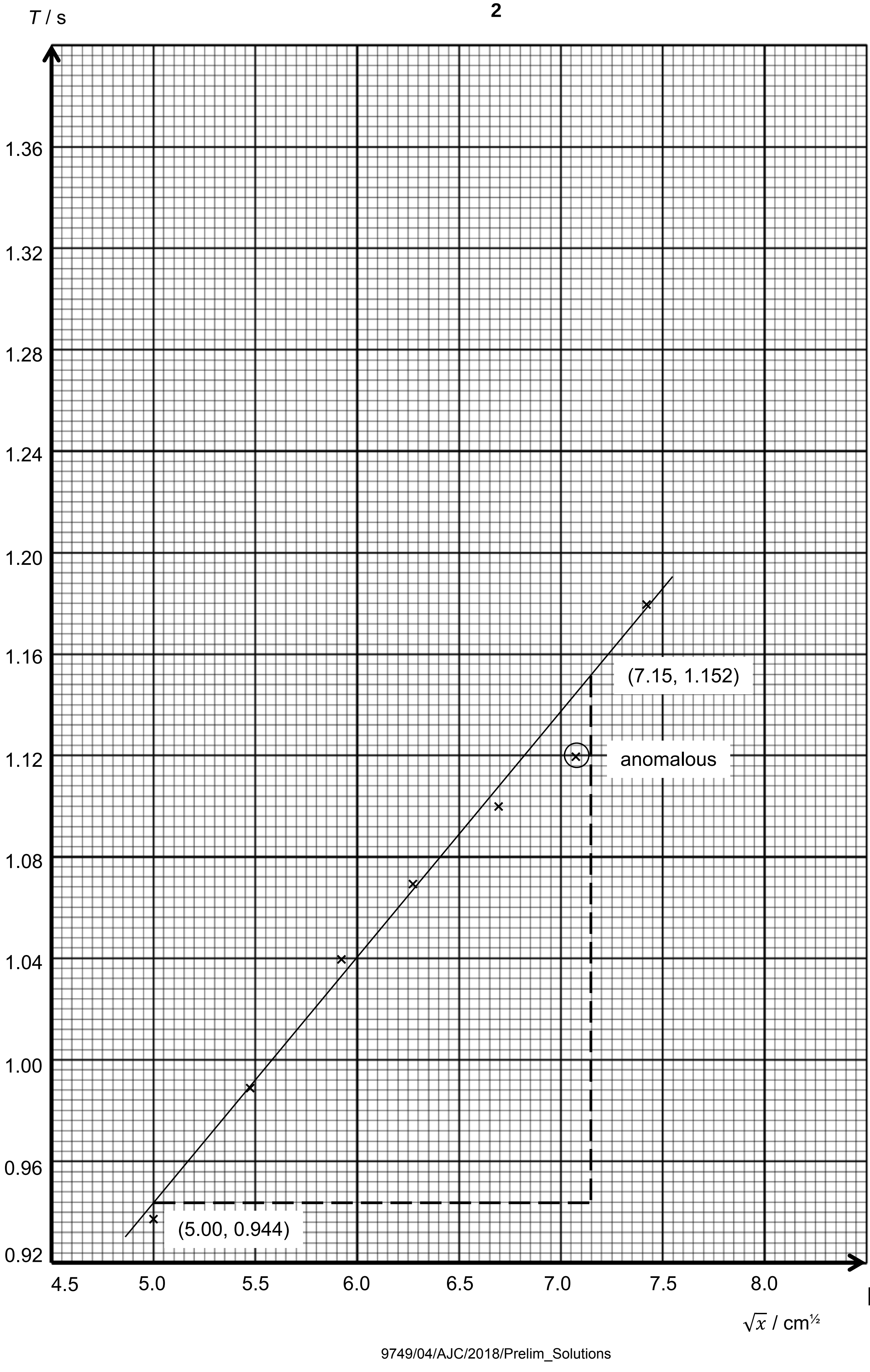
1.152 = 0.0967 (7.15) + c

c = 0.461

Q = 0.461 s

P = 0.0967 s cm$^{-\frac{1}{2}}$

Q = 0.461 s [4]


T / s
1.36
1.32
1.28
1.24
1.20
1.16
1.12
1.08
1.04
1.00
0.96
0.92
(7.15, 1.152)
anomalous
(5.00, 0.944)
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
√x / cm½

[3]

(e) Set up a simple pendulum of length x = 55.0 cm. Take repeat timing t_1 and t_2 for 20 oscillations and determine the period $T_x = (t_1 + t_2)/40$.

Keeping x constant, take readings of timing t for N oscillations to determine the period T for different values of L.

Record the readings in a table with headings:

L / cm	No of oscillations N	Time for N oscillations		$T = (t_1 + t_2) / 2N$ T / s
		t_1 / s	t_2 / s	

Plot a graph of T vs L, read off the value L_1 for T = 0.6 T_x and calculate the required ratio L/x.

[4]

[Total: 19 marks]

2 (a) (i) $d = \frac{7.0 + 7.2}{2} = 7.1\,\text{cm}$

d = 7.1 cm [2]

(ii) uncertainty of d = 0.2 cm [1]

(iii) $x = 2\pi\frac{d}{2} = \pi \times 7.1 = 22\text{ cm}$

x = 22 cm [1]

(b) (i)

n = 4

V = 1.78 V

I = 0.20 A

[1]

(ii) $R = \frac{V}{I} = \frac{1.78}{0.20} = 8.9\ \Omega$

R = 8.9 Ω [1]

(iii) $\mu = \frac{R}{xn} = \frac{8.9}{0.22 \times 4} = 10\ \Omega\ m^{-1}$

μ = 10 Ω m^{-1} [2]

[Total: 8 marks]

3 (a) (ii)

h = 1.000 m [1]

(b) (ii)

$m_A - m_B$ = 20 g [1]

(iii) $t = \frac{3.2 + 3.4}{2} = 3.3\ s$

t = 3.3 s [1]

(iv) percentage uncertainty of t = $\frac{0.5}{3.3} \times 100\%$ = 15 %

percentage uncertainty = 15 % [1]

(v) $t = \frac{1.6 + 1.5}{2} = 1.6\ s$

$m_A - m_B$ = 40 g

t = 1.6 s [1]

(c) (i) first value for k = 20 × 3.3^2 = 220 g s^2

second value for k = 40 × 1.6^2 = 100 g s^2

first value for k = 220 g s^2

second value for k = 100 g s^2 [2]

(ii) The criterion for the relationship to be valid is percentage difference in $k \leq$ percentage uncertainty of t.

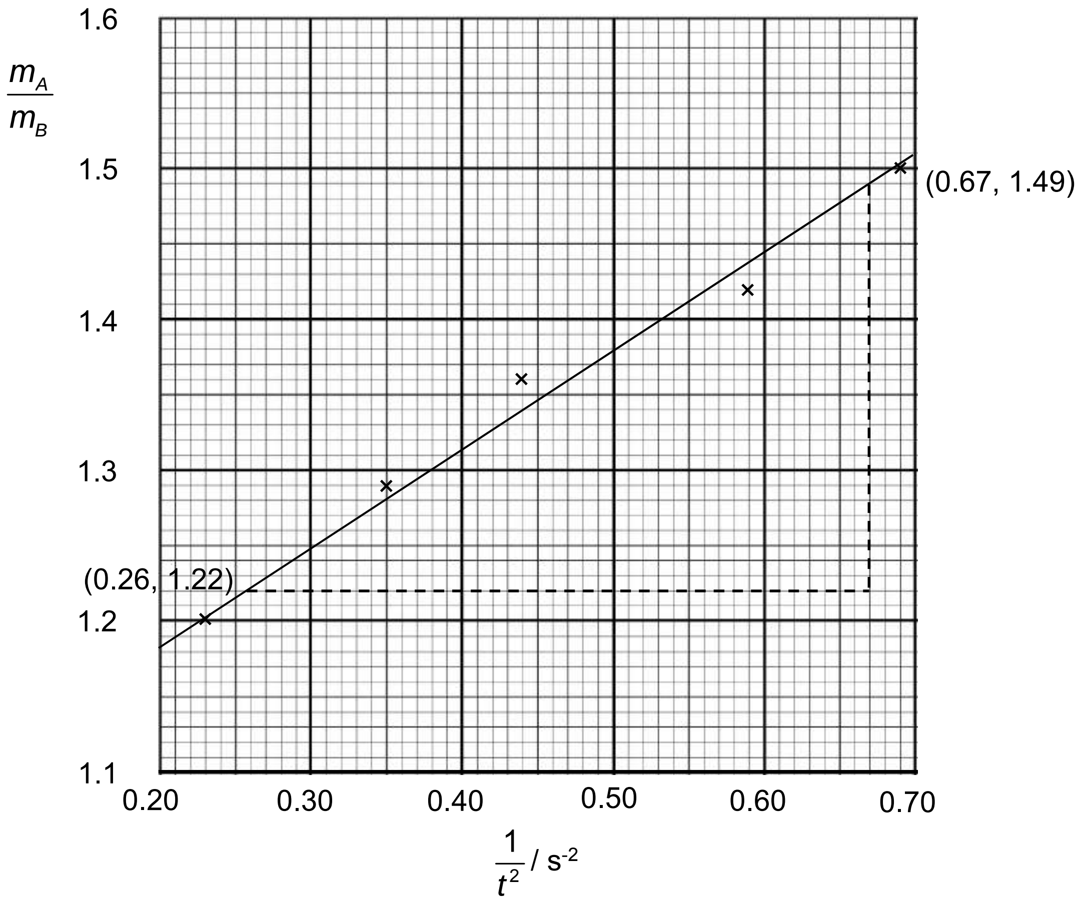
percentage difference in k = $\frac{220 - 100}{100}$ × 100 % = 120 %

Since the percentage difference in k is greater than the percentage uncertainty of t, the relationship is not valid. [1]

(d) (i) Refer to mark scheme

(ii) Refer to mark scheme

(e) **(i)** Plot the points on the grid and draw the straight line of best fit.



[2]

(ii)

gradient = $\frac{1.49 - 1.22}{0.67 - 0.26}$ = 0.659

Sub (0.67, 1.49) into $y = mx + c$,
y-intercept c = 1.49 – 0.659 (0.67)
= 1.05

y-intercept = ……………1.05…………… [2]

(iii) Since the y-intercept is not zero, $\frac{m_A}{m_B}$ is not proportional to $\frac{1}{t^2}$.

……………………………………………………………………………………………

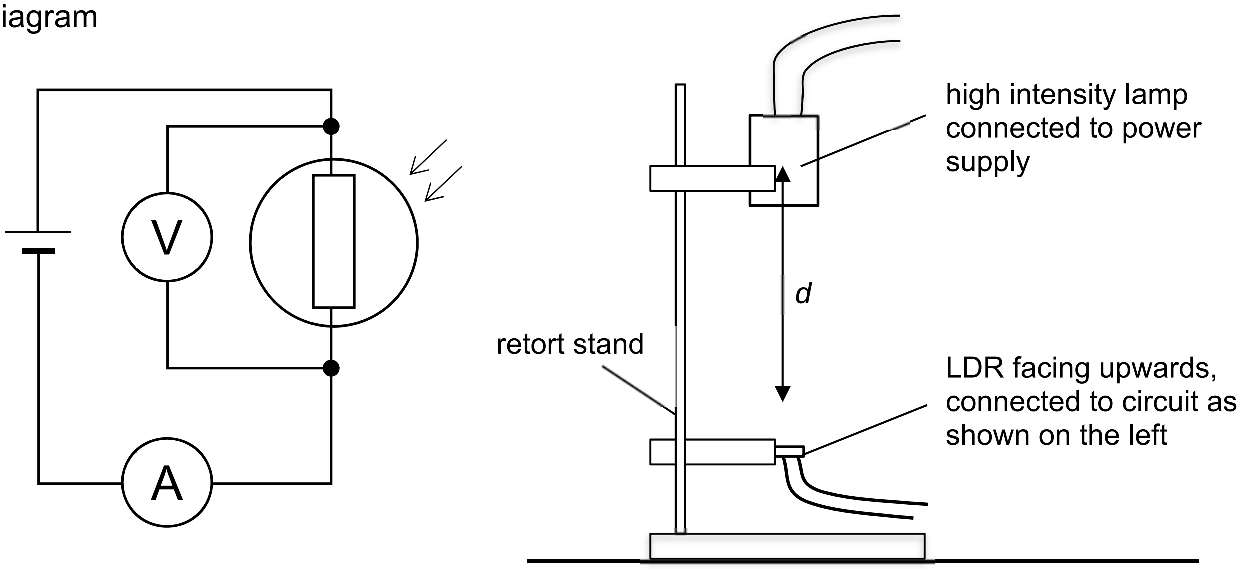
…………………………………………………………………………………………… [1]

[Total: 17 marks]

Q4 Suggested Solution

Independent Variable	Dependent Variable	Control Variables
What? Distance *d* between LDR and light source	Resistance *R* of LDR	Power of light source
How? Measure with metre rule Vary by moving LDR farther away from light source.	*R* = *V*/*I* Measure *V* with voltmeter in parallel Measure *I* with ammeter in series.	Maintain the same current in the source with variable resistance checked with ammeter.

Diagram



Procedure

1. Set up the apparatus as shown in the diagram.
2. Measure and record the distance *d* between the light source and LDR with a metre rule.
3. Measure and record the voltage *V* across the light dependent resistor (LDR) with the voltmeter and the current *I* with the ammeter. Calculate the resistance *R* = *V*/ *I*.
4. Vary *d* by moving the LDR farther away from the light source to obtain six readings of *d* and *R*.

Control of Variables

1. Keep the current to the light source constant by adjusting the variable resistor and checking the ammeter connected to the light source.

Analysis

1. Given $R = kd^n$ where *k* and *n* are constants.
2. $\lg R = \lg k + n \lg d$
3. Plot a graph of lg *R* vs lg *d*, *n* can be found from the gradient of the graph, $k = 10^C$ where C is the y-intercept.

Safety and Accuracy

1. Do not look directly at the light source as it can hurt the eyes.
2. Perform the experiment in a dark room to reduce light from other sources.
3. Align the face of the LDR perpendicular to the light source by using a ruler and a set square, so as to capture maximum light intensity.

JC2 Prelim Question 1 MS

Q1	Answer	Marks
(b)(ii)	**MMO** Value of *T* with unit and appropriate s.f., and time *t* for *N* oscillations to nearest 0.1 s.	**1**
(c)	**MMO** • Award 2 marks if the student has successfully collected 6 or more sets of data (*T*,*x*) without assistance/intervention. Maximum value for *x* is 60 cm. • Award 1 mark if student has successfully collected 5 sets of data (*T*,*x*) without assistance/intervention. • Award 0 mark if student has successfully collected 4 or fewer sets of data (*T*,*x*) without assistance/intervention. • Deduct 1 mark if student requires some assistance/intervention but has been able to do most of the work independently. Indicate the nature of assistance. • Deduct 2 marks if student has been unable to collect data without substantial assistance/intervention **OR *wrong trend in data***.	**2**
	MMO Evidence of repeat readings with *t* at least 20 s.	**1**
	PDO Layout: column headings (raw data and calculated quantities: *x*, *t*, *T* and $\sqrt{x}$). Each column heading must contain a quantity and unit.	**1**
	PDO All values of e.g. *t* and *x* to the correct precision.	**1**
	PDO For each calculated value of e.g. *T* and $\sqrt{x}$, the number of s.f. should be the same or one more than the number of s.f. in the raw data.	**1**
	ACE Correctly calculated values of calculated quantities	**1**
(d)	**ACE** Linearising equation.	**1**
	ACE Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square.	**1**
	ACE *y*-intercept must be read off to the nearest half small square or determined from $y = mx + c$ using a point on the line.	**1**
	ACE Values of *P* and *Q* calculated correctly with units.	**1**
	PDO Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that plotted points occupy at least half the graph grid in both *x* and *y* directions.	**1**

Q1	Answer	Marks
	Axes must be labelled with the quantity which is to be plotted.	
	PDO All observations must be plotted. Work to an accuracy of half a small square. **PDO** Straight line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line.	**1** **1**
(e)	**P** Keep *x* constant. **P** Take reading for period T_x for simple pendulum of length *x*. **P** Table with headings: quantities (e.g. *t*,*T*,*L*) with units. **P** Correct graph (*T* vs *L*) and read off L_1 for $T = 0.6T_x$. Then calculate L_1/x. OR plot T/T_x vs L/x and read off L/x for $T/T_x = 0.6$.	**1** **1** **1** **1**

JC2 Prelim Question 2 MS

Q2	Answer	Mark
(a)(i)	**MMO** Value of *d* with unit and to nearest 1 mm. **MMO** Evidence of repeat reading.	2
(a)(ii)	**ACE** Sensible value of Δ*d* (e.g. 2 mm to 4 mm).	1
(a)(iii)	**ACE** Correct estimation of *x* with unit.	1
(b)(i)	**MMO** Value of *V* with unit and to nearest 0.01 V. Value of *I* with unit and to nearest 0.01 A.	1
(b)(ii)	**ACE** Correct calculation of *R* with unit.	1
(b)(iii)	**PDO** Correct calculation of μ to appropriate number of significant figures with units. **ACE** Range of $7.0\ \Omega\ m^{-1} \le \mu \le 13.0\ \Omega\ m^{-1}$.	2

JC2 Prelim Question 3 MS

Q3	Answer	Mark
(a)(ii)	**MMO** Value of *h* measured to the nearest 1 mm with unit.	1
(b)(ii)	**ACE** Value of $m_A - m_B$ to the nearest 1 g with unit.	1
(b)(iii)	**MMO** Value of *t* measured to the nearest 0.1 s or 1 s.	1
(b)(iv)	**ACE** Percentage uncertainty in *t* calculated correctly to 2 s.f. using sensible value of Δt (e.g. 0.5 s ≤ Δt ≤ 1 s) to account for reaction time between spotting contact of mass A with the ground and stopping the stopwatch.	1
(b)(v)	**MMO** *t* in **(b)(v)** < *t* in **(b)(iii)**.	1
(c)(i)	**ACE** Correct calculation of *k* values with appropriate s.f. **ACE** Correct units for *k.*	2
(c)(ii)	**ACE** Draw conclusion based on stated criterion e.g. not obeyed because % difference in *k* more than % uncertainty in *t*.	1
(d)(i)	**ACE** 1. Difficult to release mass A, hold ruler and start stopwatch at the same time 2. The masses hit each other during the motion. 3. Difficult to drop mass A at *h* due to hands shaking. 4. Difficult to measure / judge position of *h* accurately with positioning reason e.g. ruler is not vertical 5. There is friction at the pulley.	2
(d)(ii)	**ACE** 1. Clamp the ruler with a retort stand so that it is easier to release mass A and start the stopwatch at the same time. 2. Use a larger pulley. 3. Use a card gate / clamp to position and release mass A from *h*. 4. Use a set square on ground / hang a plumbline and check that ruler is vertical. 5. Lubricate the axle of the pulley to reduce the effect of friction.	2

Q3	Answer	Mark
(e)(i)	**PDO** Points correctly plotted. **PDO** Straight line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points on either side of the line.	2
(e)(ii)	**ACE** Gradient – the hypotenuse of the ∆ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. **ACE** y-intercept must be determined from $y = mx + c$ using a point on the line.	2
(e)(iii)	**ACE** Correct conclusion based on whether the y-intercept obtained in **(e)(ii)** is zero.	1
	Examiner's Comment: Many students are still struggling with stating the sources of error. A rather common error is to state friction between string and pulley. A general statement like lubricate the pulley will not get any credit. What is needed is for students to mention "lubricate the axle of the pulley".	

JC2 Prelim Question 4 MS (11 marks)

Design/Diagram

Diagram showing an LDR in an appropriate circuit and an independent lamp.	D1
Workable arrangement with lamp and LDR aligned and secured.	D2

Procedure

R measured with appropriate instrument (e.g. using $R = V/I$ where *V* is measured with voltmeter and *I* measured with ammeter.)	P1
d measured with metre rule.	P2
Vary *d* by moving LDR further or nearer the light source (or vice versa)	P3

Control of variables

Keep output of light source constant (allowable methods include constant current/e.m.f./voltage/power)	C1

Analysis

Clear description of what graph to plot (e.g. plot lg *R* vs lg *d*)	G1
Clear description of how *k* and *n* are found from the graph	G2

Safety and Accuracy (max 3 = 1S + 2A or 3A)

Do not look directly at bright light source/wear safety glasses with reference to light source.	S1
Do not touch the light source as it is hot.	S2
Any other sensible safety measure.	S3
Perform the experiment in a dark room/tube	A1
Keep orientation of LDR with respect to light source constant (method required)	A2
Taking six sets of readings (by varying *d*)	A3
Keep the temperature constant (performing experiment in an air-conditioned room)	A4
Take preliminary readings of *d* or light intensity to obtain suitable range of *R*.	A5
Other possible good physics suggestions.	A6

NAME ______________________ **CLASS** 2T

Catholic Junior College
JC2 Preliminary Examinations
Higher 2

PHYSICS 9749/01

Multiple Choice Questions

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name and tutorial group on this cover page.

Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet (OMR sheet), unless this has been done for you.
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are a total of 30 Multiple Choice Questions in this paper.

Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Answer Sheet (OMR sheet) provided.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_P	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T / K	=	$T / {}^{\circ}C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2} kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^{2} - x^{2}}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 A student measured the mass and linear dimensions of a rectangular block in order to determine its density. The measurements are:

Height = (1.00 ± 0.01) cm
Length = (5.00 ± 0.01) cm
Breadth = (2.00 ± 0.01) cm
Mass = (80.0 ± 0.2) g

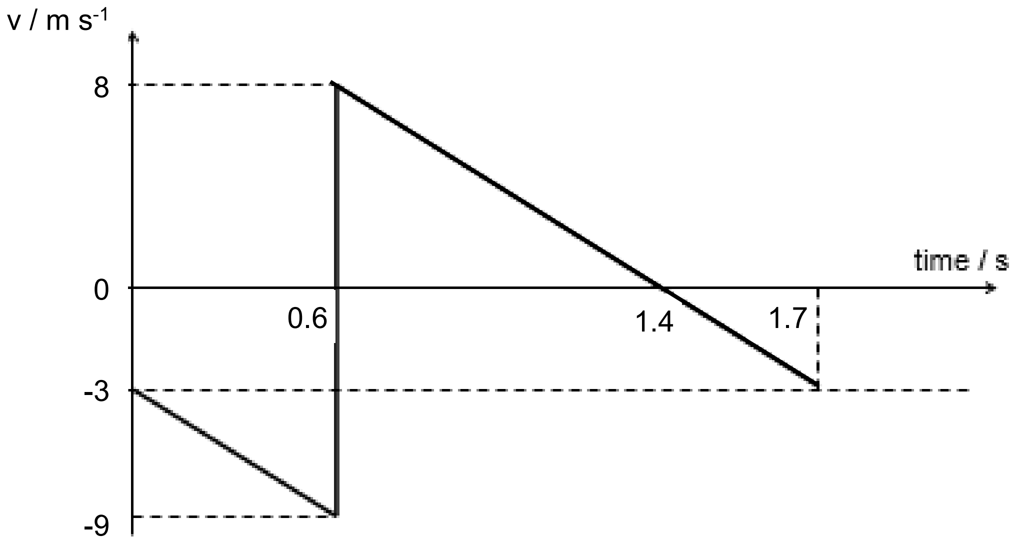
What is the uncertainty in the value of the density calculated?

A 0.01 g cm^{-3} **B** 0.02 g cm^{-3} **C** 0.1 g cm^{-3} **D** 0.2 g cm^{-3}

2 Express the *volt* in SI base units.

A kg m^2 s^{-3} A^{-1} **B** kg m s^{-2} A^{-1} **C** J C^{-1} **D** V

3 A student throws a rubber ball vertically downwards at a speed of 3.0 m s^{-1}. It hits the ground and rebounds vertically. The graph below shows the velocity-time graph for the first 1.7 s of the motion of the rubber ball



What is the displacement of the ball between the point at which it was first thrown and the highest point of the motion?

A zero **B** 0.4 m **C** 1.8 m **D** 3.6 m

4 An object is thrown vertically upwards in air in which the air resistance is not to be neglected.

If the times of flight for the upward motion t_u and the time of flight to return to the same level t_d are compared, then

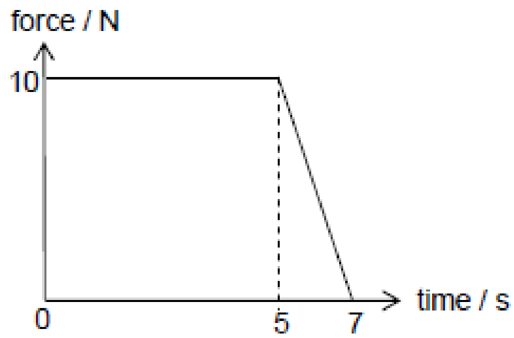
A $t_d > t_u$, because the object moves faster on its downward flight and therefore the air resistance is greater.

B $t_d = t_u$, because the effect of the air resistance is the same whether the object is moving upwards or downwards.

C $t_d < t_u$, because at any given speed the net force when the object is moving downwards is greater than the net force when it is moving upwards.

D $t_d > t_u$, because at a given speed the net force when the object is moving downwards is smaller than the net force when it is moving upwards.

5 A body of mass 2.0 kg is moving along a smooth horizontal surface to the right with a constant velocity of 18 m s^{-1} when a left force is applied on it for 7 s. The graph below shows how the applied force varies with time.



What is the final velocity of the body after 7 s?

A 12 m s^{-1} to the right

B 48 m s^{-1} to the right

C 12 m s^{-1} to the left

D 48 m s^{-1} to the left

6 A fast moving neutron with an initial velocity u has a head-on elastic collision with a stationary proton. After the collision, the velocity of the neutron is v and that of the proton is w.

Taking the masses of the neutron and proton to be equal, which of the following statements is **incorrect**?

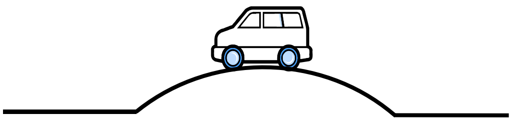
A Since collision is elastic, it shows that $u + v = w$.

B The proton and the neutron move off in opposite directions with equal speeds.

C By considering kinetic energies of the particles, it can be shown that $u^2 = v^2 + w^2$.

D The speed of the proton after the collision is the same as that of the neutron before the collision.

7 A car is travelling on a hump with a radius of curvature of 30 m as shown in figure below. The car loses contact with the hump at the highest point.



At what speed will the car be losing contact as it moves over the hump at the highest point?

A 15.7 m s^{-1} **B** 17.2 m s^{-1} **C** 22.2 m s^{-1} **D** 29.4 m s^{-1}

8 A proposed space laboratory is to create artificial gravity as shown in Fig. 8.a and Fig. 8.b below.

The space laboratory is rotated about an axis so that it simulates an acceleration due to gravity equal to that of the gravity due to Earth at the outer ring which has a radius R_1 of 2150 m.

What should be the approximate radius R_2 of the inner ring, so that it simulates the acceleration due to the gravity of Mars which is 3.72 m s^{-2} ?

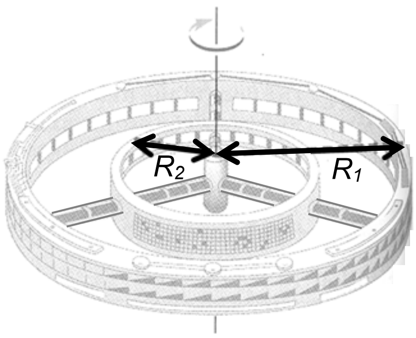


Fig. 8.a

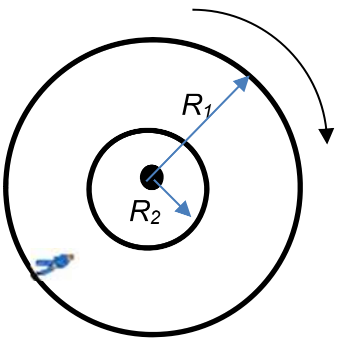


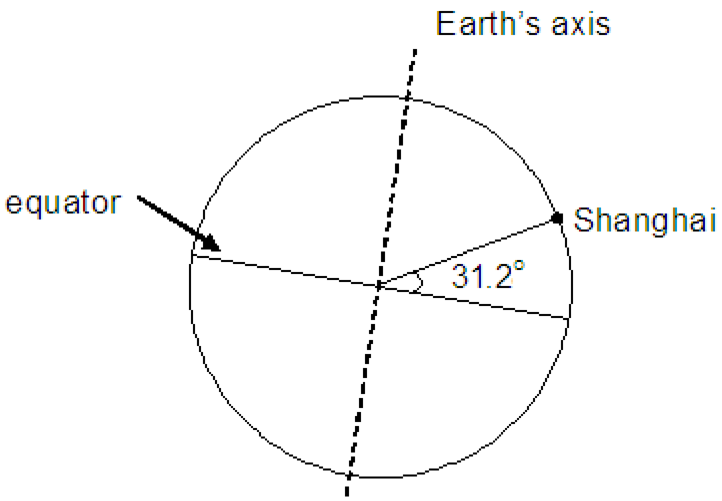
Fig. 8.b

A 700 m **B** 800 m **C** 900 m **D** 1000 m

[Turn over

9 A person is located near the city of Shanghai which has a latitude of 31.28° N.

Assuming that the Earth is a sphere of radius 6380 km, find the linear velocity of the person due to the rotation of the Earth about its axis.



A 240 m s^{-1} **B** 337 m s^{-1} **C** 397 m s^{-1} **D** 464 m s^{-1}

10 The density of a sample of helium gas at the pressure of 100 kPa is 0.180 kg m^{-3}. The root- mean- square speed of the helium molecules is

A 41 m s^{-1} **B** 561 m s^{-1} **C** 1290 m s^{-1} **D** 1685 m s^{-1}

11 A car tyre, initially at 28°C, has been inflated to a pressure of 160 kPa as indicated by the pressure gauge. This means that the pressure in the tyre is 160 kPa above the atmospheric pressure of 100 kPa.

After driving on hot roads, the temperature of the air in the tyre is 65°C.

What is the percentage increase in the pressure gauge reading?

A 10% **B** 20% **C** 200% **D** 270%

12 Fig. 12a shows the variation with displacement x of the velocity v of a body in simple harmonic motion. Fig. 12b shows the variation with time t of the net force F acting on the body.

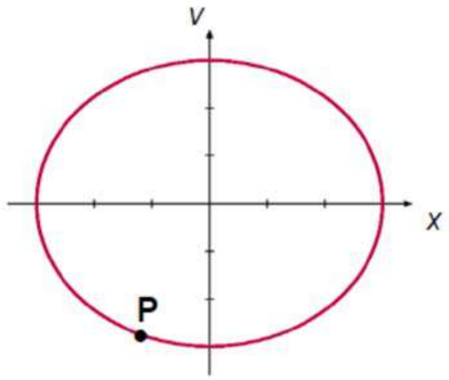


Fig. 12a

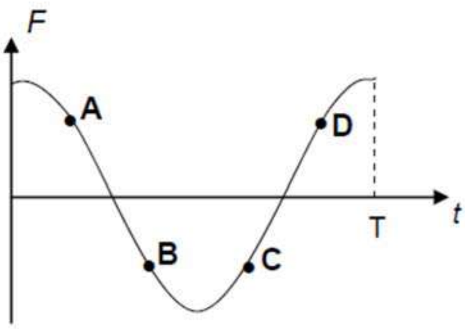


Fig. 12b

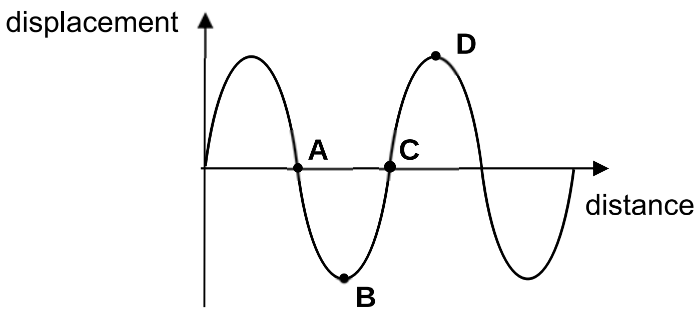
Which of the points on Fig. 12b corresponds to the state of motion represented by point P on Fig. 12a?

13 The phase difference between 2 points at a distance 60 cm apart along a progressive transverse wave is $\frac{\pi}{2}$ rad.

If the frequency of the wave is 200 Hz, what is the speed of the wave?

A 240 m s^{-1} **B** 480 m s^{-1} **C** 24000 m s^{-1} **D** 48000 m s^{-1}

14 A sound wave travelling towards the right through air causes the air molecules to be displaced from their original positions. The graph below shows the variation with distance of the displacement of the air molecules at a particular instant in time.



Taking the displacement towards the right as positive, at which point is the pressure maximum?

[Turn over

15 In a two-slit interference experiment, one slit transmits waves of twice the amplitude compared to the other slit.

If the maximum intensity of the interference pattern is I_o, what is the minimum intensity of the pattern?

A zero **B** $\frac{I_o}{2}$ **C** $\frac{I_o}{4}$ **D** $\frac{I_o}{9}$

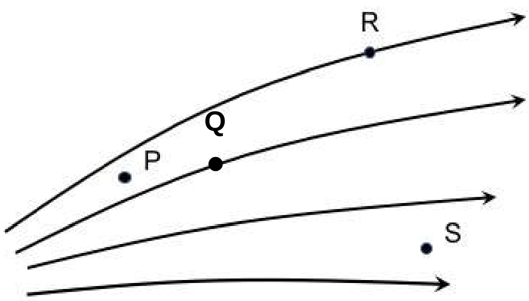
16 A space station orbits at a height of 335 km above the surface of the Earth. It carries two panels separated by a distance of 25 m. The panels reflect light of wavelength 500 nm towards an observer on the Earth's surface.

The observer views the panels with a telescope that has an aperture diameter of 200 mm. Assume that the panels act as point sources of light for the observer.

Which of the following is correct?

	Will the two images seen by the observer be resolved?	Angular separation of two sources as measured from aperture / rad
A	Yes	2.5×10^{-6}
B	Yes	7.5×10^{-5}
C	No	2.5×10^{-6}
D	No	7.5×10^{-5}

17 A region of electric field is represented by the electric field lines shown below. P, Q, R and S are 4 points in the field.



Which of the following statements is **incorrect**?

A The electric force on a charged particle is stronger when it is located at P than that at R.

B A positively charged particle released from rest at Q will travel along the electric field line which passes through Q.

C The electric potential energy of a negatively charged particle at S is higher than that at P.

D The electric field strength at Q is stronger than that at S.

18 A isolated metal sphere of radius 0.1 m is positively charged. A small charge was brought from a distant point to a point 0.5 m from the centre of the metal sphere. The work done against the electric field is *W*. At its final position, the electric force on the charge is *F*.

If the charge has been brought to a point 1.0 m from the centre of the metal sphere, what would have been the values for the work done against the electric field and the electric force on the charge at its final position?

	work done against electric field	force on charge at its final position
A	$\frac{W}{4}$	$\frac{F}{4}$
B	$\frac{W}{4}$	$\frac{F}{2}$
C	$\frac{W}{2}$	$\frac{F}{4}$
D	$\frac{W}{2}$	$\frac{F}{2}$

19 The electrical potential difference between two points in a wire carrying a current is

A the ratio of the power supplied to the current between the points.

B the force required to move a unit positive charge between the points.

C the ratio of the energy dissipated to the current between the points.

D the product of the square of the current and the resistance between two points.

20 An electrical source with internal resistance *r* is used to operate a lamp of resistance *R*.

What fraction of the total power is delivered to the lamp?

A $\frac{R+r}{R}$ **B** $\frac{R-r}{R}$ **C** $\frac{R}{R+r}$ **D** $\frac{R}{r}$

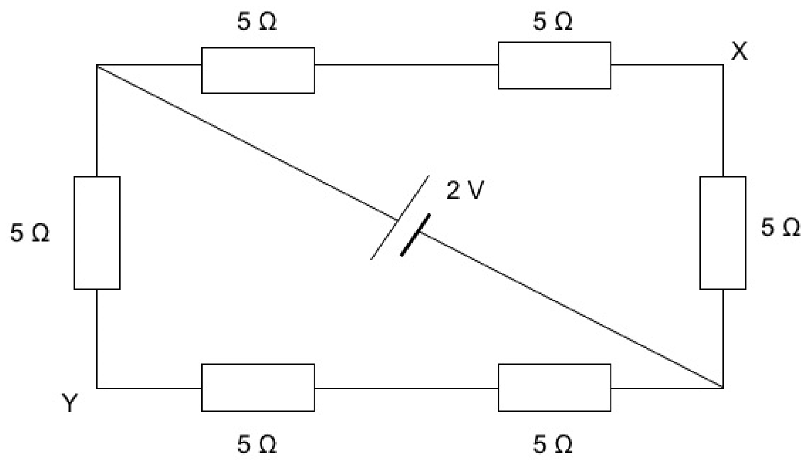
[Turn over

21 A high potential is applied between the electrodes of a hydrogen discharge tube so that the gas is ionised. Electrons then move towards the positive electrode and protons towards the negative electrode. In each second, 7×10^{18} electrons and 2×10^{18} protons pass a cross section of the tube.

The current flowing in the discharge tube is

A 0.32 A **B** 0.80 A **C** 1.12 A **D** 1.44 A

22 Six 5 Ω resistors are connected to a 2 V cell of negligible internal resistance, as shown in the figure below.

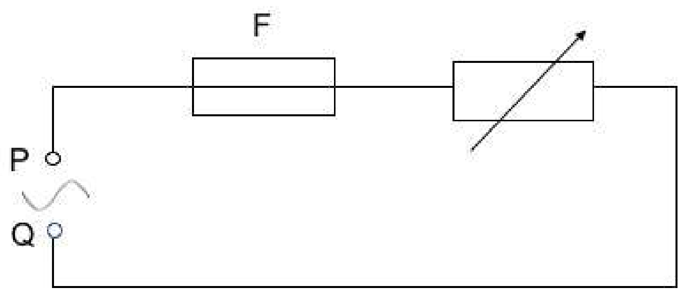


The potential difference between X and Y is

A 0 V **B** $\frac{2}{3}$ V **C** $\frac{8}{9}$ V **D** $\frac{4}{3}$ V

23 When an alternating power supply of 240 V r.m.s. is connected across PQ in the circuit shown below.

The fuse F breaks the circuit if the current in it just exceeds 13 A r.m.s.



When the alternating power supply is replaced with a 120 V d.c. source, an identical fuse breaks the circuit if the current just exceeds

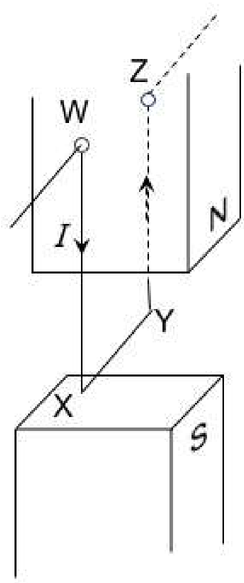
A $\frac{13}{2}$ A **B** $\frac{13}{\sqrt{2}}$ A **C** 13 A **D** 26 A

24 An alternating power supply of root-mean-square voltage 4.0 V is connected across a resistive load such that the average power dissipated across it is P.

What is the d.c. voltage applied across the same load which will give rise to an average power dissipation of $3P$?

A 6.9 V **B** 8.5 V **C** 12 V **D** 17 V

25 A piece of wire WXYZ is pivoted freely about a horizontal axis at points W and Z. Section XY of the wire is situated between the North (N) and South (S) poles of a horse-shoe magnet. WXYZ is connected to an electrical circuit.



What will happen to the wire, if any, when the circuit is just turned on and there is a constant current I in the wire as shown?

A swings to the left

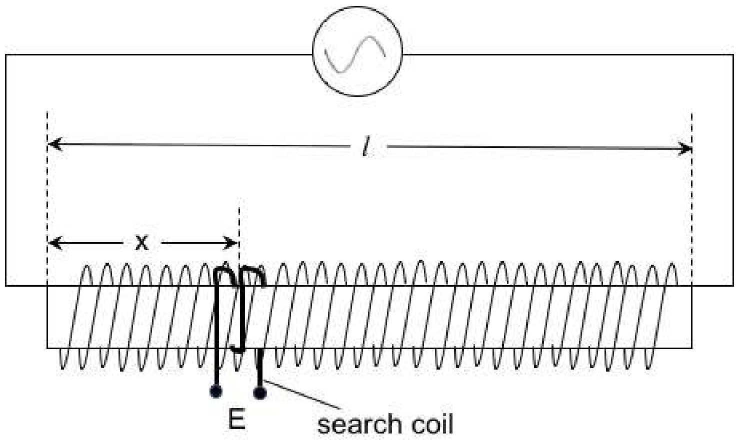
B swings to the right

C swings from X to Y

D remains at rest at its original position

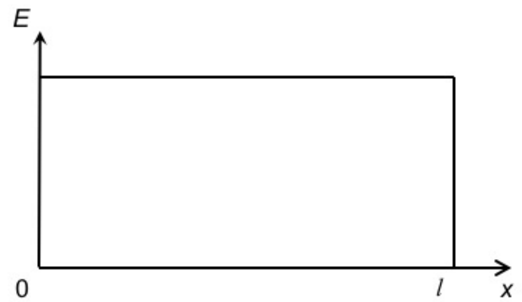
[Turn over

26 In the diagram below, the solenoid of length l which is closely and uniformly wound, carries an alternating current of constant amplitude. A search coil (which is a coil consisting of a few turns of wires) is placed in different positions along the solenoid.

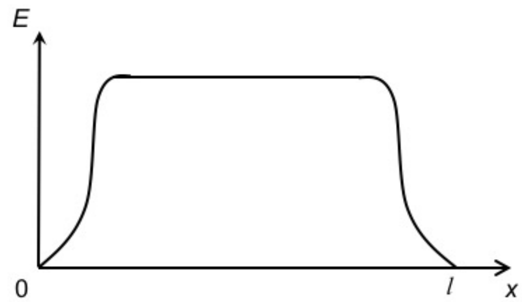


Which one of the following graphs most nearly shows how the amplitude of the e.m.f. E induced in the search coil varies with its position?

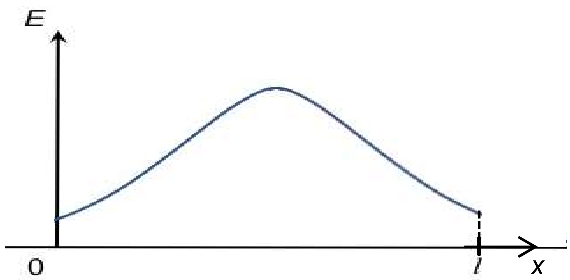
A



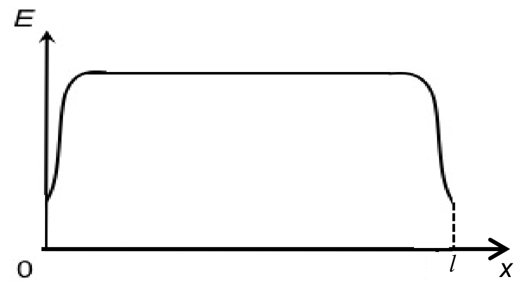
B



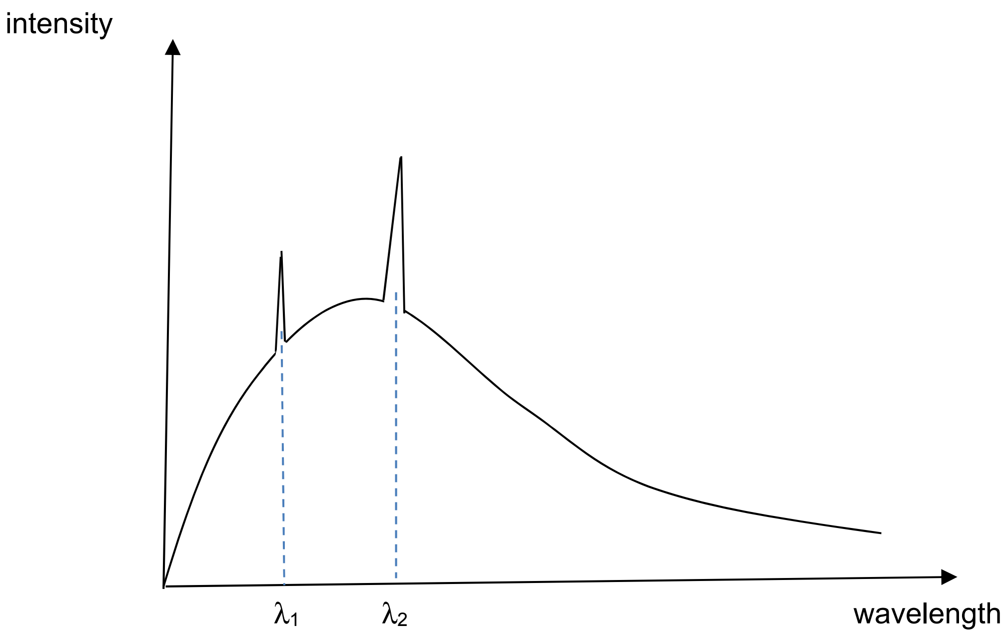
C



D



27 The diagram below shows a typical X-ray spectrum produced by an X-ray tube.

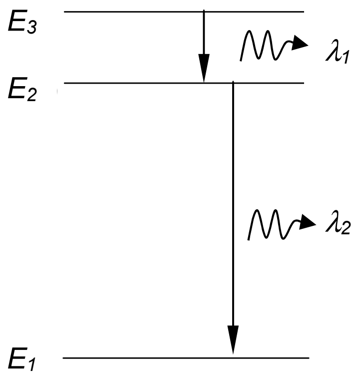


The operating voltage across the X-ray tube is increased. Which of the following gives the corresponding changes, if any, in λ_1 and λ_2?

	λ_1	λ_2
A	no change	no change
B	no change	decrease
C	decrease	no change
D	decrease	decrease

[Turn over

28 The diagram below shows a simplified representation of the three electron energy levels in an atom.



Cool vapour of this element at low pressure is bombarded with electrons accelerated from rest across a potential difference *V*. Two possible transitions which result in the emission of photons of wavelengths $\lambda_1 = 6.22 \times 10^{-7}$ m and $\lambda_2 = 1.78 \times 10^{-7}$ m are observed.

What is the minimum value of *V* for the above transitions to occur?

A 1.56 V **B** 2.80 V **C** 7.00 V **D** 9.00 V

29 A stationary uranium nucleus of mass 238 units disintegrates by the emission of an α-particle of mass 4 units.

The ratio $\dfrac{\text{kinetic energy of the } \alpha\text{-particle}}{\text{kinetic energy of the recoiling daughter nucleus}}$ is

A $\dfrac{4}{234}$ **B** $\dfrac{4}{238}$ **C** $\dfrac{234}{4}$ **D** $\dfrac{238}{4}$

30 The half-life of a certain radioactive material is 3.0 s.

How long does it take for its activity to become 10 % of the original activity?

A 0.46 s **B** 5.4 s **C** 10 s **D** 15 s

Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME

CLASS 2T

PHYSICS 9749/02
Paper 2

2 hours

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST
Write your name and class on all the work you hand in.
Write in dark blue or black pen in the space provided. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The number of marks is given in brackets [ ] at the end of each question or part of the question.

FOR EXAMINER'S USE		DIFFICULTY		
		L1	L2	L3
Q1	/6			
Q2	/10			
Q3	/7			
Q4	/8			
Q5	/5			
Q6	/7			
Q7	/10			
Q8	/8			
Q9	/19			
TOTAL FOR PAPER 2	/ 80			

This document consists of **20** printed pages and **0** blank page.

[Turn over

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_P	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T / K	=	$T / {}^{\circ}C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^{\,2} - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 A hydroelectric power station could make a significant contribution to energy requirements. Fig. 1.1 shows a dam at the hydroelectric power station which traps water behind a dam. When the height of the water behind the dam reaches 10.0 m, the water is released and passed through the turbines.

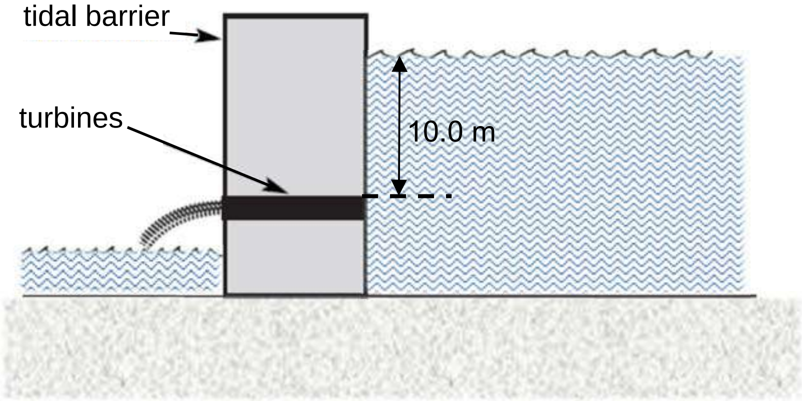


Fig. 1.1

(a) It takes 6.0 hours for a total mass of 1.32×10^{12} kg of water to flow through the turbines. The centre of mass of this amount of water is 5.0 m above the turbines.

Calculate the loss in the potential energy of the trapped water when it is released through the turbines completely. Assume that the density of the water is uniform.

loss in the potential energy = ………………………………..J [2]

(b) The potential energy calculated in part **(a)** is lost and the efficiency of the power station is 40 %.

Calculate the average power output of the power station over this time period of 6.0 hours.

average power output = ……………………………………W [3]

[Turn over

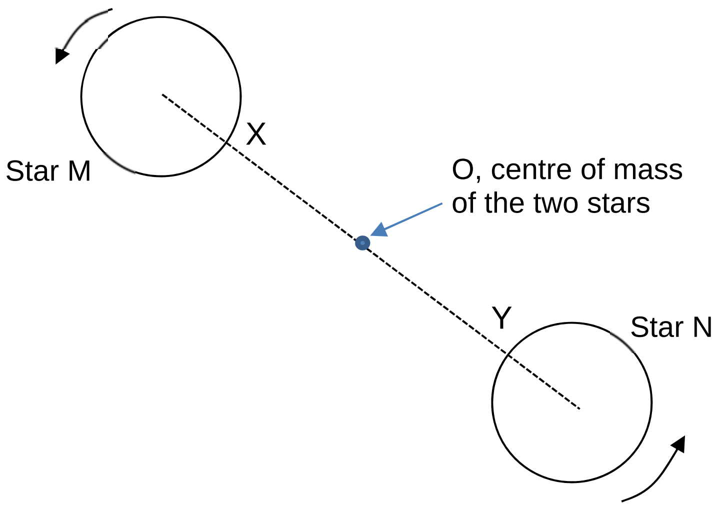
(c) Suggest how the output power of the hydroelectric power station can be controlled as the level of trapped water decreases.

………

………

……… **[1]**

2 In a binary star system, two stars, each of equal mass 3.5 x 10^{30} kg, rotate about their common centre of mass O which is equidistant from the centres of the stars. The separation between the two centres of the stars is 2.0 x 10^{11} m.



(a) Define gravitational potential at a point.

………

………

……… [1]

(b) Calculate the gravitational potential at O, the centre of mass of the binary star system.

gravitational potential = ………………………..…… J kg^{-1} [2]

(c) An asteroid passes through point O, at a speed v.

Determine the minimum speed of the asteroid if it is to escape from the gravitational pull of the binary star system.

minimum speed = ………………….. m s^{-1} [3]

(d) **(i)** On Fig. 2.1, sketch a graph showing the variation of gravitational potential along the line XY between the two stars. [2]

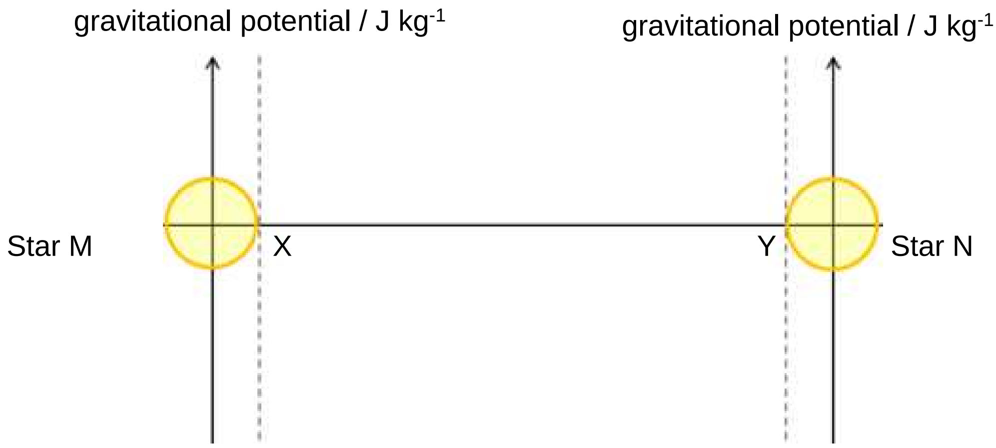


Fig. 2.1

(ii) Hence describe the variation in gravitational potential energy of an object moving from O towards star M.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[Turn over

3 **(a)** Define *specific latent heat*.

....

....

.... [1]

(b) A beaker containing a liquid is placed on a balance, as shown in Fig. 3.1.

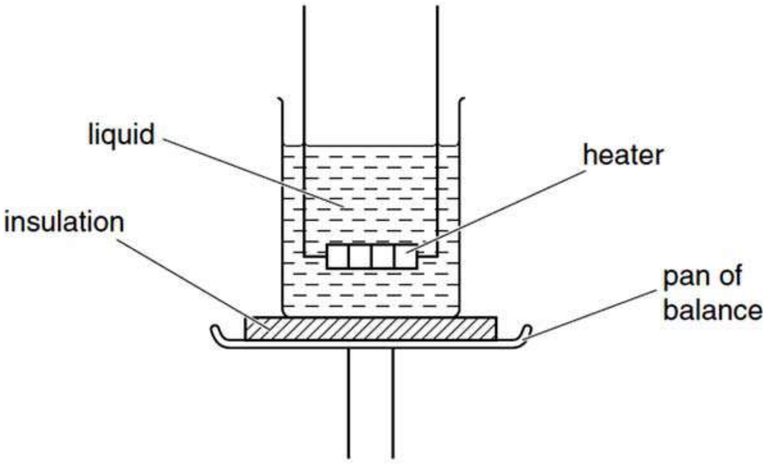


Fig. 3.1

A heater of power 120 W is immersed in the liquid. The heater is switched on and, when the liquid is boiling, balance readings M are taken at corresponding times t.

A graph of the variation with time t of the balance reading M is shown in Fig. 3.2.

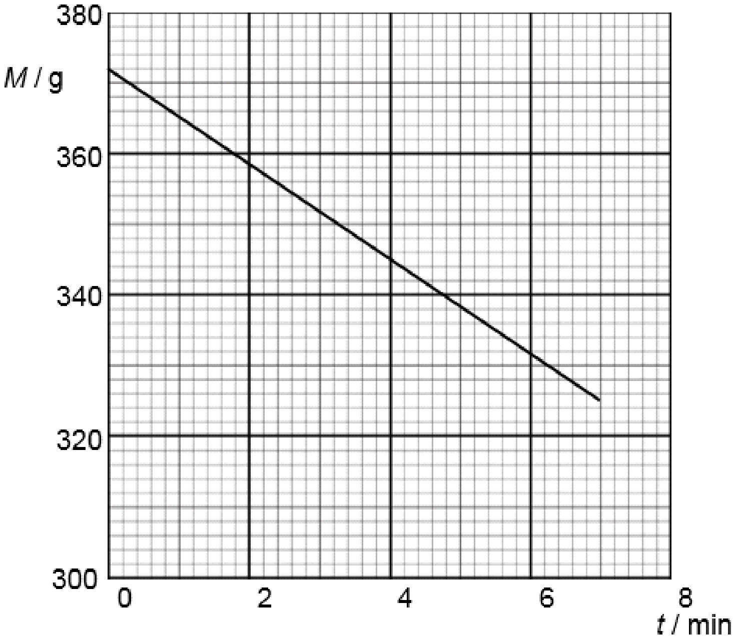


Fig. 3.2

(i) State the feature of Fig. 3.2 which suggests that the liquid is boiling at a steady rate.

....

.... [1]

(ii) Use data from Fig. 3.2 to determine a value for the specific latent heat of vaporisation l_v of the liquid. Explain your working.

l_v = ………………………………… J kg^{-1} [3]

(c) State, with a reason, whether the experimental value determined in **(b)(ii)** is likely to be an overestimate or an underestimate of the expected value for the specific latent heat of vaporisation of the liquid.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

4 **(a)** Describe one condition necessary for observable two-source interference fringes to be formed.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(b) Two microwaves transmitters produce waves of the same frequency are placed at P and Q which are at a distance of 2*d* apart. Points Y and Z are equidistant from O. The line YXZ is perpendicular to OX, as shown in Fig. 4.1.

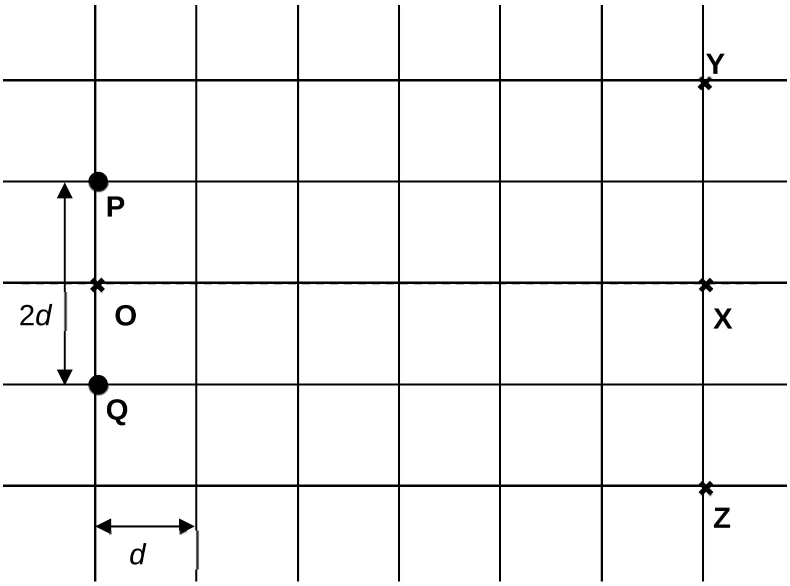


Fig. 4.1

(i) The waveforms of the microwaves from P and Q arriving at point Y vary with time as shown in Fig. 4.2.

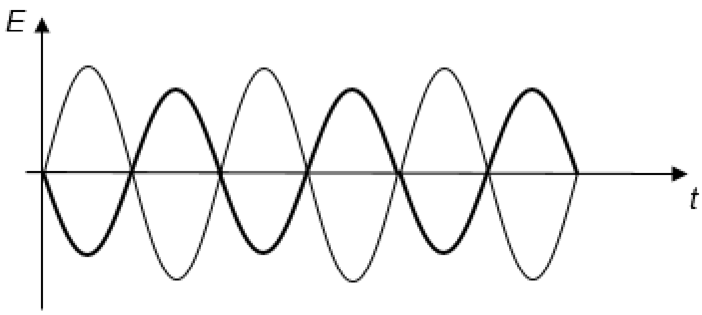


Fig. 4.2

1. State and explain if the waves arriving at Y are coherent.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

2. Explain why a minimum intensity is detected at Y.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Show that the path difference of the waves arriving at point Y from P and Q is 0.625*d*.

[1]

(iii) As a detector is moved along a straight line from X to Y, it encountered three intensity maxima, including the maximum at X.

Determine the frequency of the wave in terms of *d*.

frequency = …………………Hz [3]

5 In a simple experiment to find the wavelength of monochromatic red light emitted by a laser, a fine beam of red laser light is incident on a diffraction grating as shown in Fig. 5.1. The diffraction grating has 300 lines per millimeter and it is arranged such that its plane is normal to the incident light.

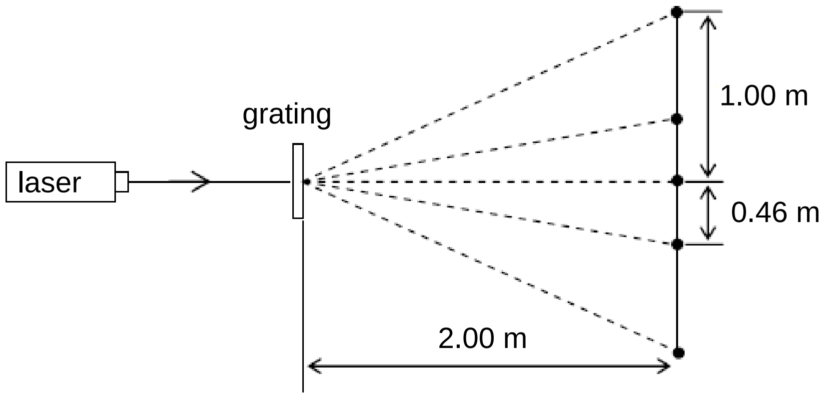


Fig. 5.1

Bright spots are observed at 0.46 m and 1.00 m from the central spot on a screen, which is 2.00 m from the grating.

(a) By considering the bright spot at 0.46 m from the central spot, calculate the wavelength of the laser light.

wavelength = …………………… m [3]

(b) Suggest and explain an experimental advantage of obtaining the wavelength of the laser light by using the second-order diffracted light rather than the first-order diffracted light.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

[Turn over

6 **(a)** Define *magnetic flux density*.

……..

……..

…… [2]

(b) Fig. 6.1 shows a long, straight, vertical wire WX, carrying a current of 9.0 A downwards. A second long, straight wire YZ is placed horizontally, and carries a current of 12.0 A in the direction shown.

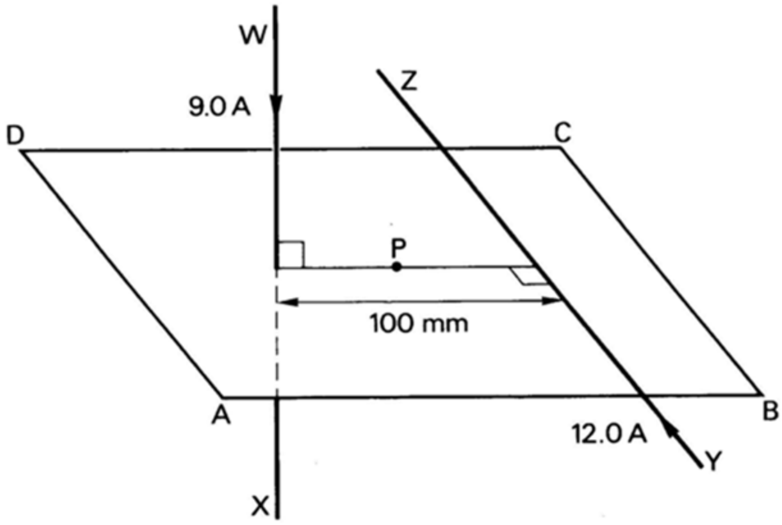


Fig. 6.1

ABCD is a horizontal, rectangular table-top. The wire YZ is parallel to the side BC of this table, and the wire WX passes through a small hole in the table. The perpendicular distance between the wires is 100 mm. P is the point 50 mm from YZ along the perpendicular between the wires.

(i) Determine the magnitude of the magnetic flux density at the point P due to WX only.

magnetic flux density = ………………………..…. T [2]

(ii) Determine the magnitude of the net magnetic flux density at the point P.

net magnetic flux density at P = ………………. T [3]

7 A spring is attached to the middle of a horizontal wooden rod AB. A U-shaped metal wire ASTB is attached to the rod AB. The U-shaped wire is placed with side ST in a region of uniform magnetic flux pointing out of the page, as shown in Fig. 7.1.

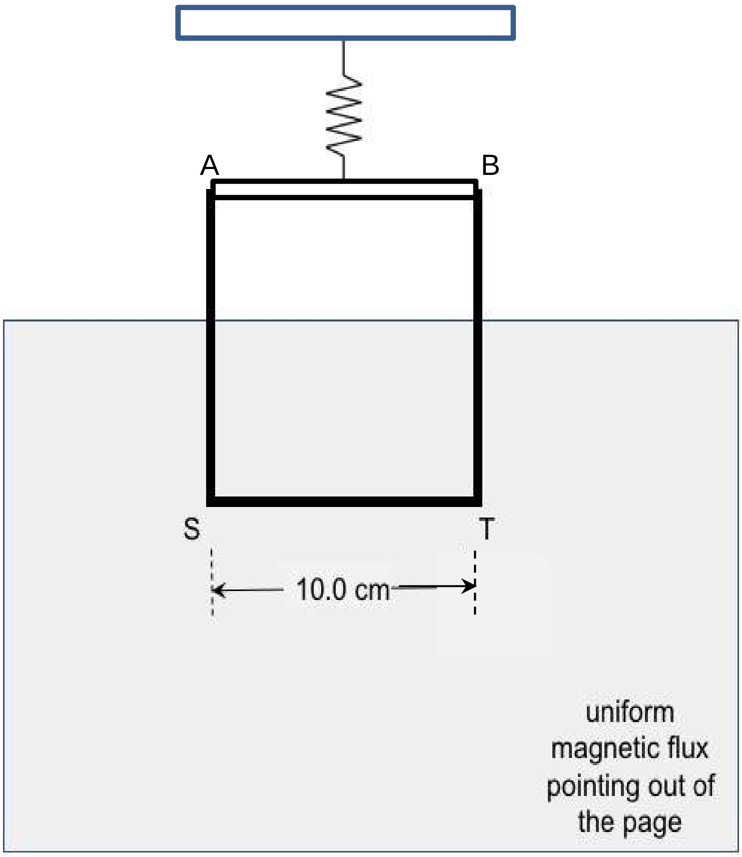


Fig. 7.1

The frame is then pulled down a distance of 1.0 cm and then released. The wire ST undergoes simple harmonic motion in the vertical direction.

(a) (i) Using Faraday's law of electromagnetic induction, explain why there is an induced e.m.f. in the wire ST while it is in motion.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [3]

(ii) Explain why the induced e.m.f. varies sinusoidally with time.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Turn over

(b) The wooden rod AB is replaced by a metal rod. The frame is then set to oscillate as in **(a).**

(i) Sketch the time variation of the induced e.m.f. observed on Fig. 7.2. Explain your answer.

Fig. 7.2

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

(ii) Explain, how your graph in Fig. 7.2 will change, if any, when the metal rod AB and the wire ASTB are both fully inside the magnetic field.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

8 **(a)** **(i)** State what is meant by the *photoelectric effect.*

……

……

…… [1]

(ii) Describe the principal features that are observed in the photoelectric effect that support the particulate nature of electromagnetic radiation.

……

……

……

……

……

……

…… [3]

(b) A low pressure sodium lamp produces an intensity of 0.20 W m^{-2} of yellow light of frequency 4.55 x 10^{14} Hz at a distance of 5.0 m from the lamp.

(i) Assuming that the lamp acts a point source, show that the intensity a distance 20 m from the lamp is 0.013 W m^{-2}.

[1]

(ii) Estimate the number of photons per second that would strike a piece of A4 size paper which is held 20 m perpendicular to the ray of light from the lamp.

number of photons per second = …………………… s^{-1} [3]

[Turn over

9 The bow is a powerful two-arm string machine used for archery. Fig. 9.1 shows the three types of bows, namely the Longbow, the Recurved and the Compound bow.

Longbow Recurved bow Compound bow

Fig. 9.1

Each bow consists of a limb and a handle as shown in Fig.9.2. The distance between the string and the bow handle at rest is known as the bracing distance. When a bow is drawn by the fingers of the archer, the string is not stretched but the shape of the bow is changed and bent and the string is displaced by a drawing distance. The shaft of the arrow is rested on the handle and the tail of the arrow is rested on the middle of the string.

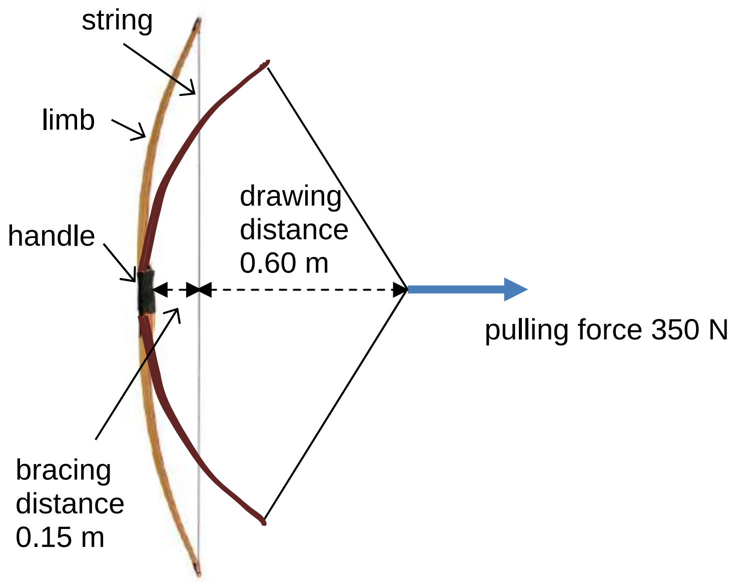


Fig. 9.2

In a Longbow, if we suppose that the bow is initially unstressed and the string is almost slack, then the archer starts to draw his arrow with a pulling force which is nearly zero and the pulling force increases with the drawing distance. The energy stored in the bow is equal to the work done in drawing back the string. In practice, a typical archer can draw an arrow back about 0.60 m and with a maximum force of about 350 N as shown in Fig. 9.3.

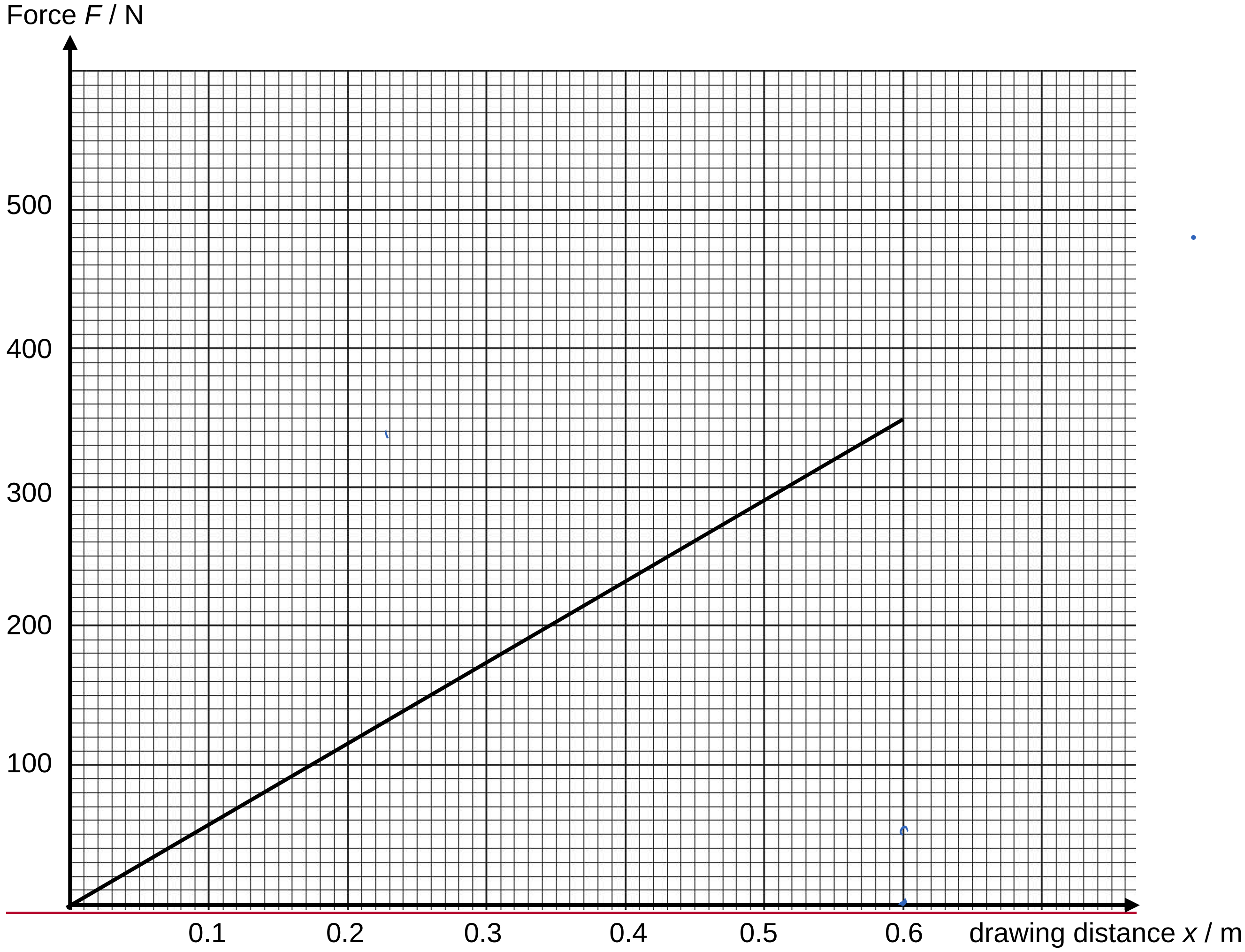


Fig. 9.3

The efficiency of the bow, η, can be defined as

$$\eta = \frac{\text{kinetic energy of the arrow}}{\text{elastic potential energy stored in the bow}}$$

When an arrow is shot, the force due to the tension in the string accelerates the arrow. A larger part of the energy stored in the bow is transferred to the arrow. Since this transferred energy is converted into the kinetic energy of the arrow ½ $m\,v^2$ (where v is the speed of the arrow as it leaves the bow), the increase in the length and therefore the mass of the arrow has two opposing effects: an increase in efficiency but a decrease in speed.

When a bow string is released, the string exerts a forward force on the arrow and causes it to accelerate forward. At the same time, there is a sudden compressive force along the length of the arrow, causing it to buckle. Hence the arrow will undergo **lateral vibrations** as it accelerates forward. Fig. 9.4 shows the top view of the arrow leaving bow (not to scale).

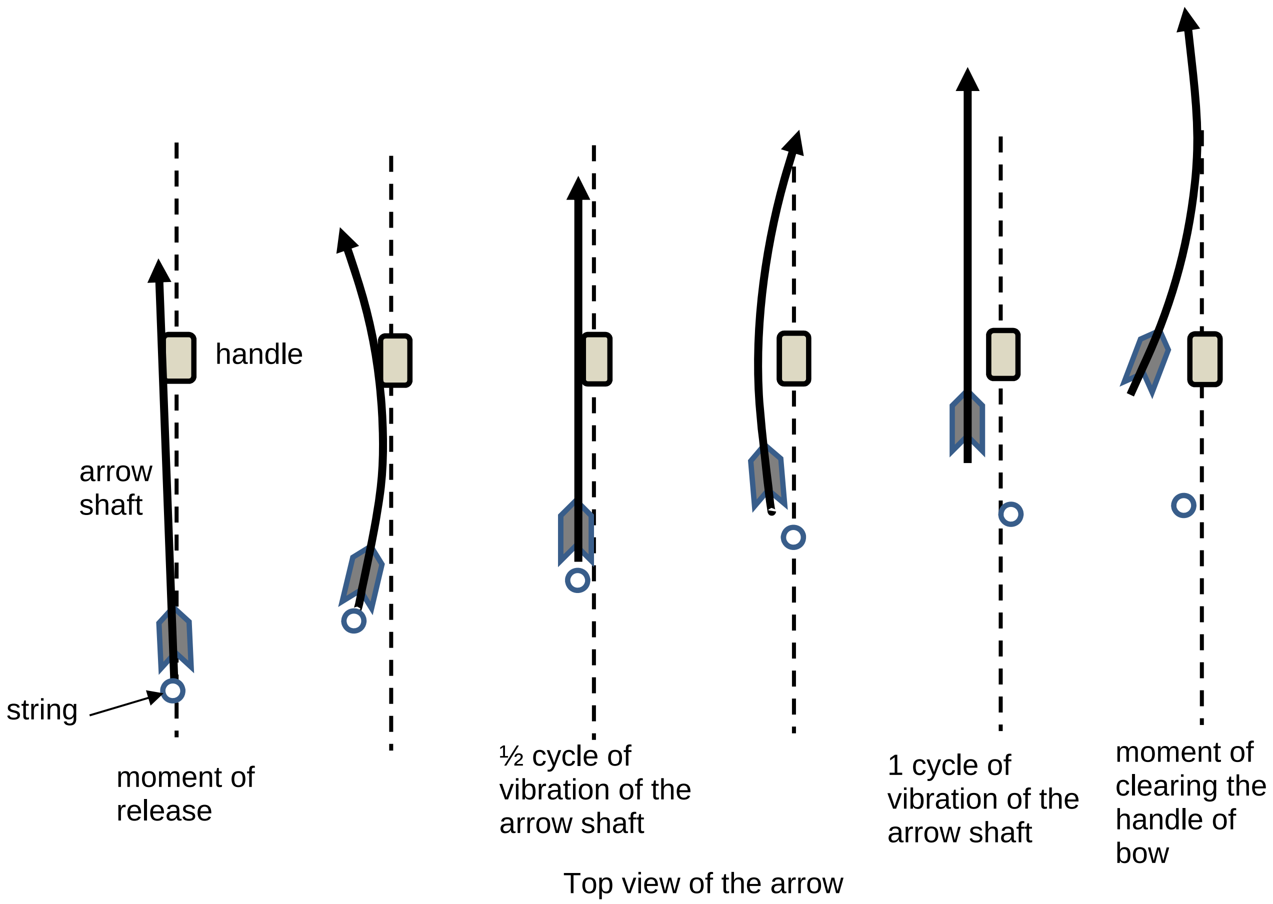


Fig. 9.4

Both the frequency and the amplitude of these vibrations must be matched to the bow if the arrow is to avoid hitting the side of the handle during its discharge. Ideally the arrow will make 1¼ vibrations from the moment of release until it finally clears the handle of the bow.

A Recurved bow is one in which the end of each limb curve away from the archer such that the limbs are braced with a bracing distance. The archer must start his pull with a non-zero force which is about 1/3 of the maximum force. When using a Recurved bow, the average force will be higher as compared to a Longbow without bracing.

In a Compound bow, which utilizes levers, the drawing force increases and decreases with the drawing distance as shown in Fig. 9.5.

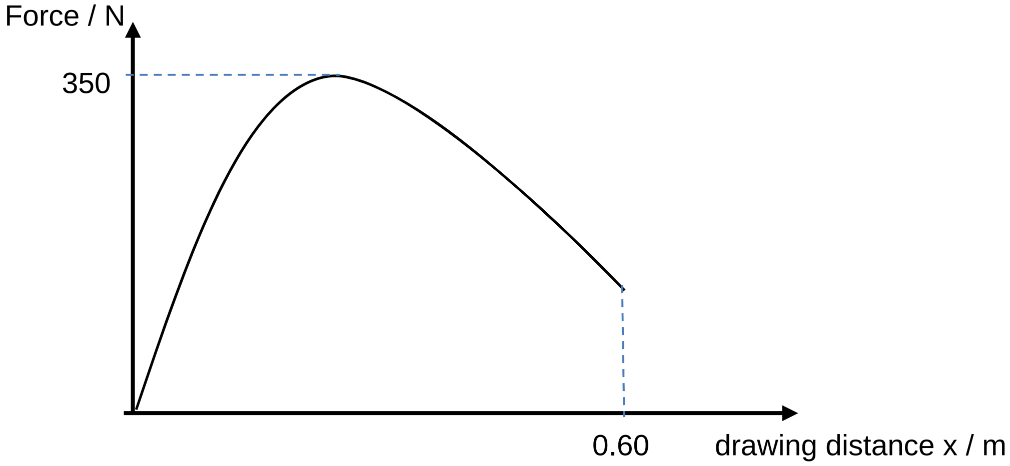


Fig. 9.5

(a) Explain what is meant by *lateral vibrations*.

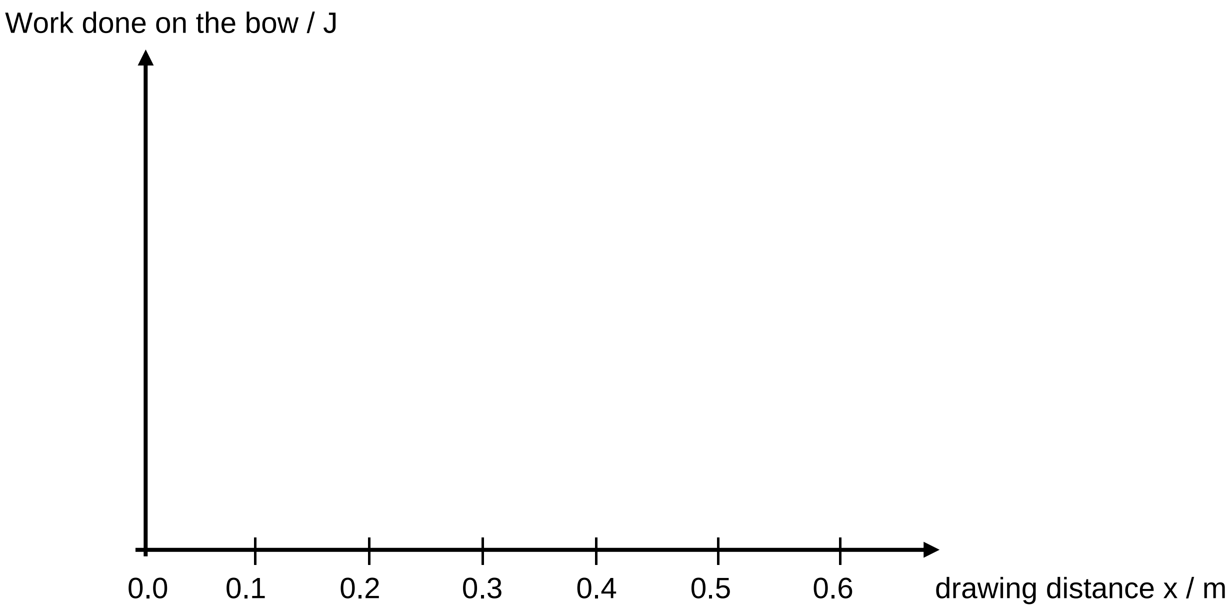
………..

……….. [1]

(b) Use the graph in Fig. 9.3 to calculate the energy stored in the Longbow when the maximum pulling force of 350 N is exerted on the string.

energy stored = ……………………………….J [2]

(c) On Fig. 9.6, sketch a graph to show how the work done on the Longbow changes with the drawing distance of the string. Label the work done axis clearly.



[2]

Fig. 9.6

(d) It is thought that the efficiency η of the bow obeys a relation of the form

$$\eta = \frac{m}{m + k}$$

where m is the mass of the arrow and
k is a constant depending on the mass of the bow.

A student performed an experiment to investigate how η, the efficiency of the bow varies with m, the mass of the arrow. He obtained data which allows him to plot the graph of Fig. 9.7.

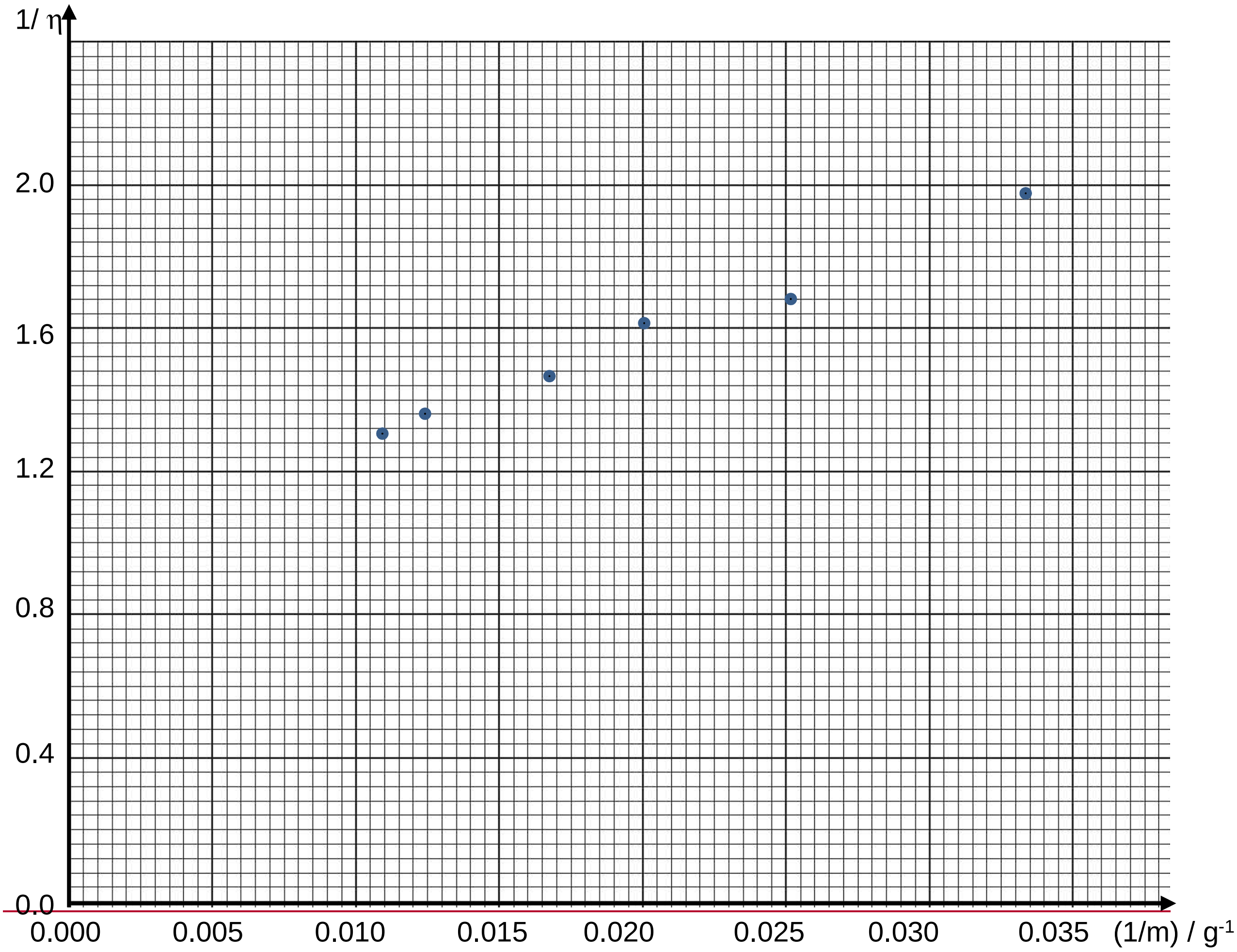


Fig. 9.7

(i) Draw the line of best fit for the points. [1]

(ii) Explain whether the relation in **(d)** is valid using the line drawn in Fig. 9.7.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

(iii) Use the line drawn in Fig. 9.7 to determine the magnitude of the constant k in the expression in **(d)**.

k = ………………………………….. [2]

(iv) An arrow of mass 70 g is being shot from an initially unstressed Longbow drawn back as shown in Fig. 9.2. Use the graph in Fig. 9.7 and the definition of the efficiency to determine the speed of the arrow leaving the bow.

speed of the arrow = ………………………..m s^{-1} [3]

(e) Calculate the frequency of vibration for an arrow leaving the string at 50 m s^{-1}, from a bow of bracing distance of 0.15 m, and shot by an archer with a drawing distance 0.60 m, as shown in Fig. 9.2.

frequency of vibration = ………………………….. s^{-1} [2]

(f) **(i)** On Fig. 9.3, sketch the force-drawing distance graph for a Recurved bow which is already braced by 150 N. The maximum drawing force of 350 N is exerted on the string at the maximum drawing distance of 0.60 m. [1]

[Turn over

(ii) State and explain, in terms of the energy stored, why the Recurved bow is better than a Longbow.

……

…… [1]

(g) Refer to the force-drawing distance graph of a Compound bow as shown in Fig. 9.5. Suggest an advantage of a Compound bow as compared to the Longbow.

. ……………………………………………………………………………………………………

……………………………………………………………………………………………………… [1]

- END OF PAPER -

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Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME

CLASS 2T

PHYSICS 9749/03
Paper 3

2 hours

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name and class on the first page of **both** of Section A and Section B.
Write in dark blue or black pen in the space provided. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in **Section A**, and **ONE** out of **two** questions in **Section B.**
Circle the **question number attempted in Section B** in the summary table below.

FOR EXAMINER'S USE		DIFFICULTY		
		L1	L2	L3
Q1	/13			
Q2	/8			
Q3	/7			
Q4	/9			
Q5	/10			
Q6	/13			
Q7	/ 20			
Q8	/ 20			
TOTAL PAPER 3	/ 80			
TOTAL PAPER 1	/ 30			
TOTAL PAPER 2	/ 80			
TOTAL	/190			

This document consists of **20** printed pages and **zero** blank page.

[Turn over

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on / by a gas	W	=	$p\Delta V$
hydrostatic pressure	P	=	ρgh
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	$T/{}^\circ C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + ...$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + ...$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in the spaces provided

1 A construction worker on the roof of a hemispherical dome releases a wrench at the highest point A with negligible speed as shown in Fig 1.1. The radius *R* of the dome is 30.0 m. The surface of the dome's roof is smooth. At a certain point B, the wrench just loses contact with the surface of the dome and falls with a projectile motion through the air, and finally hits the ground at point C.

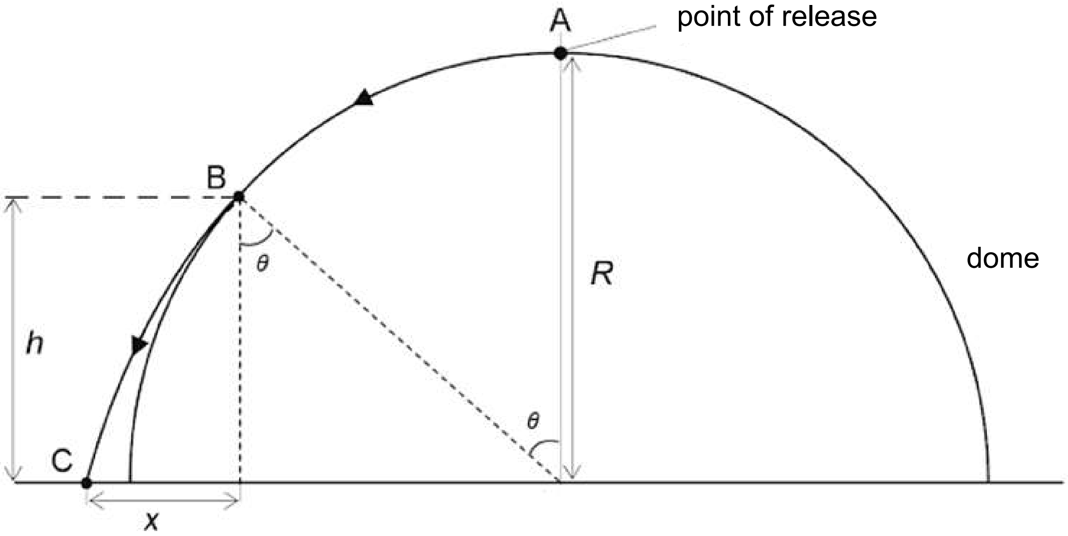


Fig 1.1

(a) **(i)** Explain why the centripetal acceleration of the wrench increases as it slides from A to B.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) State the magnitude of the normal contact force on the wrench at point B.

normal contact force = …………………..N [1]

[Turn over

(b) By considering the forces contributing to the centripetal force on the wrench at point B, show that the vertical distance between B and C, h is

$$h = \frac{v^2}{g}$$

where v is the linear velocity of the wrench at point B and
g is the acceleration due to gravity.

[3]

(c) (i) At the point of losing contact with the surface of the dome, h is related to R by $h = \frac{2R}{3}$.

Use this relation and the relation in **(b)** to calculate for the wrench at the point of losing,

1. its speed and
2. its direction of motion with respect to the horizontal.

speed = ………………………….. m s^{-1}

direction from the horizontal = ……………………………………….° [2]

(ii) Using the equations of motion, determine the time taken for the wrench to fall from point B to C. Air resistance is assumed to be negligible.

time taken = …………………... s [3]

(iii) Hence determine x, the horizontal distance between points B and C.

horizontal distance, x = ………………………. m [2]

2 In a diesel engine, a fixed amount of gas undergoes a cycle of four stages. The cycle is shown in Fig. 2.1.

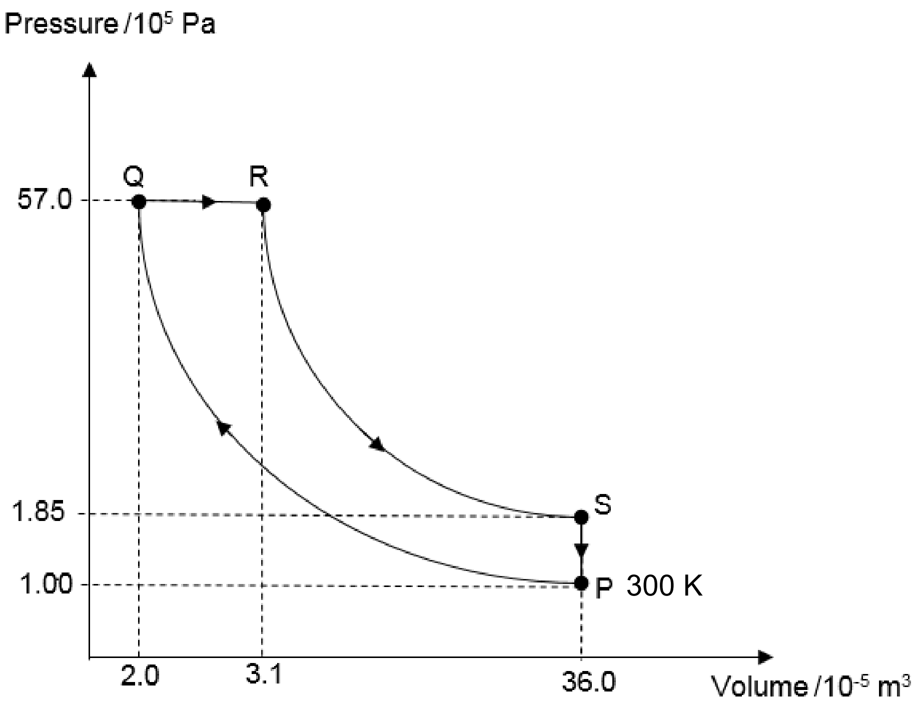


Fig. 2.1 (not to scale)

The four stages are

P → Q : compression with a rise in temperature and pressure,
Q → R : expansion at constant pressure while fuel is being burnt,
R → S : expansion with a drop in both temperature and pressure,
S → P : decrease in pressure at constant volume.

Some numerical values of temperature, pressure and volume are given on Fig. 2.1.

(a) Using Fig. 2.1, calculate the work done by the gas during the stages

(i) Q → R,

work done = ……………….J [1]

(ii) S → P.

work done = ……………….J [1]

(b) Using your answers in **(a)**, complete Fig. 2.2 for the four stages of the cycle.

Stage of cycle	heat supplied to gas /J	work done on gas /J	increase in internal energy of the system /J
P → Q	0	235	
Q → R	246		
R → S	0	–333	
S → P			

Fig. 2.2

[4]

(c) Assuming that the gas is ideal, calculate the temperature of the gas at point Q.

temperature = ………………… K [2]

3 The variation with displacement of the acceleration of an animal's eardrum is shown in Fig. 3.1.

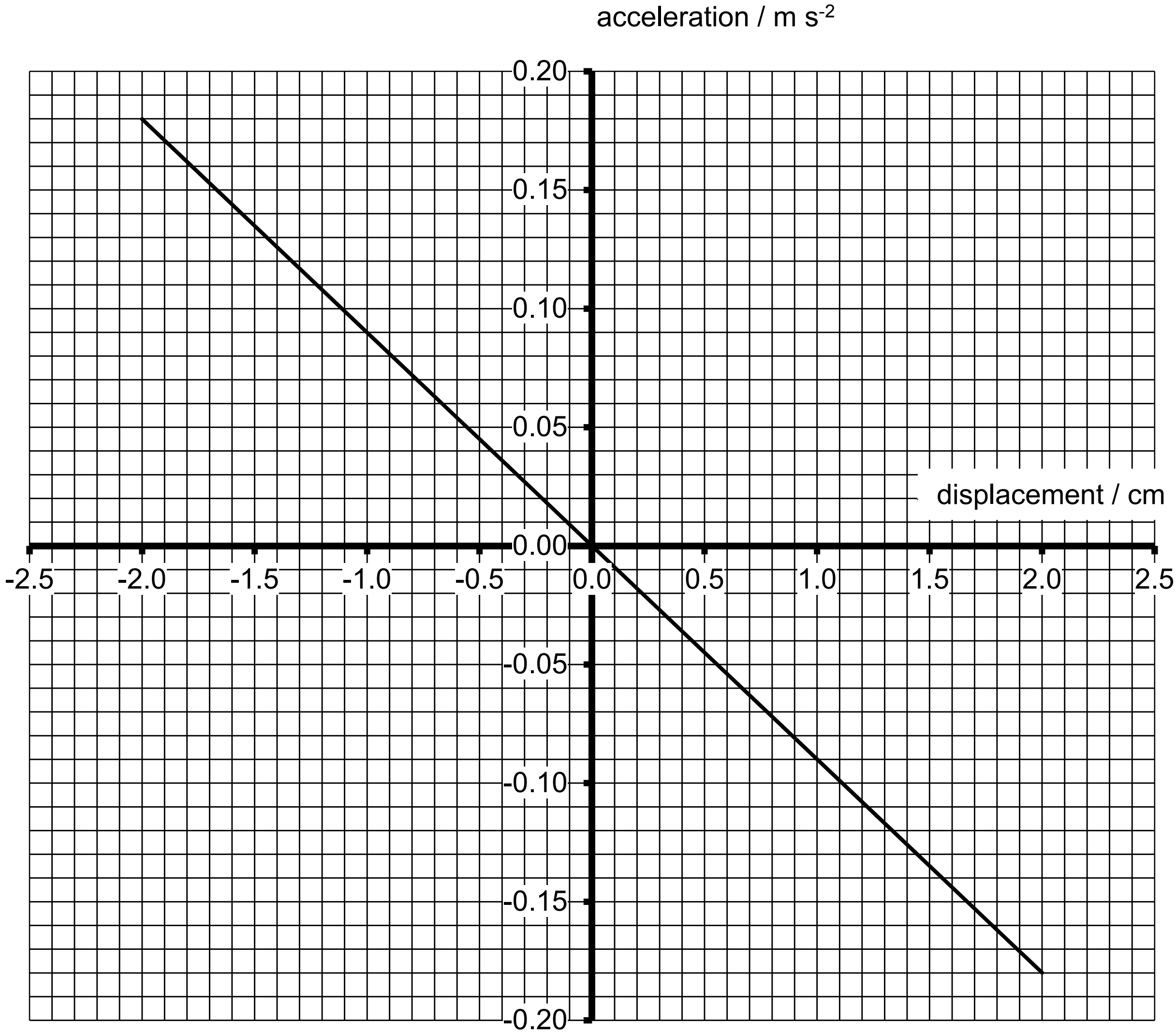


Fig. 3.1

(a) Explain how Fig. 3.1 shows that the motion of the eardrum is simple harmonic.

....

....

....

.... [2]

(b) The period of the oscillation is 2.10 s.

Calculate the time taken for the eardrum to travel a distance of 0.50 cm starting from its maximum displacement towards the equilibrium point.

time taken = ………………….. s [3]

(c) The mass of the eardrum is 100 g.

Show that the potential energy of the eardrum is 2.5×10^{-5} J when its displacement is 0.75 cm. [2]

4 A length of wire is held taut between two points M and P as shown in Fig. 4.1. A signal generator which produces an alternating current of variable frequency is passed through the wire and a pair of magnets is placed on either side of the wire.

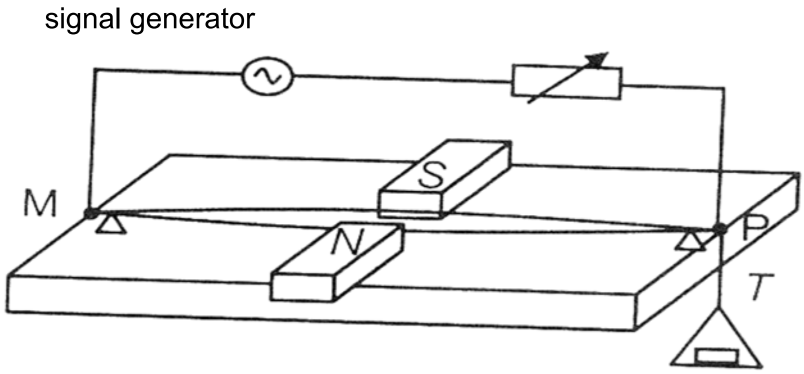


Fig. 4.1

The frequency of the alternating current is gradually increased from zero. A stationary wave is set up as shown in Fig. 4.1 when the frequency is 10 Hz.

(a) Explain how the stationary wave is formed on the wire when an alternating current is passed through it.

……

……

……

……

………………………………………………………………………………………………………..

………………………………………………………………………………………………………..

……………………………………………………………………………………………………….. [4]

(b) The distance between M and P is 0.60 m.

Calculate the wavelength of the stationary wave formed.

wavelength = …………………………..m [1]

(c) Determine the speed of the wave.

speed = ………………………. m s^{-1} [2]

(d) Sketch the stationary wave formed in the space below when the frequency of the alternating current is adjusted to 30 Hz.

[2]

[Turn over

5 **(a)** A particle of mass *m*, carrying a negative charge - q and travelling at speed *v*, enters a region of uniform magnetic field of flux density *B* directed at right angles to the motion of the particle as shown in Fig. 5.1.

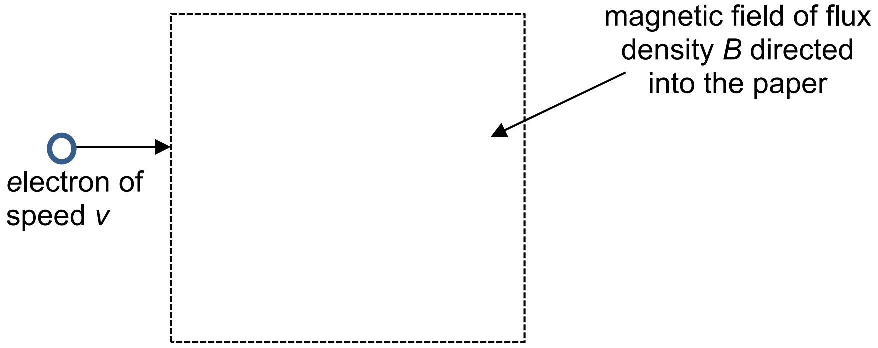


Fig. 5.1

(i) State the expression for the magnitude of the force *F* acting on the particle and the direction of the force.

F = ...

direction =..................................... [2]

(ii) Explain why the path of the electron is circular.

....

....

....

.... [3]

(b) The diagram in Fig. 5.2 shows a type of cathode ray tube containing a small quantity of gas. Electrons from a hot cathode emerge from a small hole in the conical shaped anode, and the path subsequently followed is made visible by the gas in the tube.

The accelerating voltage is 5.0 kV.

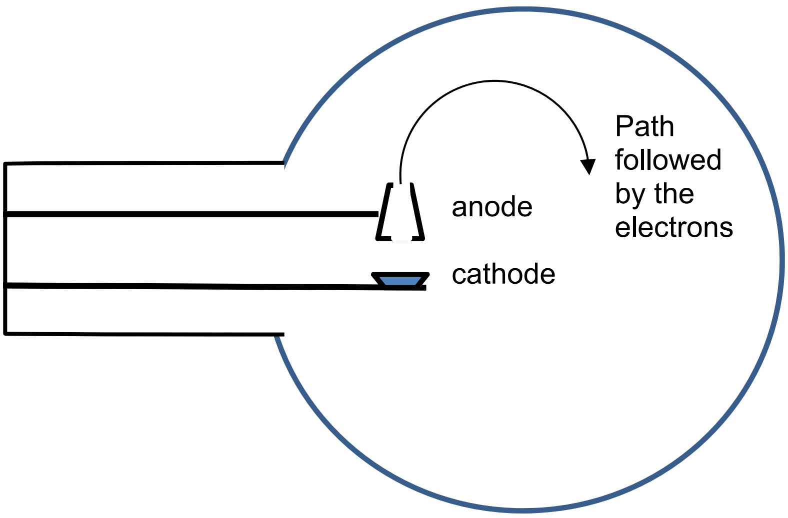


Fig. 5.2

(i) Calculate the speed of the electrons as they emerge from the anode.

speed = …………………..m s^{-1} [2]

(ii) The apparatus is situated in a uniform magnetic field acting into the plane of the paper.

1. Calculate the radius of the circular path for a flux density of 2.0×10^{-3} T.

radius = …………………… m [2]

2. Suggest how the gas in the tube might make the path of the electrons visible.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

6 **(a)** In 1919, Rutherford performed the first nuclear reaction induced in a laboratory in which a stationary nitrogen nucleus $^{14}_{7}N$ bombarded with an α-particle of a certain energy, transmutes to an oxygen nucleus $^{17}_{8}O$ and a proton.

Data:
mass of $^{14}_{7}N$ = 13.9993 u;
mass of $^{17}_{8}O$ = 16.9947 u;
mass of a proton = 1.0073 u;
mass of an α-particle = 4.0015 u.

(i) Write an equation for this nuclear reaction, showing the mass numbers and the atomic numbers of the particles involved.

[2]

(ii) Calculate the minimum kinetic energy of the alpha particle for the reaction to make this reaction occur.

kinetic energy = ...J [3]

(b) A radioactive isotope of thallium $^{207}_{81}Tl$ emits a *β*-particle and is thought to emit a gamma photon. The half-life of $^{207}_{81}Tl$ is 135 days.

(i) The radiation is allowed to pass though perpendicularly a vertical uniform magnetic field and the photographs of traces is obtained in a cloud chamber under certain conditions. Fig 6.1 show tracks produced by the beta-particles and gamma ray photons.

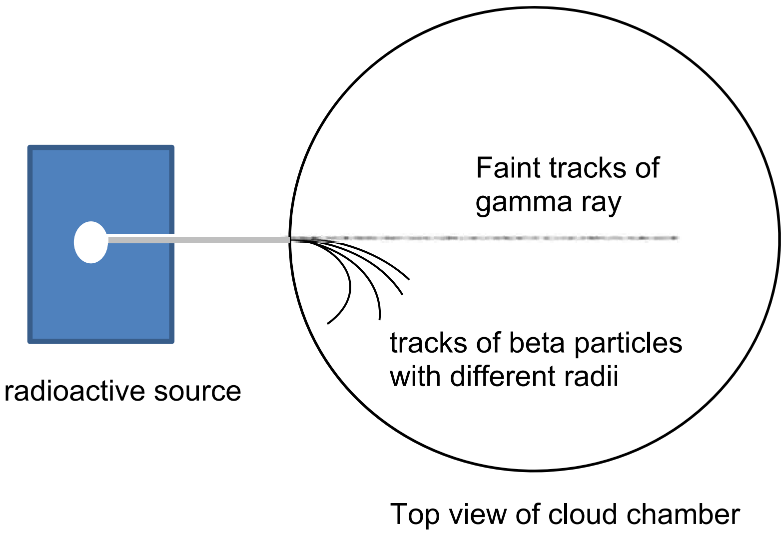


Fig. 6.1

Explain the features of the tracks.

....

....

....

....

....

.... [3]

(ii) An isotope of thallium $^{207}_{81}Tl$ emits a β-particle with an average energy of 2.4 x 10^{-13} J.

Calculate

1. the total energy available from 1 g of thallium-207,

total energy = ………………..J [2]

2. the initial rate at which the β-particles are emitted from 1 g of the freshly prepared isotope,

initial rate of emission = …..………………..day^{-1} [2]

3. the initial power available from the beta particles emitted at the rate calculated in **b(ii)2**.

initial power = ………………. W [1]

[Turn over

Section B

Answer **One** question from this section

7 A uniform wooden rod of weight 50 N and length 1.0 m is gently lowered into water. The upper end of the rod is attached to a light string. When the rod is in equilibrium, the string is vertical and exactly half of the rod is underwater as shown in Fig. 7.1. The rod makes an angle θ with the surface of the water.

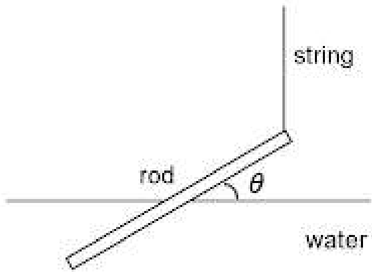


Fig. 7.1

(a) (i) Explain why the string is vertical.

....

.... [1]

(ii) On Fig. 7.1, draw the three forces tension *T*, upthrust *U* and the weight *W* acting on the rod. [2]

(iii) By considering moments about the centre of gravity of the rod, show that $T = 0.5\ U$.

[2]

(iv) Calculate the magnitude of *T*.

T = ………………..N [2]

(v) By balancing the forces, determine the density of the wooden rod. The density of water is 1.0×10^3 kg m^{-3}.

density of rod = ...kg m^{-3} [4]

(b) **(i)** State the principle of the conservation of momentum.

....

.... [1]

(ii) Object **A** of mass 1.2 kg collides head-on and elastically with object **B** of mass 0.60 kg moving with a speed 0.20 m s^{-1} towards it as shown in Fig. 7.2.

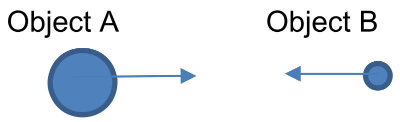


Fig. 7.2

After the collision, object **B** moves off with a speed of 0.10 m s^{-1} opposite to its initial motion.

Calculate the initial speed of object **A**.

initial speed of **A** = ... m s^{-1} [3]

[Turn over

(c) An 80 kg astronaut is at a distance of 30 m away from a space shuttle. He wishes to return to the space shuttle by means of a thruster. The thruster is attached to the body of the astronaut and it emits a stream of gas when it is turned on.

(i) State and explain the direction in which the gas has to be ejected for him to return to the space shuttle.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(ii) The gas is ejected at a constant rate of 0.5 kg s^{-1} and at a speed of 20 m s^{-1} relative to the astronaut for a period of 1.0 s.

Calculate the speed of the astronaut at the end of 1.0 s.

speed = ……………..m s^{-1} [2]

8 **(a)** A cell of e.m.f. *E* and internal resistance *r* is connected in series to a resistor of resistance *R.*

(i) Define *electromotive force*.

.... [1]

(ii) Show, by considering energy conversion, that *V* the terminal potential difference of the cell is

$$V = E - Ir$$

where I is the current flowing in the cell.

[2]

(b) Fig. 8.1 shows a battery with e.m.f. *E* and an internal resistance *r* connected to a uniform nichrome resistance wire MN. J is a movable jockey which can slide along wire MN. The voltmeter and the ammeter are taken to be ideal.

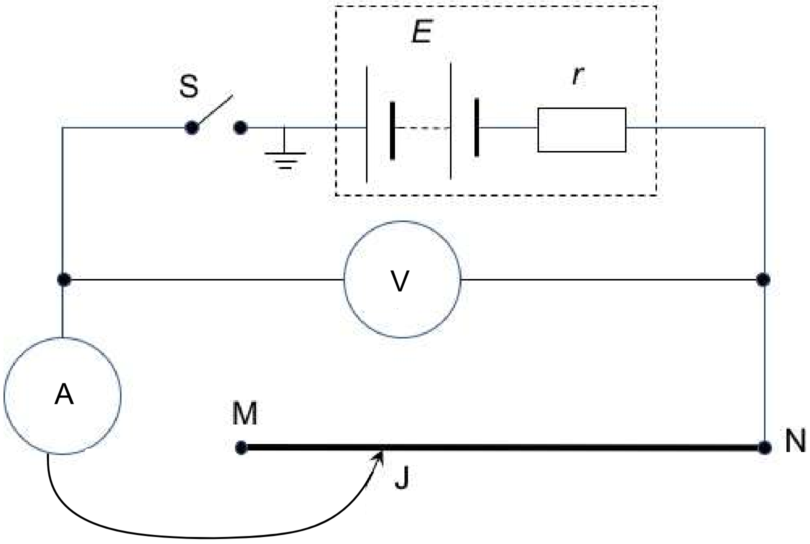


Fig. 8.1

The voltmeter readings *V* and ammeter readings I obtained for different lengths of JN are used to plot the graph in Fig. 8.2.

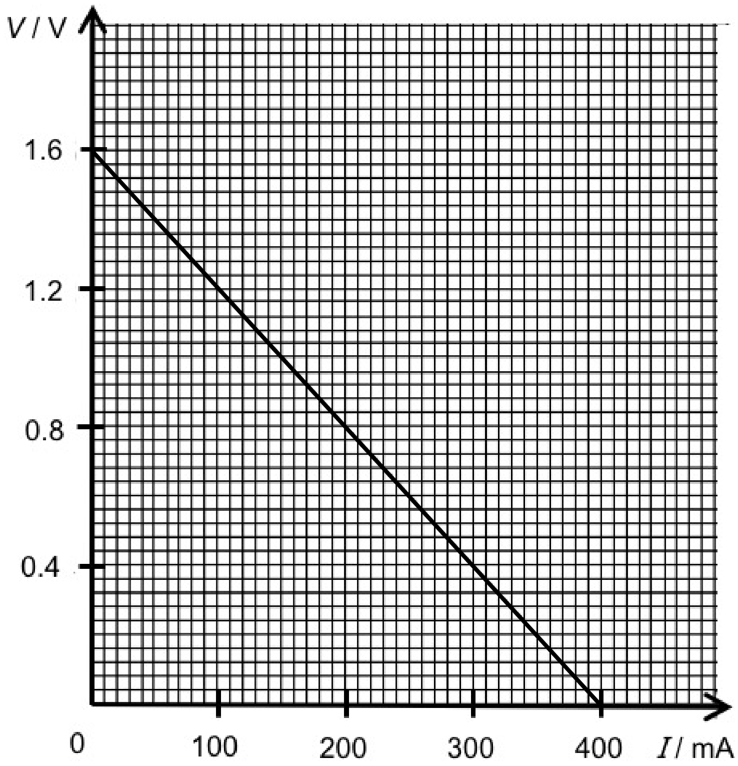


Fig. 8.2

(i) Deduce from Fig. 8.2 the e.m.f. *E* and the internal resistance *r* of the cell.

E = ……………….. V

r = ……………….. Ω [3]

(ii) J is placed at the position such that **maximum power** is delivered from the cell to the wire JN.

Determine the potential at J and N.

potential at J = ………….V

potential at N = …………V [3]

(iii) On Fig. 8.3 sketch the graph to show how electric potential varies with position along the wire JN. Label the vertical axis clearly. Explain your answer.

Fig. 8.3

....

....

....

.... [3]

(iv) Suggest, with a reason, why the position of the jockey J has to be shifted, when the battery has been used for a prolong period of time for maximum power transfer.

....

....

.... [1]

(c) **(i)** Explain what is meant by an *electric field*.

....

.... [1]

(ii) Draw the charge distribution and the electric field around the charged metal bodies for the following bodies

1. an isolated positively charged sphere A.

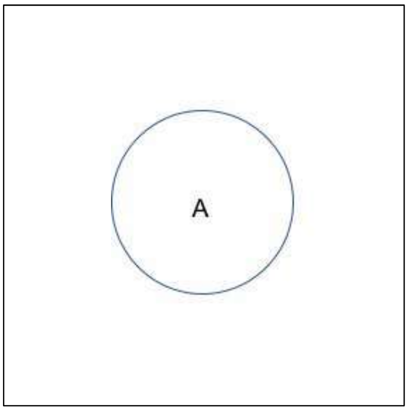


Fig. 8.1 [2]

2. When a neutral metal sphere B is brought close to the positively charged metal sphere A in **(c)(ii)1.**

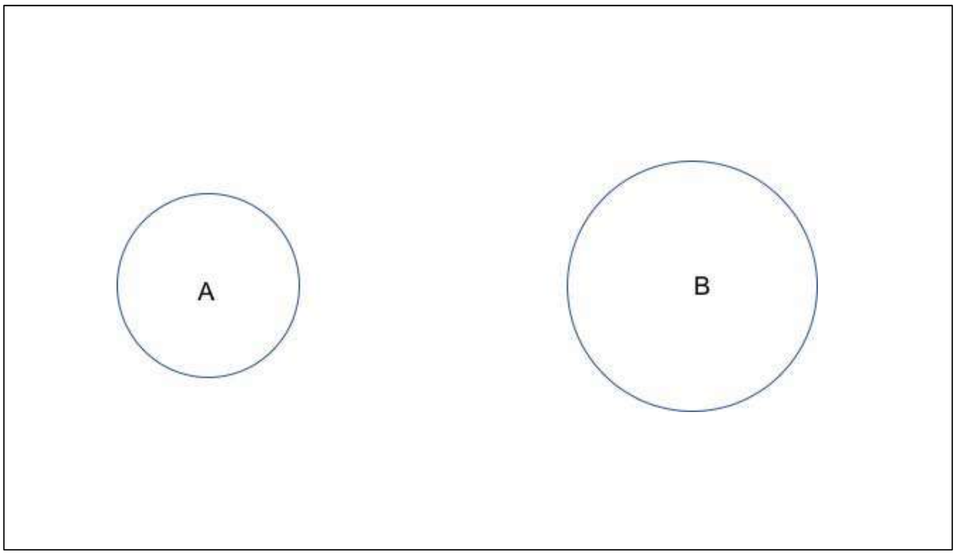


Fig. 8.2 [4]

- END OF PAPER -

Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME	
CLASS	2T

PHYSICS 9749/04

Practical Examination

2 hour 30 minutes

Candidates answer on the Question Paper.
Additional Materials: as listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST
Write your name and class on all the work you hand in.
Write in dark blue or black pen in the space provided. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use an HB or 2B pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at end of each question or part question.

Half the candidates will start Questions 1-2 for one hour and the other half on Question 3 for one hour. There will be a changeover after that time and candidates will move to the other Question(s) for one hour. All candidates will then move to Question 4 for the last 30 minutes. During this last half hour, candidates are not allowed access to the apparatus.

Shift
Laboratory

For Examiner's Use	
1	/ 14
2	/ 8
3	/ 21
4	/ 12
Total	/ 55

This document consists of **14** printed pages and **zero** blank page.

1. In this experiment, you will compare the diameters of objects seen through air with their apparent diameters seen through water and glass.

(a) The external diameter d_1 of the test-tube is shown in Fig. 1.1.

Fig. 1.1

Measure and record d_1, in the table using the half metre rule, the vernier caliper and the micrometer screw gauge.

Measuring Instrument	**Value of d_1**
half metre rule	....
vernier caliper	....
micrometer screw gauge	....

[3]

(b) (i) Stand the test-tube upside down in the **centre** of the beaker of water as shown in Fig. 1.2.

Look through the glass and water at the test-tube.

The external diameter d_2 of the test-tube as **seen through the water and glass** is shown in Fig. 1.2.

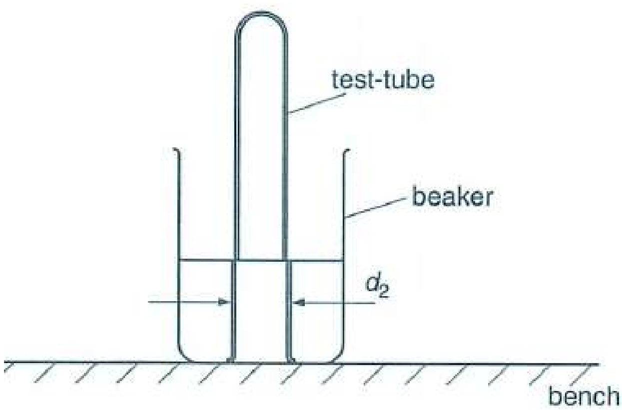


Fig. 1.2

(ii) **1.** Measure and record d_2 using only **one** of the measuring instruments.

d_2 = ... [1]

2. State which measuring instrument you used to measure d_2.

.... [1]

(iii) Remove the test-tube from the beaker and place the test-tube back into the container.

(c) **(i)** Use **one** of the measuring instruments to measure and record the external diameter of d_1 of the measuring cylinder.

d_1 = ...

(ii) Repeat **(b)** for the measuring cylinder.

d_2 = ... [1]

(iii) Determine the percentage uncertainty in your value of d_2 for the measuring cylinder.

percentage uncertainty in d_2 = ... [1]

(d) A student suggested that d_1 and d_2 are related by the expression

$$d_2 = kd_1$$

where k is a constant.

(i) Use your values from **(a)**, **(b)(ii)**, **(c)(i)**, and **(c)(ii)** to determine two values of k.

first value of k = ...

second value of k = ...

[1]

(ii) Do the results of your experiment support the suggested relationship?
Justify your answer by referring to your value in **(c)(iii).**

....

....

....

....

....

.... [2]

(e) The external diameter d_2 of the test-tube as seen through the water and glass is thought to be larger than the external diameter d_1 as seen through air. The magnification factor, k is proposed as,

$$k = \frac{d_2}{d_1}$$

It is suggested that the magnification factor of the setup in Fig. 1.2 depends on the internal diameter of the beaker of water.

Plan an investigation to determine the internal diameter of the beaker for which the magnification factor equal to 2.

You are provided with several beakers, each with uniform internal diameter.

Your account should include:

- your experimental procedure
- the table of measurements with appropriate units,
- how you determine the internal diameter of the beaker for which the magnification factor is 2.

[4]

Total: 14 marks

2 In this experiment, you will investigate how the current in a circuit changes when a resistor is added to the circuit.

(a) **(i)** You have been provided with five identical resistors.

Use two resistors and other components to connect the circuit of Fig. 2.1.

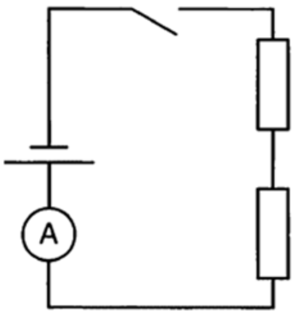


Fig. 2.1

(ii) Close the switch. Record the ammeter reading I_1.

I_1 = ... [1]

(iii) Open the switch.

(b) **(i)** Add a resistor as shown in Fig. 2.2 so that $n = 2$ where n is the number of resistors in the parallel arrangement.

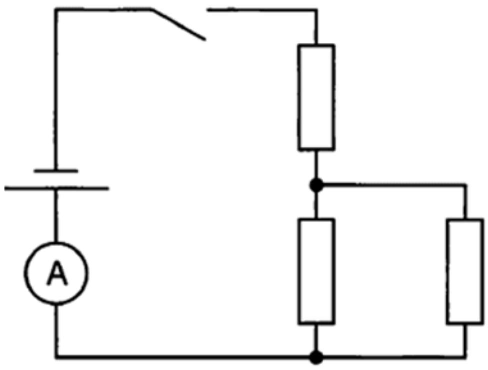


Fig. 2.2

(ii) Close the switch. Record the ammeter reading I_2.

I_2 = ... [1]

(iii) Open the switch.

(c) It is suggested that I and n are related by the expression,

$$I = k\frac{n}{(n+1)}$$

where k is a constant.

(i) Use the apparatus to take sufficient readings to verify whether the suggestion is correct by calculating values for k. Present your results in tabular form.

[3]

(ii) State whether or not the results of your experiment support the relationship suggested. Justify your conclusion.

[1]

(iii) Justify the number of significant figures that you have given for your values of k.

[1]

(d) The resistance of each of the resistors used in this experiment is 47 Ω.

Suggest one problem that might arise if the experiment was repeated using five identical resistors of resistance 0.047 Ω.

[1]

Total: 8 marks

3 In this experiment, you will investigate how the period of a spring pendulum varies with load.

(a) Set up the apparatus as shown in Fig. 3.1.

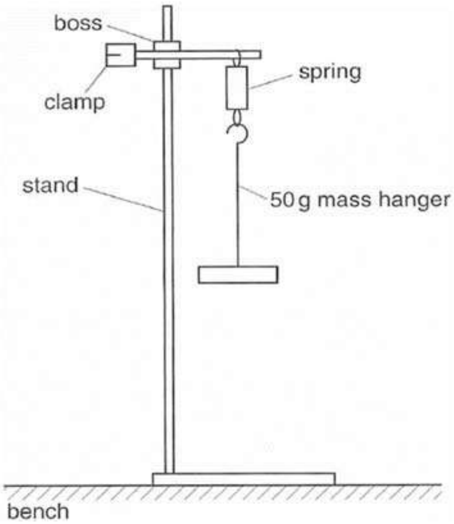


Fig. 3.1

(b) Displace the mass **horizontally**.

Release the mass and allow it to oscillate.

Take measurements to determine the period *T* of these oscillations.

T = ... [1]

(c) Vary the mass *m* suspended from the spring and repeat **(b)** for further values of *m*.

[7]

[3]

(d) It is suggested that T and m are related by the expression

$$T = am^b$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b.

a = ____________________

b = ____________________ [4]

(e) Comment on any anomalous data or results that you may have obtained. Explain your answer.

____

____

____________________ [1]

(f) State one significant source of error or limitation of taking the readings for this experiment. Give a reason.

____

____

____________________ [1]

(g) **(i)** Calculate the value of T when m = 1500 g.

T = ____________________ s [1]

(ii) Suggest a problem with determining an experimental value of T when m = 1500 g.

[1]

(h) **(i)** It is suggested that the value of a is proportional to the spring constant of the spring used in this experiment while the value of b is independent of the spring constant.

Sketch a line on the graph paper in page 9 when the experiment is repeated with a spring with a larger spring constant. Label this line **X**.

[2]

[Total: 21 marks]

4 In the early 19th century, it was observed that gases were able to absorb light of certain wavelengths. In addition, the extent of the absorption of the incident light increases with increasing amount of the gas. Such observations led to the development of a non-intrusive method to determine the amount of substance in a given sample.

The intensity I of a beam of light after passing through a gas depends on the concentration c of the gas. The concentration c is defined as the number of moles per unit volume of the gas. When incident light of intensity I_0 passes through the gas placed in a transparent container, the intensity I of the transmitted light can be measured for analysis as shown in Fig. 4.1.

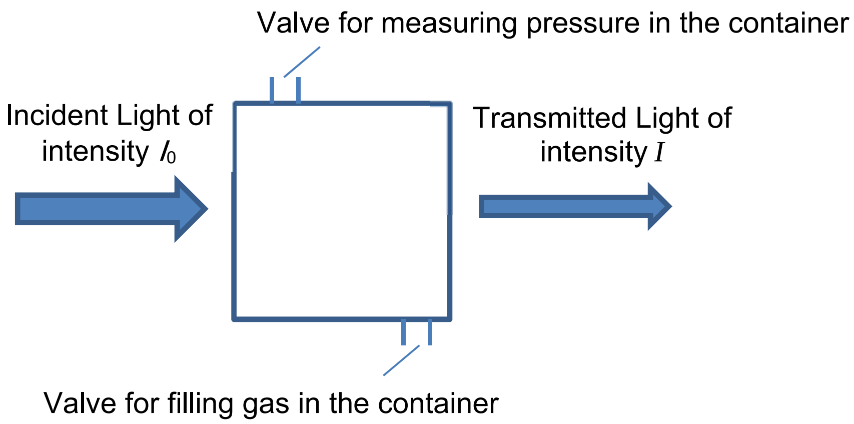


Fig. 4.1

It is suggested that the intensity I of the transmitted light is related to the concentration of the gas c by the relationship,

$$I = I_0 e^{-\varepsilon L c}$$

where I_0 is the intensity of the incident light before passing through the gas,
ε is an unknown constant and
L is the length the beam of light travelled through the gas.

Design an experiment to determine the value of ε for the gas provided. You may use the following apparatus with any standard apparatus available in a college Physics laboratory.

Meter to measure light intensity	Transparent cubic container (Fig. 4.1)	Gas supply
Red laser light source	Device to insert gas into the container	Pressure gauge
Vacuum pump	Thin sheets of glass	

You should draw a labelled diagram to show the arrangement of your apparatus and you should pay attention to

(a) the identification and control of variables,

(b) the equipment you would use,

(c) the procedure to be followed,

(d) how ε is determined from your readings,

(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

[12]

-- END OF PAPER –

NAME **MARK SCHEME** CLASS **2T**

Catholic Junior College

JC2 Preliminary Examinations

Higher 2

PHYSICS 9749/01

Multiple Choice Questions

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name and tutorial group on this cover page.

Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet (OMR sheet), unless this has been done for you.
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are a total of 30 Multiple Choice Questions in this paper.

Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Answer Sheet (OMR sheet) provided.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_P	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T / K	=	$T / {}^{\circ}C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega\sqrt{x_0^{\,2} - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1	A student measured the mass and linear dimensions of a rectangular block in order to determine its density. The measurements are: Height = (1.00 ± 0.01) cm Length = (5.00 ± 0.01) cm Breadth = (2.00 ± 0.01) cm Mass = (80.0 ± 0.2) g What is the uncertainty in the value of the density calculated?							
	A	0.01 g cm^{-3}	**B**	0.02 g cm^{-3}	**C**	0.1 g cm^{-3}	**D**	0.2 g cm^{-3}

L2 **Solution: D**

$$\rho = \frac{M}{lbh} = \frac{80}{(5)(2)(1)} = 8$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + \frac{\Delta l}{l} + \frac{\Delta b}{b} + \frac{\Delta h}{h}$$

$$\Delta\rho = \left[\frac{0.2}{80.0} + \frac{0.01}{5.00} + \frac{0.01}{2.00} + \frac{0.01}{1.00}\right](8)$$

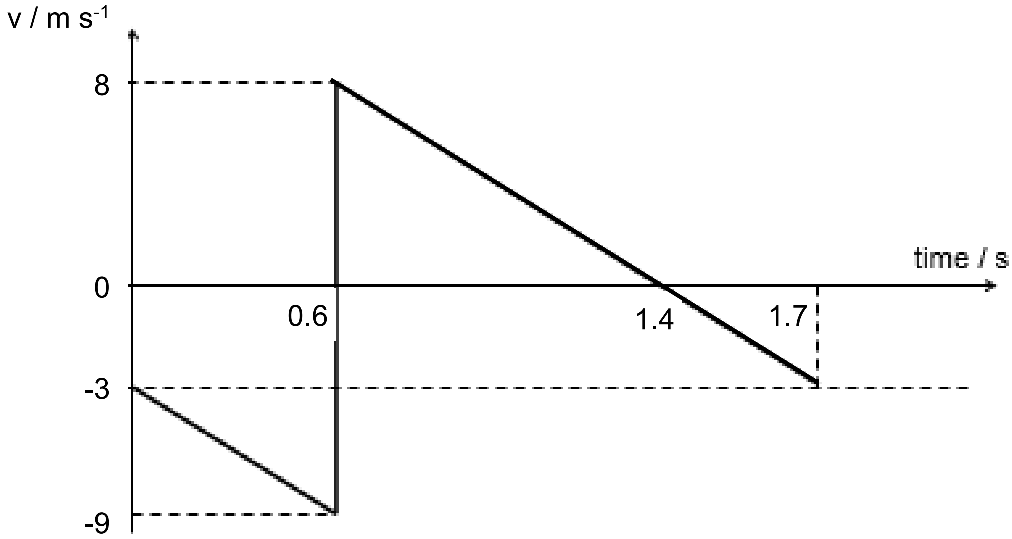
$$= 0.156$$

$$= 0.2 \text{ g cm}^{-3}$$

2	Express the *volt* in SI base units.							
	A	kg m^2 s^{-3} A^{-1}	**B**	kg m s^{-2} A^{-1}	**C**	J C^{-1}	**D**	V

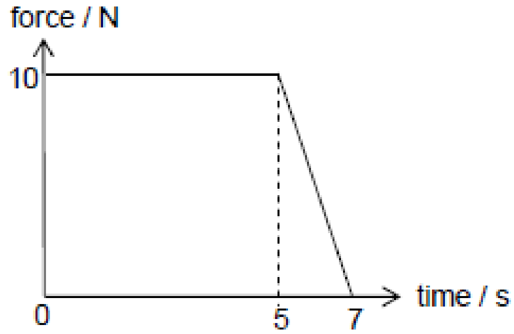
L2 **Solution: A**

$$[V] = \frac{[W]}{[Q]} = \frac{[F][s]}{[I][t]} = \frac{kgms^{-2}m}{As} = kgm^2s^{-3}A^{-1}$$

3	A student throws a rubber ball vertically downwards at a speed of 3.0 m s^{-1}. It hits the ground and rebounds vertically. The graph below shows the velocity-time graph for the first 1.7 s of the motion of the rubber ball  What is the displacement of the ball between the point at which it was first thrown and the highest point of the motion?							
	A	zero	**B**	0.4 m	**C**	1.8 m	**D**	3.6 m
L2	Solution: B Distance from initial point to the ground is = (0.6)(3) + ½ (6)(0.6) = 3.6 m Distance from ground to highest point = ½ (0.8)(8) = 3.2 m ➔ displacement is 3.6 – 3.2 = 0.4 m							

4	An object is thrown vertically upwards in air in which the air resistance is not to be neglected. If the times of flight for the upward motion t_u and the time of flight to return to the same level t_d are compared, then		
	A	$t_d > t_u$, because the object moves faster on its downward flight and therefore the air resistance is greater.	
	B	$t_d = t_u$, because the effect of the air resistance is the same whether the object is moving upwards or downwards.	
	C	$t_d < t_u$, because at any given speed the net force when the object is moving downwards is greater than the net force when it is moving upwards.	
	D	$t_d > t_u$, because at a given speed the net force when the object is moving downwards is smaller than the net force when it is moving upwards.	
L3	Solution: D Consider forces on the object when it moves upwards and it falls. The net force in the downward motion is smaller than that in the upwards direction. The average deceleration in the downward motion is lower than the average acceleration in the upward motion. Hence the time taken to rise is shorter than the time taken to fall.		

5 A body of mass 2.0 kg is moving along a smooth horizontal surface to the right with a constant velocity of 18 m s^{-1} when a left force is applied on it for 7 s. The graph below shows how the applied force varies with time.



What is the final velocity of the body after 7 s?

A	12 m s^{-1} to the right	
B	48 m s^{-1} to the right	
C	12 m s^{-1} to the left	
D	48 m s^{-1} to the left	

L3 Solution: C

The initial momentum of the body = (2.0) (18) = 36 Ns to the right

The change in momentum
= area under the graph
= (10)(5) + (0.5)(2)(10)
= 60 N s

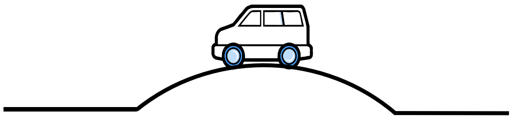
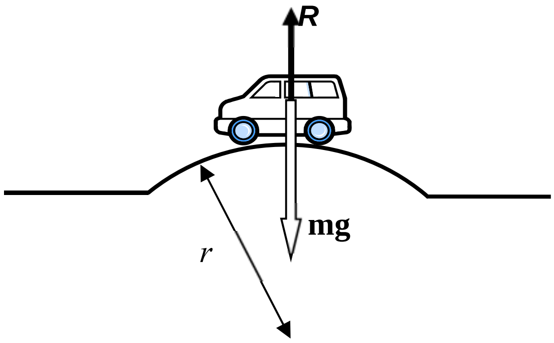
The applied force is to the left hence the change in the momentum is to the left.

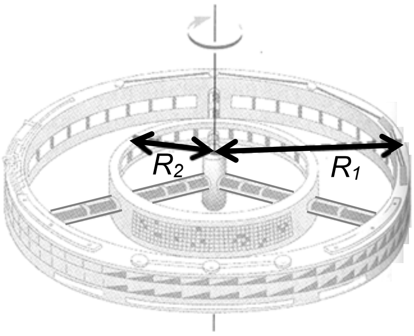
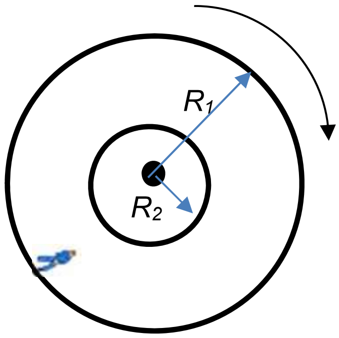
final momentum of the body
= initial momentum + change in momentum
= 36 + (– 60) = - 24 Ns to the right

final velocity = - 24 / 2.0 = - 12 m s^{-1} to the right

i.e. 12 m s^{-1} to the left

6	A fast moving neutron with an initial velocity *u* has a head-on elastic collision with a stationary proton. After the collision, the velocity of the neutron is *v* and that of the proton is *w*. Taking the masses of the neutron and proton to be equal, which of the following statements is **incorrect**?	
	A	Since collision is elastic, it shows that $u + v = w$.
	B	The proton and the neutron move off in opposite directions with equal speeds.
	C	By considering kinetic energies of the particles, it can be shown that $u^2 = v^2 + w^2$.
	D	The speed of the proton after the collision is the same as that of the neutron before the collision.
L2	**Solution: B** Relative velocity of approach = Relative velocity of separation Taking vectors to the right as positive. $u – 0 = w – v$ $u + v = w$ Option A is true. For elastic collision of the same mass, the velocities are exchanged. ➔ Option B is incorrect ➔ but option D is correct Option C is correct since the total K.E. before and after collision is the same for an elastic collision.	

7	A car is travelling on a hump with a radius of curvature of 30 m as shown in figure below. The car loses contact with the hump at the highest point. 							
	At what speed will the car be losing contact as it moves over the hump at the highest point?							
	A	15.7 m s^{-1}	**B**	17.2 m s^{-1}	**C**	22.2 m s^{-1}	**D**	29.4 m s^{-1}
L2	**Answer: B**  Net force towards centre of curve provides centripetal force $mg - R = mv^2/r$ where R is the normal contact force on car by road car loses contact with road $R = 0$ $\Rightarrow$ $v = \sqrt{rg} = 17.2$ m s^{-1}							

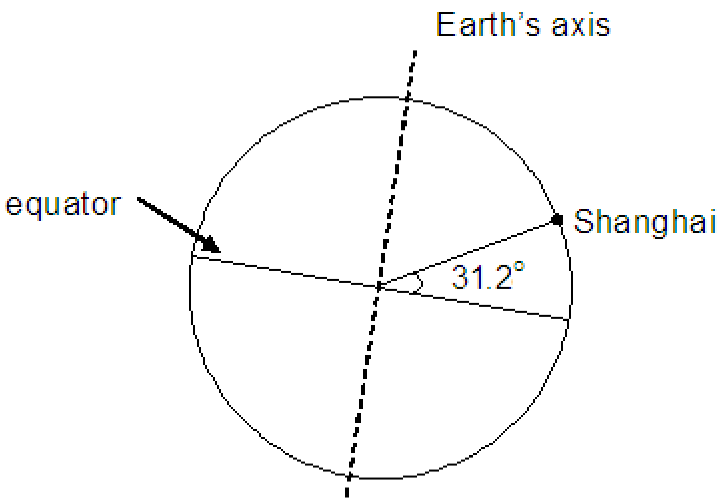
8	A proposed space laboratory is to create artificial gravity as shown in Fig. 8.a and Fig. 8.b below. The space laboratory is rotated about an axis so that it simulates an acceleration due to gravity equal to that of the gravity due to Earth at the outer ring which has a radius R_1 of 2150 m. What should be the approximate radius R_2 of the inner ring, so that it simulates the acceleration due to the gravity of Mars which is 3.72 m s^{-2} ?  **Fig. 8.a**  **Fig. 8.b**	

	A	700 m	**B**	800 m	**C**	900 m	**D**	1000 m	

L3	Answer: B To simulate gravity ➔ normal contact force N = mg; where g = acceleration due to gravity Centripetal force is provided by the normal contact force $F_c = N$ $F_c = ma_c = mr\omega^2 = mg$ $r\omega^2 = g$ $g \propto r$ since ω^2 is a constant $\frac{9.81}{2150} = \frac{3.72}{r}$ $r = 815\ m$	

9 A person is located near the city of Shanghai which has a latitude of 31.28° N.

Assuming that the Earth is a sphere of radius 6380 km, find the linear velocity of the person due to the rotation of the Earth about its axis.



A	240 m s^{-1}	**B**	337 m s^{-1}	**C**	397 m s^{-1}	**D**	464 m s^{-1}

L2 **Answer: C**

$v = r\omega$

$v = (6.38\ x\ 10^6) \cos 31.2\ (\frac{2\pi}{24\ x\ 60\ x\ 60})$

$v = 397\ m\ s^{-1}$

10 The density of a sample of helium gas at the pressure of 100 kPa is 0.180 kg m^{-3}. The root- mean- square speed of the helium molecules is

A	41 m s^{-1}	B	561 m s^{-1}	C	1290 m s^{-1}	D	1685 m s^{-1}

L2 **Answer: C**

$P = \frac{1}{3}\frac{Nm}{V}v_{rms}^2$

$P = \frac{1}{3}\rho v_{rms}^2$

$100000 = \frac{1}{3}(0.180)v_{rms}^2$

$v_{rms} = 1290$ m s^{-1}

11	A car tyre, initially at $28^{o}C$, has been inflated to a pressure of 160 kPa as indicated by the pressure gauge. This means that the pressure in the tyre is 160 kPa above the atmospheric pressure of 100 kPa. After driving on hot roads, the temperature of the air in the tyre is $65^{o}C$. What is the percentage increase in the pressure gauge reading?

A	10%	**B**	20%	**C**	200%	**D**	270%

L3 **Answer: B**

Taking n,R, V to be constant

Using the ideal gas equation,

$P_i = 160 + 100 = 260$ kPa

$T_i = 273.15 + 28 = 301.15$ K

$T_f = 273.15 + 65 = 338.15$ K

$PV = nRT$

$\frac{P}{T} = \frac{nR}{V} = \text{constant}$

$\frac{P_i}{T_i} = \frac{P_f}{T_f}$

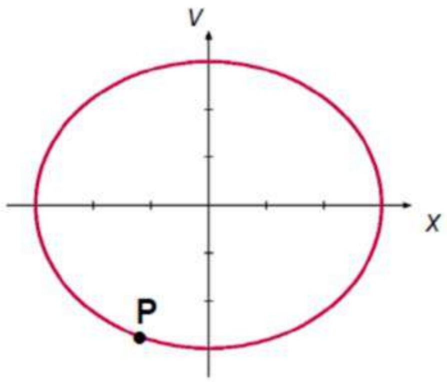
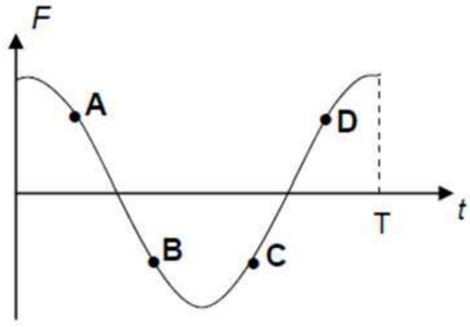
$\frac{260}{301.15} = \frac{P_f}{338.15}$

$P_f = 291.94$ kPa

New reading of Pressure Gauge

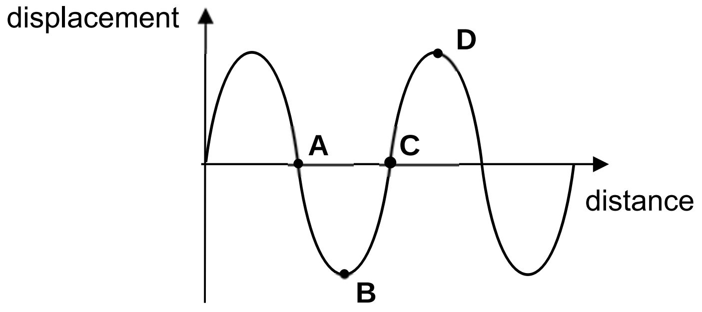
$= 291.94 - 100 = 191.9$ kPa

$\%\text{tage increase} = \frac{191.9 - 160}{160} x100\% = 20\%$

12	Fig. 12a shows the variation with displacement *x* of the velocity *v* of a body in simple harmonic motion. Fig. 12b shows the variation with time *t* of the net force *F* acting on the body.  **Fig. 12a**  **Fig. 12b** Which of the points on Fig. 12b corresponds to the state of motion represented by point P on Fig. 12a?	
L3	**Answer: D** At point P, the displacement is negative and velocity is negative. For s.h.m. net force F = ma = - mω^2x, x is negative implies net F is positive (B and C not possible). As the displacement is negative and the velocity is negative, the displacement will be more negative in the next instant. Hence the force will increase positively.	

13	The phase difference between 2 points at a distance 60 cm apart along a progressive transverse wave is $\frac{\pi}{2}$ rad. If the frequency of the wave is 200 Hz, what is the speed of the wave?								
	A	240 m s^{-1}	**B**	480 m s^{-1}	**C**	24000 m s^{-1}	**D**	48000 m s^{-1}	
L2	**Answer: B** Since phase difference of $\frac{\pi}{2}$ at distance 60 cm apart, the wavelength = 60 x 4 = 240 cm = 2.40 m speed = $f\lambda$ = 200 x 2.40 = 480 m s^{-1}								

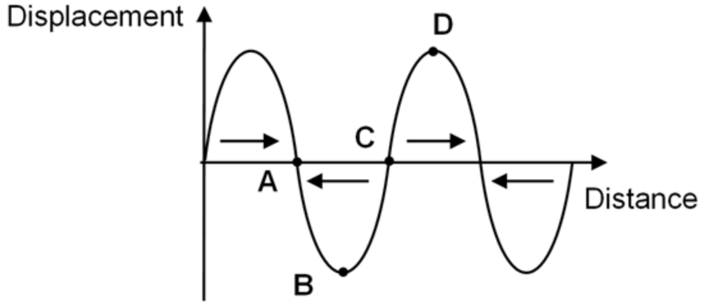
14 A sound wave travelling towards the right through air causes the air molecules to be displaced from their original positions. The graph below shows the variation with distance of the displacement of the air molecules at a particular instant in time.



Taking the displacement towards the right as positive, at which point is the pressure maximum?

L2 **Answer: A**

Since displacement towards the right is taken as positive, we can label the directions of displacement of air molecules as follows:



It can be seen from the figure that at point **A**, it is a region of compression as air molecules on the left side of **A** is displaced to the right and on the right side of **A**, they are displaced to the left. Hence **A** has the maximum pressure.

15 In a two-slit interference experiment, one slit transmits waves of twice the amplitude compared to the other slit.

If the maximum intensity of the interference pattern is I_o, what is the minimum intensity of the pattern?

A	zero	**B**	$\frac{I_o}{2}$	**C**	$\frac{I_o}{4}$	**D**	$\frac{I_o}{9}$

L2 **Answer: D**

$I \propto A^2$

For maximum intensity, $I_o \propto (2A + A)^2$

For minimum intensity, $I \propto (2A - A)^2$

$$\frac{I}{I_o} = \left(\frac{A}{3A}\right)^2$$

$$I = \frac{I_o}{9}$$

16 A space station orbits at a height of 335 km above the surface of the Earth. It carries two panels separated by a distance of 25 m. The panels reflect light of wavelength 500 nm towards an observer on the Earth's surface.

The observer views the panels with a telescope that has an aperture diameter of 200 mm. Assume that the panels act as point sources of light for the observer.

Which of the following is correct?

	Will the two images seen by the observer be resolved?	Angular separation of two sources as measured from aperture / rad
A	Yes	2.5×10^{-6}
B	Yes	7.5×10^{-5}
C	No	2.5×10^{-6}
D	No	7.5×10^{-5}

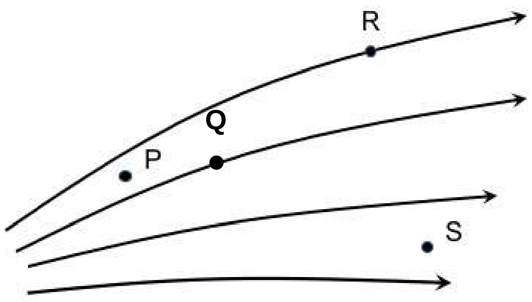
L2 **Answer: B**

$s = r\theta$

$$\theta = \frac{s}{r} = \frac{25}{335x10^3} = 7.46x10^{-5} = 7.5x10^{-5}\,rad$$

Min angle of resolution $\theta_m = \frac{\lambda}{b} = \frac{500x10^{-9}}{200x10^{-3}} = 2.5x10^{-6}\ rad$

Images seen are resolved since angular separation between two sources is larger than the min angle of resolution.

17	A region of electric field is represented by the electric field lines shown below. P, Q, R and S are 4 points in the field.  Which of the following statements is **incorrect**?	
	A The electric force on a charged particle is stronger when it is located at P than that at R.	
	B A positively charged particle released from rest at Q will travel along the electric field line which passes through Q.	
	C The electric potential energy of a negatively charged particle at S is higher than that at P.	
	D The electric field strength at Q is stronger than that at S.	
L2	**Answer: B** The force on the charged particle is along the tangent of the field at a point and hence it experiences an acceleration along the tangent of the field. This implies that the change in the velocity is in the direction of the acceleration but the instantaneous velocity is not along the field line. Hence the path of the charged particle is not along the field line.	

18 A isolated metal sphere of radius 0.1 m is positively charged. A small charge was brought from a distant point to a point 0.5 m from the centre of the metal sphere. The work done against the electric field is *W*. At its final position, the electric force on the charge is *F*.

If the charge has been brought to a point 1.0 m from the centre of the metal sphere, what would have been the values for the work done against the electric field and the electric force on the charge at its final position?

	work done against electric field	force on charge at its final position
A	$\frac{W}{4}$	$\frac{F}{4}$
B	$\frac{W}{4}$	$\frac{F}{2}$
C	$\frac{W}{2}$	$\frac{F}{4}$
D	$\frac{W}{2}$	$\frac{F}{2}$

L2 Answer: C

Treating the sphere as a point source,

At 0.5 m $F = \frac{kq_{sphere}q}{0.5^2}$

At 1.0 m $F_{new} = \frac{kq_{sphere}q}{1.0^2} = \frac{1}{4}\frac{kq_{sphere}q}{0.5^2} = \frac{1}{4}F$

At 0.5 m $W = U = \frac{kq_{sphere}q}{0.5}$

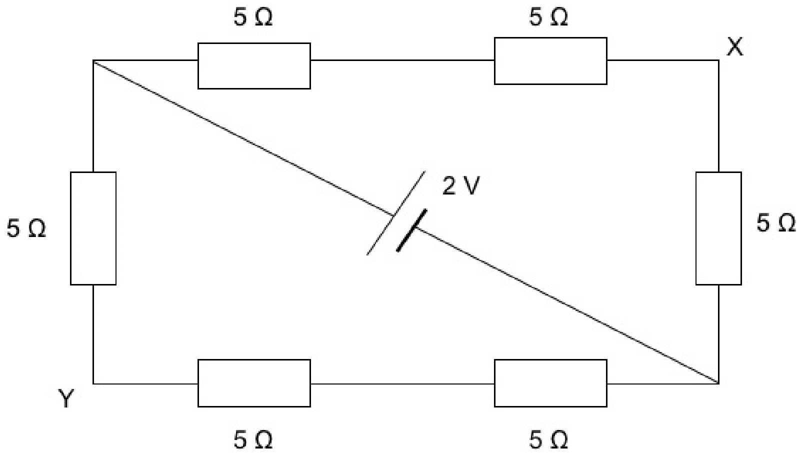
At 1.0 m $W_{new} = \frac{kq_{sphere}q}{1.0} = \frac{1}{2}\frac{kq_{sphere}q}{0.5} = \frac{1}{2}W$

19	The electrical potential difference between two points in a wire carrying a current is
	A the ratio of the power supplied to the current between the points.
	B the force required to move a unit positive charge between the points.
	C the ratio of the energy dissipated to the current between the points.
	D the product of the square of the current and the resistance between two points.
L2	**Answer: A** $V = W/Q = P/I$ it can be expressed as the ratio of P to I.

20	An electrical source with internal resistance r is used to operate a lamp of resistance R. What fraction of the total power is delivered to the lamp?							
	A	$\frac{R+r}{R}$	**B**	$\frac{R-r}{R}$	**C**	$\frac{R}{R+r}$	**D**	$\frac{R}{r}$
L2	**Answer: C** $\frac{P_L}{P_{tot}} = \frac{I^2R}{I^2R+I^2r}$ $= \frac{R}{R+r}$							

21	A high potential is applied between the electrodes of a hydrogen discharge tube so that the gas is ionised. Electrons then move towards the positive electrode and protons towards the negative electrode. In each second, 7 x 10^{18} electrons and 2 x 10^{18} protons pass a cross section of the tube. The current flowing in the discharge tube is							
	A	0.32 A	**B**	0.80 A	**C**	1.12 A	**D**	1.44 A
L2	**Answer: D** Since the electrons and protons are moving in opposite directions, the total current is the sum of the current due to both charges $I = \frac{N_e q_e}{t} + \frac{N_p q_p}{t}$ $= \left(\frac{7\times10^{18}}{1} + \frac{2\times10^{18}}{1}\right)\times(1.6\times10^{-19})$ = 1.44 A							

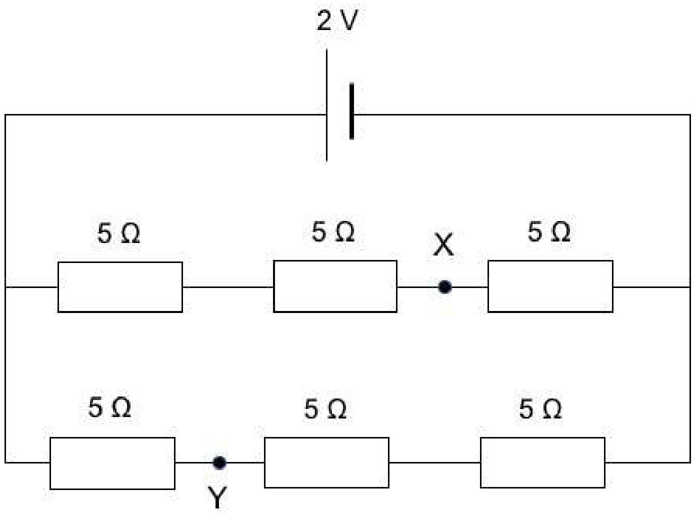
22	Six 5 Ω resistors are connected to a 2 V cell of negligible internal resistance, as shown in the figure below.							
	A	0 V	**B**	$\frac{2}{3}$ V	**C**	$\frac{8}{9}$ V	**D**	$\frac{4}{3}$ V



The potential difference between X and Y is

L2 **Answer: B**

The diagram can be re-drawn as shown:



the resistors are all with the same resistance,

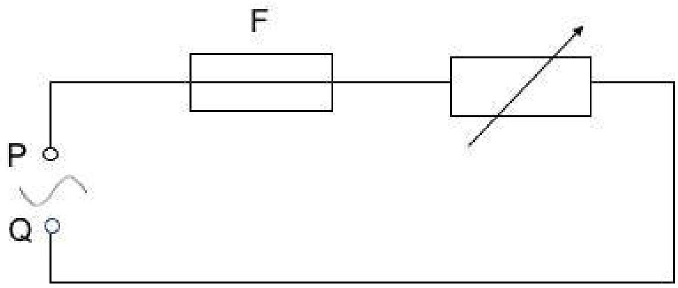
the potential drop across each resistor $=\frac{1}{3}(2)=\frac{2}{3}$ V

potential at X is $= \frac{2}{3}$ V.

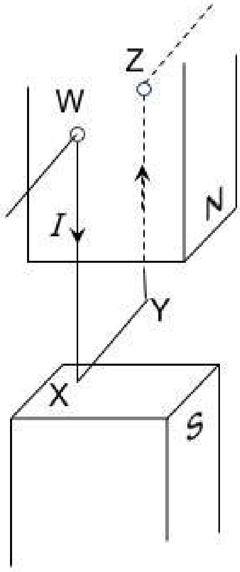
potential at Y is $2 \times \frac{2}{3} = \frac{4}{3}$ V.

potential difference between XY is

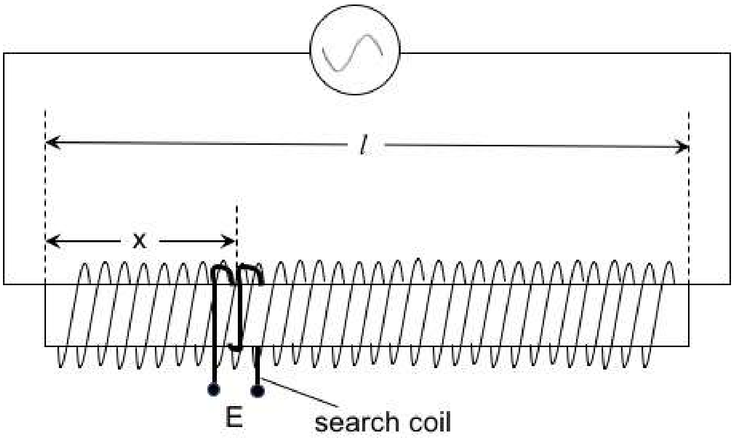
$\frac{4}{3}-\frac{2}{3}=\frac{2}{3}$ V

23	When an alternating power supply of 240 V r.m.s. is connected across PQ in the circuit shown below. The fuse F breaks the circuit if the current in it just exceeds 13 A r.m.s.  When the alternating power supply is replaced with a 120 V d.c. source, an identical fuse breaks the circuit if the current just exceeds							
	A	$\frac{13}{2}$ A	**B**	$\frac{13}{\sqrt{2}}$ A	**C**	13 A	**D**	26 A
L2	**Answer: C** As the r.m.s current is the equivalent dc current for the same power dissipation in the same resistor, since the fuse breaks when the a.c. r.m.s. current is 13 A, this implies that the fuse will also break at d.c. current of 13 A.							

24	An alternating power supply of root-mean-square voltage 4.0 V is connected across a resistive load such that the average power dissipated across it is *P*. What is the d.c. voltage applied across the same load which will give rise to an average power dissipation of 3*P* ?							
	A	6.9 V	**B**	8.5 V	**C**	12 V	**D**	17 V
L2	**Answer: A** For an alternating supply, $\langle P \rangle = P$ $P = \frac{V_{rms}^2}{R}$ ……(1) Across the same load, to have average power to be 3P, $\langle P \rangle_{new} = \frac{V_{rms}^2{}_{new}}{R}$ $3P = \frac{V_{rms}^2{}_{new}}{R}$ …(2) (1) / (2) $1/3 = \frac{\frac{V_{rms}^2}{R}}{\frac{V_{rms}^2{}_{new}}{R}}$ $V_{rms,\ new} = \sqrt{3V_{rms}^2} = \sqrt{3(4)^2} = 6.9$ V							

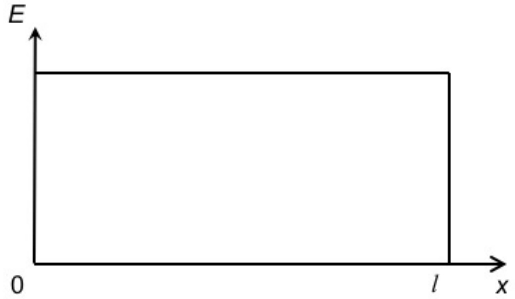
25	A piece of wire WXYZ is pivoted freely about a horizontal axis at points W and Z. Section XY of the wire is situated between the North (N) and South (S) poles of a horse-shoe magnet. WXYZ is connected to an electrical circuit.  What will happen to the wire, if any, when the circuit is just turned on and there is a constant current *I* in the wire as shown?	
	A swings to the left	
	B swings to the right	
	C swings from X to Y	
	D remains at rest at its original position	
L1	**Answer: A** By Fleming's left hand rule, the force acting on the wire section XY will be towards the left.	

26 In the diagram below, the solenoid of length *l* which is closely and uniformly wound, carries an alternating current of constant amplitude. A search coil (which is a coil consisting of a few turns of wires) is placed in different positions along the solenoid.

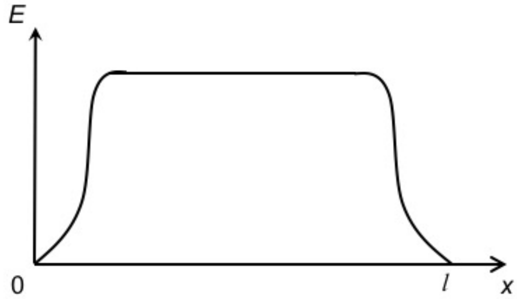


Which one of the following graphs most nearly shows how the amplitude of the e.m.f. *E* induced in the search coil varies with its position?

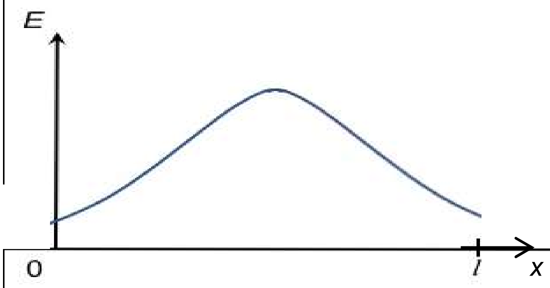
A



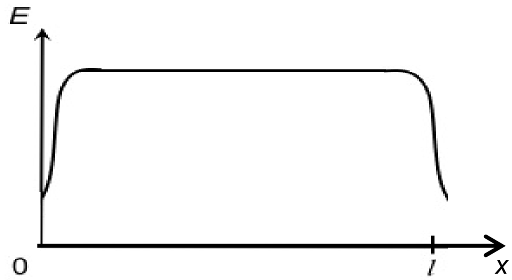
B



C



D



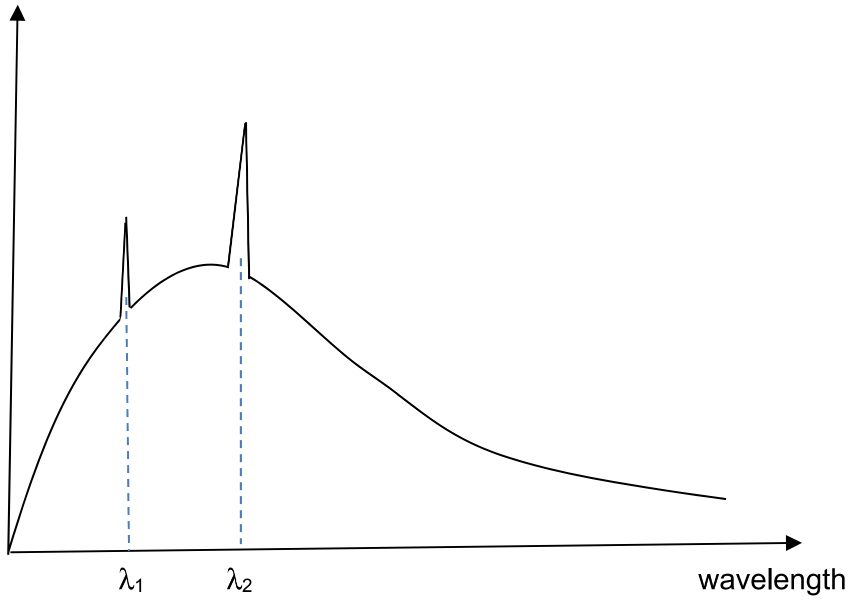
L3 **Answer: D**

As the current in the solenoid is alternating, the amplitude of the e.m.f. induced in the search coil is proportional to the max magnetic flux density which varies sinusoidally

The maximum magnetic flux density along the length of the solenoid is uniform since it is long. The maximum magnetic flux density near the ends decreases.

Hence maximum e.m.f. induced in the search coil is almost constant along the length of the solenoid and decreases at the ends.

27 The diagram below shows a typical X-ray spectrum produced by an X-ray tube.



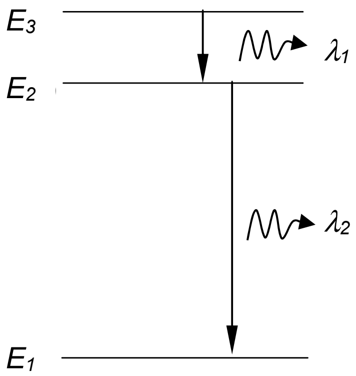
The operating voltage across the X-ray tube is increased. Which of the following gives the corresponding changes, if any, in λ_1 and λ_2?

	λ_1	λ_2
A	no change	no change
B	no change	decrease
C	decrease	no change
D	decrease	decrease

L2 **Answer: A**

λ_1 and λ_2 is only dependent on the target.

28	The diagram below shows a simplified representation of the three electron energy levels in an atom.								



Cool vapour of this element at low pressure is bombarded with electrons accelerated from rest across a potential difference V. Two possible transitions which result in the emission of photons of wavelengths $\lambda_1 = 6.22 \times 10^{-7}$ m and $\lambda_2 = 1.78 \times 10^{-7}$ m are observed.

What is the minimum value of V for the above transitions to occur?

A	1.56 V	**B**	2.80 V	**C**	7.00 V	**D**	9.00 V

L2 **Ans: D**

Minimum energy of the electrons
$= hc/\lambda_1 + hc/\lambda_2$
$= 1.44 \times 10^{-18}$ J

Since E = qV
=> V = E/e
$= 1.44 \times 10^{-18} / 1.6 \times 10^{-19}$
= 9 V

29	A stationary uranium nucleus of mass 238 units disintegrates by the emission of an α-particle of mass 4 units. The ratio $\frac{\text{kinetic energy of the } \alpha \text{ - particle}}{\text{kinetic energy of the recoiling daughter nucleus}}$ is								
	A	$\frac{4}{234}$	**B**	$\frac{4}{238}$	**C**	$\frac{234}{4}$	**D**	$\frac{238}{4}$	
L3	Ans: C The reaction can be represented by $^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$ By principle of conservation of momentum, $(238 - 4)\ V_{th} = 4\ V_{\alpha}$ *where* V_{th} : velocity of the recoiling thorium nucleus and v_{α} : velocity of the α – particle $\Rightarrow \frac{V_{\alpha}}{V_{th}} = \frac{234}{4}$ Ratio of the kinetic energies is $\frac{\text{kinetic energy of the } \alpha - \text{particle}}{\text{kinetic energy of the recoiling thorium nucleus}} = \frac{4V_{\alpha}^2}{234V_{th}^2} = \frac{4}{234}\left(\frac{234}{4}\right)^2 = \frac{234}{4}$								

30	The half-life of a certain radioactive material is 3.0 s. How long does it take for its activity to become 10 % of the original activity?								
	A	0.46 s	**B**	5.4 s	**C**	10 s	**D**	15 s	
L2	Ans: C $\lambda = \ln 2 / t_{½} = \ln 2 / 3$ $A = A_o e^{-\lambda t}$ $\ln (A / A_o) = -\lambda t$ $\ln 0.1 = -(\ln 2 /3)\ t$ t = 10 s								

Catalic Junior College

JC2 Preliminary Examinations

Higher 2

CANDIDATE NAME	MARK SCHEME
CLASS	2T

PHYSICS — 9749/02

Paper 2

2 hours

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen in the space provided. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The number of marks is given in brackets [ ] at the end of each question or part of the question.

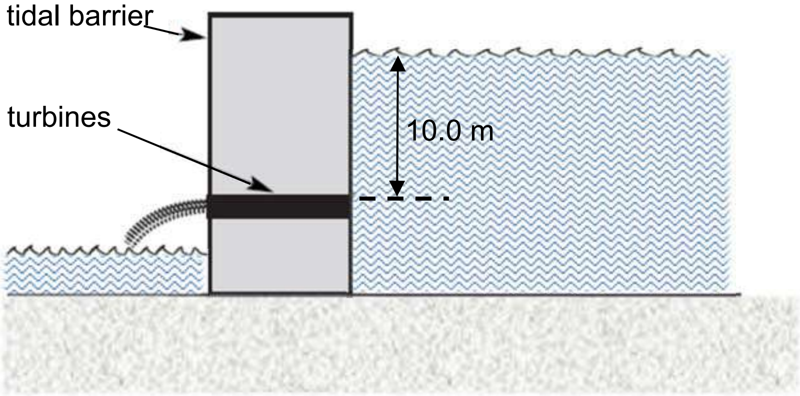
FOR EXAMINER'S USE		DIFFICULTY		
		L1	L2	L3
Q1	/6			
Q2	/10			
Q3	/7			
Q4	/8			
Q5	/5			
Q6	/7			
Q7	/10			
Q8	/8			
Q9	/20			
TOTAL FOR PAPER 2	/ 80			

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_P	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential	ϕ	=	$-\dfrac{Gm}{r}$
temperature	T / K	=	$T / {}^\circ C + 273.15$
pressure of an ideal gas	p	=	$\dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\dfrac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\dfrac{\ln 2}{t_{\frac{1}{2}}}$

1	A hydroelectric power station could make a significant contribution to energy requirements. Fig. 1.1 shows a dam at the hydroelectric power station which traps water behind a dam. When the height of the water behind the dam reaches 10.0 m, the water is released and passed through the turbines.  **Fig. 1.1**		
	(a)	It takes 6.0 hours for a total mass of 1.32×10^{12} kg of water to flow through the turbines. The centre of mass of this amount of water is 5.0 m above the turbines. Calculate the loss in the potential energy of the trapped water when it is released through the turbines completely. Assume that the density of the water is uniform. loss in the potential energy = ……………………………….J	[2]
		Loss in potential energy = mgh $= 1.32 \times 10^{12} \times 9.81 \times 5.0$ (since the average height of the water is 5.0 m) $= 6.5 \times 10^{13}$ J	
	(b)	The potential energy calculated in part (a) is lost over a time period of 6.0 hours and the efficiency of the power station is 40 %. Calculate the average power output of the power station over this time period of 6.0 hours.	[3]
		Power from sea water = gravitational energy lost / time $= 6.5 \times 10^{13} / 6.0 \times 3600$ $= 3000 \times 10^{6}$ W Average power output $= 3000 \times 10^{6} \times 0.40$ = 1200 MW	

(c) Suggest how the output power of the hydroelectric power station can be controlled as the level of trapped water decreases.

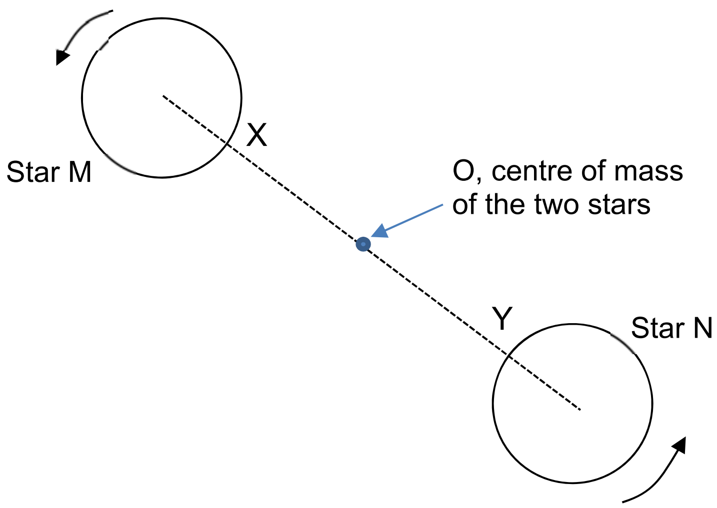
……

……

…… **[1]**

There are valves within the dam that controls and regulates the flow of water into the turbines.

2 In a binary star system, two stars, each of equal mass 3.5 x 10^{30} kg, rotate about their common centre of mass O which is equidistant from the centres of the stars. The separation between the two centres of the stars is 2.0 x 10^{11} m.



(a) Define gravitational potential at a point.

……

……

…… [1]

The gravitational potential at a point is the work done per unit mass by an external agent in bringing a point mass from infinity to that point.

(b) Calculate the gravitational potential at O, the centre of mass of the binary star system. [2]

Gravitational potential at the centre of mass O

$$= \left(-\frac{Gm}{0.5d}\right) + \left(-\frac{Gm}{0.5d}\right)$$

$$= -\frac{4Gm}{d}$$

$$= -\frac{4(6.67\ x\ 10^{-11})(3.5\ x\ 10^{30})}{2.0\ x\ 10^{11}}$$

$$= -4.67\ x\ 10^{9} Jkg^{-1}$$

Where d is the separation between the two stars.

(c) An asteroid passes through point O, at a speed v. Determine the minimum speed of the asteroid if it is to escape from the gravitational pull of the binary star system.

minimum speed = ………………….. m s^{-1} [3]

By the principle of conservation of energy,

Loss in kinetic energy of the asteroid = Gain in gravitational potential energy of the asteroid as it completely leaves the gravitational pull of the binary star system

$$0 - \frac{1}{2}mv^2 = -\frac{4GMm}{d} - 0$$

$$v = \sqrt{\frac{8GM}{d}}$$

$$= \sqrt{\frac{8(6.67\ x\ 10^{-11})(3.5\ x\ 10^{30})}{2.0\ x\ 10^{11}}}$$

$$v = 9.66\ x\ 10^{4}\ ms^{-1}$$

(d) (i) On Fig.2.1, sketch a graph showing the variation of gravitational potential along the line XY between the two stars. [2]

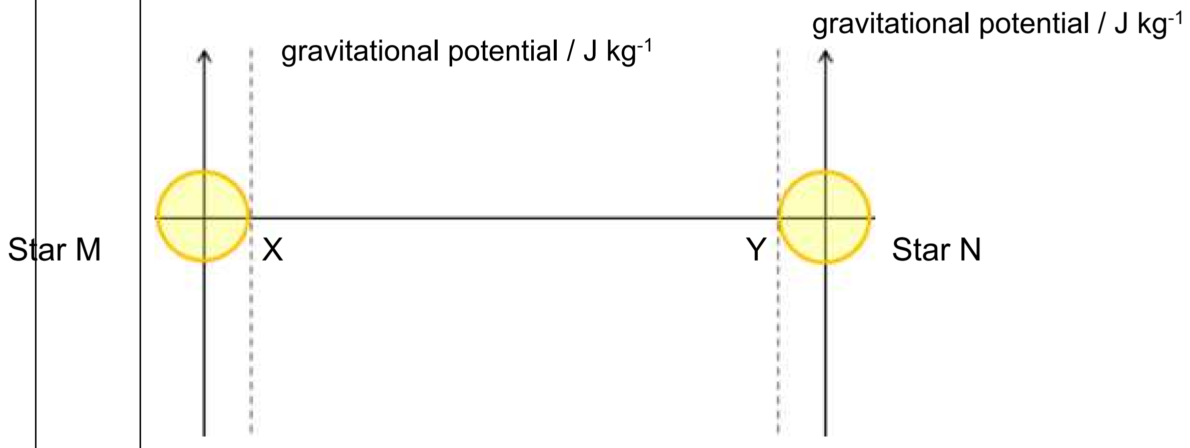
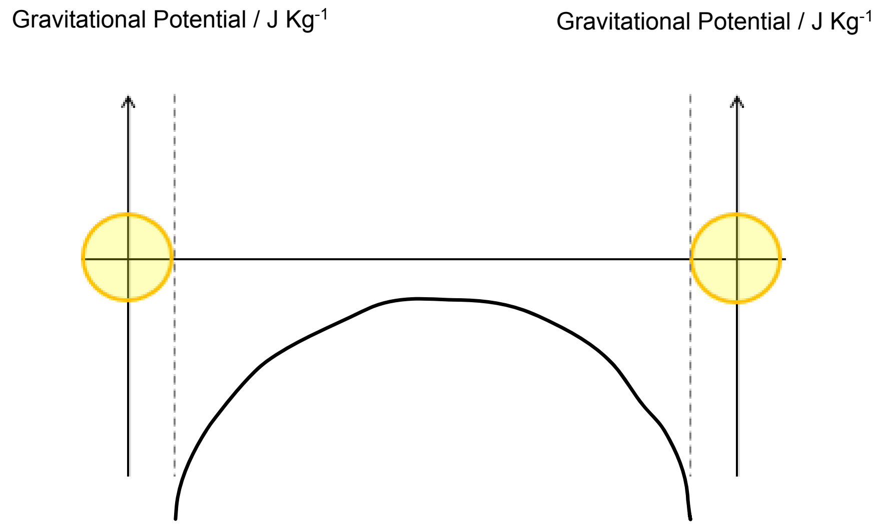


Fig. 2.1



		(ii)	Hence describe the variation in gravitational potential energy of an object moving from O towards star M.	
			....	[2]
			The gravitational potential energy of the object will decrease as it moves towards one of the stars. As the object leaves the centre of mass, the gravitational potential decreases at an increasing rate and since the mass of the object is constant, the gravitational potential energy of the object decreases.	

3	**(a)**	Define *specific latent heat*.	
		....	[1]
		Solution: is a value that is numerically equal to the thermal energy transferred when **unit mass** of a substance **changes state**, **without any change of temperature**.	

(b) A beaker containing a liquid is placed on a balance, as shown in Fig. 3.1.

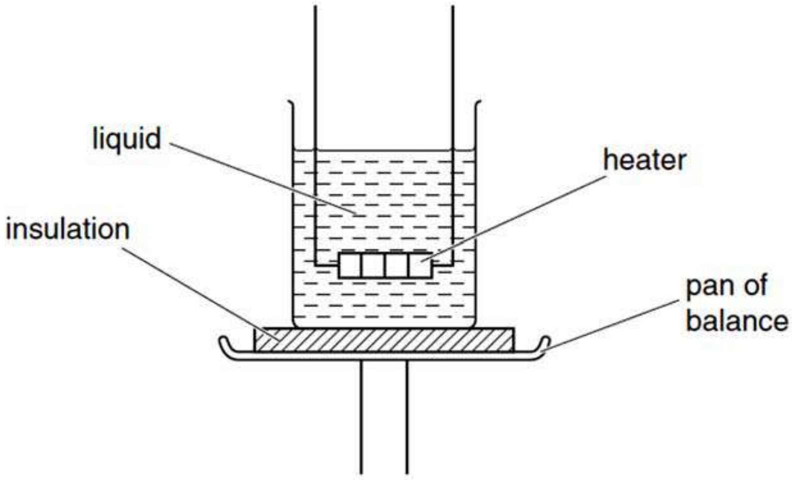


Fig. 3.1

A heater of power 120 W is immersed in the liquid. The heater is switched on and, when the liquid is boiling, balance readings *M* are taken at corresponding times *t*.

A graph of the variation with time *t* of the balance reading *M* is shown in Fig. 3.2.

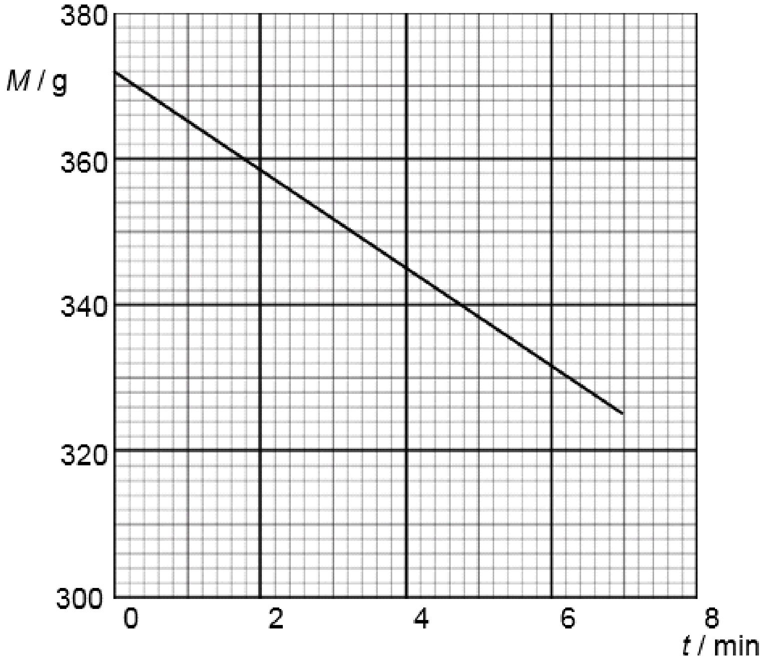


Fig. 3.2

(i) State the feature of Fig. 3.2 which suggests that the liquid is boiling at a steady rate.

....

.... [1]

Solution:

Straight line graph with **<u>constant gradient</u>**

(Note: total mass *M* decreases linearly with time which means that mass of liquid evaporated increases linearly with time)

		(ii)	Use data from Fig. 3.2 to determine a value for the specific latent heat of vaporisation l_v of the liquid. Explain your working.	
			     l_v = ... J kg^{-1}	[3]
			Solution: *$Q = Pt = ml_v$ (where m is the mass that has evaporated)* $P = \frac{m}{t} l_v$ $\frac{m}{t} = -\frac{\Delta M}{t}$ *(Note: $\frac{\Delta M}{t}$ is a negative gradient of the graph in Fig 3.2 [where ΔM is the mass loss]* *Since gradient of graph = $-\frac{\Delta M}{t}$* $P = (-\frac{\Delta M}{t})l_v$ or [power = - gradient × l_v] Determine gradient of graph *(or two points separated by at least 3.5 minutes)* $120 = l_v \times \frac{(372 - 325) \times 10^{-3}}{(7.0 - 0) \times 60}$ $l_v = 1.07 \times 10^6$ J kg^{-1} *(accept 2 s.f.) [will get a negative gradient but times negative will become positive]*	
	(c)	State, with a reason, whether the experimental value determined in **(b)(ii)** is likely to be an overestimate or an underestimate of the expected value for the specific latent heat of vaporisation of the liquid.		
		....		[2]
		Solution: some energy/ heat is lost to surroundings so value is an overestimate In calculating for l_v in part bii, heat lost was not taken into consideration $P = (-\frac{\Delta M}{t})l_v$ However, if heat lost is taken into consideration,		

$P = (-\frac{\Delta M}{t})l_v + Q$

l_v will be a smaller value.
Therefore, l_v found in bii is an overestimation.

4 (a) Describe one condition necessary for observable two-source interference fringes to be formed.

....

.... [1]

Solution:

The sources must be **coherent**; i.e. they must maintain a *constant phase difference* with respect to each other.
OR
The two wave sources must also emit waves of roughly the same amplitude.

(b) Two microwaves transmitters produce waves of the same frequency are placed at P and Q which are at a distance of 2*d* apart. Points Y and Z are equidistant from O. The line YXZ is perpendicular to OX, as shown in Fig. 4.1.

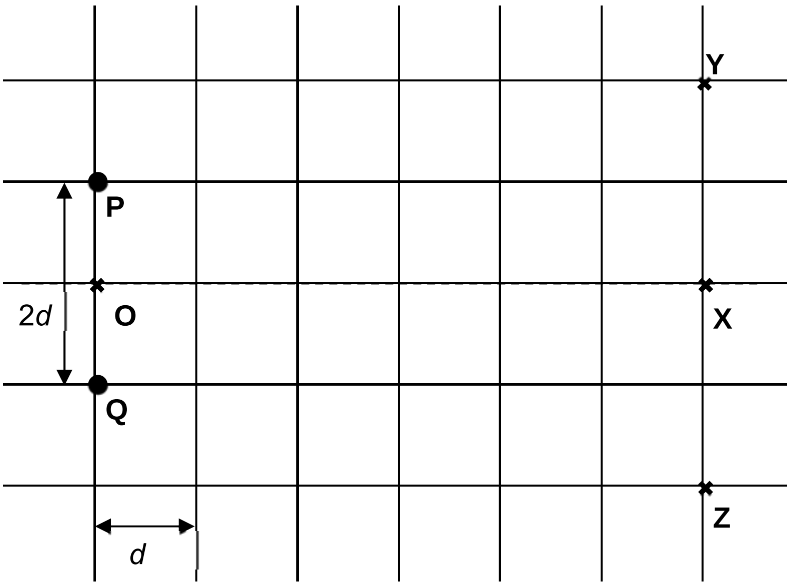


Fig. 4.1

(i) The waveforms of the microwaves from P and Q arriving at point Y vary with time as shown in Fig. 4.2.

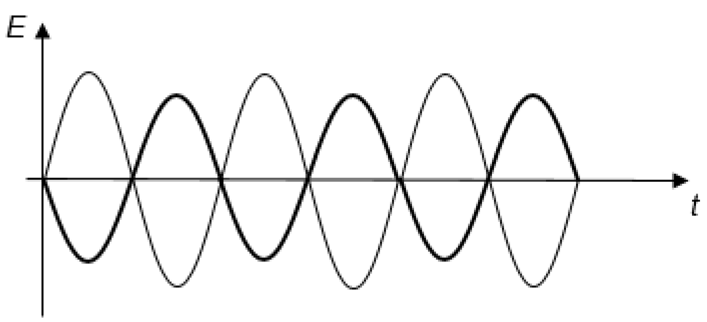


			Fig. X.2		
		1.	State and explain if the waves arriving at Y are coherent.		
			....		[2]
			Solution: They are coherent as the phase difference between them is a constant value of π.		
		2.	Explain why a minimum intensity is detected at Y.		
			....		[1]
			Solution: From the graph, the waves arrive at point Y in antiphase, and interfere destructively.		
	(ii)	Show that the path difference of the waves arriving at point Y from P and Q is 0.625*d*.			
					[1]
		Solution: Path difference, = QY – PY = $\left(\sqrt{6^2+3^2}-\sqrt{6^2+1^2}\right)d$ = 0.625 d			
	(iii)	As a detector is moved along a straight line from X to Y, it encountered three intensity maxima, including the maximum at X. Determine the frequency of the wave in terms of *d*.			
		frequency = ...Hz			[3]
		Solution: 3rd order minimum is formed at Y (can see from graph that the waves meet in antiphase, hence destructive interference occurs.) Path difference = 0.625 d = 2.5 λ			

$\lambda = 0.25\,d$

From $v = f\lambda$

$$f = \frac{v}{\lambda}$$

$$f = \frac{3.0 \times 10^8}{0.25d}$$

$$= \frac{1.2 \times 10^9}{d}\ \text{Hz}$$

5 In a simple experiment to find the wavelength of monochromatic red light emitted by a laser, a fine beam of red laser light is incident on a diffraction grating as shown in Fig.5.1. The diffraction grating has 300 lines per millimeter and it is set so that its plane is normal to the incident light.

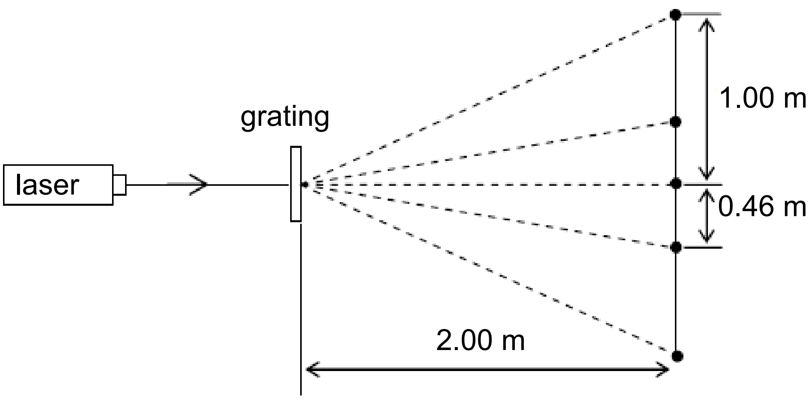


Fig. 5.1

Bright spots are observed at 0.46 m and 1.00 m from the central spot on a screen, which is 2.00 m from the grating.

(a) By considering the bright spot at 0.46 m from the central spot, calculate the wavelength of the laser light.

wavelength = …………………….. m [3]

Solution:

The first order maximum is diffracted at an angle $\theta = \tan^{-1}(0.46/2.00) = 12.95^{\circ}$.

From $d \sin\theta = n\lambda$

where $d = 1/N$ = $1/300 \times 10^3$ and $n = 1$

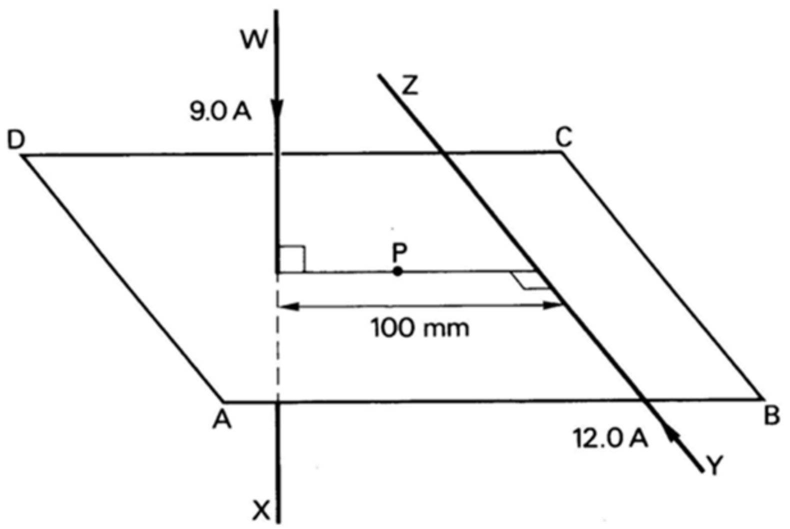
$$\frac{\sin 12.95}{300 \times 10^3} = 1 \times \lambda$$

$\Rightarrow \lambda = 7.47 \times 10^{-7}$ m

(b) Suggest and explain an experimental advantage of obtaining the wavelength of the laser light by using the second-order diffracted light rather than the first-order diffracted light.

……………………………………………………………………………………………………

			....	[2]
			Solution: Using the second-order diffracted light to measure the wavelength is more accurate. This is because the larger angle of diffraction can be measured experimentally with a lower percentage error for a given precision of the measuring instrument used.	**B1** **B1**

6	**(a)**	Define *magnetic flux density*.		
		....		**[2]**
		Solution: It is the **force experienced per unit length of wire** carrying **per unit electric current** when placed inside a magnetic field, with the **conductor placed perpendicular to the magnetic field.**		
	(b)	Fig. 6.1 shows a long, straight, vertical wire WX, carrying a current of 9.0 A downwards. A second long, straight wire YZ is placed horizontally, and carries a current of 12.0 A in the direction shown.  **Fig. 6.1** ABCD is a horizontal, rectangular table-top: the wire YZ is parallel to the side BC of this table, and the wire WX passes through a small hole in the table. The perpendicular distance between the wires is 100 mm. P is the point 50 mm from YZ along the perpendicular between the wires.		
		(i)	Determine the magnitude of the magnetic flux density at the point P due to WX only.	
			magnetic flux density at P due to WX = ... T	**[2]**
			Solution:	

$$B_{WX,P} = \frac{\mu_0 I_{WX}}{2\pi r_p}$$
$$= \frac{(4\pi\times10^{-7})(9.0)}{2\pi(50\times10^{-3})}$$
$$= 3.6\times10^{-5}\ \text{T}$$

(ii) Determine the magnitude of the net magnetic flux density at the point P.

net magnetic flux density at P = ……………… T **[3]**

Solutions

$$B_{YZ,P} = \frac{\mu_0 I_{YZ}}{2\pi r_p}$$
$$= \frac{(4\pi\times10^{-7})(12.0)}{2\pi(50\times10^{-3})}$$
$$= 4.8\times10^{-5}\ \text{T}$$

$$B_{res} = \sqrt{B_{WX,P}^{\ 2} + B_{YZ,P}^{\ 2}}$$
$$= \sqrt{(3.6\times10^{-5})^2 + (4.8\times10^{-5})^2}$$
$$= 6.0\times10^{-5}\text{T}$$

7 A spring is attached to the middle of a horizontal wooden rod AB. A U-shaped metal wire ASTB is attached to the rod AB. The U-shaped wire is placed with side ST in a region of uniform magnetic flux pointing out of the page, as shown in Fig. 7.1

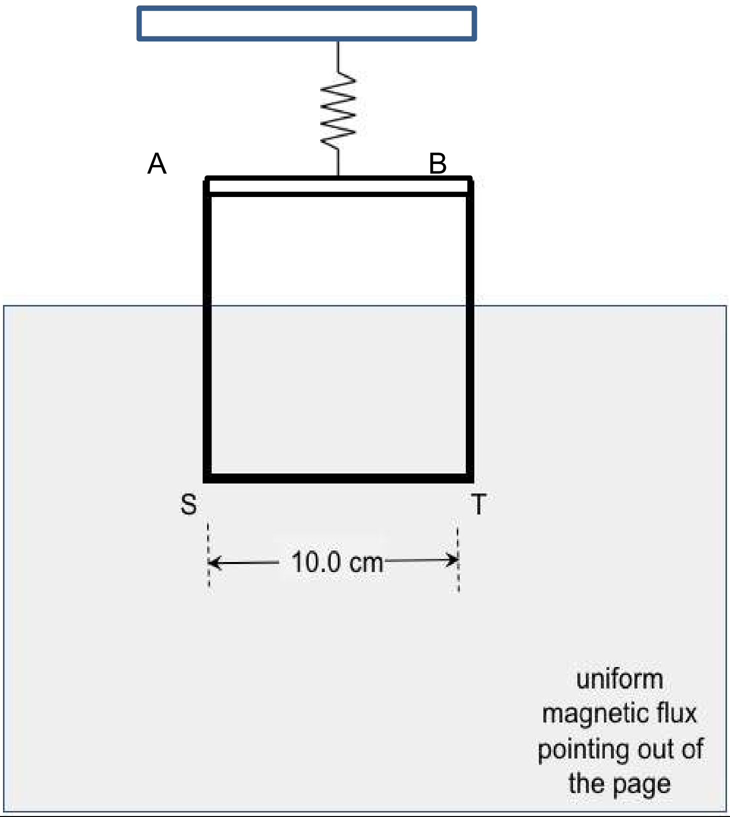
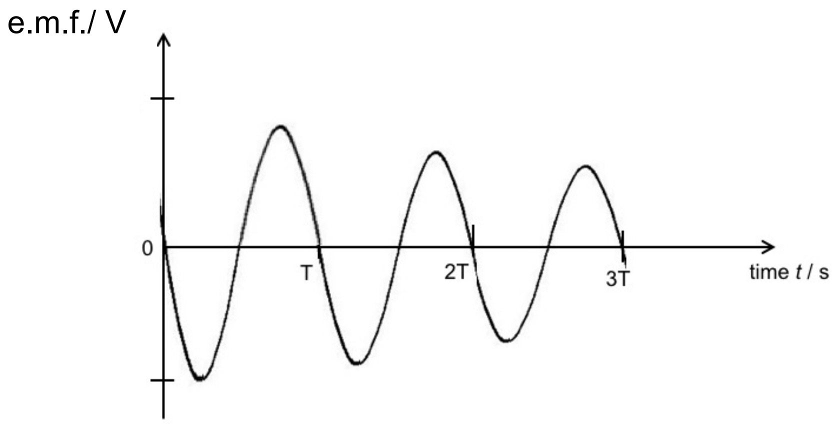


	Fig. 7.1 The frame is then pulled down a distance of 1.0 cm and then released. The wire ST undergoes simple harmonic motion.			
	(a)	**(i)**	Using Faraday's law of electromagnetic induction, explain why there is an induced e.m.f. in the wire ST while it is in motion	
			....	[3]
			As the frame is in motion, the wire ST cuts the magnetic field and there is a rate of change of magnetic flux linkage The e.m.f. induced is proportional to the rate of change of flux linkage Hence there is an induced e.m.f. in the wire ST.	
		(ii)	Explain why the induced e.m.f. varies sinusoidally with time,	
			....	[2]
			Solution: As the frame oscillates, its velocity will vary in a sinusoidal manner. Therefore, the rate of change of magnetic flux linkage will also change sinusoidally. Since the emf across ST is proportional to the rate of change of magnetic flux linkage, it will also vary sinusoidally.	
	(b)		The wooden rod AB is replaced by a metal rod. The frame is then set to oscillate as in (a).	
		(i)	Sketch the time variation of the induced e.m.f. observed on Fig. 7.2. Explain your answer.	[3]

Fig. 7.2

Solution:



1 mark: sinusoidal e.m.f with decreasing amplitude

The induced current results in a magnetic force on the metal wire ST which opposes the motion of the frame ASTB and hence the oscillation is damped.

This affects the maximum speed and hence induced e.m.f in the frame. Therefore, amplitude of e.m.f decreases.

(ii) Explain, how your graph in Fig. 7.2 will change, if any, when the metal rod AB and the wire ASTB are now inside the magnetic field.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

Solution:

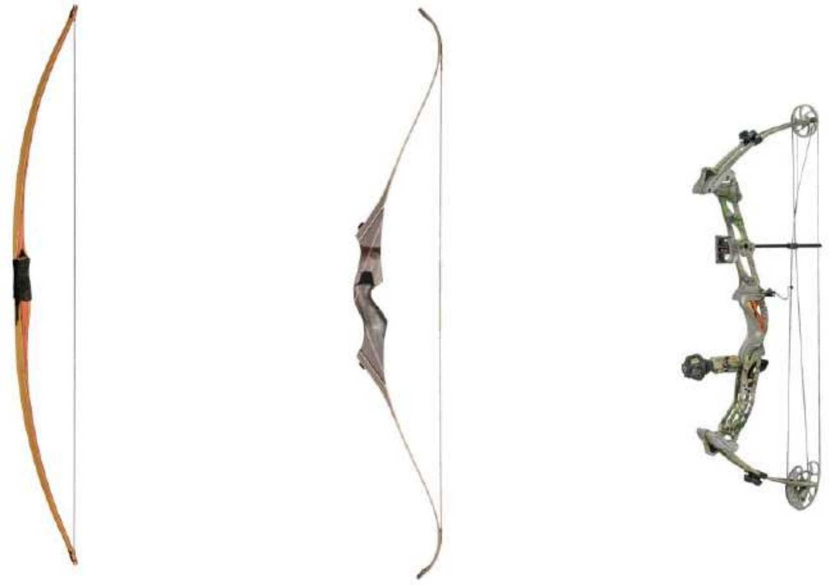
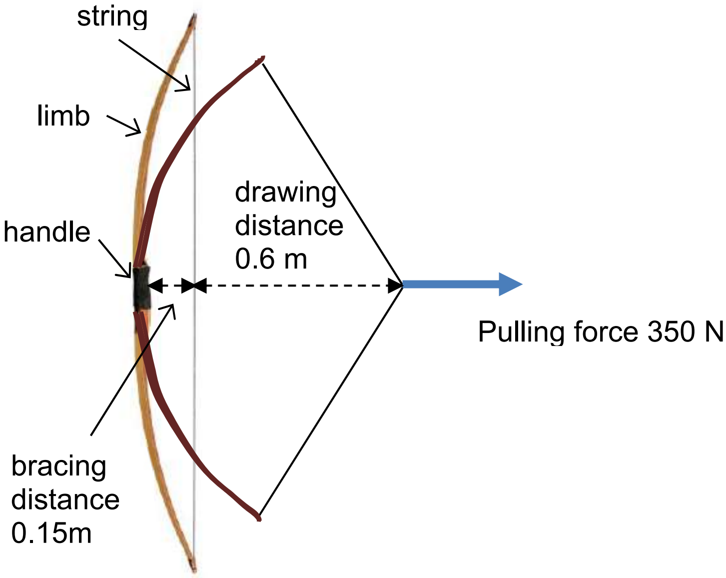
Case 1 (considering the whole loop)

The oscillation will be undamped and the amplitude will be unchanged because there is no e.m.f. induced in the frame and there will be no current in the loop and there is no

			electromagnetic damping. OR There is no change in the magnetic flux linkage, thus there is no emf induced. Thus, the graph is a straight horizontal line, cutting the emf = 0. *Case 2 (considering ST)* Net emf induced is zero, therefore no current within rod ST, thus, no damping force. The graph drawn in Fig 7.2 remains the same.	

8	**(a)**	**(i)**	State what is meant by the *photoelectric effect.*	
			…………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………	[1]
			Photoelectric effect is a phenomenon in which electrons are emitted from the surface of a metal when it is irradiated with electromagnetic radiation of high enough frequency.	
		(ii)	Describe the principal features that are observed in the photoelectric effect that support the particulate nature of electromagnetic radiation.	
			…………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………	[3]
			<u>Experimental observations which support the particulate nature of em radiation are</u> 1. There is a minimum frequency below which no photoelectric emission of electrons is possible, even with very intense radiation. 2. The maximum KE of the emitted electrons increases with the frequency of the radiation. The max KE does not depend on the intensity of the radiation. 3. Photoelectrons are emitted almost immediately when radiation was incident; no time lag was observed. 4. The rate of emission of photoelectrons is proportional to the intensity of the incident radiation. Max three marks.	
	(b)		A low pressure sodium lamp produces an intensity of 0.2 W m^{-2} of yellow light of frequency 4.55 x 10^{14} Hz at a distance of 5.0 m from the lamp.	
		(i)	Assuming that the lamp acts a point source, show that the intensity a distance 20 m from the lamp is 0.013 W m^{-2}.	

				[1]
			Solutions For a point source of constant power, intensity is inversely proportional to the distance from the source, i.e. $I \propto 1/r^2$ $I'/I = (1/r'^2)/(1/r^2) = (r/r')^2$ $I'/0.20 = (5/20)^2$ $I' = 0.013\ W\ m^{-2}$	
		(ii)	Estimate the number of photons per second that would strike a piece of A4 size paper which is held 20 m perpendicular to the light from the lamp. number of photons per second = …………………… s^{-1}	[3]
			Solutions Energy of each photon = hf $= 6.63 \times 10^{-34} \times 4.55 \times 10^{14}$ $= 3.02 \times 10^{-19}$ J Estimate area of writing paper = $0.15 \times 0.30\ m^2$ Intensity = E / t A = Nhf / t A = (N/t) hf / A $0.013 = (N/t)\ 3.02 \times 10^{-19}\ J / 0.15 \times 0.30$ $N/t = 1.94 \times 10^{15}$	

9	The bow is a powerful two-arm string machine used for archery. Figure. 9.1 shows the three types of bows, namely the Longbow, the Recurved and the Compound bow.  Longbow Recurved bow Compound bow. **Fig. 9.1**	
	Each bow consists of a limb, a handle and a as shown in Fig.9.2. The distance between the string and the bow handle at rest is known as the bracing distance. When a bow is drawn by the fingers of the archer, the string is not stretched but the shape of the bow is changed and bent and the string is displaced by a drawing distance. The shaft of the arrow is rested on the handle and the tail of the arrow is rested on the middle of the string.  	
	Fig. 9.2	
	In a Longbow, if we suppose that the bow is initially unstressed and the string is almost slack, then the archer starts to draw his arrow with a pulling force which is nearly zero and the pulling force increases with the drawing distance. The energy stored in the bow is equal to the work done in drawing back the string. In practice, a typical archer can draw an arrow back about 0.6 m and with a maximum force of about 350 N as shown in Fig. 9.3.	

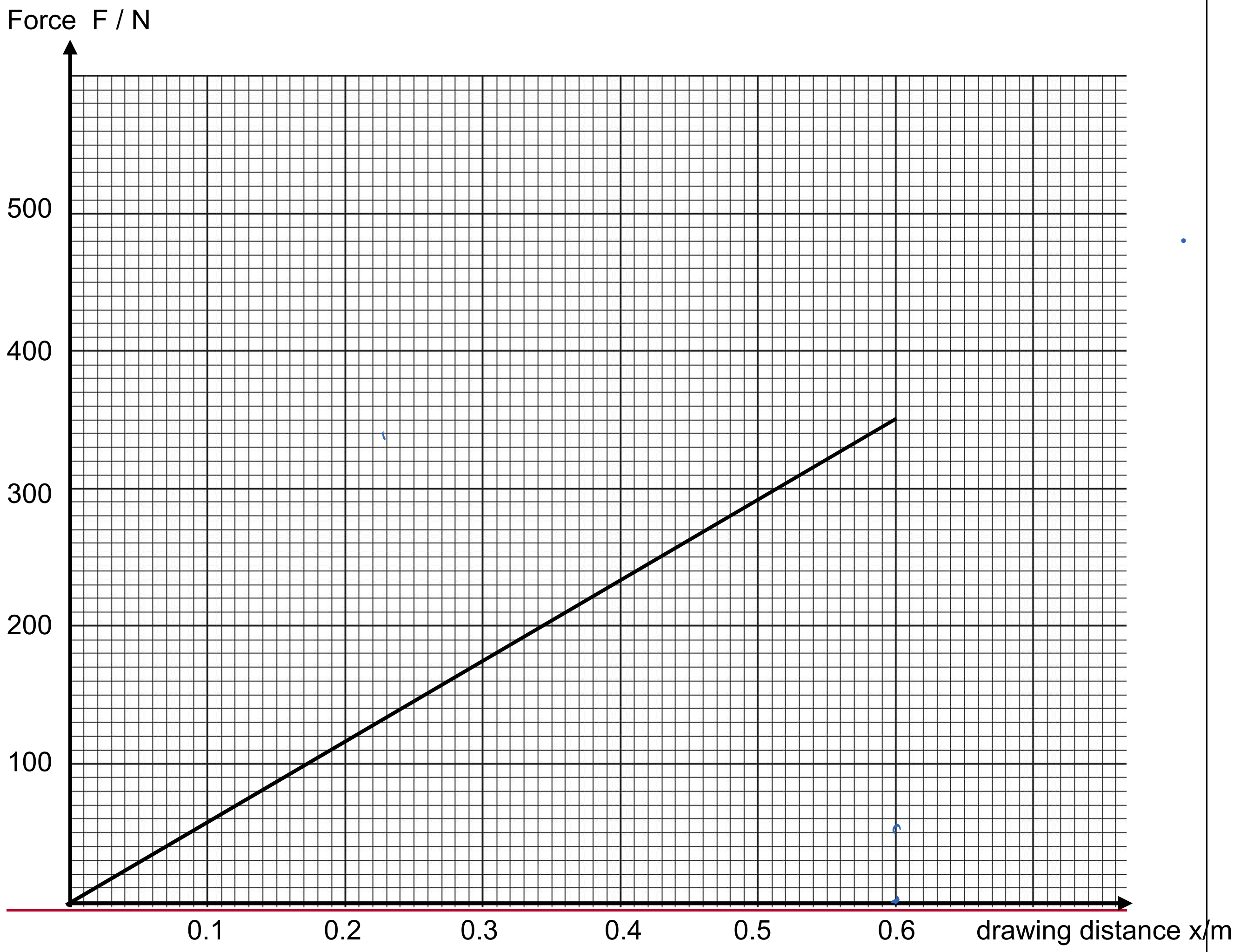


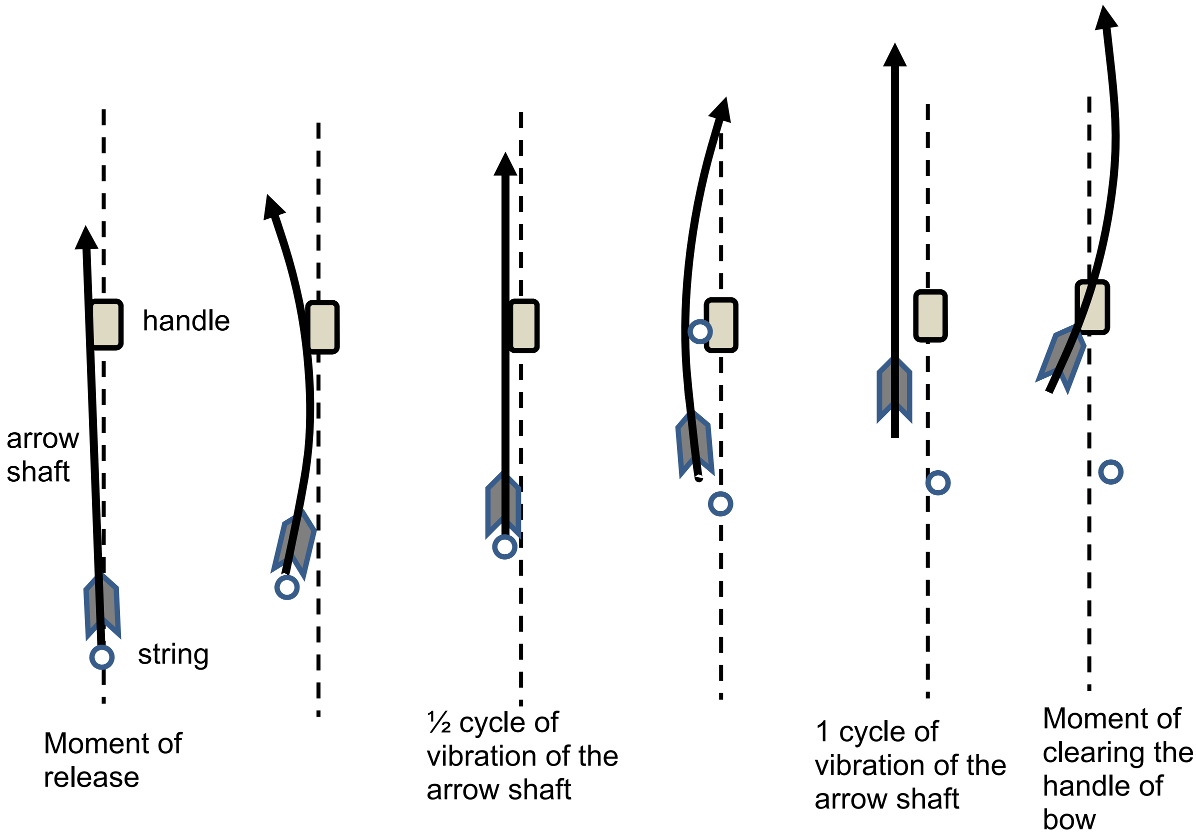
Fig. 9.3

The efficiency of the bow, η, can be defined as

$$\eta = \frac{\text{kinetic energy of the arrow}}{\text{elastic potential energy stored in the bow.}}$$

When an arrow is shot, the force due to the tension in the string accelerates the arrow. A larger part of the energy stored in the bow is transferred to the arrow. Since this transferred energy is converted into the kinetic energy of the arrow ½ mv^2 (where v is the speed of the arrow as it leaves the bow), the increase in the length and therefore the mass of the arrow has two opposing effects: an increase in efficiency but a decrease in speed.

When a bow string is released, the string exerts a forward force on the arrow and causes it to accelerate forward. At the same time, there is a sudden compressive force along the length of the arrow causes it to buckle. Hence the arrow will undergo **lateral vibrations** as it accelerates forwards. Fig. 9.4 shows the view from above the arrow leaving bow (not to scale)



Top view of the arrow

Fig. 9.4

Both the frequency and the amplitude of these vibrations must be matched to the bow if the arrow is to avoid hitting the side of the handle during its discharge. Ideally the arrow will make 1¼ vibrations from the moment of release until it finally clears the handle of the bow.

A Recurved bow is one in which the end of each limb curve away from the archer such that the limbs are braced with a bracing distance. The archer must start his pull with a non-zero force which is about 1/3 of the maximum force. When using a Recurved bow, the average force will be higher as compared to a Longbow without bracing.

In a Compound bow, which utilizes levers, the drawing force increases and decreases with the drawing distance as shown in Fig.9.5.

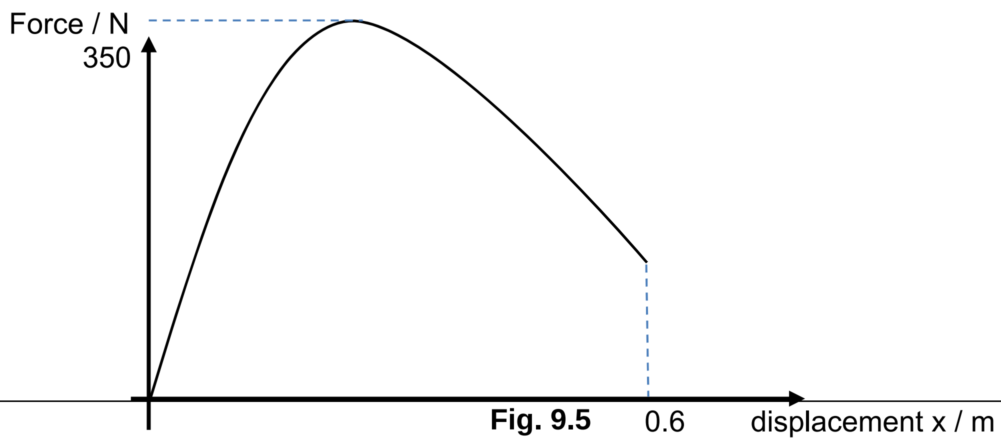


Fig. 9.5

(a) Explain what is meant by *lateral vibrations*.

………………………………………………………………………………………………………

……………………………………………………………………………………………………… [1]

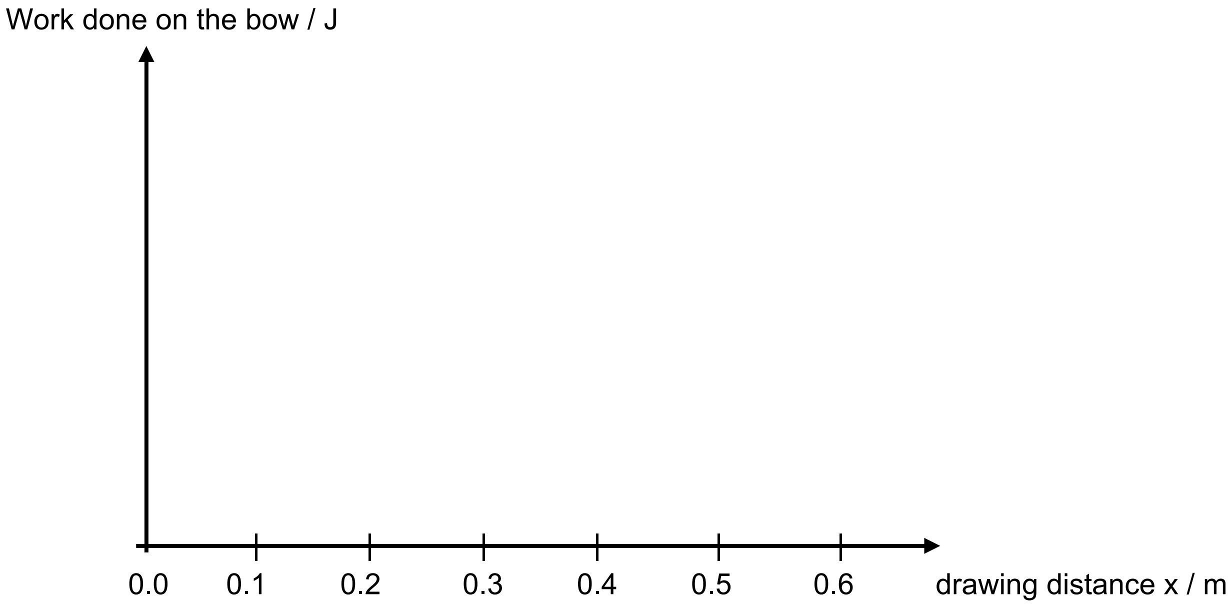
Solution:
Periodic to and fro motion of a segment of the arrow from its position before release in a direction perpendicular to the motion of arrow/ limb of the bow/ left-right

(b) Use the graph in Fig. 9.3 to calculate the energy stored in the Longbow when the maximum pulling force of 350 N is exerted on the string.

energy stored = ……………………………….J [2]

Energy stored
= area under the force-displacement graph
= ½ (350)(0.6)
= 105 J

(c) On Fig. 9.6, sketch a graph to show how the work done on the Longbow changes with the drawing distance of the string. Label the work done axis clearly.



[2]

Fig. 9.6

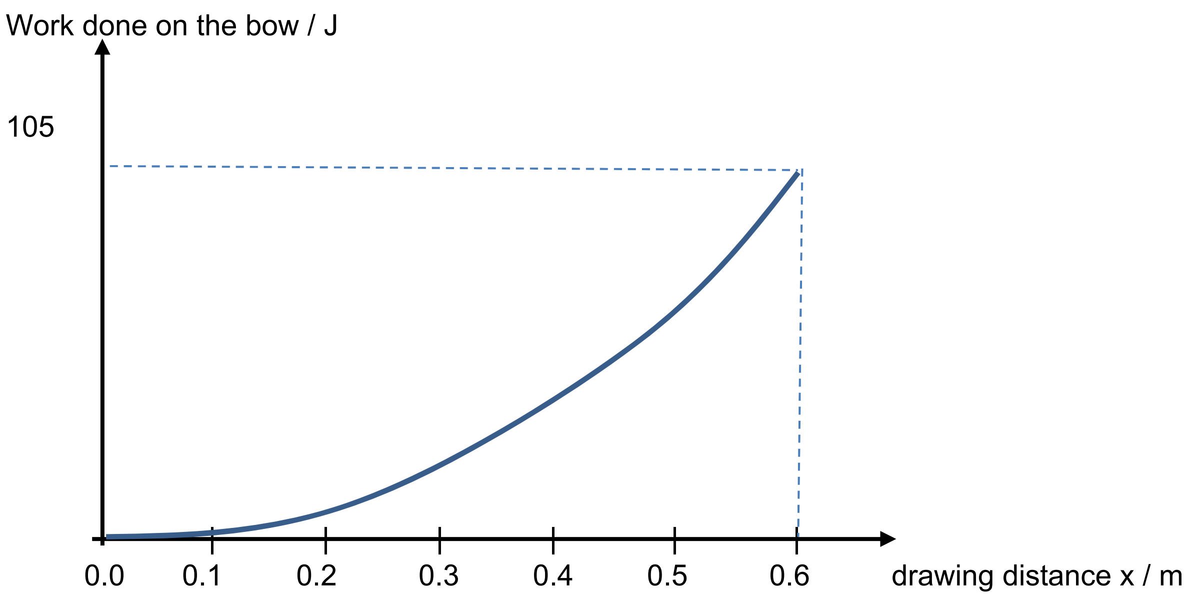


Fig. 9.6

Curve line from 0 J to 105 J when x changes from 0 to 0.6 m
Zero gradient at x = 0 and increasing gradient

(d) It is thought that the efficiency η of the bow obeys a relation of the form

$$\eta = \frac{m}{m + k}$$

where m is the mass of the arrow and
k is a constant depending on the mass of the bow.

A student performed an experiment to investigate how η, the efficiency of the bow varies with m, the mass of the arrow. He obtained data which allows him to plot the graph of Fig. 9.7.

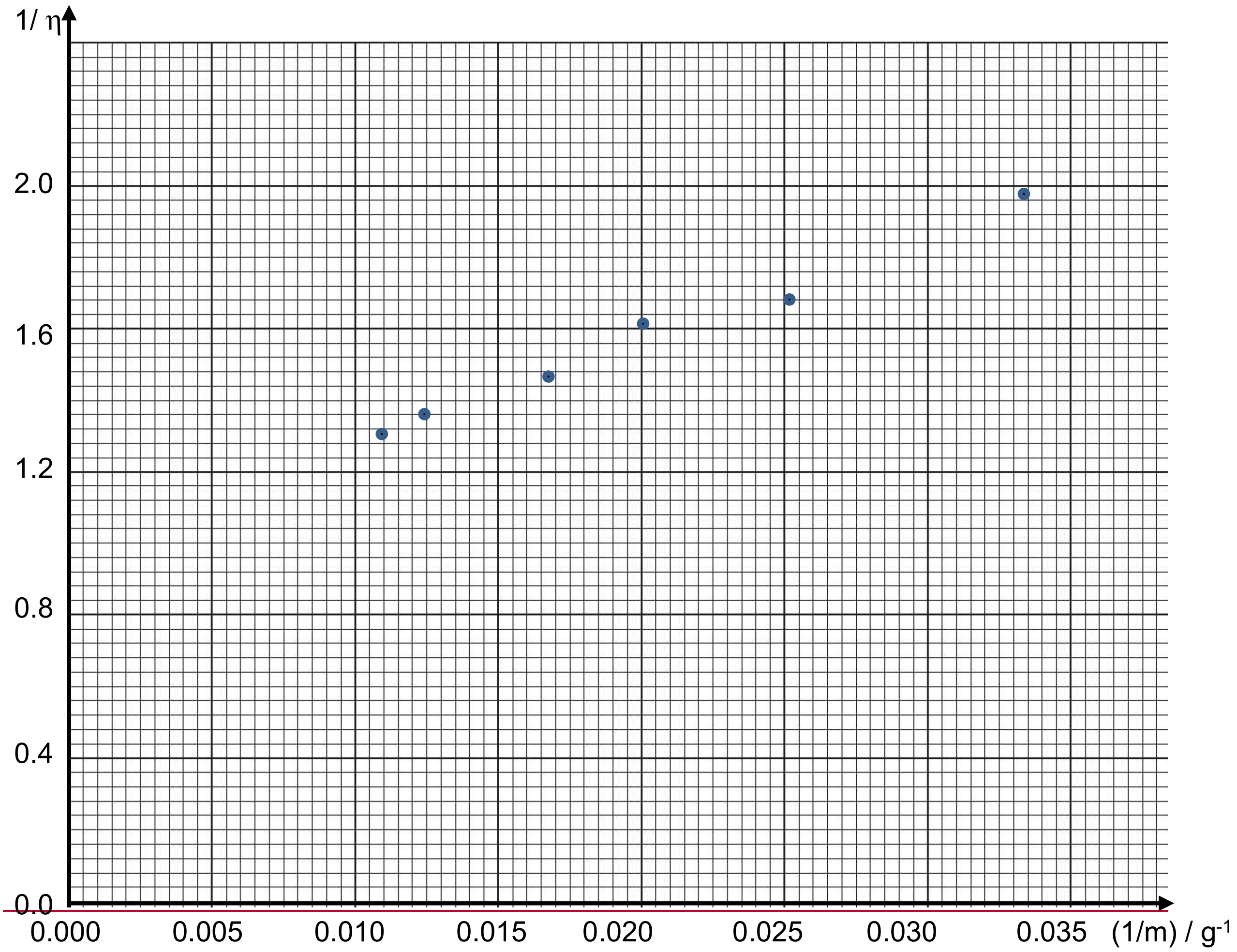
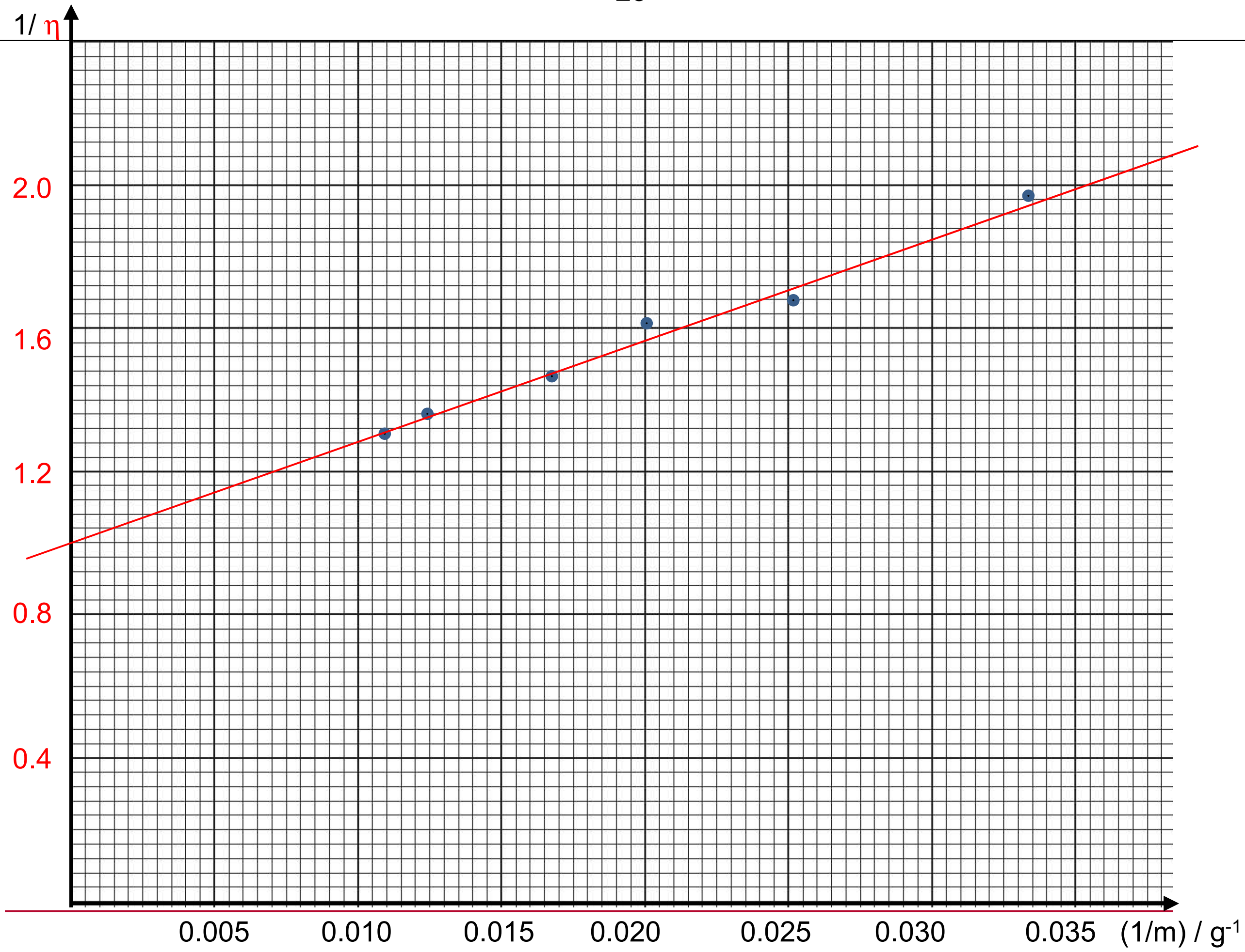


Fig. 9.7

(i) Draw the line of best fit for the points [1]



(ii) Explain whether the relation in **(d)** is valid using the line drawn in Fig. 9.7.

....

....

....

....

.... [3]

From η = m / (m + k)

1/η = (m + k)/ m = 1 + k/m

If the graph of 1/η against 1/m is a straight line with y-intercept equal to 1

Since the graph is a straight line with a y-intercept equal to 1, the relation is tested correct

(iii) Use the line drawn in Fig. 9.7 to determine the magnitude of the constant k in the expression in (d).

[2]

k = gradient of the line

= 1.84 – 1.0 / 0.030 – 0 = 28 g

Calculate gradient correctly, read coordinate to ½ smallest grid

		(iv)	An arrow of mass 70 g is being shot from an initially unstressed Longbow drawn back as shown in Fig. 9.2. Use the graph in Fig. 9.7 and the definition of the efficiency to determine the speed of the arrow leaving the bow.	
			speed of the arrow = ……………………….m s^{-1}.	[3]
			Let m = 70 g , 1/m = 1/70 = 0.0143 From the graph 1/ η= 1.40 η = 0.714 η = KE/Energy stored = ½ m v^2 / E 0.714 = ½ (0.070)v^2 / 105 v = 46 m s^{-1}	
	(e)		Calculate the frequency of vibration for an arrow leaving the string at 50 m s^{-1}, from a bow of bracing distance of 0.15 m, and shot by an archer with a drawing distance 0.6 m, as shown in Fig. 9.2.	
			frequency of vibration = ………………………….. s^{-1}	[2]
			time to clear handle = (0.15 +0.60)/ 50 = 0.015 s 1 ¼ T = 0.0150 s T = 0.012 s f = 1/T = 1/0.0120 = 83 s^{-1}	
	(f)	(i)	On Fig. 9.3, sketch the force-drawing distance graph for a Recurved bow which is already braced to 150 N. The maximum drawing force of 350 N is exerted on the string at the maximum drawing displacement of 0.6 m.	[1]

Straight line from F = 150 N to F = 350 N

(ii) State and explain, in terms of the energy stored, why the Recurved bow is better than a Longbow.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

Energy stored = ½ (350 + 150) x 0.6 = 150 N

This is greater than that of the Longbow. Hence the arrow can travel at greater speed and further.

(g) Refer to the force-displacement graph of a Compound bow as shown in Fig. 1.5. Suggest an advantage of a compound bow as compared to the Longbow.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

As compared to the fully drawn Longbow at same max drawing force (350 N) at the drawing distance of 0.6 N

1. It can store more energy for a fully drawn bow.
2. It allows the archer to hold and aim a fully drawn bow without as much strain or fatigue since the drawing force at the fully drawn distance is smaller.

-- END OF PAPER –

Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME: **MARK SCHEME**

CLASS: **2T**

PHYSICS
9749/03

Paper 3

2 hours

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name and class on the first page of **both** of Section A and Section B.
Write in dark blue or black pen in the space provided. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in **Section A**, and **ONE** out of **two** questions in **Section B.**
Circle the **question number attempted in Section B** in the summary table below.

FOR EXAMINER'S USE		DIFFICULTY		
		L1	L2	L3
Q1	/13			
Q2	/8			
Q3	/7			
Q4	/9			
Q5	/10			
Q6	/13			
Q7	/ 20			
Q8	/ 20			
TOTAL PAPER 3	/ 80			
TOTAL PAPER 1	/ 30			
TOTAL PAPER 2	/ 80			
TOTAL	/190			

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T / K	=	$T / {}^{\circ}C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in the spaces provided

1 A construction worker on the roof of a hemispherical dome releases a wrench at the highest point A with negligible speed as shown in Fig 1.1. The radius R of the dome is 30.0 m. The surface of the dome's roof is smooth. At a certain point B, the wrench just loses contact with the surface of the dome and falls with a projectile motion through the air, and finally hits the ground at point C.

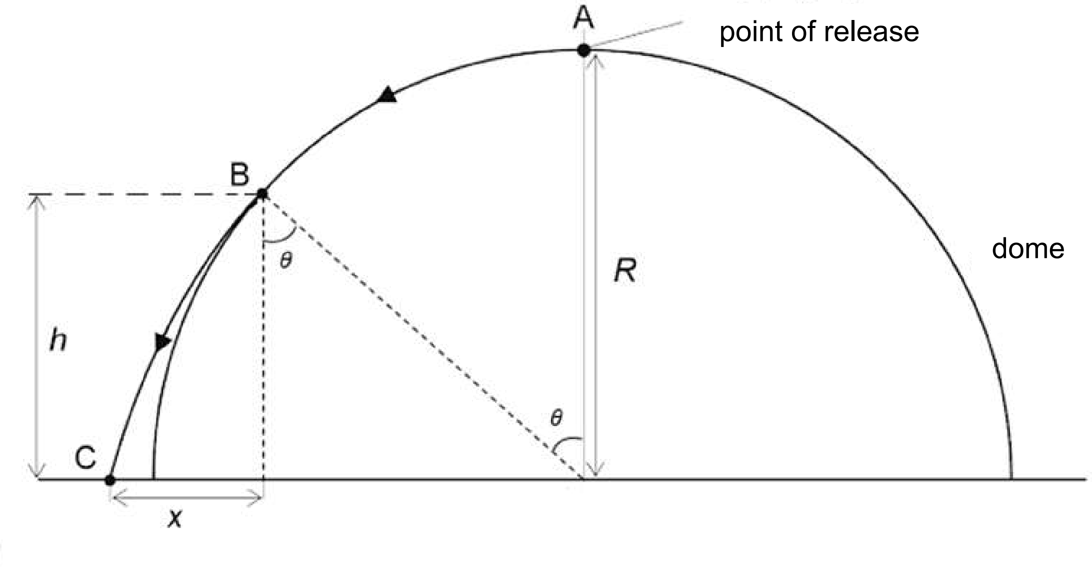


Fig 1.1

(a) (i) Explain why the centripetal acceleration of the wrench increases as it slides from A to B.

....

....

....

....

....

.... [2]

As the wrench falls, it loses gravitational potential energy but it gains kinetic energy. Kinetic energy = ½ mass x square of speed, therefore its speed increases.

Centripetal acceleration is directly proportional to the square of the velocity and inversely proportional to the radius of the circular path, which in this case is the radius of the dome, and is constant.

Therefore, the centripetal acceleration of the wrench increases as it slides from A to B.

(ii) State the magnitude of the normal contact force on the wrench at point B.

normal contact force = ...N [1]

N = 0

(b) By considering the forces contributing to the centripetal force on the wrench at point B, show that the vertical distance between B and C, h is

$$h = \frac{v^2}{g}$$

where v is the linear velocity of the wrench at point B and
g is the acceleration due to gravity. [3]

Since N = 0 when wrench loses contact with the surface,

$$mg\cos\theta = \frac{mv^2}{r}$$

$$mg\left(\frac{h}{R}\right) = \frac{mv^2}{R}$$

$$h = \frac{v^2}{g}$$

(c) **(i)** At the point of losing contact with the surface of the dome, h is related to R by $h = \frac{2R}{3}$.

Use this relation and the relation in **(b)** to calculate for the wrench at the point of losing,

1. its speed and
2. its direction of motion with respect to the horizontal.

speed = ... m s^{-1}

direction from the horizontal = ...° [2]

$v^2 = hg$

$v^2 = \frac{2}{3}(30.0)(9.81)$

$v = 14.0\ m\ s^{-1}$

We also have,

$$\cos\theta = \frac{h}{R}$$

$$\cos\theta = \frac{\frac{2}{3}R}{R} = \frac{2}{3}$$

$\theta = 48.2°$

(ii) Using the equations of motion, determine the time taken for the wrench to fall from point B to C. Air resistance is assumed to be negligible.

time taken = ... s [3]

Considering vertical components and taking vectors downwards as positive,

$$s_y = u_y t + \frac{1}{2} g t^2$$

$$h = \frac{2}{3} R = (v \sin\theta) t + \frac{1}{2}(9.81) t^2$$

$$h = \frac{2}{3} R = (14.0 \sin(48.2)) t + \frac{1}{2}(9.81) t^2$$

$$\frac{2}{3}(30.0) = (14.0 \sin(48.2)) t + \frac{1}{2}(9.81) t^2$$

$$20.0 = (10.44) t + \frac{1}{2}(9.81) t^2$$

$$t = 1.22 \text{ s}$$

(iii) Hence determine *x*, the horizontal distance between points B and C.

horizontal distance, *x* = ... m [2]

$$s_x = u_x t + \frac{1}{2} a_x t^2$$

$$s_x = v \cos\theta (t)$$

$$s_x = 14(\frac{2}{3})(1.22)$$

$$x = 11.4 \text{ m}$$

2 In a diesel engine, a fixed amount of gas undergoes a cycle of four stages. The cycle is shown in Fig. 2.1.

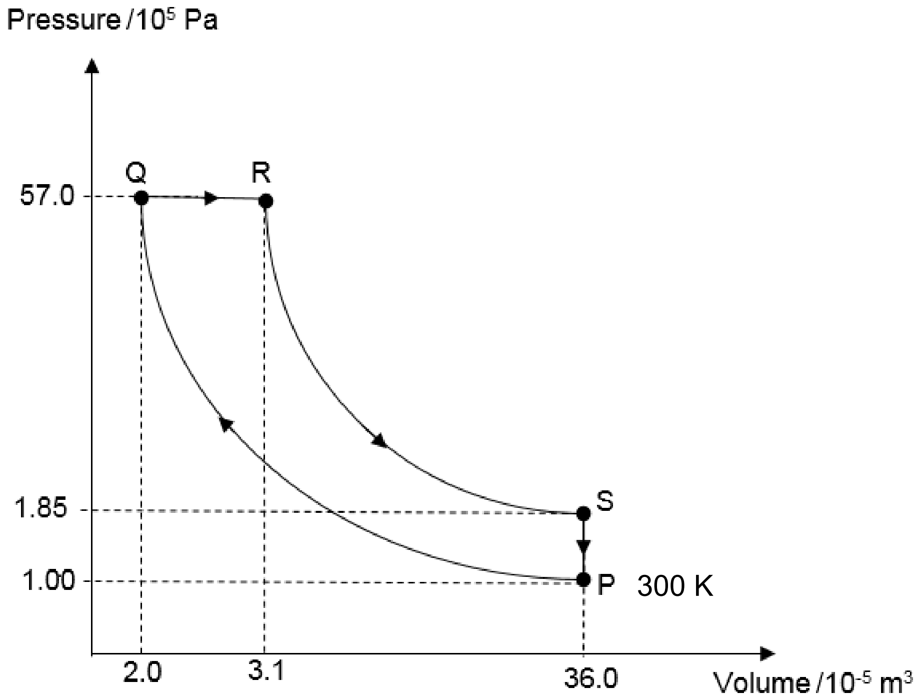


Fig.2.1 (not to scale)

The four stages are

P → Q : compression with a rise in temperature and pressure,
Q → R : expansion at constant pressure while fuel is being burnt,
R → S : expansion with a drop in both temperature and pressure,
S → P : decrease in pressure at constant volume.

Some numerical values of temperature, pressure and volume are given on Fig. 2.1.

(a) Using Fig. 2.1, calculate the work done by the gas during the stages

(i) Q → R,

work done = ……………….J [1]

Solution:

$W = p\,\Delta V = 57.0 \times 10^5 \text{ Pa} \times (3.1 - 2.0) \times 10^{-5} \text{ m}^{-3}$
$= 62.7 \text{ J}$

(ii) S → P.

work done = ……………….J [1]

Solution:
W = **0** J

(b) Using your answers in **(a)**, complete Fig. 2.2 for the four stages of the cycle.

Stage of cycle	heat supplied to gas /J	work done on gas /J	increase in internal energy of the system /J
P → Q	0	235	
Q → R	246		
R → S	0	–333	
S → P			

[4]

Fig. 2.2

Solution:

Stage of cycle	heat supplied to gas /J	work done on gas /J	increase in internal energy of the system /J
P → Q	0	235	**ΔU = Q + W = 0 + 235 = 235 [A]**
Q → R	246	**–62.7 [B] Since it is work done ON gas, put a negative sign.**	**ΔU = Q + W = 246 – 62.7 = 183 [A]**
R → S	0	–333	**ΔU = Q + W = 0 – 333 = – 333 [A]**
S → P	**ΔU = Q + W -85 = Q Q = –85 [A]**	**No change in vol→ no work done 0 [C]**	**ΔU = 0 235 + 183 – 333 + $\Delta U_{S\to P}$ = 0 $\Delta U_{S\to P}$ = –85 [D]**

[A] (application of first law equation – mark by merit),
[B] (insertion of negative sign),
[C] (identifying work done is 0),
[D] (ΔU = 0)

	(c)		Assuming that the gas is ideal, calculate the temperature of the gas at point Q.	
			temperature = ………………… K	[2]
			Solution: $$\frac{P_P V_P}{T_P} = \frac{P_Q V_Q}{T_Q}$$ $$T_Q = \frac{P_Q V_Q T_P}{P_P V_P} = \frac{(57.0\times10^5)(2.0\times10^{-5})(300)}{(1.00\times10^5)(36.0\times10^{-5})}$$ $$= 950\ K$$	

3 The variation with displacement of the acceleration of an animal's eardrum is shown in Fig. 3.1.

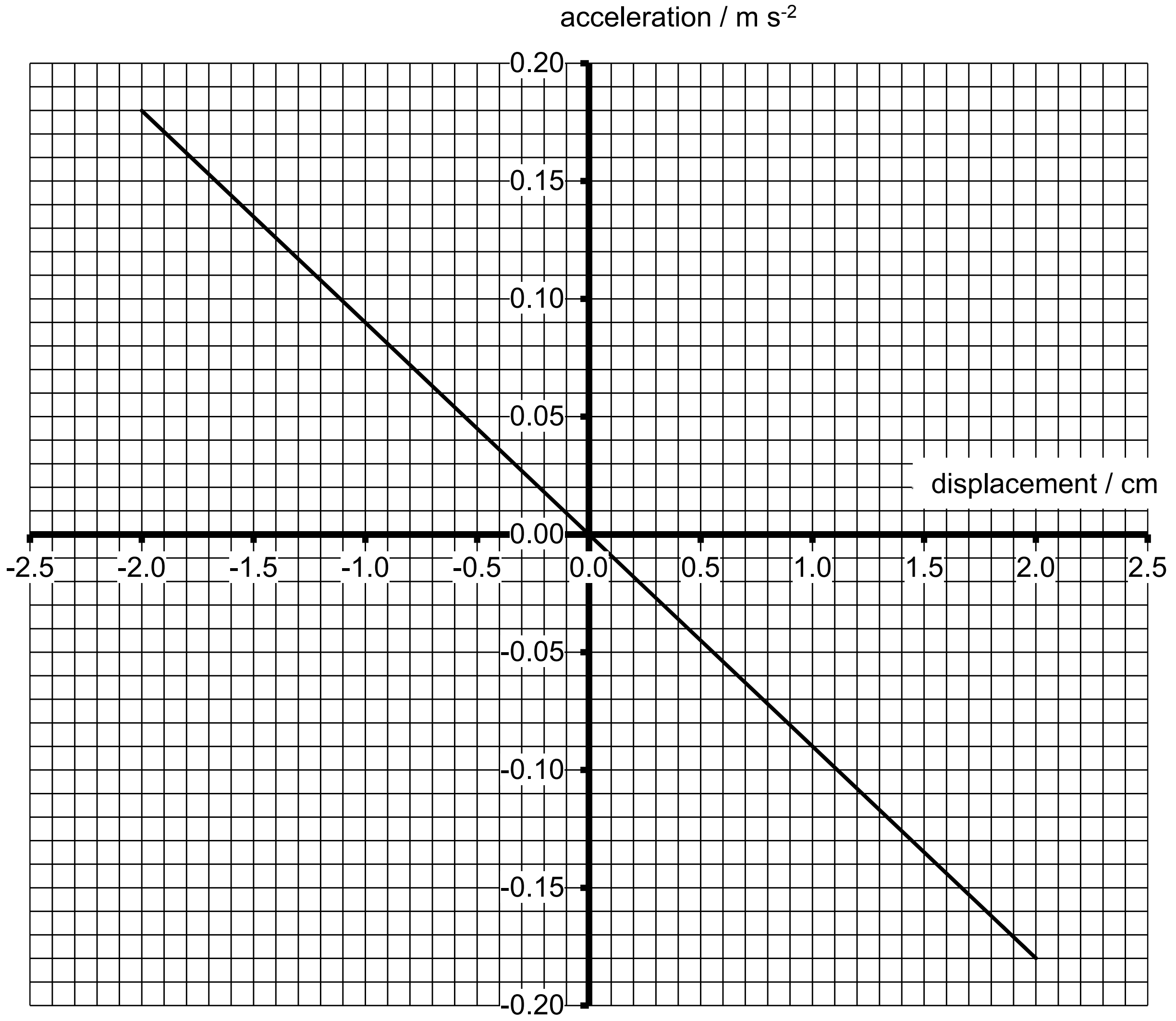


Fig. 3.1

(a)	Explain how Fig. 3.1 shows that the motion of the eardrum is simple harmonic.	
	…………………………………………………………………………………………………	
	…………………………………………………………………………………………………	

		....	[2]
		Solution: The graph is a **straight line passing through the origin** which shows that the acceleration is directly proportional to the displacement. The straight line has a **negative gradient** which shows that direction of acceleration is always opposite to the direction of displacement.	**B1** **B1**
	(b)	The period of the oscillation is 2.10 s. Calculate the time taken for the eardrum to travel a distance of 0.50 cm starting from its maximum displacement towards the equilibrium point.	
		time taken = ... s	[3]
		Solution: When the eardrum travels a distance of 0.50 cm from max displacement, its displacement will be 1.50 cm from equilibrium position. $x = x_0 \cos(\omega t)$ $1.50 = 2.00 \cos(\frac{2\pi}{2.10} t)$ $t = 0.242$ s	
	(c)	The mass of the eardrum is 100 g. Show that the potential energy of the eardrum is 2.5 × 10^{-5} J when its displacement is 0.75 cm.	[2]
		Solution: Total energy = Maximum kinetic energy $= \frac{1}{2} m v_{max}^2 = \frac{1}{2} m \omega^2 x_0^2$	

Potential energy $= Total\ energy - Kinetic\ energy$

$$= \frac{1}{2}m\omega^2 x_0^2 - \frac{1}{2}m\omega^2 (x_0^2 - x^2)$$

$$= \frac{1}{2}m\omega^2 x^2$$

$$= \frac{1}{2} \times 0.100 \times (\frac{2\pi}{2.10})^2 \times (0.75 \times 10^{-2})^2$$

$$= 2.5 \times 10^{-5}\ J$$

4 A length of wire is held taut between two points M and P as shown in Fig. 4.1. A signal generator which produces an alternating current of variable frequency is passed through the wire and a pair of magnets is placed on either side of the wire.

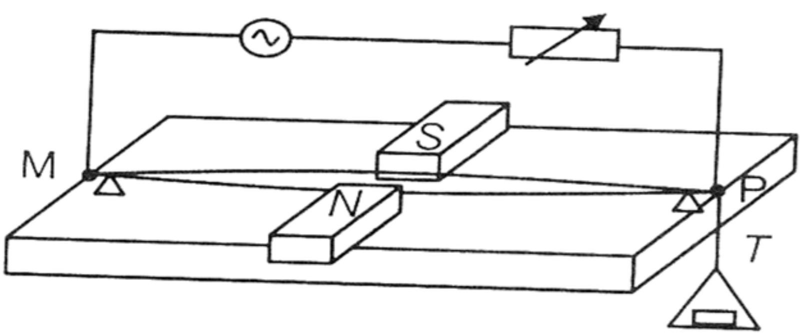


Fig. 4.1

The frequency of the alternating current is gradually increased from zero. A stationary wave is set up as shown in Fig. 4.1 when the frequency is 10 Hz.

(a) Explain how the stationary wave is formed on the wire when an alternating current is passed through it.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [4]

L3 Solution:

The current carrying wire **experiences a magnetic force in the vertical plane** as given by Fleming's Left Hand Rule.

Since the current is alternating and changes direction, the **direction of force alternates and causes the wire to vibrate.**

The vibration will cause **progressive waves travelling towards P & M and the reflected waves will superpose.**

Resonance occurs and a stationary wave will be formed when the **frequency of the periodic magnetic force (due to the sinusoidal current) matches the natural frequency of the stationary waves in the string.**

(b) The distance between M and P is 0.60 m.

Calculate the wavelength of the stationary wave formed.

wavelength = ……………………………..m [1]

Solution:

$0.6 = \frac{\lambda}{2}$

$\lambda = 1.20$ m

(c) Determine the speed of the wave.

speed = ……………………….. m s^{-1} [2]

Solution:

$v = f\lambda = (10)1.20$

$= 12.0$ m s^{-1}

(d) Sketch the stationary wave formed in the space below when the frequency of the alternating current is adjusted to 30 Hz.

[2]

Solution:

Correctly drawn stationary wave with 3 antinodes and 4 nodes, with 2 of the nodes at M and P.

(Three loops with nodes at the ends with equal distance between adjacent nodes)

Reason:

Same tension, speed is the same

Determine new wavelength when freq is increased to 30 Hz.

$\lambda = \frac{v}{f} = \frac{12}{30} = 0.4\ m$

Number of wavelengths formed = 0.6/0.4 = 1.5

There will be 3 loops formed.

5 **(a)** A particle of mass *m*, carrying a negative charge - q and travelling at speed *v*, enters a region of uniform magnetic field of flux density *B* directed at right angles to the motion of the particle as shown in Fig. 5.1.

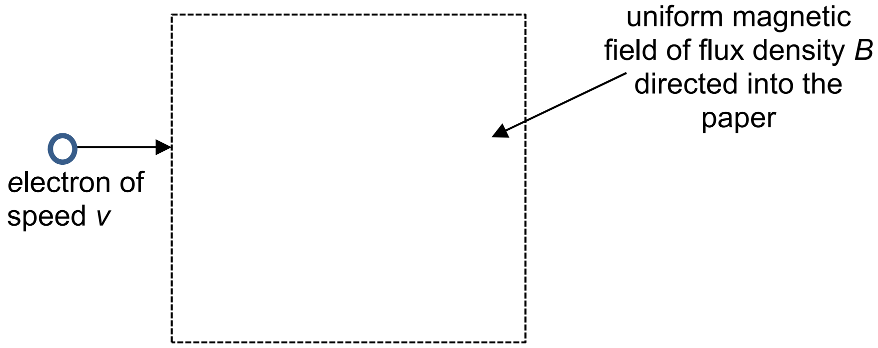


Fig. 5.1

(i) State the expression for the magnitude of the force *F* acting on the particle and the direction of the force.

F = ...

Direction = ... [2]

F = *Bqv*

And

Direction downwards

(ii) Explain why the path of the electron is circular.

....

....

....

.... [3]

Magnetic force is perpendicular to the motion hence the kinetic energy of the particle is unchanged.

Since K.E. is proportional to the square of the speed and mass.

Hence its speed and the magnetic force it experiences is unchanged

Since F = Bqv, the magnetic force is constant.

Hence the path is circular

(b) The diagram in Fig. 5.2 shows a type of cathode ray tube containing a small quantity of gas. Electrons from a hot cathode emerge from a small hole in the conical shaped anode, and the path subsequently followed is made visible by the gas in the tube.

The accelerating voltage is 5.0 kV.

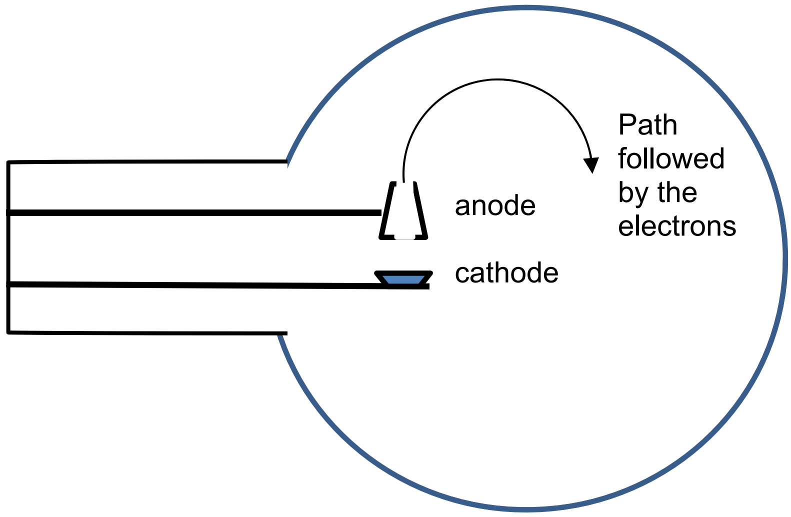


Fig. 5.2

(i) Calculate the speed of the electrons as they emerge from the anode.

speed = ……………………m s^{-1} [2]

Work done on electron = gain in K.E

$qV = \frac{1}{2} m v^2$

$v = \sqrt{2qV / m}$

$= \sqrt{2(1.6 \times 10^{-19})(5000) / 9.11 \times 10^{-31}} = 4.19 \times 10^7$ m s^{-1}

(ii) The apparatus is situated in a uniform magnetic field acting into the plane of the paper.

1. Calculate the radius of the circular path for a flux density of 2.0×10^{-3} T.

radius = …………………… m [2]

The magnetic force provides the centripetal force

$Bqv = mv^2/r$

$r = mv / Bq$

$= 9.11 \times 10^{-31} \times 4.19 \times 10^7 / 2.0 \times 10^{-3} \times 1.6 \times 10^{-19}$

$= 0.12$ m

2. Suggest how the gas in the tube might make the path of the electrons visible.

……

…… [1]

Condensation of the vapour/alcohol in the tube occurs and this forms a visible track along the trails of the charged particles (β-particles or α-particles or gamma ray photons). When the charged particles collide electrostatically with the gas atoms, they are ionized and the ions cause condensation of the vapour.

6 **(a)** In 1919, Rutherford performed the first nuclear reaction induced in a laboratory in which a stationary nitrogen nucleus $^{14}_{7}N$ bombarded with an α-particle of a certain energy, transmutes to an oxygen nucleus $^{17}_{8}O$ and a proton.

Data:

mass of $^{14}_{7}N$ = 13.9993 u;

mass of $^{17}_{8}O$ = 16.9947 u;

mass of a proton = 1.0073 u;

mass of an α-particle = 4.0015 u.

(i) Write an equation for this nuclear reaction, showing the mass numbers and the atomic numbers of the particles involved.

[2]

$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$.

Symbol, mass number and atomic number of alpha particle
Symbol, mass number and atomic number of proton
Correct representation of nuclear equation

(ii) Calculate the minimum kinetic energy of the alpha particle for the reaction to make this reaction occur.

kinetic energy = ……………………………J [3]

Solutions

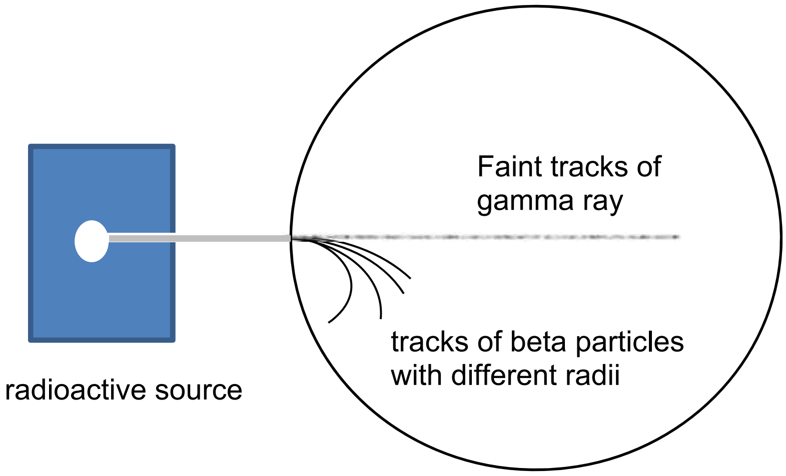
Sum of the masses of $^{14}_{7}N$ and an α-particle
= 13.9993 u + 4.0015 u
= 18.0008 u

Sum of the masses of $^{17}_{8}O$ and proton
= 16.9947 u + 1.0073 u
= 18.0020 u

increase in mass
= 18.0020 u - 18.0008 u
= 0.0012 u

The minimum energy is to be supplied to the reactants in the form of kinetic energy of the α-particle

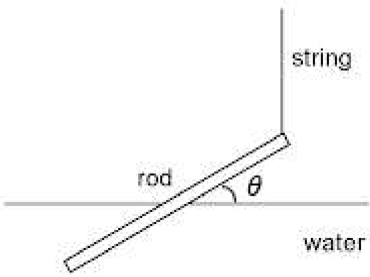
The kinetic energy of the alpha particle
= mass increase x c^2
= 0.0012 u x c^2
= 0.0012 x 1.66 x 10^{-27} x $(3 \times 10^8)^2$
= 1.79 x 10^{-13} J

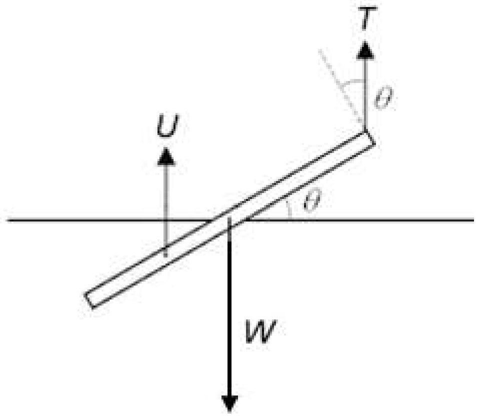
	(b)	A radioactive isotope of thallium $^{207}_{81}Tl$ emits a β-particle and is thought to emit a gamma photon. The half-life of $^{207}_{81}Tl$ is 135 days.		
		(i)	The radiation is allowed to pass though perpendicularly a vertical uniform magnetic field and the photographs of traces is obtained in a cloud chamber under certain conditions. Fig 6.1 show tracks produced by the beta-particles and gamma ray photons.  Top view of cloud chamber **Fig. 6.1** Explain the features of the tracks.	
			…………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………	[3]
			Circular paths of small radii show that beta particles are present and that beta particles are charged. Circular paths of different radii show that the beta particles have different speed and hence different kinetic energy. The faint straight line path shows the presence of gamma ray photons which have no charge and not deflected by the magnetic field. The faint path shows that the gamma ray photon has much less ionization ability as compared to the beta particles. Max 3 marks	
		(ii)	An isotope of thallium $^{207}_{81}Tl$ emits a β-particle with an average energy of 2.4 x 10^{-13} J. Calculate	

			1. the total energy available from 1 g of thallium-207,	
			total energy = ………………J	[2]
			Solutions Energy available from 1 g of thallium-207 = number of thallium-207 atoms x 2.4 x 10^{-13} = (1/207) x 6.02 x 10^{23} x 2.4 x 10^{-13} = 6.98 x 10^{8} J	
			2. the initial rate at which the β-particles are emitted from 1 g of the freshly prepared isotope,	
			initial rate of emission = ……………………day^{-1}	[2]
			Solution: Initial rate of β-particle emission = activity of thallium = decay constant x number of thallium nuclei = (ln 2 / half-life) x number of thallium nuclei = (ln 2 /135) x (1/207) x 6.02 x 10^{23} = 1.493 x 10^{19} = 1.5 x 10^{19} day^{-1}	
			3. the initial power available from the beta particles emitted at the rate calculated in **b(ii)2**.	
			initial power =………………. W	[1]
			Solutions Initial power = initial rate x energy of a β-particle = 1.493 x 10^{19} / (24 x 60 x 60) x 2.4 x 10^{-13} = 41.5 W	

Section B

Answer **One** question from this section

7	A uniform wooden rod of weight 50 N and length 1.0 m is gently lowered into water. The upper end of the rod is attached to a light string. When the rod is in equilibrium, the string is vertical and exactly half of the rod is underwater as shown in Fig. 7.1. The rod makes an angle θ with the surface of the water.  **Fig. 7.1**			
	(a)	**(i)**	Explain why the string is vertical.	
			………………………………………………………………………………………… …………………………………………………………………………………………	[1]
		(ii)	On Fig. 7.1, draw the three forces tension T, upthrust U and the weight W acting on the rod.	[2]



Where

W is the weight of the rod and T is the tension on the string
U is the upthrust on the rod

(iii) By considering moments about the centre of gravity of the rod, show that *T* = 0.5 *U*. [2]

Taking moments about the centre of gravity of the rod,

$$U\cos\theta\left(\frac{0.5}{2}\right)=T\cos\theta\,(0.5)$$

$$0.5\,U=T$$

(iv) Calculate the magnitude of *T*. [2]

T = ……………….N

Balancing vertical forces,

$$T + U = W$$

Using,

$$0.5\,U = T$$

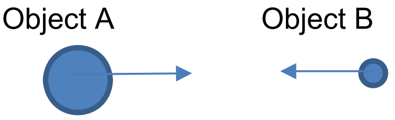
We have,

$$T + 2T = W$$
$$T = 16.7\ N$$

(v) By balancing the forces, determine the density of the wooden rod. The density of water is 1.0 x 10^3 kg m^{-3}.

density of rod = ……………………..kg m^{-3} [4]

Balancing vertical forces,

			$T + U = W$ $0.5\,U + U = W$ $U = \frac{2}{3}W$ $U = V_f \rho_f g$ Since volume of the rod, V_r is equal to the twice the volume of the fluid displaced, $2V_f$ $U = 0.5V_r\rho_f g$ $\frac{2U}{\rho_f g} = V_r$ We have, $W = V_r\rho_r g$ $W = \frac{2U}{\rho_f g}\rho_r g$ $W = \frac{4W}{3\rho_f g}\rho_r g$ $\rho_r = \frac{3(1000)}{4} = 750\ kg\ m^{-3}$	B1 B1
	(b)	**(i)**	State the principle of the conservation of momentum.	
			....	[1]
			The total linear momentum of a system will remain constant if no net external force acts on it.	A1
		(ii)	Object **A** of mass 1.2 kg collides head-on and elastically with object **B** of mass 0.60 kg moving with a speed 0.20 m s^{-1} towards it as shown in Fig. 7.2.  **Fig. 7.2** After the collision, object **B** moves off with a speed of 0.10 m s^{-1} opposite to its initial motion.	
			Calculate the initial speed of object **A**.	
			initial speed of **A** = ... m s^{-1}	[3]
			Taking vectors to the right as positive.	

Using conservation of linear momentum

$1.2u+0.6(-0.2)=1.2v+0.6(0.1)$

$1.2u=1.2v+0.18$----(1)

Using relative speed of approach = relative speed of separation:

$u+0.2=0.1-v$-----(2)

Solving (1) and (2)

u = 0.025 m s^{-1}

(c) A 80 kg astronaut is at a distance of 30 m from a space shuttle. He wishes to return to the space shuttle by means of a thruster. The thruster is attached to the body of the astronaut and it emits a stream of gas when it is turned on.

(i) State and explain the direction in which the gas has to be ejected for him to return to the space shuttle.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [3]

When the gas is ejected from the thruster, it gains a momentum. As a consequence, based on the conservation of momentum, the astronaut gains an equal and opposite momentum.

Hence the gas is to be ejected in the opposite direction to that in the direction of the space shuttle.

OR

The thruster exerts a force onto the gas.

By Newton's third law, the gas exerts an equal and opposite force on the thruster and the astronaut.

To allow the astronaut to move towards the space shuttle, the gas is to be ejected in the opposite direction to that in the direction of the space shuttle.

(ii) The gas is ejected at a constant rate of 0.5 kg s^{-1} and at a speed of 20 m s^{-1} relative to the astronaut for a period of 1.0 s.

Calculate the speed of the astronaut at the end of 1.0 s.

speed = ……………..m s^{-1} [2]

Based on the conservation of momentum,

$m\Delta u= M\Delta v$

$(0.5)(1)(20 – 0) = 80 (v – 0)$

v = 0.125 m s^{-1}

OR

			Magnitude of momentum of gas $F\Delta t = \Delta p$ $\frac{dp}{dt}\Delta t = m\Delta v$ $(0.5)(20)(1.0)=80(v-0)$ $v = 0.125 \text{ m s}^{-1}$	

8	**(a)**	A cell of electromotive force *E* and internal resistance *r* is connected to a resistor of resistance *R*.		
		(i)	Define *electromotive force*.	
			…………………………………………………………………………………………	[1]
			It is the energy transferred per unit charge from some form into electrical energy when charge is moved round a complete circuit. Alternate solution: The energy delivered by the cell per unit charge flow.	
		(ii)	Show, by considering energy conversion, that *V* the terminal potential difference of the cell is $$V = E - Ir$$ where *I* is the current flowing in the cell.	
				[2]
			Energy supplied by the cell = energy dissipated in the external and internal resistance Energy supplied by the cell per unit charge = energy dissipated in the external and internal e.m.f. of cell per unit charge = p.d across the external circuit + p.d across the internal resistance of the cell $E = V + V_r$ $E = V + Ir$ $V = E - Ir$	
	(b)		Fig. 8.1 shows a battery with e.m.f. *E* and an internal resistance *r* connected to a uniform nichrome resistance wire MN. J is a movable jockey which can slide along wire MN. The voltmeter and the ammeter are taken to be ideal.	

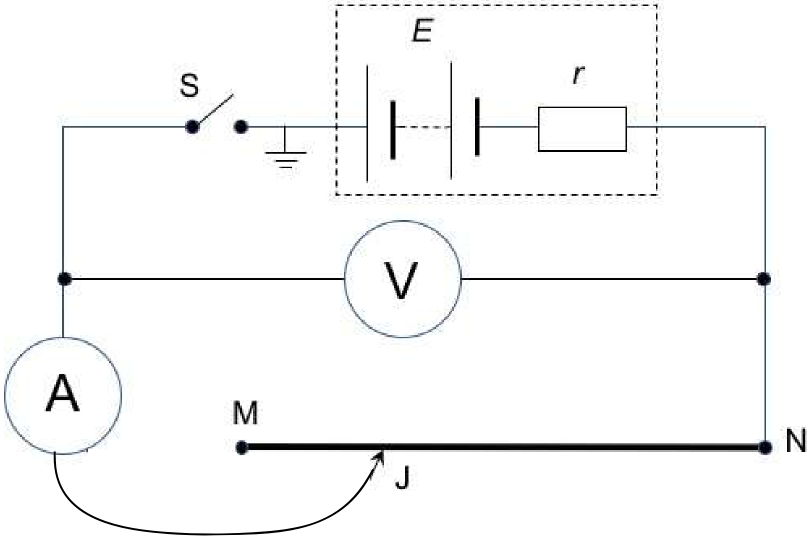


Fig. 8.1

The voltmeter readings V and ammeter readings I obtained for different lengths of JN are used to plot the graph in Fig. 8.2.

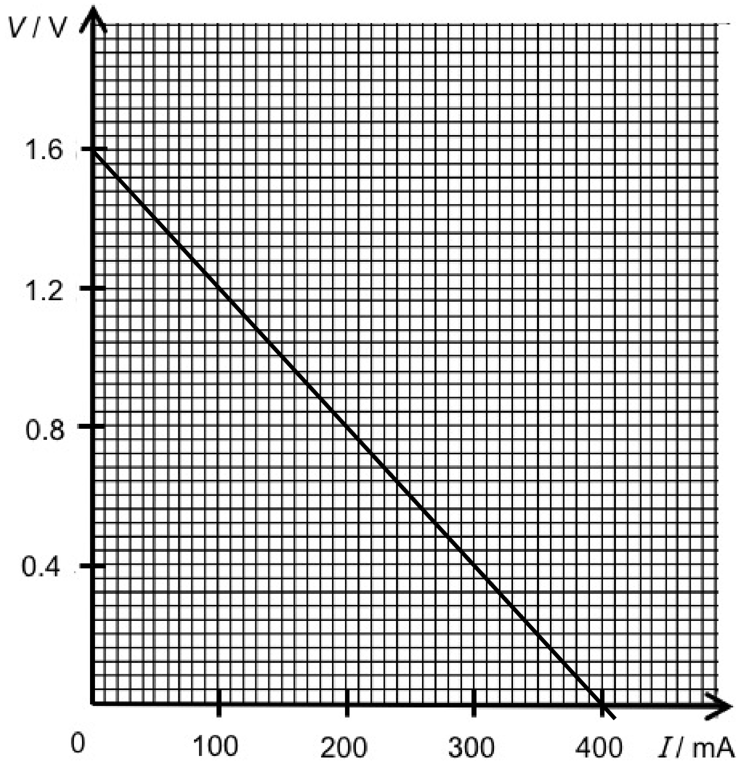


Fig. 8.2

(i) Deduce from Fig. 8.2 the e.m.f. E and the internal resistance r of the cell.

E = ………………. V

r = ………………. Ω [3]

Solution:

$V = E - Ir$

At (300, 0.4),

$0.4 = E - (300\times10^{-3})r$ - - - *(1)*

At (100, 1.2),

$1.2 = E - (100\times10^{-3})r$ - - - *(2)*

(2) – (1):

$$0.8 = (200\times10^{-3})r$$
$$r = 4\ \Omega$$

Sub into (2):

$$1.2 = E - (100\times10^{-3})(4)$$
$$E = 1.6\ \text{V}$$

(ii) J is placed at the position such that maximum power is delivered from the cell to the wire JN.

Determine the potential at J and N.

potential at J = ...V

potential at N = ...V [3]

Solution:

The emf is 1.6 V as calculated in b(i).

For maximum power to be delivered to JN, the resistance of JN must be the same as that of the internal resistance.

Hence the potential difference across the internal resistance must be the same as that across JN. Since JN is the only external resistor in the circuit, the potential difference must be 0.8 V (which is 50% of the emf), as it is a series connection.

Since J is connected to earth, potential at J is **0 V** and since pd drops from J to N, N is at a lower potential of **-0.8 V**. (allow for ecf)

(iii) On Fig. 8.3, sketch the graph to show how electric potential varies with position along the wire JN. Label the vertical axis clearly. Explain your answer.

[3]

Fig. 8.3

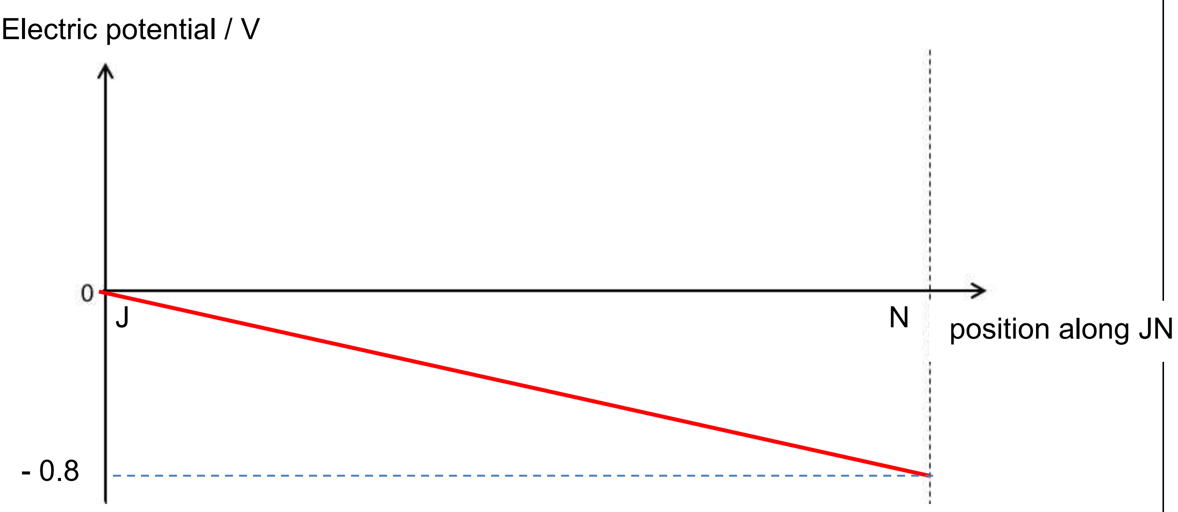


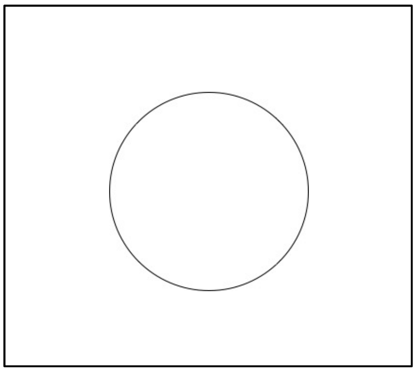
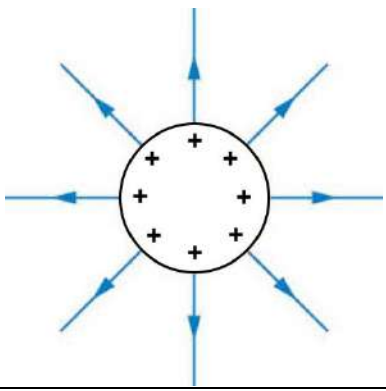
Fig. 8.3

straight line graph starting with 0 V at J and ending at – 8 V at N

Reasons:
Current along JN is constant
Potential drops along wire JN is equal to current x resistance of wire
Resistance of wire is proportional to the length since wire is uniform

Potential difference drop is proportional to length of wire measured from J, therefore graph is linear.

(iv) Suggest, with a reason, why the position of the jockey J has to be shifted, when the battery has been used for a prolong period of time for maximum power transfer.

			....	[1]
			Solution: As the battery is used, its e.m.f. is reduced but its internal resistance will be increased. For maximum power transfer, the external resistance should be larger now since it is equal to that of the internal resistance of the battery, hence the wire JN will be longer , so that jockey J has to be shifter to the left.	
	(c)	**(i)**	Explain what is meant by an *electric field*.	
			....	[1]
			Solution: It is the **region of space** where a **charged particle experiences an electric force**.	
		(ii)	Draw the charge distribution and the electric field around the charged metal bodies for the following bodies	
			1. an isolated positively charged sphere A.  **Fig. 8.1**	[2]
			Solution: 	

approximately equal distribution of positive charges
electric field pattern must correspond to the position of the charges, correct directional arrows indicated

2. When a neutral metal sphere B is brought close to the positively charged metal sphere A in **(c)(ii)1.**

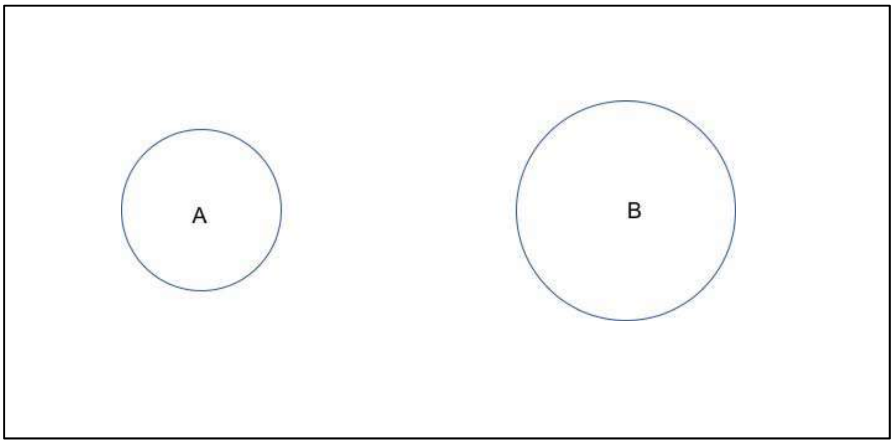
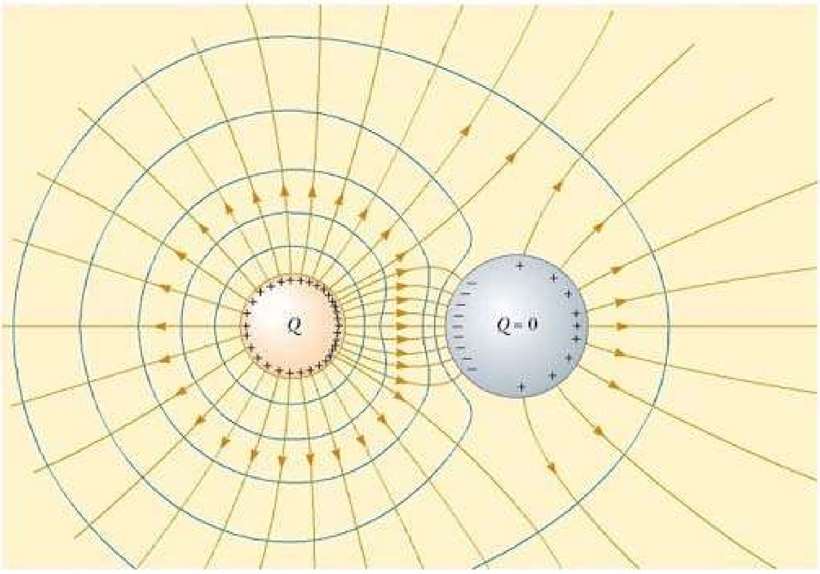


Fig. 8.2 [4]

Solution:



This solution also shows the equipotential lines.

closer distribution of positive charges on A facing B
equal number of positive charges and negative charges on B, at the correct sides
correct direction of electric field lines for A and B
correct shape of the electric field pattern

Note: equipotential lines are not required

Catholic Junior College
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME	MARK SCHEME
CLASS	2T

PHYSICS 9749/04

Practical Examination

2 hour 30 minutes

Candidates answer on the Question Paper.
Additional Materials: as listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST
Write your name and class on all the work you hand in.
Write in dark blue or black pen in the space provided. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use an HB or 2B pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

Shift
Laboratory

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at end of each question or part question.

Half the candidates will start Questions 1-2 for one hour and the other half on Question 3 for one hour. There will be a changeover after that time and candidates will move to the other Question(s) for one hour. All candidates will then move to Question 4 for the last 30 minutes. During this last half hour, candidates are not allowed access to the apparatus.

For Examiner's Use	
1	/ 14
2	/ 8
3	/ 21
4	/ 12
Total	/ 55

This document consists of **19** printed pages and **1** blank page.

[Turn over

1. In this experiment, you will compare the diameters of objects seen through air with their apparent diameters seen through water and glass.

(a) The external diameter d_1 of the test-tube is shown in Fig. 1.1.

Fig. 1.1

Measure and record d_1, in the table using the half metre rule, the vernier caliper and the micrometer screw gauge.

Measuring Instrument	Value of d_1
half metre rule	....
vernier caliper	....
micrometer screw gauge	....

[3]

Solution:
Range: $1.5 \le d_1 < 1.7$ cm
rule: 1.5 cm
vernier caliper: 1.58 cm
micrometer screw gauge: 15.78 mm

(b) **(i)** Stand the test-tube upside down in the **centre** of the beaker of water as shown in Fig. 1.2.

Look through the glass and water at the test-tube.

The external diameter d_2 of the test-tube as **seen through the water and glass** is shown in Fig. 1.2.

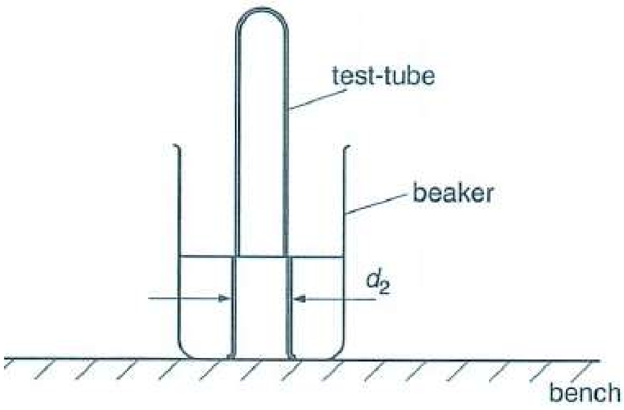


Fig. 1.2

(ii) **1.** Measure and record d_2 using only **one** of the measuring instruments.

d_2= 2.0 cm [1]

Marking point:

- Acceptable range between 1.8 cm to 2.1 cm
- Include unit
- d_2 larger than d_1

2. State which measuring instrument you used to measure d_2.

[1]

Solution:
Metre Rule

(iii) Remove the test-tube from the beaker and place the test-tube back into the container.

(c) **(i)** Use **one** of the measuring instruments to measure and record the external diameter of d_1 of the measuring cylinder.

d_1 = 3.24 cm

(ii) Repeat **(b)** for the measuring cylinder.

d_2 = 3.8 cm [1]

Solution:

- Use a metre rule to measure d_2 and using micrometer screw gauge for d_1 or vernier calipers.
- Testing on the skill of using appropriate instrument for measurements.

Marking Point:

- To be the same precision as b(ii)
- d_2 larger than d_1

(iii) Determine the percentage uncertainty in your value of d_2 for the measuring cylinder.

percentage uncertainty in d_2 = 5.3 % [1]

Solution:

$\Delta d_2 \geq 0.2$ cm

$$\% = \frac{0.2}{3.8} \times 100\% = 5.3\%$$

Marking Point

- $\Delta d_2 \geq 0.2$ cm (ecf from (c)(ii) for 0.02 cm for vernier caliper or 0.02 mm for micrometer screw gauge.)
- Final answer to 1 or 2 s.f.

(d) A student suggested that d_1 and d_2 are related by the expression

$$d_2 = kd_1$$

where k is a constant.

(i) Use your values from **(a)**, **(b)(ii)**, **(c)(i)**, and **(c)(ii)** to determine two values of k.

first value of k = 1.27

second value of k = 1.17 [1]

Solution:

$$d_2 = kd_1$$

$$k = \frac{d_2}{d_1}$$

First value of k,

$$k_1 = \frac{2.0}{1.58} = 1.266 \approx 1.27$$

Second value of k

$$k_2 = \frac{3.8}{3.24} = 1.173 \approx 1.17$$

(ii) Do the results of your experiment support the suggested relationship? Justify your answer by referring to your value in **(c)(iii).**

[2]

Solution:
The percentage difference between the two values of *k*,

$$\% = \frac{k_1 - k_2}{k_1} \times 100\% = \frac{1.27 - 1.17}{1.27} \times 100\% = 7.9\%$$

The percentage uncertainty of *k*

$$\frac{\Delta k}{k} \times 100\% = \left(\frac{\Delta d_1}{d_1} + \frac{\Delta d_2}{d_2}\right) \times 100\%$$

$$\frac{\Delta k}{k} \times 100\% = \left(\frac{0.02}{1.58} + \frac{0.2}{2.0}\right) \times 100\% = 11\%$$

Since the percentage difference of the two values of *k* obtained is 7.9 % which is less than the percentage uncertainty in the determination of *k*, the two values of *k* obtained are equal to one another within experimental confidence. As such, my results support the suggested relationship.

(e) The external diameter d_2 of the test-tube as seen through the water and glass is thought to be larger than the external diameter d_1 as seen through air. The magnification factor, *k* is proposed as,

$$k = \frac{d_2}{d_1}$$

It is suggested that the magnification factor of the setup in Fig. 1.2 depends on the internal diameter of the beaker of water.

Plan an investigation to determine the internal diameter of the beaker for which the magnification factor equal to 2.

You are provided with several beakers, each with uniform internal diameter.

Your account should include:

- your experimental procedure
- the table of measurements with appropriate units,
- how you determine the internal diameter of the beaker for which the magnification factor is 2.

[4]

Solution:

1. Measure the internal diameter *s* of the beaker using the back end of a Vernier caliper and take repeated measurements.
2. Fill the beaker with the smallest internal diameter with water until it is half full.
3. Perform the same experiment as per (a) and (b)(i),(ii) to measure the external diameter of a test tube in the first beaker with the smallest internal diameter. Measure d_1 and d_2 using a Vernier caliper and a metre rule respectively as per (a) and (b)(i)(ii).
4. Calculate the magnification factor by k = d_2 / d_1.
5. Repeat steps 1 and 3 using the several beakers with different internal diameter for at least 5 more sets of *s* and *k*.

6. The table of measurements are as follow:

s_1 / cm	s_2 / cm	<s> / cm	d_1 / cm	d_2 / cm	k (no units)

7. Plot a graph of internal diameter <s> against *k*.
8. Read off the position where *k* is equal to 2 and identify the internal diameter of the beaker that gives the result.

Do not accept by trial and error to get the diameter. Use a graphical method to determine.

Total: 14 marks

2 In this experiment, you will investigate how the current in a circuit changes when a resistor is added to the circuit.

(a) (i) You have been provided with five identical resistors.

Use two resistors and other components to connect the circuit of Fig. 2.1.

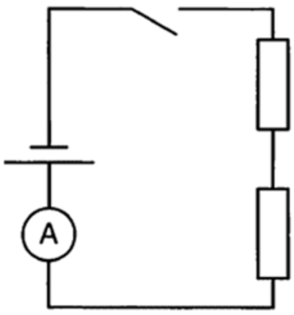


Fig. 2.1

(ii) Close the switch. Record the ammeter reading I_1.

I_1 = 16.9 mA [1]

Marking Point:

- Sensible value
- Record to 0.1 mA or 0.01 mA precision
- Appropriate units

(iii) Open the switch.

(b) (i) Add a resistor as shown in Fig. 2.2 so that *n* = 2 where *n* is the number of resistors in the parallel arrangement.

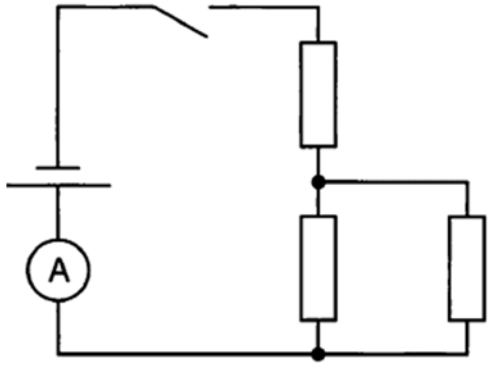


Fig. 2.2

(ii) Close the switch. Record the ammeter reading I_2.

I_2 = 22.2 mA [1]

Marking Point:

- Sensible value
- Record to 0.1 mA or 0.01 mA precision
- Appropriate units
- Value larger than (a)(ii)

(iii) Open the switch.

(c) It is suggested that I and n are related by the expression

$$I = k\frac{n}{(n+1)}$$

where k is a constant.

(i) Use the apparatus to take sufficient readings to verify whether the suggestion is correct by calculating values for k. Present your results in tabular form.

[3]

Solution:

n	*I* / mA	*k* / mA
1	16.9	33.8
2	22.2	33.3
3	24.8	33.3
4	26.6	33.3

Marking Point:

- 4 sets of readings (1 mark)
- Tabulation with correct table heading (1 mark)
- Correct calculation for k (1 mark)

(ii) State whether or not the results of your experiment support the relationship suggested. Justify your conclusion.

[1]

Solution:

% difference of k = (33.8 – 33.0 / 33) x 100% = 2.4 %
% uncertainty of k
= % uncertainty of I = (0.1 /16.9) x100% = 0.6 %

% difference of k values is larger than % uncertainty of k.
Hence the data does not support the suggested relationship

(iii) Justify the number of significant figures that you have given for your values of k.

[1]

Solution:
n is an exact number it does not affect accuracy of k value. The accuracy of k is dependent only on that of l.
Hence the s.f. of k follows that of l.

(d) The resistance of each of the resistors used in this experiment is 47 Ω.

Suggest one problem that might arise if the experiment was repeated using five identical resistors of resistance 0.047 Ω.

[1]

This will cause:

- Damage to the devices such as the digital multimeter
- Overheating of the wire, risking burning of the resistors and wire.

Total: 8 marks

3 In this experiment, you will investigate how the period of a spring pendulum varies with load.

(a) Set up the apparatus as shown in Fig. 3.1.

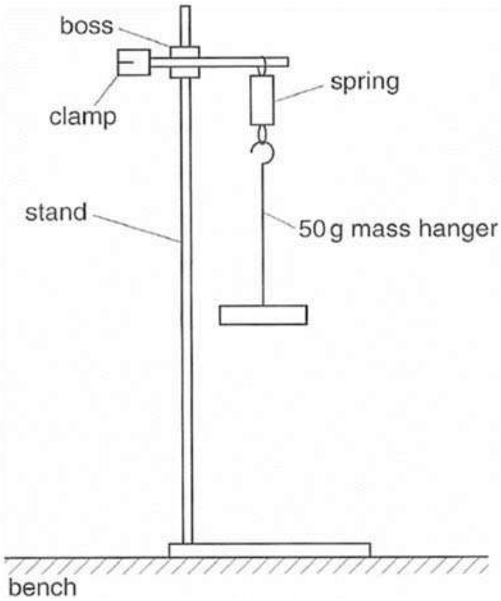


Fig. 3.1

(b) Displace the mass **horizontally**.

Release the mass and allow it to oscillate.

Take measurements to determine the period *T* of these oscillations.

T = ________________ [1]

Solution:

Time taken for 15 oscillations, $t_{15,1}$ = 12.8 s

Repeat reading, $t_{15,2}$ = 12.6 s

Therefore, the period is $T = \frac{t_{15,1}+t_{15,2}}{2\times15} = \frac{12.8+12.6}{2\times15} = 0.847$ s

Marking point

- Raw timing to be more than or equal to 10.0 s
- Evidence of time readings to 0.1 s precision
- Includes units
- 3 s.f.

(c) Vary the mass *m* suspended from the spring and repeat **(b)** for further values of *m*.

[7]

Solution:

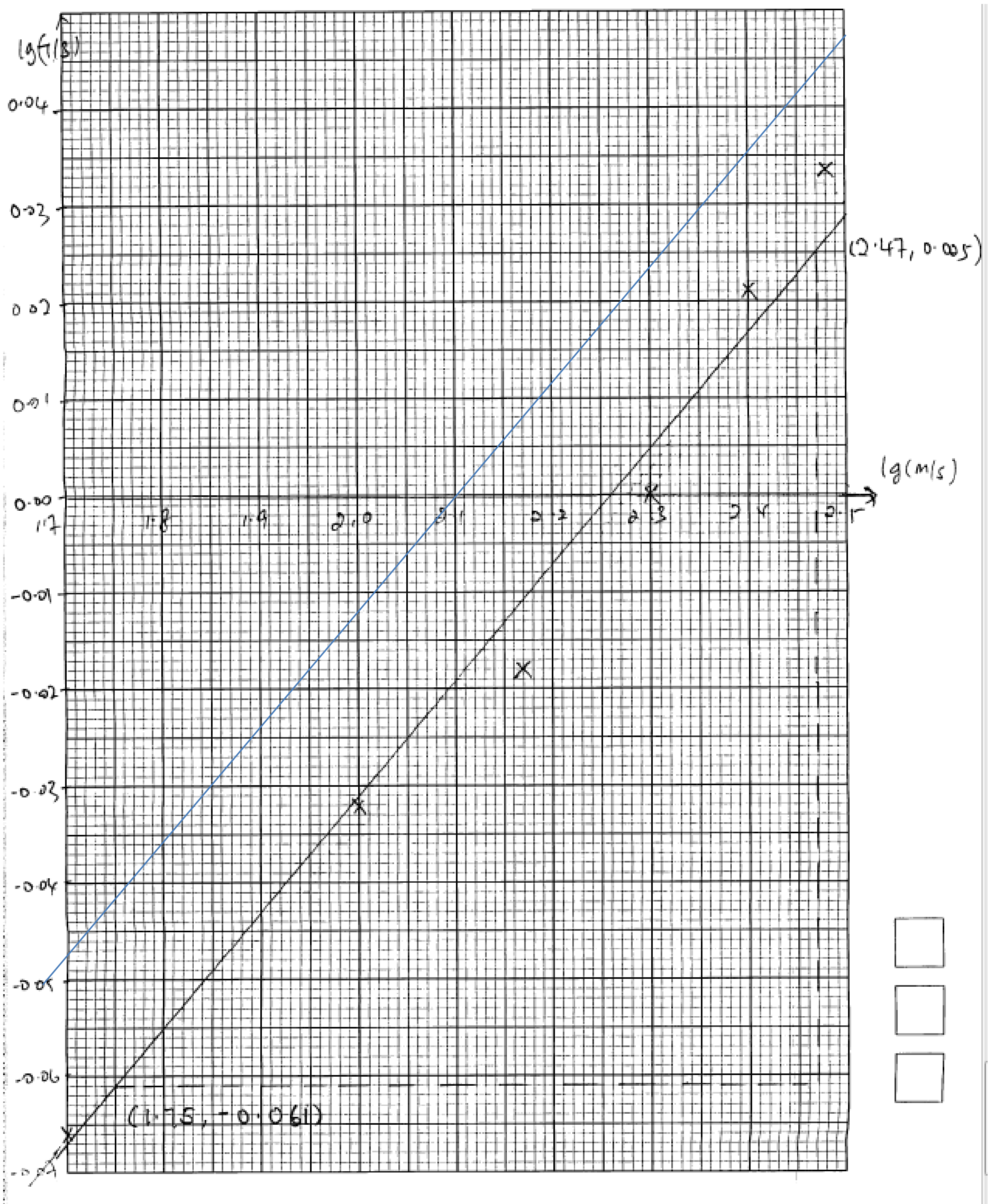
m / g	*n*	$t_{n,1}$ / s	$t_{n,2}$ / s	$t_{n,avg}$ / s	*T* / s	lg (*T*/s)	lg (*m* / g)
50	15	12.8	12.6	12.7	0.847	-0.0721	1.70
100	15	13.8	13.7	13.8	0.920	-0.0362	2.000
150	15	14.2	14.5	14.4	0.960	-0.0177	2.176
200	15	15.0	14.9	15.0	1.00	0.000	2.301
250	15	15.7	15.6	15.7	1.05	0.0212	2.398

300	15	16.3	16.1	16.2	1.08	0.0334	2.477

Marking Point:

- Each column heading contains an appropriate quantity and unit. Quantity and unit are distinguished with a solidus.
- Consistency of no. of d.p. for time reading, to 0.1 s.
- Consistent least s.f. of calculated values, lg T and lg m according to the least s.f. of raw measurements. Number before the decimal place is NOT a significant figure.
- Calculate lg T and lg m correctly. Allow at most 2 slips in calculation.
- Repeat readings for t
- Methods
  - At least 6 sets of readings without assistance
  - At least 5 sets of readings without assistance

[3]



Marking Point:

- Good line of best fit with good scatter of plotted points.
- Plot at least 3 data points accurately to ½ the smallest division, all data points plotted.
- Scale and labels

(d) It is suggested that *T* and *m* are related by the expression

$$T = am^b$$

where *a* and *b* are constants.

Plot a suitable graph to determine the values of *a* and *b*.

a = ______________________

b = ______________________ [4]

Solution:

Plot a graph of lg T against lg m. A straight line graph with gradient b and y-int lg a is expected.

Gradient = $\frac{0.025-(-0.061)}{2.47-1.75}=0.119$

Hence, b = 0.119 (no units)

Taking point (2.47, 0.025),

$\lg a = 0.025 - 0.119 \times 2.47 = -0.270$

Hence, lg a = -0.270 s^2 m

a = 0.537 s $g^{-0.119}$

(e) Comment on any anomalous data or results that you may have obtained. Explain your answer.

____

____

____

____ [1]

Solution:

Marking Point:

- Appropriate identification of anomalous data.
- At most two anomalous points

(f) State one significant source of error or limitation of taking the readings for this experiment. Give a reason.

____

____

____

____ [1]

Solution:

When the spring is hanging freely on the rod, it can oscillate not only in one plane as what this experiment require, but in other planes as well, causing a conical oscillation instead of vibrating in a plane. This causes difficulty in determining the period of the oscillation.

(g) **(i)** Calculate the value of T when m = 1500 g.

T = ________________________ s [1]

Solution:

$$T = 0.537m^{0.119}$$
$$T = 0.537(1500)^{0.119}$$
$$T = 1.28 \text{ s}$$

(ii) Suggest a problem with determining an experimental value of T when m = 1500 g.

[1]

Solution:

Any of the following point:

- The spring provided might be stretched too long such that the base of the mass touches the bench.
- The spring might be stretched beyond its limit of proportionality or even the limit of elasticity, causing permanent changes to the spring which will not behave as it should be in this experiment.

(h) **(i)** It is suggested that the value of a is proportional to the spring constant of the spring used in this experiment while the value of b is independent of the spring constant.

Sketch a line on the graph paper in page 9 when the experiment is repeated with a spring with a larger spring constant. Label this line **X**.

[2]

[Total: 21 marks]

4 In the early 19th century, it was observed that gases were able to absorb light of certain wavelengths. In addition, the extent of the absorption of the incident light increases with increasing amount of the gas. Such observations led to the development of a non-intrusive method to determine the amount of substance in a given sample.

The intensity I of a beam of light after passing through a gas depends on the concentration c of the gas. The concentration c is defined as the number of moles per unit volume of the gas. When incident light of intensity I_0 passes through the gas placed in a transparent container, the intensity I of the transmitted light can be measured for analysis as shown in Fig. 4.1.

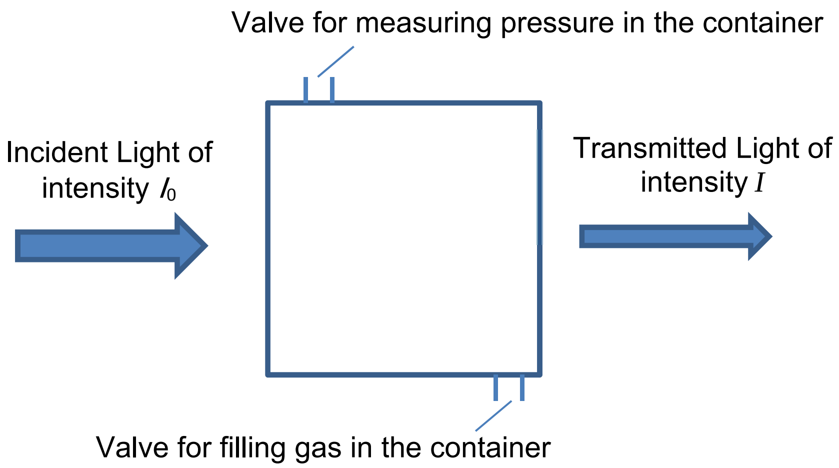


Fig. 4.1

It is suggested that the intensity I of the transmitted light is related to the concentration of the gas c by the relationship,

$$I = I_0 e^{-\varepsilon L c}$$

where I_0 is the intensity of the incident light before passing through the gas,
ε is an unknown constant and
L is the length the beam of light travelled through the gas.

Design an experiment to determine the value of ε for the gas provided. You may use the following apparatus with any standard apparatus available in a college Physics laboratory.

Meter to measure light intensity	Transparent cubic container (Fig. 4.1)	Gas supply
Red laser light source	Device to insert gas into the container	Pressure gauge
Vacuum pump	Thin sheets of glass	

You should draw a labelled diagram to show the arrangement of your apparatus and you should pay attention to

(a) the identification and control of variables,

(b) the equipment you would use,

(c) the procedure to be followed,

(d) how ε is determined, and

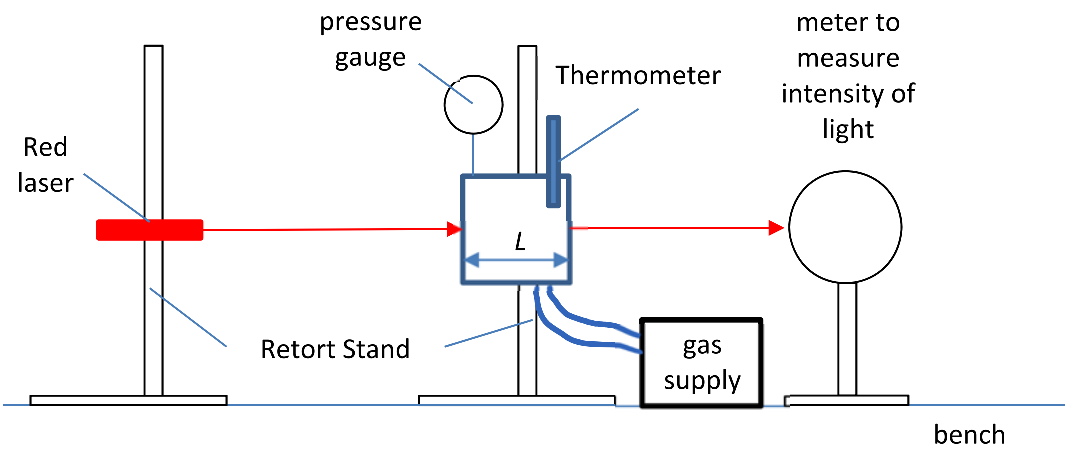
(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

....[12]

Solution:

Diagram:



Independent Variable: Concentration of gas, *c*
Dependent Variable: Intensity of the transmitted light, *I*
Controlled Variable: Distance between light source to meter, volume of container, Intensity of red laser light source before transmission, temperature of gas

Procedure:

1. Set up the experiment as shown in the above diagram. Align the red laser such that the light enters the container at right angle and falls on the meter. Check using a set square, a ruler and a protractor.
2. Use a set square with a metre rule to measure the distance between the laser light and the bench to check that the laser beam is parallel to the bench. Once in position, secure the red laser, container and meter in place with a G-clamp, such that the distance between the laser and the meter and the alignment is fixed throughout the experiment.
3. At the start, there is no gas molecules in the container. Use a vacuum pump to remove any air particles in the container.
4. Switch on the laser light and measure the intensity I_0 of the light source before passing through.

5. Fill the container with the gas provided and measure the pressure of the gas in the container using a pressure gauge.
6. pV = nRT
   p = (n/V) RT
   c = p / RT
   Calculate *c* from the measured pressure using the equation above. Measure the temperature of the gas from the thermometer inserted into the container.
7. Switch on the laser light and measure the intensity of the light after passing through the gas using the meter.
8. Repeat steps 2 to 5 by varying the concentration *c* of the gas molecules in the container. Increase the gas molecules from the gas provided and measure the changes in p to determine the change in concentration *c*. Repeat until at least 6 sets of I and *c* are obtained.
9. Taking the natural ln of the equation,
   $$I = I_0 e^{-\varepsilon L c}$$
   $$\ln I = \ln I_0 - \varepsilon L c$$
   Plot a graph of ln I against *c*, a straight line should be obtained. Calculate the gradient of the line and the gradient value will be equal to $-\varepsilon L$. Measure the length of the container with a metre rule to get L, and from there, calculate for a value of ε.

Additional Details:

- Use the same gas to ensure that the energy level of the gas molecules still allow absorption of the laser light. Use the same container to keep the volume of the gas fixed.
- Conduct a preliminary experiment to determine the suitable range of pressure p that will cause an observable change in the light intensity measured. In addition, use a low pressure p in the preliminary experiment to ensure values changes are still obtainable while keeping the pressure low to prevent breakage of the container. Low pressure also ensures that the ideal gas equation, pV = nRT is more valid in this experiment.
- Switch on the laser light and allow time (e.g. 5 min) for the laser light to stabilize before taking any reading. Conduct step 4 to check for the stability in the laser intensity. Wait for a longer period of time if laser light intensity is not stable yet.
- Conduct the experiment in an air-conditioned room so that the temperature at which the experiment is conducted is kept constant. Continue to measure the temperature of the gas with a thermometer. When there is a difference in the temperature, allow time for the temperature to stabilize before taking the reading.
- Have the laser light passing through the container at the same entry and exit point when repeating the readings for different sets of I and *c* so that the optical path length that the light passes through the container is kept the same
  - To ensure the laser light enters the container perpendicular to the surface, check for possible reflection of the laser light from the container surface. The laser beam is perpendicular to the surface once the reflected beam and the incident beam are in the same line.
- Calculate ln I_0 from the data collected in step 4 and compared with the y-int values from the graph. Calculating the percentage difference between the two values will inform us the extent of the systematic error in this experiment.

Safety:

- Wear goggles to prevent accidental eye contact to the strong laser light
- Have signs put around the experiment area to warn passer-by on laser light being used in the experiment.
- Conduct the experiment starting with low pressure and conduct preliminary experiment to determine the smallest increment necessary to take sensible reading. This is to avoid over-filling the container with too much gas so as to

prevent over-building up of pressure which might cause harm to instrument and people nearby.

-- END OF PAPER –

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/01

Paper 1 Multiple Choice

September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided unless this has been done for you.

DO **NOT** WRITE IN ANY BARCODES.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **14** printed pages and **0** blank page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

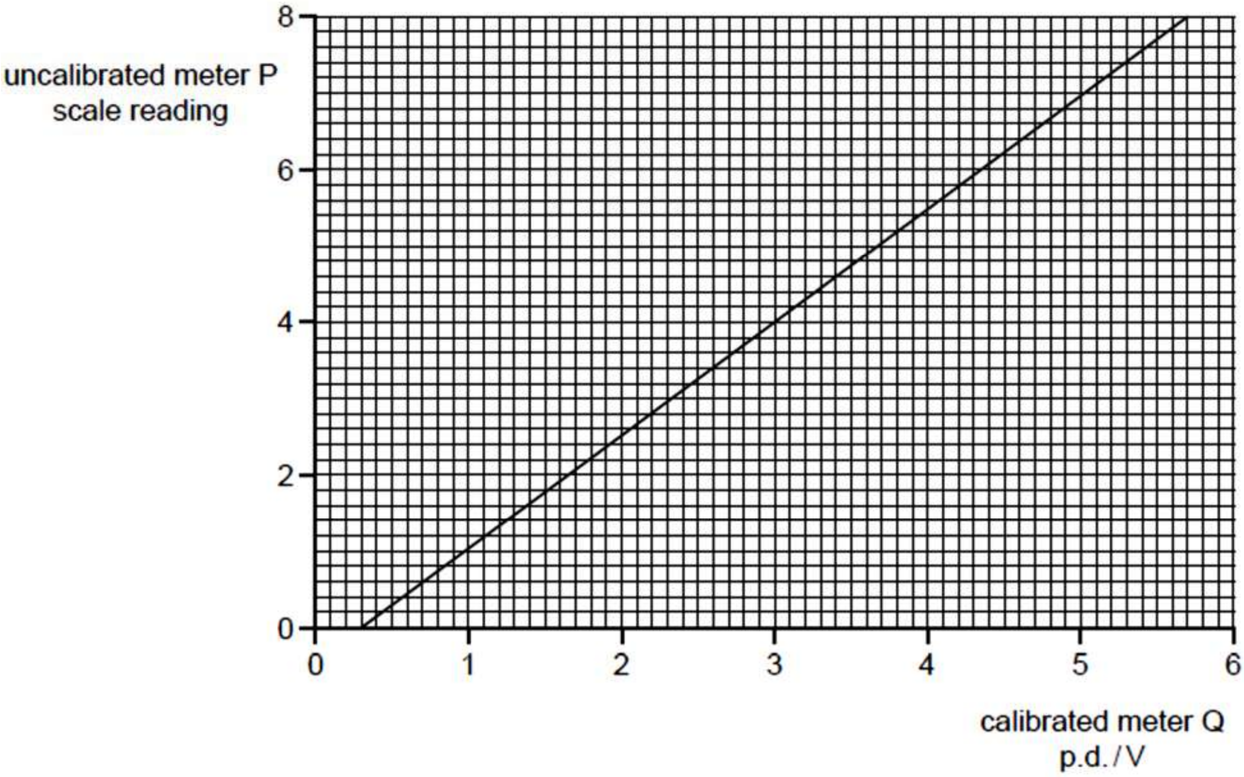
uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux denxity due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 Determine the angle between two equal forces *F* when their resultant force is also equal to *F*.

A 45° **B** 60° **C** 120° **D** 135°

2 An un-calibrated analogue voltmeter P is connected in parallel with another voltmeter Q which is known to be accurately calibrated. For a range of values of potential difference (p.d.), readings are taken from the two meters.

The diagram shows the calibration graph obtained.



The graph shows that meter P has a zero error. This meter is now adjusted to remove this zero error. When the meter is re-calibrated, the gradient of the calibration graph is found to be unchanged.

What is the new scale reading on meter P when it is used to measure a p.d. of 5.0 V?

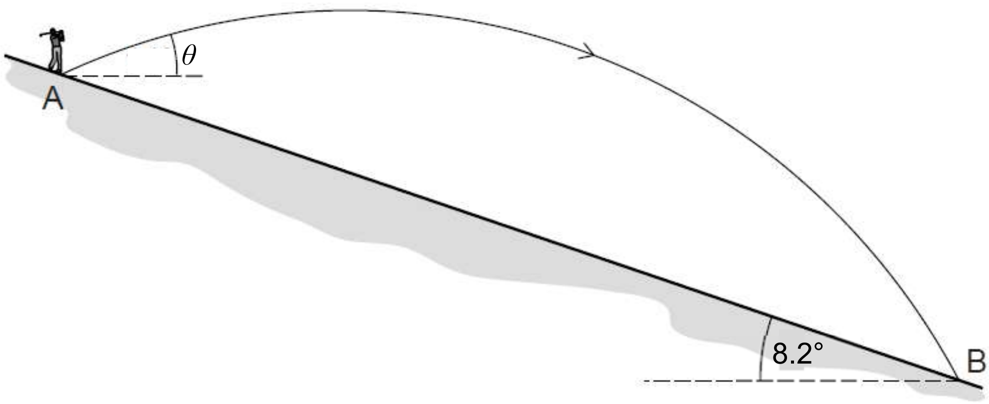
A 6.6 **B** 6.7 **C** 7.2 **D** 7.4

3 A projectile of mass 2.0 kg is launched on the Earth with some initial velocity. Another projectile of mass 4.0 kg is launched on the Moon with the same initial velocity. The acceleration of free fall on the Moon is 1.6 m s^{-2}.

Neglecting air resistance, what is the ratio $\frac{\text{range of projectile on the Earth}}{\text{range of projectile on the Moon}}$?

A 0.16 **B** 0.33 **C** 3.3 **D** 6.1

4 A golf ball is hit from point A on the ground and moves through the air to point B as shown in the figure which is not drawn to scale.

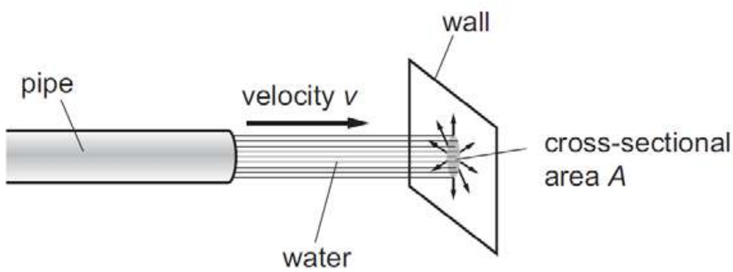


The ground slopes downhill with constant gradient of angle 8.2° to the horizontal. The ball has an initial velocity of 63 m s^{-1} at an angle of θ to the horizontal. Time taken for the ball to travel from A to B is 4.9 s.

Determine the angle θ.

A 8.0º **B** 10º **C** 12º **D** 14º

5 Water flows out of a pipe and hits a wall.

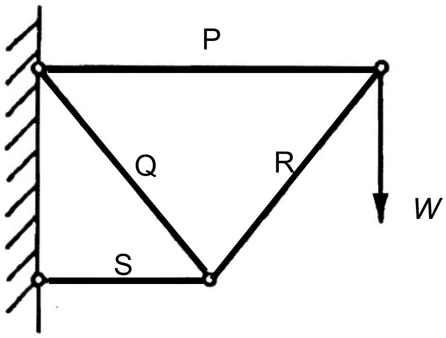


When the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A. The density of the water is ρ. The water does not rebound from the wall.

What is the force exerted on the wall by the water?

A $\dfrac{\rho v}{A}$ **B** $\dfrac{\rho v^2}{A}$ **C** $\rho A v$ **D** $\rho A v^2$

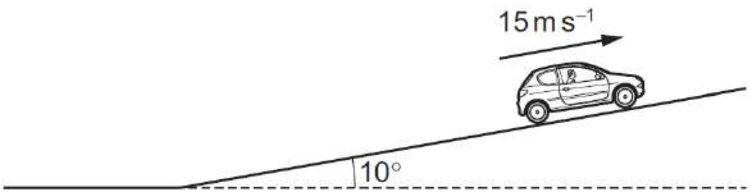
6 In order to support a load W, four light hinged rods P, Q, R and S are connected as shown below and mounted in a vertical plane.



Which rods are in compression and which in tension?

	in compression	*in tension*
A	P	Q, R, S
B	P, Q	R, S
C	Q, R	P, S
D	R, S	P, Q

7 A car of mass 1100 kg is travelling at a constant speed of 15 m s^{-1} up a slope inclined at 10° to the horizontal. The combined frictional forces acting on the car are directed down the slope and are equal to $\frac{W}{5}$, where W is the weight of the car.



What is the useful output power of the car's engine?

A 28 kW **B** 32 kW **C** 60 kW **D** 190 kW

8 An old-fashioned 60 W lamp converts 95% of its energy supply into heat. A 4.0 W modern lamp has the same power output of light as the old-fashioned lamp.

What is the efficiency of the modern lamp?

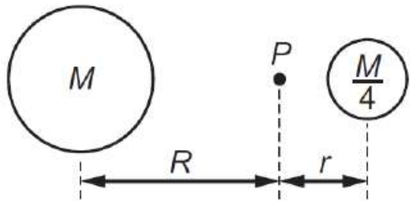
A 5.0% **B** 6.7% **C** 75% **D** 95%

9 The reading of a speedometer fitted to the front wheel of a bicycle is directly proportional to the angular velocity of the wheel. A certain speedometer is correctly calibrated for use with a wheel of diameter 61 cm but, by mistake, is fitted to a 51 cm wheel.

What is the value of $\dfrac{\text{indicated speed} - \text{actual speed}}{\text{actual speed}} \times 100\%$?

A +16% **B** −16% **C** +20% **D** −20%

10 Two large masses, one of mass M, the other of mass $\dfrac{M}{4}$, are positioned as shown.



A small mass is placed at point P such that it experiences zero gravitational force from the masses.

What is the ratio $\dfrac{R}{r}$?

A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** 2 **D** 4

11 Io and Ganymede are moons of Jupiter. The orbital period of Ganymede is four times that of Io. Io's orbital radius is 4.20×10^8 m.

What is the orbital radius of Ganymede?

A 1.06×10^9 m

B 1.68×10^9 m

C 3.36×10^9 m

D 2.70×10^{10} m

12 In deriving the equation $pV = \frac{1}{3}Nm\langle c^2 \rangle$ in the simple kinetic theory of gases, which of the following is **not** taken as a valid assumption?

A The molecules suffer negligible change of momentum on collision with the walls of the container.

B Collisions with the walls of the container and with other molecules cause no change in the average kinetic energy of the molecules.

C The duration of a collision is negligible compared with the time between collisions.

D The volume of the molecules is negligible compared with the volume of the gas.

13 Atoms of neon are at a temperature such that the root mean square (r.m.s.) speed of its atoms is 400 m s^{-1}.

What will be the r.m.s. speed of molecules of hydrogen at the same temperature?

Mass of neon atom = 20 u.
Mass of hydrogen molecule = 2 u.

A 130 m s^{-1} **B** 400 m s^{-1} **C** 1300 m s^{-1} **D** 4000 m s^{-1}

14 A particle performs simple harmonic motion according to the equation

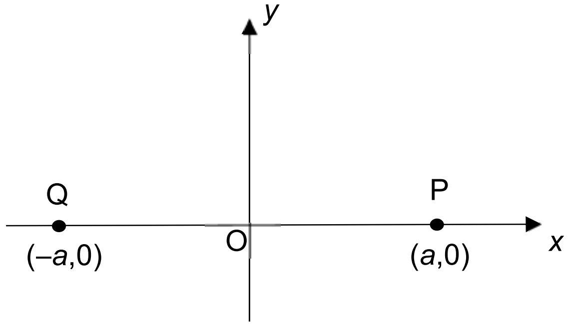
$$x = 2.0 \cos(\omega t)$$

where its displacement x is measured in cm and time t is measured in s.

If the angular frequency ω is π rad s^{-1}, what is the total distance travelled by the particle from t = 0.0 s to t = 1.5 s?

A 0 cm **B** 2.0 cm **C** 3.0 cm **D** 6.0 cm

15 An object is executing simple harmonic motion along the x-axis between P (a, 0) and Q ($-a$, 0) about the origin O. The kinetic energy of the particle is E_K, its potential energy is E_P and the total energy is E_T.



When the particle is mid-way between O and Q, what are the values of $\frac{E_K}{E_T}$ and $\frac{E_P}{E_T}$?

	$\frac{E_K}{E_T}$	$\frac{E_P}{E_T}$
A	$\frac{1}{4}$	$\frac{3}{4}$
B	$\frac{1}{2}$	$\frac{1}{2}$
C	$\frac{3}{4}$	$\frac{1}{4}$
D	$\frac{1}{8}$	$\frac{7}{8}$

16 A beam of plane-polarised light of intensity I falls normally on a thin sheet of polaroid.

If the transmitted beam has an intensity of $\frac{I}{4}$, what is the angle between the plane of incident polarisation and the polarising direction of the polaroid?

A 22.5° **B** 30° **C** 45° **D** 60°

17 S_1 and S_2 are loudspeakers facing each other and emitting continuous sound waves of frequency 1100 Hz. M is a small microphone which runs on a straight track between S_1 and S_2 at a speed of 30 m s^{-1}. The sound received by M will fluctuate with a frequency f.

If the velocity of sound is 330 m s^{-1}, what is the value of f?

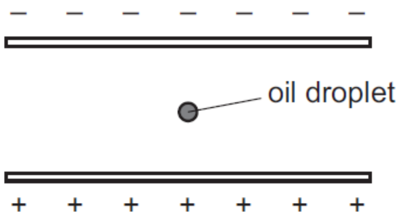
A 100 Hz **B** 200 Hz **C** 400 Hz **D** 800 Hz

18 Light of wavelength 600 nm is incident on a pair of slits. Fringes with a spacing of 4.0 mm are formed on a screen.

What will be the fringe spacing when the wavelength of the light is changed to 400 nm and the separation of the slits is doubled?

A 1.3 mm **B** 3.0 mm **C** 5.3 mm **D** 12 mm

19 A positively charged oil droplet is held stationary in an electric field of strength E.

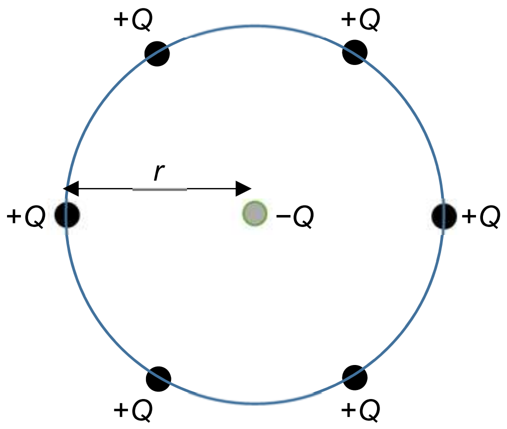


A different droplet of the same oil is held stationary in an electric field of different strength. The droplet has half the charge and twice the radius of the original droplet.

What is the electric field strength?

A $2E$ **B** $4E$ **C** $8E$ **D** $16E$

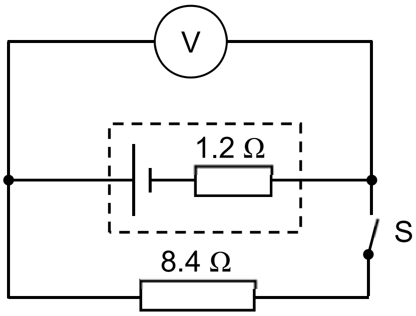
20 A negative point charge is surrounded symmetrically by six positive point charges at distance r as shown in diagram.



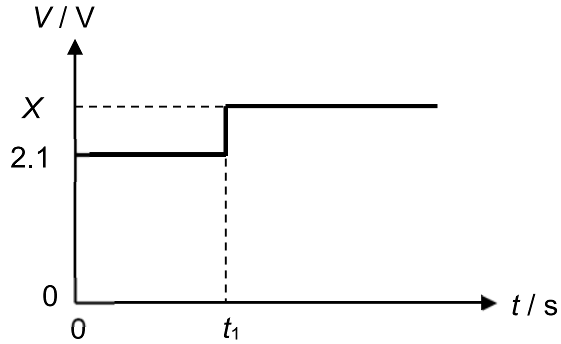
How much work is done by the forces of attraction when the point charge at the centre is removed to infinity?

A $-\dfrac{6Q^2}{4\pi\varepsilon_o r}$ **B** $+\dfrac{6Q^2}{4\pi\varepsilon_o r}$ **C** $-\dfrac{6Q^2}{4\pi\varepsilon_o r^2}$ **D** $+\dfrac{6Q^2}{4\pi\varepsilon_o r^2}$

21 A cell with internal resistance 1.2 Ω is connected in the circuit as shown.



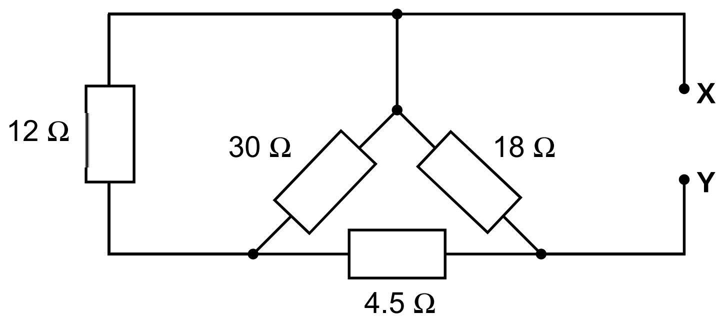
The graph shows the variation with time t of the voltmeter reading V. At time t = 0 s, switch S is closed. At time $t = t_1$, switch S is opened and a rise in the voltmeter reading V was observed.



What is the value of X?

A 2.2 V **B** 2.4 V **C** 3.6 V **D** 4.2 V

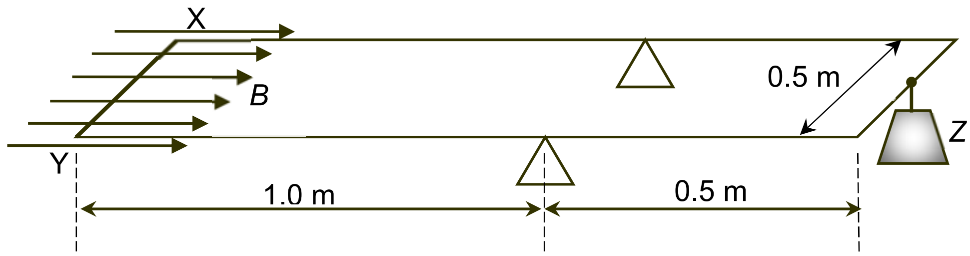
22 The circuit diagram shows a network of resistors.



What is the effective resistance between the points **X** and **Y**?

A 3.5 Ω **B** 7.6 Ω **C** 10.5 Ω **D** 15.0 Ω

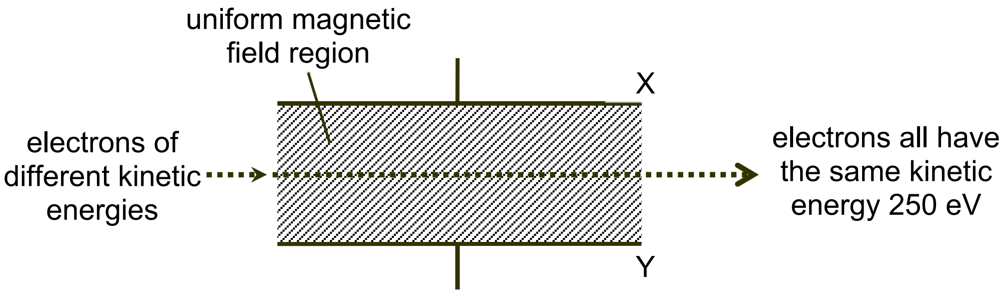
23 A 1.5 m by 0.5 m light and rigid rectangular conducting frame is pivoted along its longer sides with a weight *Z* hung on one shorter side as shown. A uniform horizontal magnetic field *B* of flux density 0.050 T is applied at right-angles to the section XY of the frame.



When a current passes through the section XY of the frame, which combination of the magnitude and direction of current flowing in section XY, and the weight *Z* makes the frame horizontal?

	magnitude of current in section XY	direction of current in section XY	*Z* / N
A	1.96 A	from X to Y	0.049
B	1.96 A	from Y to X	0.098
C	3.92 A	from X to Y	0.196
D	3.92 A	from Y to X	0.098

24 In certain experiments involving scattering of electrons by nucleus, a beam of electrons of kinetic energy 250 eV are needed. It can be obtained by passing a beam of electrons of different kinetic energies through a velocity selector as shown, with plate Y at a higher potential with respect to plate X.



Which of the following gives the correct effect on electrons that enter the velocity selector with kinetic energies that differs from the required 250 eV?

	electrons with kinetic energies greater than 250 eV	electrons with kinetic energies lower than 250 eV
A	impact on plate X	impact on plate X
B	impact on plate X	impact on plate Y
C	impact on plate Y	impact on plate X
D	impact on plate Y	impact on plate Y

25 A coil of 160 turns and area 0.20 m^2 is placed with its axis parallel to a magnetic field in the *x*-direction. The magnetic flux density changes from 0.40 T in the positive *x*-direction to 0.40 T in the negative *x*-direction in 2.0 s.

If the resistance of the coil is 16 Ω, what is the rate of energy generated in the coil?

A 5 W **B** 10 W **C** 13 W **D** 20 W

26 A sinusoidal alternating current of peak value I_o passes through a resistor of resistance *R*. The mean power developed by the current in the resistor is *P*.

Another sinusoidal alternating current passes through a resistor of resistance 2*R*. If the mean power developed by this current in it is 4*P*, what is the root-mean-square value of this current?

A 0.7 I_o **B** I_o **C** 1.4 I_o **D** 2.0 I_o

27 When electromagnetic radiation of frequency *f* irradiates a metal surface, electrons are emitted and the measured stopping potential is V_s. The frequency of the incident radiation is halved to 0.5*f*.

What change occurs in the stopping potential?

A The stopping potential decreases to less than $0.5V_s$.

B The stopping potential decreases to $0.5V_s$.

C The stopping potential decreases to more than $0.5V_s$.

D The stopping potential remains at V_s.

28 A proton has a kinetic energy of 1.00 MeV.

If its momentum is measured with an uncertainty of 1.00 %, what is the minimum uncertainty in its position?

A 5.64×10^{-14} m

B 9.08×10^{-14} m

C 2.87×10^{-12} m

D 9.77×10^{-10} m

29 Two deuterium nuclei fuse together to form a Helium-3 nucleus, with the release of a neutron. The reaction is represented by

$$^{2}_{1}\text{H} + ^{2}_{1}\text{H} \rightarrow ^{3}_{2}\text{He} + ^{1}_{0}\text{n} + \text{energy}$$

The binding energies per nucleon are:

for $^{2}_{1}\text{H}$	1.09 MeV,
for $^{3}_{2}\text{He}$	2.54 MeV.

How much energy is released in this reaction?

A 0.36 MeV **B** 1.45 MeV **C** 3.26 MeV **D** 5.44 MeV

30 Nuclide X decays to stable nuclide Y with a half-life of *T* years.

Geologists are sure that nuclide Y found in a particular rock sample has all came from nuclide X which was present when the rock formed.

The rock is thought to be 3*T* years old.

What is the expected ratio $\frac{\text{number of atoms of X}}{\text{number of atoms of Y}}$ for this rock?

A $\frac{1}{6}$ **B** $\frac{1}{7}$ **C** $\frac{1}{8}$ **D** $\frac{1}{9}$

- END OF PAPER -

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**12**
2	**7**
3	**8**
4	**8**
5	**8**
6	**8**
7	**9**
8	**20**
Total	**80**

This document consists of **21** printed pages and **1** blank page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 **(a)** A liquid L fills a container of very large uniform cross-sectional area to a certain depth. Another liquid M is now added to the container. The two liquids do not mix as shown in Fig. 1.1. The total depth of the liquids is 0.17 m.

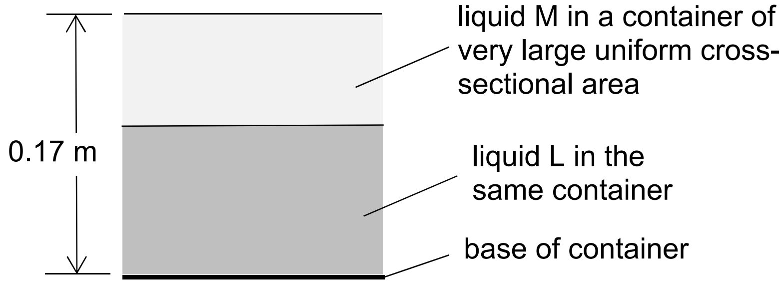


Fig. 1.1 (not to scale)

Fig. 1.2 shows how the pressure *p* inside the liquids varies with height *x* above the base of the container.

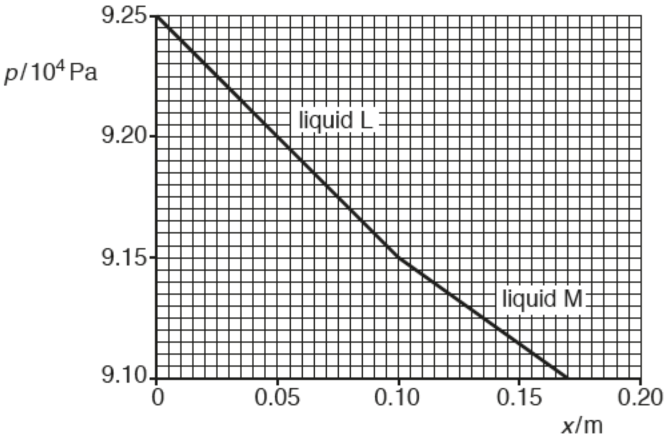


Fig. 1.2

Use Fig. 1.2 to

(i) state the value of the atmospheric pressure,

atmospheric pressure = ... Pa [1]

(ii) determine the density of liquid M.

density = ... kg m^{-3} [2]

For Examiner's Use

(b) Above the liquids, a spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially held so that the spring has zero extension as shown in Fig. 1.3.

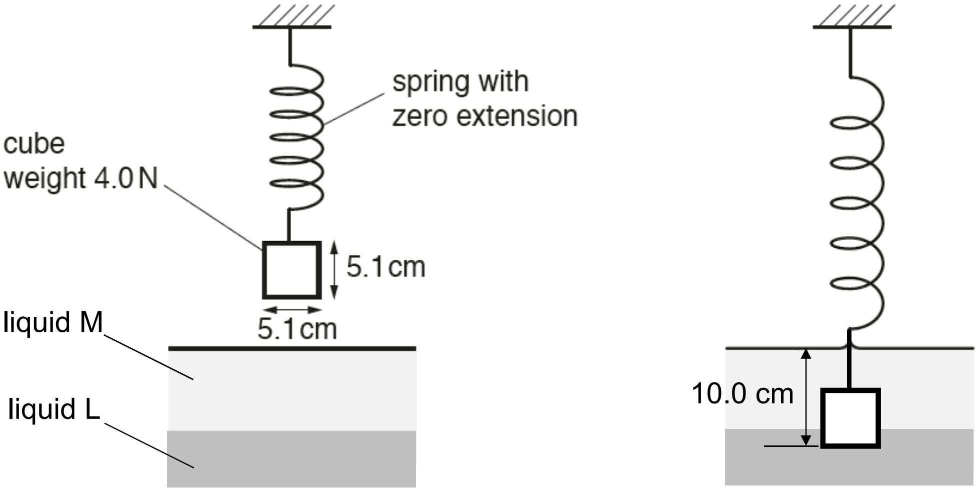


Fig. 1.3 (not to scale)

The cube has weight 4.0 N and sides of length 5.1 cm. The cube is released and sinks into the liquids as the spring extends. The cube reaches equilibrium with its base at a depth of 10.0 cm below the top surface of the liquid M, as shown in Fig. 1.3.

(i) Determine the upthrust acting on the cube.

upthrust = ……………………………… N [3]

(ii) Calculate the magnitude of the force exerted on the spring by the cube when it is in equilibrium in the liquids.

force = ……………………………… N [1]

For Examiner's Use

(c) Suggest how to check that the elastic limit of the spring is not exceeded.

………

…………………………………………………………………………………………………… [1]

(d) Two identical balls are placed in a smooth glass container as shown in Fig. 1.4. Each ball has a mass of 170 g. Their centres and point A lies on a straight line as shown by the dotted line.

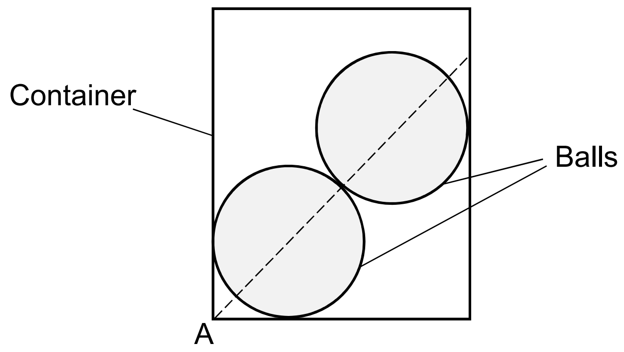


Fig. 1.4

(i) Determine the magnitude of the horizontal force by the container on the upper ball.

horizontal force = ………………………………… N [2]

(ii) Hence, or otherwise, determine the magnitude of the force exerted by the lower ball on the upper ball.

force = ………………………………… N [2]

For Examiner's Use

2 Fig. 2.1 shows the variation with distance from the centre of the Earth of the gravitational field strength *g*.

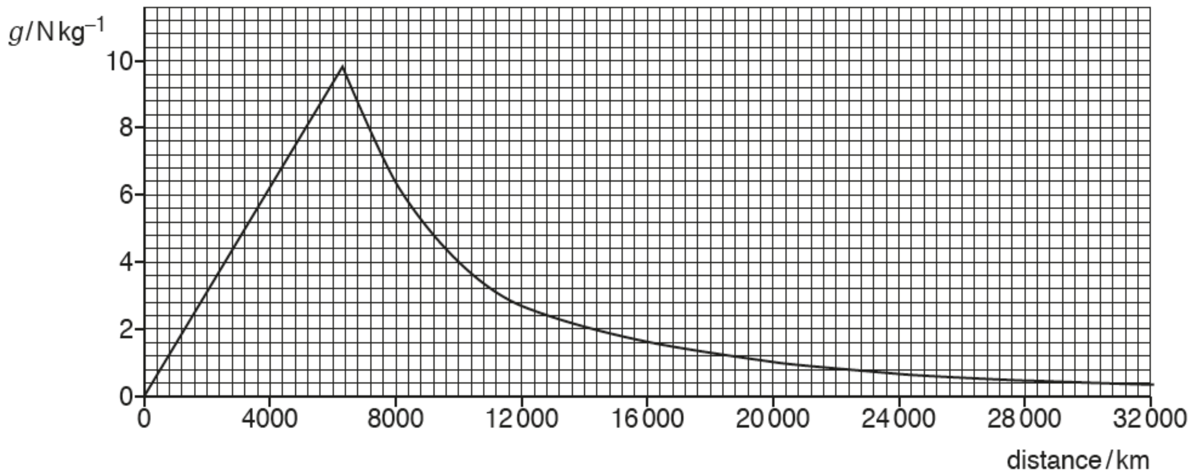


Fig. 2.1

(a) Use Fig. 2.1 to determine the gravitational force on a man-made satellite of mass 20 000 kg at a distance of 8200 km from the centre of the Earth.

gravitational force = ... N [2]

(b) Calculate the speed of the satellite in **(a)** for it to be circling the Earth at constant speed.

speed = ... m s^{-1} [2]

(c) (i) State what is meant by *gravitational potential*.

....

.... [1]

(ii) Use Fig. 2.1 to estimate the gravitational potential at a distance of 10 000 km from the centre of the Earth.

gravitational potential = ... J kg^{-1} [2]

3 (a) A small ball rests at point P on a curved track of radius *r*, as shown in Fig. 3.1.

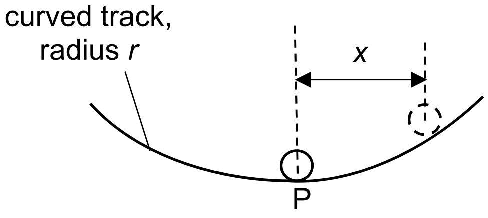


Fig. 3.1

The ball is moved a small distance to one side and is then released. The horizontal displacement *x* of the ball is related to its acceleration *a* towards P by the expression

$$a = -\frac{gx}{r}$$

where *g* is the acceleration of free fall.

(i) Show that the ball undergoes simple harmonic motion.

....

....

....

.... [2]

(ii) The radius *r* of curvature of the track is 28 cm.

Determine the time interval τ between the ball passing point P and then returning to point P.

τ = ……………… s [3]

(b) The variation with time *t* of the displacement *x* of the ball in **(a)** is shown in Fig. 3.2.

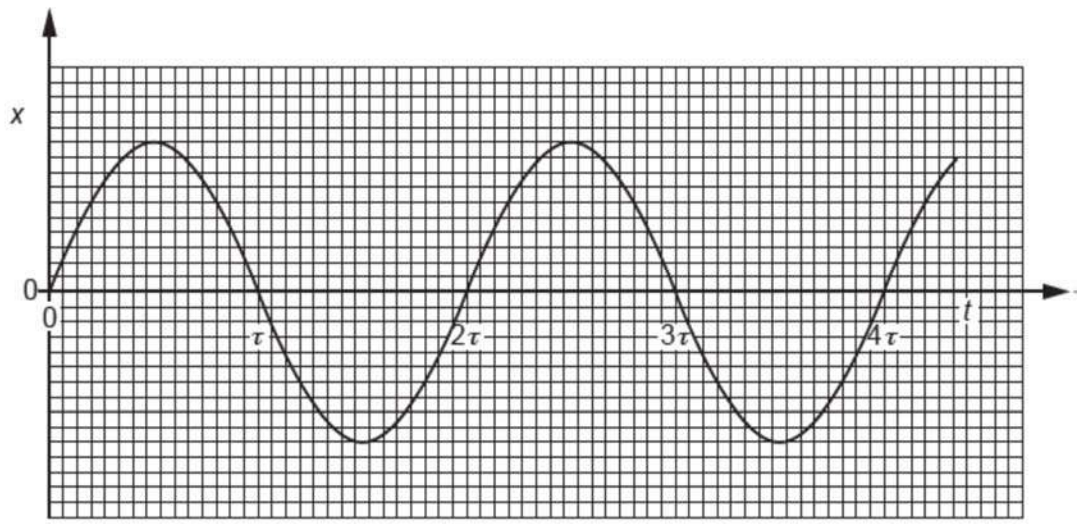


Fig. 3.2

Some moisture now forms on the track, causing the ball to come to rest after approximately 15 oscillations.

On the axes of Fig. 3.2, sketch the variation with time *t* of the displacement *x* of the ball for the first two periods after the moisture has formed. Assume the moisture forms at *t* = 0. [3]

For Examiner's Use

4 (a) A narrow beam of light of wavelength 632 nm is incident normally on a diffraction grating as shown in Fig. 4.1.

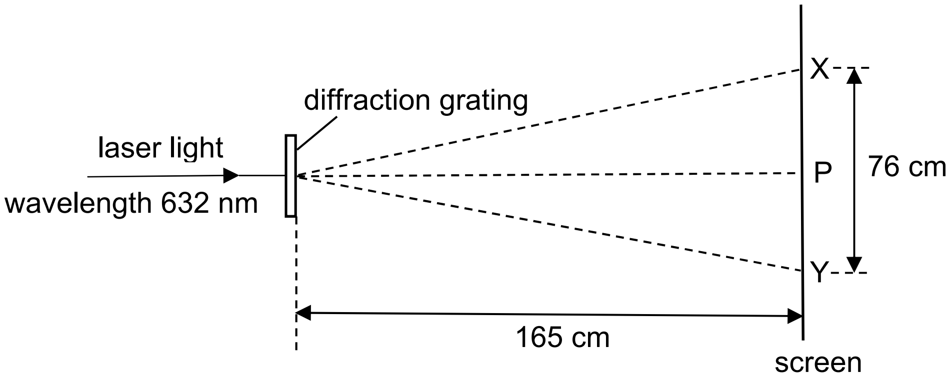


Fig. 4.1

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.

The brightest spot is P. The spots formed closest to P and on each side of P are X and Y. X and Y are separated by a distance of 76 cm.

(i) Calculate the number of lines per metre on the grating.

number per metre = …………………. [3]

(ii) Light of wavelengths 632 nm and 638 nm is now incident normally on the grating. Two lines are observed in the first order spectrum and two lines are observed in the second order spectrum, corresponding to the two wavelengths.

State two differences between the first order spectrum and the second order spectrum.

1. ……………………………………………………………………………………………

……………………………………………………………………………………………

2. ……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

For Examiner's Use

(b) **(i)** The grating in **(a)** is now rotated about an axis parallel to the incident light, as shown in Fig. 4.2.

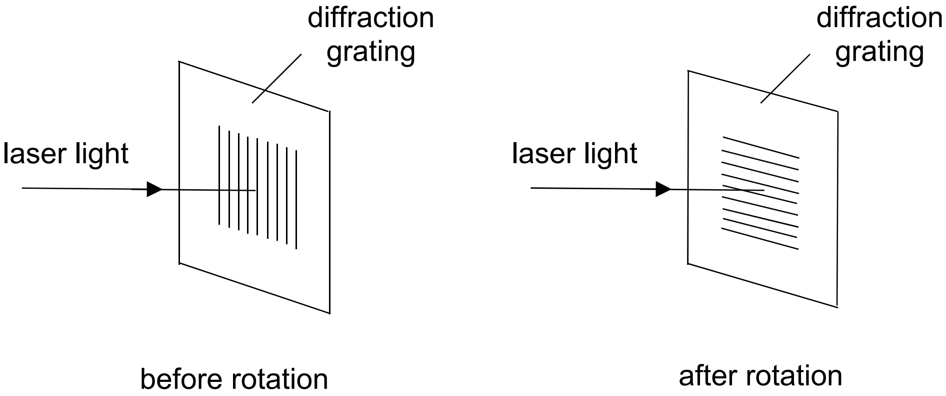


Fig. 4.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

…………………………………………………………………………………………………..

………………………………………………………………………………………… [2]

(ii) In another experiment using the apparatus in **(a)**, it was noticed that the distances XP and PY, as shown in Fig. 4.1, are not equal.

Suggest a reason for this difference.

………………………………………………………………………………………… [1]

5 **(a)** **(i)** State what is meant by the terms *electric field* and *electric field strength*.

electric field ……………………………………………………………………………………

…………………………………………………………………………………………………

electric field strength ……………………………………………………………………………

………………………………………………………………………………………………… [2]

For Examiner's Use

(ii) Determine the electric field strength at a distance of 25 cm from a point charge of 5.2×10^{-7} C. Give a unit for electric field strength with your answer.

electric field strength = ... unit .... [3]

(b) Fig. 5.1 shows three charges of value 1.0 μC at X, −1.0 μC at Y and 1.0 μC at Z. These charges are at the corners of an equilateral triangle.

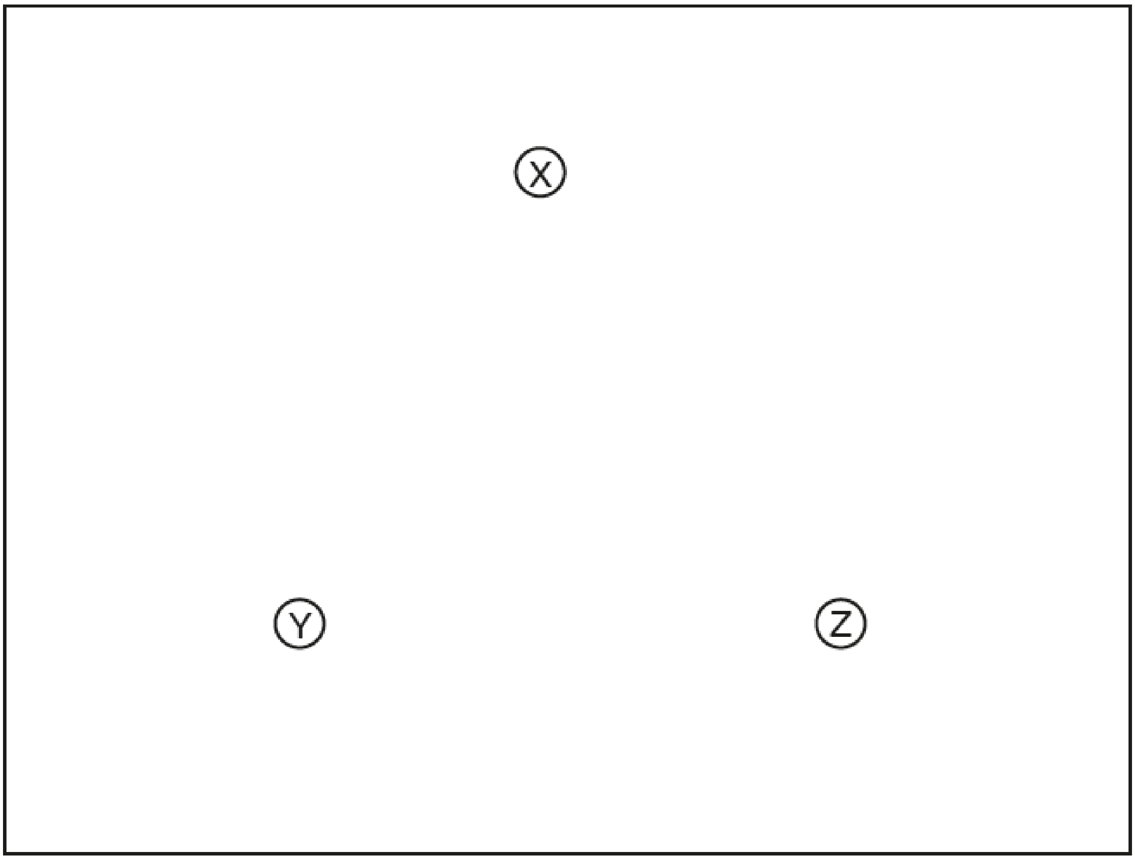


Fig. 5.1

Without making any calculations, draw on Fig. 5.1, the electric field, indicating its main characteristics, within the given rectangle area. [3]

For Examiner's Use

6 **(a)** Two identical wires A and B, are placed parallel to each other as shown in Fig. 6.1. Both wires carry a current of 90.0 A towards the left.

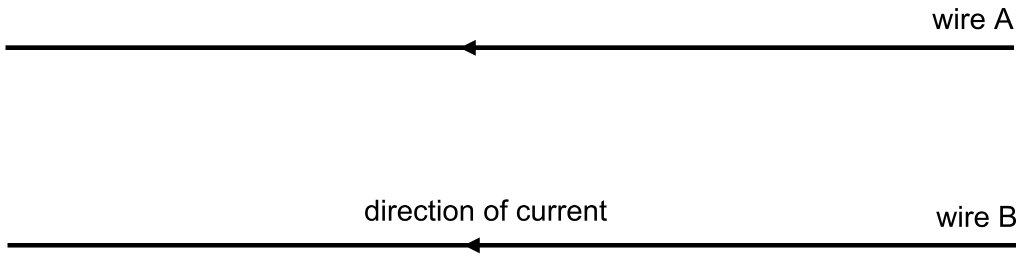


Fig. 6.1

Explain why both wires experience a force.

....

....

....

.... [2]

(b) Fig. 6.2 shows only the wire A carrying a current of 90.0 A towards the left. Point P lies in the plane of the paper containing wire A, at a distance 50.0 cm directly above wire A. At P, a proton is travelling directly towards the wire with a speed $v = 1.0 \times 10^3$ m s^{-1}. Ignore the effects of the Earth's magnetic field.

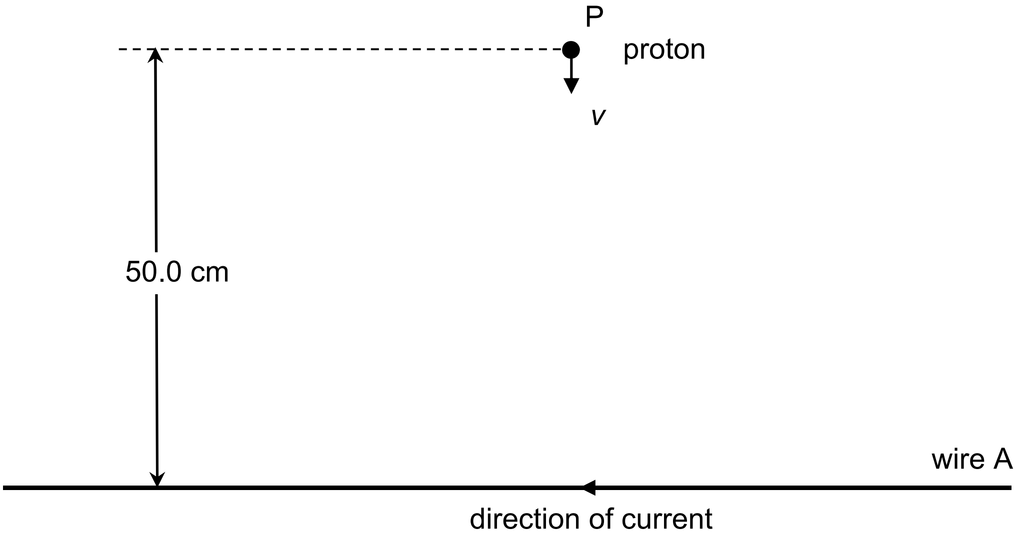


Fig. 6.2

(i) Calculate the radius of the path of the proton when it is at P.

radius = …………….....……..... m [3]

(ii) Explain how the path of the proton is affected by the magnetic field produced by the current in wire A as it moves in the region between P and wire A.

……………………………………………………………………………………………....

……………………………………………………………………………………………....

……………………………………………………………………………………………....

……………………………………………………………………………………………....

……………………………………………………………………………………………....

…………………………………………………………………………………………… [3]

7 A particular X-ray tube uses molybdenum (Mo) as the target element and another X-ray tube uses tungsten (W). An accelerating potential of 25 kV is applied to both tubes, giving rise to continuous spectrums being formed. The atomic number *Z* of molybdenum is 42 while that of tungsten is 74.

(a) Explain, with reference to the mechanism of X-ray production,

(i) how the continuous spectrum is formed, and

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………..

..…………………………………………………………………………………………. [2]

For Examiner's Use

(ii) why the minimum wavelength produced is the same for both target elements.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) Characteristic peaks K_α and K_β occur for molybdenum, but not for tungsten at an accelerating potential of 25 kV. In order to obtain the characteristic spectra for tungsten, the accelerating potential has to be increased beyond 25 kV.

Explain

(i) why the intensity of the K_α X-ray is typically greater than the K_β X-ray for molybdenum.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) why the characteristic spectra for tungsten only appear when the accelerating potential is greater than that necessary to produce characteristic spectra for molybdenum.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) The X-ray spectrum of molybdenum has a particular characteristic spectral line of wavelength 6.6×10^{-11} m, produced by electrons making transitions between two energy levels of the molybdenum atom.

Calculate, in electron-volts, the energy of an X-ray photon of wavelength 6.6×10^{-11} m.

energy = …………………………… eV [2]

8 The Singapore Mass Rapid Transit (SMRT) started its first train services in 1987. It was a massive nationwide project, beginning from the physical construction of the train tracks to the planning of the train arrival frequency. Amongst other professionals, the project involved the close collaboration of civil and structural engineers as well as transport engineers.

The Kawasaki Heavy Industries (KHI) C151 train as shown in Fig. 8.1, is Singapore's first generation of SMRT train fleet and has been in passenger service since 7 November 1987. All of the 396 KHI cars are built from 1986 to 1989 by four manufacturers in the consortium led by Kawasaki Heavy Industries.

Fig. 8.1

<u>Technical Specifications:</u>

Manufacturer:	Kawasaki Heavy Industries, Nippon Sharyo, Tokyu Car Corporation, Kinki Sharyo
Number built:	396 cars (66 trains)
Car body Construction:	Aluminium-alloy construction
Maximum Speed:	90 km h^{-1} (Design) 80 km h^{-1} (Service)
Train Length:	138 m (6 cars)
Width:	3.2 m
Height:	3.7 m
Train Mass:	286000 kg (fully laden)
Doors:	1.45 m, 8 per car
Seating Capacity:	208 seats

For Examiner's Use

Fig. 8.2 shows a section of an elevated MRT track with a train on it. From the structural aspect, the structure load is being supported as follows:

1. Each car, with passengers in it, has its load supported by the beam below it. Car 2 is thus supported by beam 2.

2. Car 2 and beam 2 are both supported by columns 1 and 2.

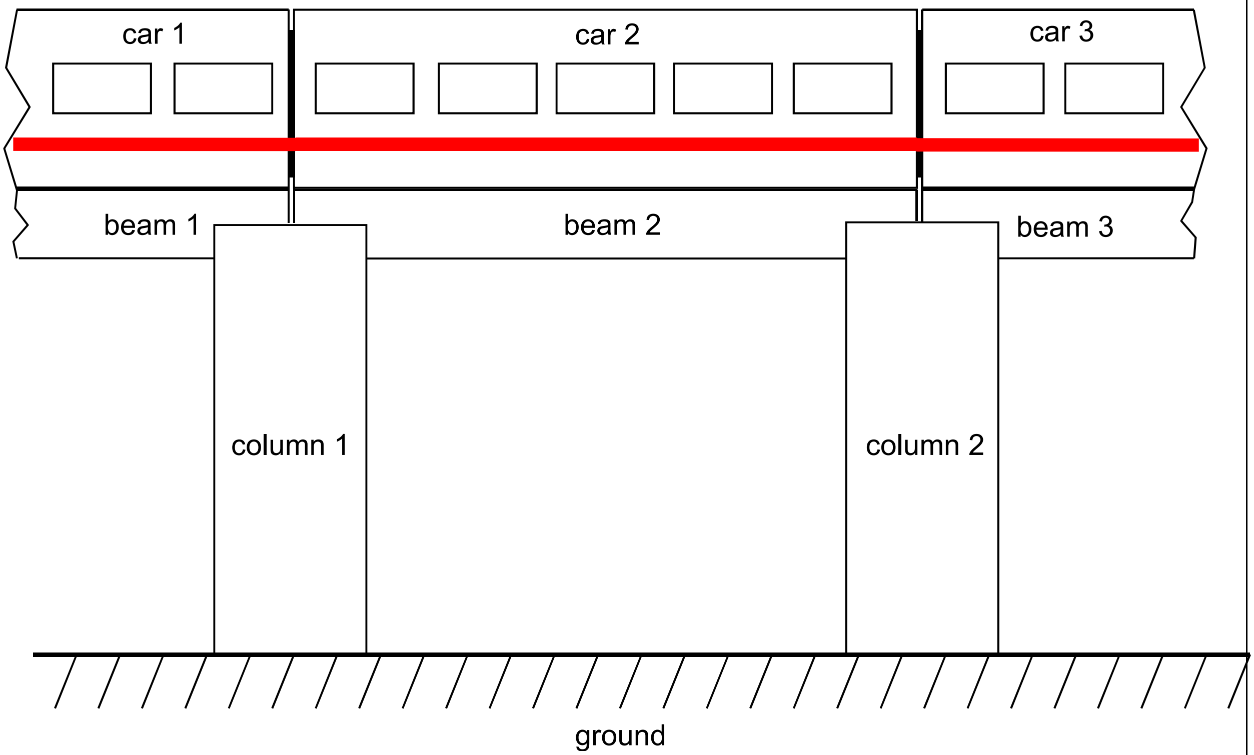


Fig. 8.2

The following set of simplified data is provided.

Weight of 1 empty car = 350 kN
Weight of 1 beam = 380 kN
Weight of 1 column = 100 kN

(a) Explain what is meant by *train arrival frequency*.

.... [1]

(b) An alloy is a combination of metals or of a metal and another element.

Suggest why trains are commonly made of aluminium alloy.

.... [1]

(c) When a train with no passengers in it, and is at the position shown in Fig. 8.2,

(i) indicate on Fig. 8.3, the portion of beam 2 that is under compression and the portion under tension when the car is on beam 2. [1]

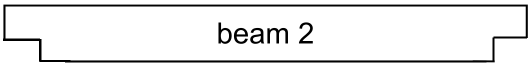


Fig. 8.3

(ii) calculate the total normal reaction force acting on beam 2 due to the supporting columns.

normal force = …………….....……..... N [1]

(iii) state the total load that the top of column 1 has to take.

total load = …………….....……..... N [1]

(iv) calculate the total load that the ground directly below each column has to take.

total load = …………….....……..... N [2]

(d) An engineer needs to design the structure such that the ground does not cave in when a fully loaded train passes overhead. In designing the structure loading, a factor of safety is incorporated.

$$\text{Factor of safety} = \frac{\text{maximum stress}}{\text{applied stress}} = \frac{\text{maximum load}}{\text{applied load}}$$

Maximum stress is defined as the maximum force the ground can withstand per unit cross-sectional area.

Applied stress is defined as the applied force the ground withstands *F*, per unit cross-sectional area *A*.

Simplified data for the applied force the ground withstands *F*, and the cross-sectional area *A*, are given in Fig. 8.4.

For Examiner's Use

F / kN	A / m^2
922	4.3
916	4.4
936	4.5
958	4.6
980	4.7
996	4.8
1020	4.9
1040	5.0

Fig. 8.4

The variation with A of F is as shown in Fig. 8.5.

(i) Complete Fig. 8.5 by drawing the best-fit line. [1]

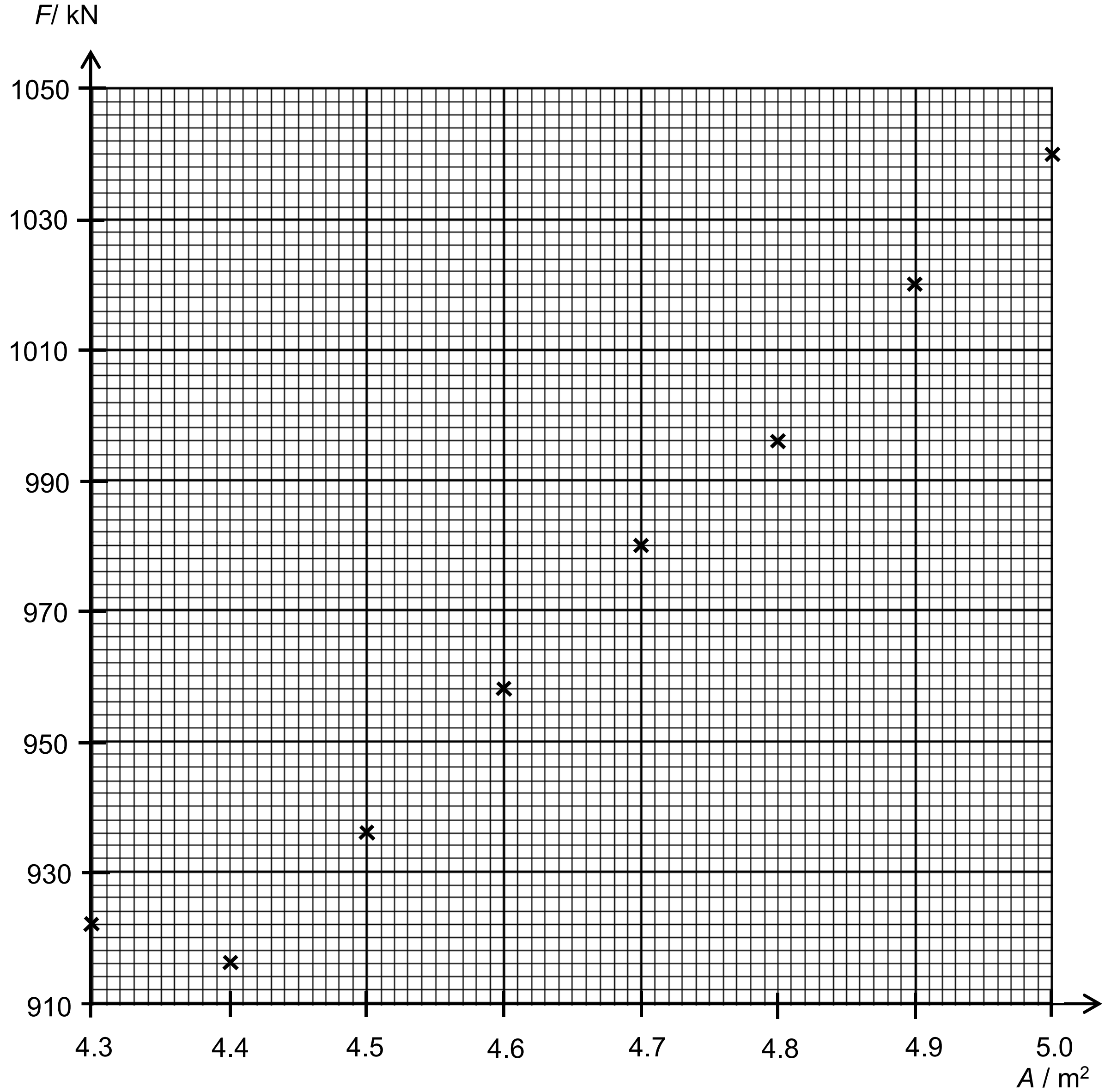


Fig. 8.5

(ii) Use Fig. 8.5 to determine the applied stress that the ground withstands.

applied stress = …………………………… N m^{-2} [2]

(iii) The column structure is considered safe if the factor of safety is greater than 2.9. Assuming that the maximum stress the ground is designed to withstand is 645 kN m^{-2}, determine whether the column structure is safe.

column structure is ……………… [2]

(e) The simplified dimensions of each column are given in Fig. 8.6.

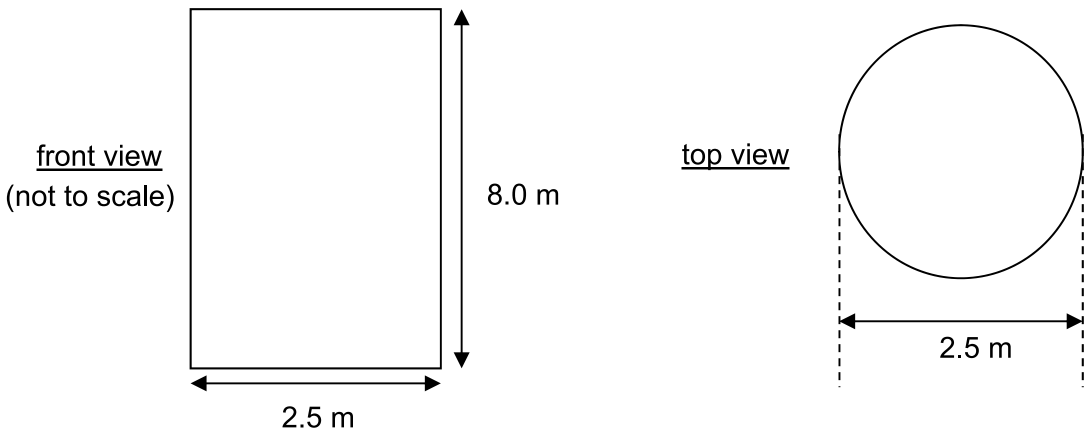


Fig. 8.6

(i) Using the value of applied stress from **(d)(ii)**, calculate the applied load that the ground withstands.

applied load = …………………………… N [2]

(ii) Hence, calculate the total allowable weight of passengers that each car can carry.

allowable weight = …………………………… N [1]

(iii) Assuming the average mass of 1 passenger to be 60 kg and value of *g* to be 10 m s^{-2}, calculate the allowable number of passengers that a car can carry at any one time.

number of passengers = …………..…......……..... [2]

(f) A transport engineer is employed to design the frequency of the trains arriving at Tuas Crescent MRT Station. In order not to cause the ground to sink, he needs to look into the allowable passengers that each car can take and not overload each car. The following information is available to him:

<u>Peak hours at Tuas Crescent MRT Station</u>

Average number of east-bound passengers per minute = 240

On average, an east-bound train is anticipated to be already 75% filled just before it arrives at Tuas Crescent MRT Station.

Assuming that each car takes equal number of passengers and all board the train, determine the possible longest time interval between arrival of consecutive east-bound trains at the station during peak hours.

longest time interval = ……………….....……... minutes [3]

END OF PAPER

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DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/03

Paper 3 Longer Structured Questions

September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**10**
2	**10**
3	**10**
4	**10**
5	**10**
6	**10**
7	**20**
8	**20**
Total	**80**

This document consists of **25** printed pages and **1** blank page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided

1 **(a)** Make estimates of the following quantities.

(i) the thickness of a sheet of A4 paper

thickness = …………………… mm [1]

(ii) the mass of a sheet of A4 paper

mass = …………………… g [1]

(b) The distance from the Earth to the Sun is 0.15 Tm.

Calculate the time in minutes for light to travel from the Sun to the Earth.

time = …………………… minutes [2]

(c) The time *T* for a satellie to orbit the Earth is given by

$$T = \sqrt{\frac{KR^3}{M}}$$

where *R* is the distance of the satellite from the centre of the Earth, *M* is the mass of the Earth and *K* is a constant.

(i) Determine the SI base units of *K*.

SI base units of *K* = …………………… [2]

(ii) Data for a particular satellite are given in Fig. 1.1

quantity	measurement	uncertainty
T	8.64×10^4 s	± 0.50%
R	4.23×10^7 m	± 1.0%
M	6.0×10^{24} kg	± 2.0%

Fig. 1.1

Express K with its associated uncertainty in SI units.

K = ……………………± ………………… SI units [3]

(iii) State the quantity which contributes the largest uncertainty in the value of K.

…………………………………………………………………………………………………

…………………………………………………………………………………………….. [1]

For Examiner's Use

2 A hot-air balloon rises vertically at a constant speed. At time t = 0, a ball is released from the balloon.

Fig. 2.1 shows the variation with time t of the ball's velocity v.

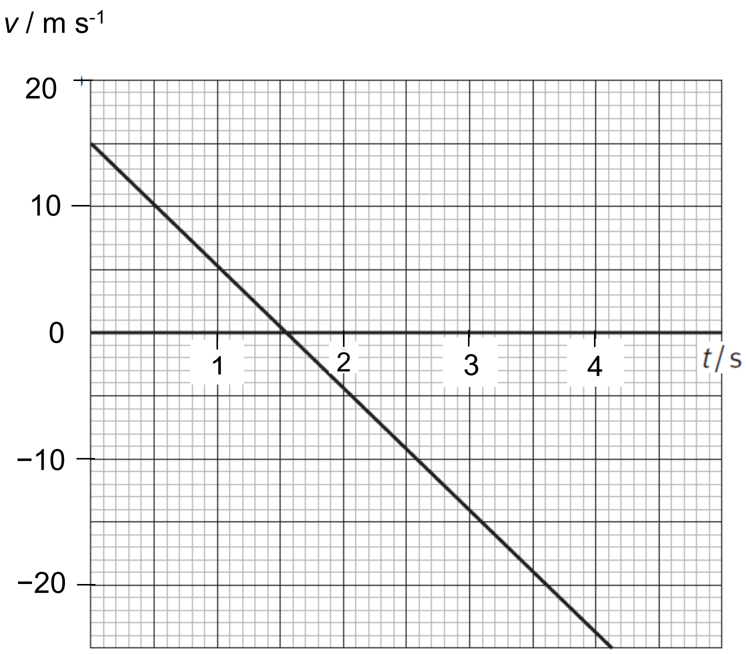

Fig. 2.1

The ball hits the ground at t = 4.1 s.

(a) State the speed of the hot-air balloon.

speed = ………………………………. m s^{-1} [1]

(b) Explain how the graph in Fig. 2.1 shows that the acceleration of the ball is constant.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(c) Use Fig. 2.1 to

(i) state the time at which the ball reaches its highest point,

time = ………………………………. s [1]

(ii) show that the ball rises for a further 12 m between release and its highest point,

[1]

For Examiner's Use

(iii) determine the distance between the point of release of the ball and the ground.

distance = ………………………………. m [2]

(d) Describe the difference between displacement of the ball and the distance it travels.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………….[2]

(e) Sketch a new graph on Fig. 2.1 showing the variation with *t* of the ball's velocity *v* if air resistance is not negligible. Assume terminal velocity is attained by the ball before hitting the ground. Label the new graph N. [2]

3 **(a)** **(i)** Define *force*.

…………………………………………………………………………………………………

………………………………………………………………………………………………[1]

(ii) State *Newton's third law of motion*.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

For Examiner's Use

(b) Fig. 3.1 shows the variation with time *t* of a jumping flea's acceleration *a*. The acceleration *a* is measured in unit of *g*, the acceleration of free fall. The flea of mass 210 μg jumped at nearly vertical take-off angle from ground.

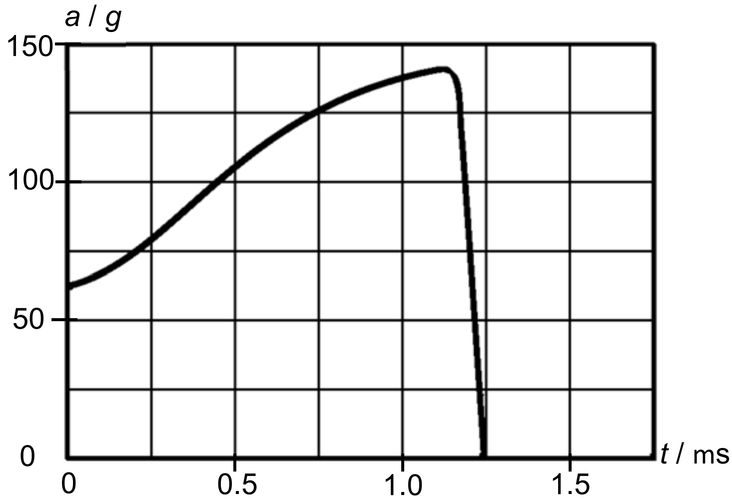

Fig. 3.1

(i) Use Fig. 3.1 to

1. determine the maximum net external force acting on the jumping flea,

force = ... N [2]

2. estimate the maximum speed achieved by the flea.

speed = ... m s^{-1} [3]

(ii) State and explain whether linear momentum is conserved during the take-off of the flea from the ground.

....

....

....[2]

For Examiner's Use

4 **(a)** Explain,

(i) what is meant by a *radian*,

....

....

....[2]

(ii) why one complete revolution is equivalent to an angular displacement of 2π rad.

....

....[1]

(b) A stone of weight 3.0 N is fixed, using glue, to one end P of a rigid rod CP, as shown in Fig. 4.1.

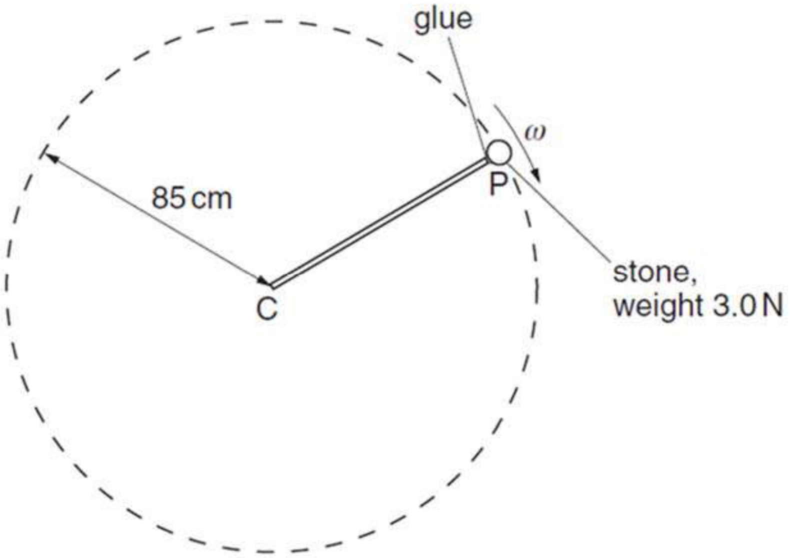

Fig. 4.1

The rod is rotated about end C so that the stone moves in a vertical circle of radius 85 cm.

The angular speed ω of the rod and stone is gradually increased from zero until the glue snaps. The glue fixing the stone snaps when the tension in it is 18 N.

For the position of the stone at which the glue snaps,

(i) mark with the letter S, the position of the stone on the dotted circle of Fig. 4.1 and [1]

(ii) calculate the angular speed ω of the stone.

angular speed = ……………………………… rad s^{-1} [3]

(c) The same stone is now fixed on a string and made to travel along a horizontal circular path, as shown in Fig. 4.2.

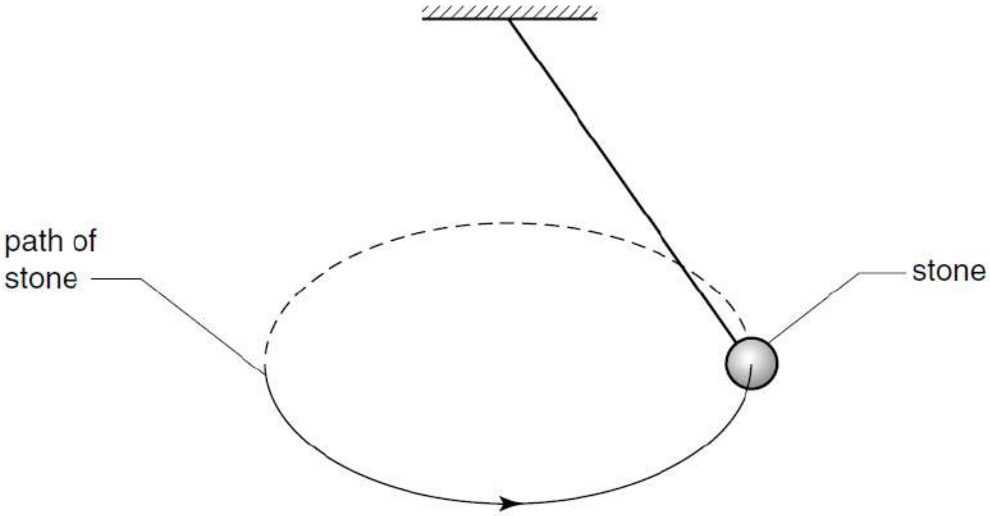

Fig. 4.2

For Examiner's Use

The string makes an angle of 35° to the vertical, as illustrated in Fig. 4.3.

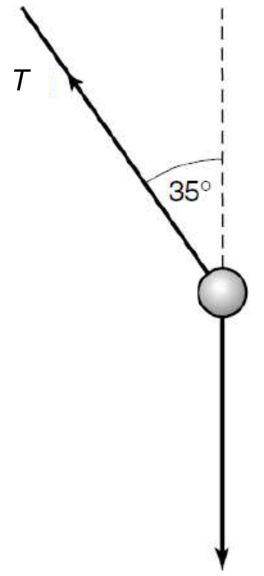

Fig. 4.3

Determine

(i) the tension T in the string, and

tension = ………………………………. N [1]

(ii) the resultant force acting on the stone in the position shown.

magnitude of force = ………………………………. N

direction of force = ………………………………. [2]

For Examiner's Use

5 A cycle of changes in pressure, volume and temperature of gas inside a cylinder of a petrol engine is illustrated in Fig. 5.1. The gas is assumed to be ideal.

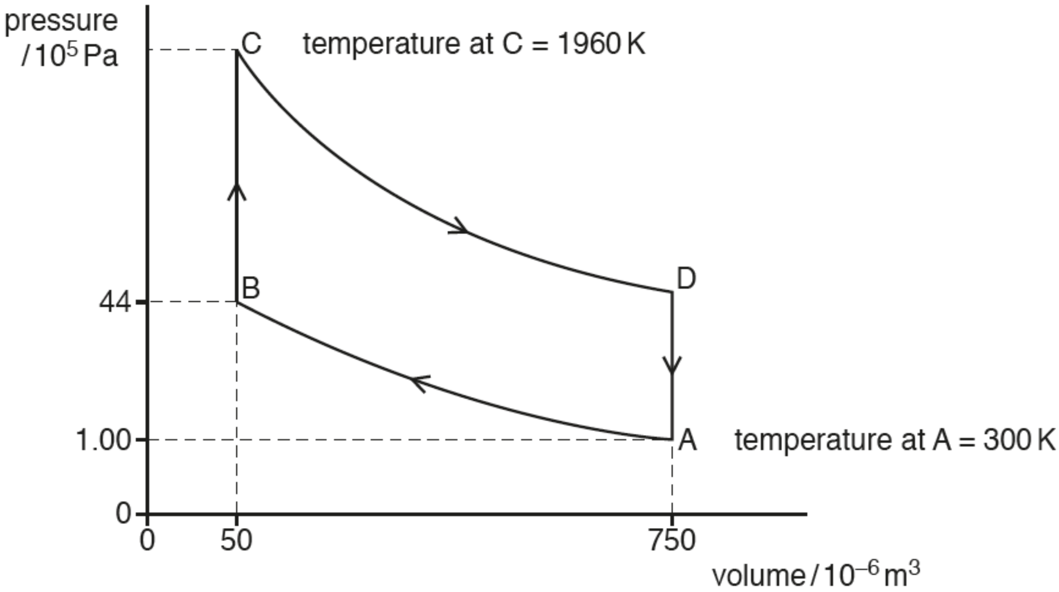

Fig. 5.1 (not to scale)

There are four stages in the cycle.

stage	description
A to B	Rapid compression of the gaseous petrol/air mixture with the temperature rising from 300 K at A and the pressure rising to 44 × 10^5 Pa at B.
B to C	The petrol/air mixture is exploded, resulting in an almost instant rise in pressure. At C the temperature has risen to 1960 K.
C to D	Rapid expansion and cooling of the hot gases.
D to A	Return to the starting point of the cycle.

(a) **(i)** State what is meant by an *ideal gas*.

....

....

....[2]

For Examiner's Use

(ii) Use the values in Fig. 5.1 to determine the number of moles present in the gases in the cycle.

number of moles = ... moles [2]

(b) Complete the table in Fig. 5.2 showing the work done on the gas, the heat supplied to the gas and the increase in the internal energy of the gas, during the four stages of one cycle.

stage	work done **on** gas /J	heat supplied **to** gas /J	**increase** in internal energy of gas / J
A to B	+ 360	0	
B to C		+ 670	
C to D		0	− 810
D to A			

[4]

Fig. 5.2

(c) Explain qualitatively how molecular movement causes the fall in temperature of the gas during the stage from C to D.

....

....

....

....

....[2]

6 (a) An alternating voltage of period 10 ms is being applied directly across a resistor of 5.0 Ω in a circuit. The variation with time t of voltage V is shown in Fig. 6.1.

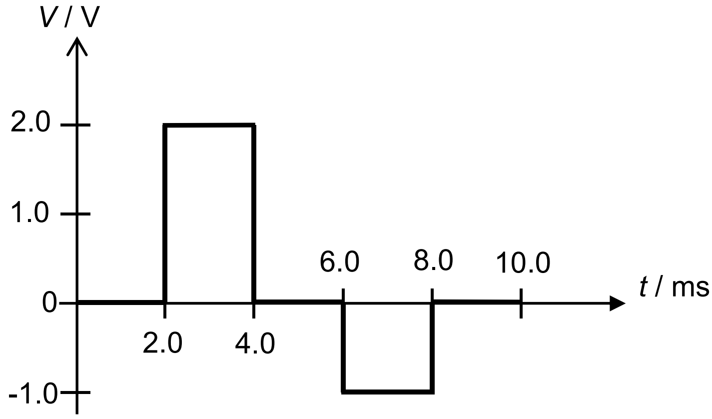

Fig. 6.1

Calculate the steady voltage passing through the same resistor that would produce an identical heating effect.

voltage = ... V [2]

(b) Explain why it is necessary to use high voltages for the efficient transmission of electrical energy.

....

....

....[2]

For Examiner's Use

(c) Another sinusoidal voltage input of 6.5 mV r.m.s. and 50 Hz is now connected to the primary coil of a transformer as shown in Fig. 6.2. The transformer is assumed to be ideal and its turns ratio, $\frac{N_s}{N_p}$ is 71. The secondary coil is connected to a resistor *R*. An average power of 0.040 W is produced in resistor *R*.

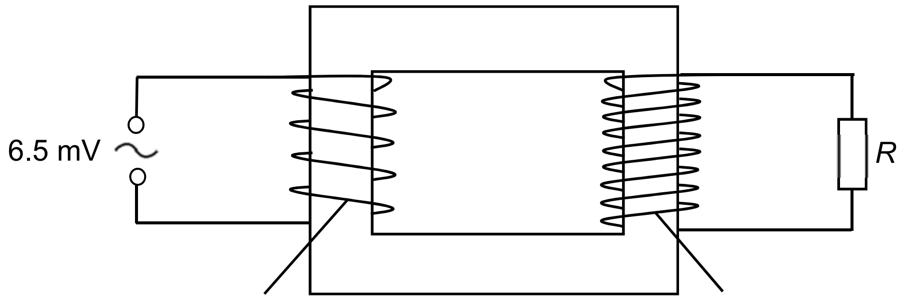

Fig. 6.2

(i) Calculate the r.m.s output voltage supplied to resistor *R*.

r.m.s. voltage = …………………. V [1]

(ii) In Fig. 6.3, sketch the variation with time *t* of the power *P* dissipated in the resistor *R.* Label all values on the axes. [2]

Fig. 6.3

For Examiner's Use

(iii) An ideal diode is now connected to the secondary coil with resistor *R* as shown in Fig. 6.4.

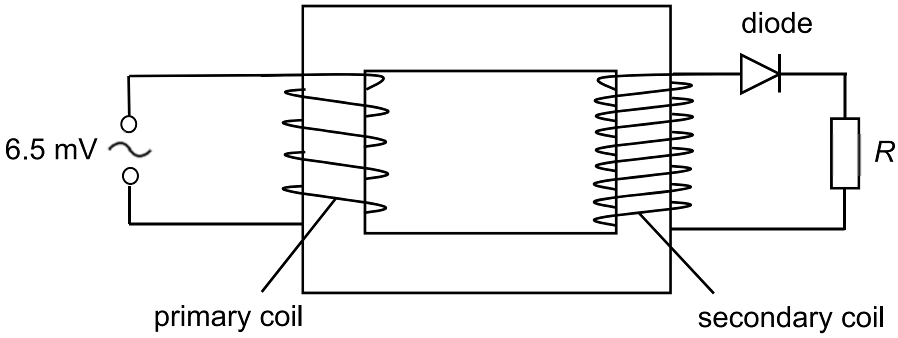

Fig. 6.4

Describe the variation with time of the

1. current flow through resistor *R*, and

....

....

....[2]

2. voltage across resistor *R*.

....

....[1]

For Examiner's Use

Section B

Answer **one** question from this Section in the spaces provided.

7 **(a)** Distinguish between the *electromotive force* and the *potential difference* in terms of energy considerations.

……

……

……

……

……

……………………………………………………………………………………………………….[2]

(b) Felix connects a voltmeter, of resistance R_V, and an ammeter, of resistance R_A, as shown in Fig. 7.1 to measure the resistance R of a resistor. V is the voltmeter reading, I is the ammeter reading and E is the e.m.f. of the cell.

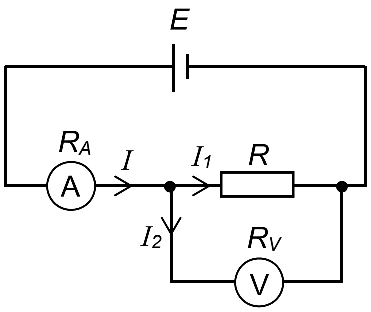

Fig. 7.1

(i) Derive an expression for the value of R in terms of I, V and R_V.

expression = ……………………. [2]

For Examiner's Use

(ii) Felix rearranges the circuit and connects the voltmeter and ammeter as shown in Fig. 7.2 to measure the same resistance *R*.

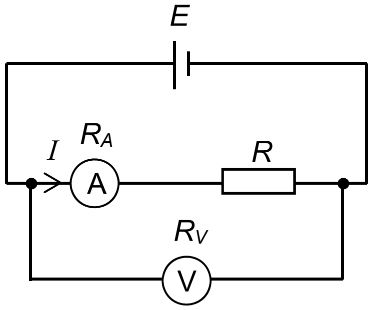

Fig. 7.2

Derive an expression for the value of *R* in terms of *I*, *V* and R_A.

expression = ……………………. [2]

(iii) Hence, suggest what the values of R_V and R_A should be such that the value of *R* is equal to $\frac{V}{I}$.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

(c) Felix set ups a potentiometer circuit as shown in Fig. 7.3. The resistivity of wire AB is 1.4×10^{-6} Ω m, with a length of 1.1 m and a circular cross-section of radius 0.304 mm. The 2.2 V and 1.8 V cells have internal resistances of 0.30 Ω and 1.1 Ω respectively.

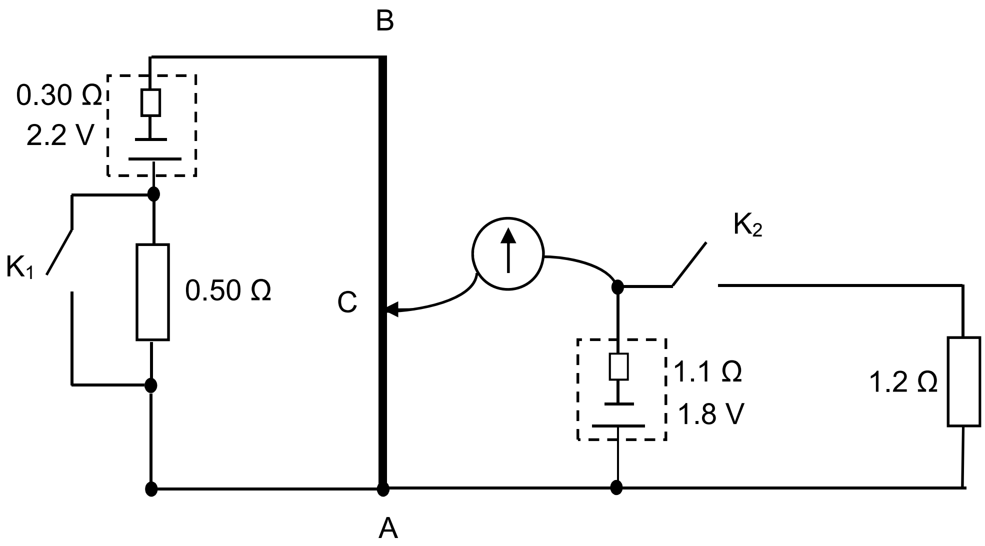

Fig. 7.3

(i) Determine the resistance of wire AB.

resistance = ... Ω [2]

(ii) **1.** Calculate the length AC required to produce zero current in the galvanometer with switch K_1 open and switch K_2 closed.

length = ... cm [2]

2. State and explain the change in length, if any, in your answer to **(ii) 1.**, if both switches K_1 and K_2 are open.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(iii) When both switches K_1 and K_2 are closed and there is zero current in the galvanometer,

1. calculate the power dissipated across wire AB and

power = ... W [2]

2. calculate the mean drift velocity *v* of the electron, if the number of electrons in one cm^3 of wire AB is 10^{23}.

v = ... $m\ s^{-1}$ [1]

(d) During his course of study in Physics, Felix comes across an electrical component. The variation with potential difference *V* of current *I* for the component is shown in Fig. 7.4.

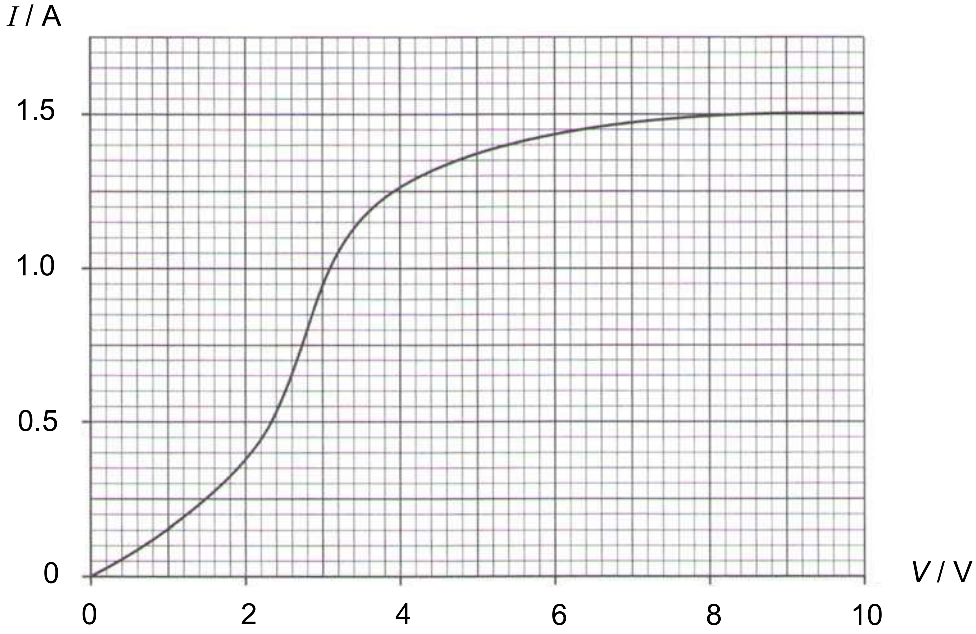

Fig. 7.4

(i) Use Fig. 7.4 to determine the resistance of the component at 3.4 V.

resistance = ... Ω [1]

(ii) Describe how the resistance of this component changes with the potential difference applied across it from 0 V to 6.0 V.

....

....

....

.... [2]

8 **(a)** Fig. 8.1 shows an α-particle A as it approaches and passes by a stationary gold nucleus N.

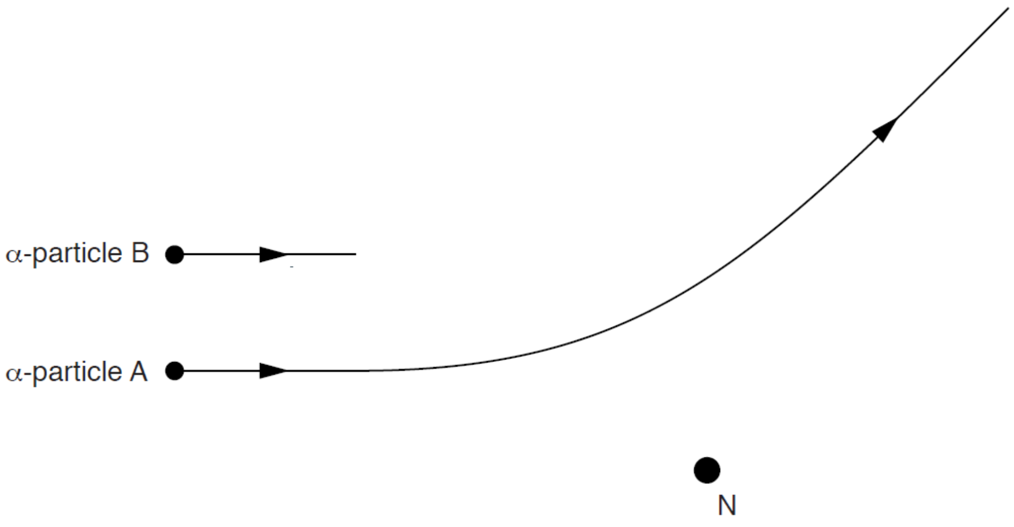

Fig. 8.1

A second α-particle B has the same initial direction and energy as α-particle A.

On Fig. 8.1, complete the path of α-particle B as it approaches and passes by the nucleus N. [2]

(b) An alpha particle has a speed of 1.30×10^{7} m s^{-1}.

(i) Calculate the kinetic energy of the alpha particle.

kinetic energy = ... J [2]

(ii) The alpha particle is aimed directly at a gold nucleus which has a proton number of 79.

Calculate the distance of closest approach *r*.

r = ... m [3]

For Examiner's Use

(c) A radiation detector is placed close to a radioactive source. The detector does not surround the source.

Radiation is emitted in all directions and, as a result, the activity of the source and the measured count rate are different.

Suggest two other reasons why the activity and the measured count rate may be different.

1. ……………………………………………………………………………………………

……………………………………………………………………………………………

2. ……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(d) The variation with time *t* of the measured count rate in **(c)** is shown in Fig. 8.2.

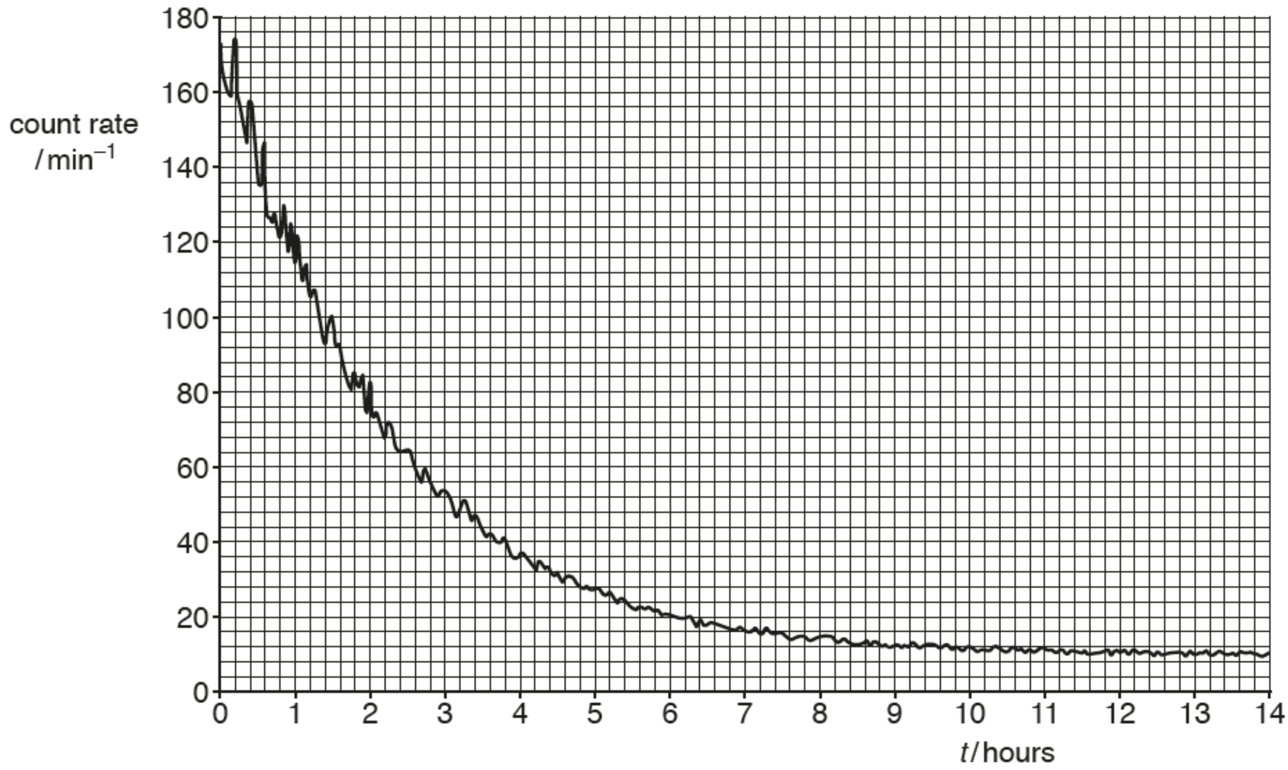

Fig. 8.2

(i) State the feature of Fig. 8.2 that indicates the random nature of radioactive decay.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Use Fig. 8.2 to determine the half-life of the radioactive isotope in the source.

half-life = ... hours [4]

(e) The readings in **(d)** were obtained at room temperature. A second sample of this isotope is heated to a temperature of 500 °C. The initial count rate at time t = 0 is the same as that in **(d)**. The variation with time t of the measured count rate from the heated source is determined.

State, with a reason, the difference, if any, in

1. the half-life,

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

2. the measured count rate for any specific time.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

…………………………………………………………………………………………………….. [3]

For Examiner's Use

(f) A small volume of solution containing the radioactive isotope sodium-24 ($^{24}_{11}Na$) has an initial activity of 3.8×10^4 Bq. Sodium-24, of half-life 15 hours, decays to form a stable daughter isotope.

All of the solution is poured into a container of water. After 36 hours, a sample of water of volume 5.0 cm^3, taken from the container, is found to have an activity of 1.2 Bq.

Assuming that the solution of the radioactive isotope is distributed uniformly throughout the container of water, calculate the volume of water in the container.

volume = ... cm^3 [3]

END OF PAPER

For Examiner's Use

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DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME	

CLASS		INDEX NUMBER	

PHYSICS

9749/04

Paper 4 Practical

August 2018

2 hour 30 minutes

Candidates answer on the Question Paper.
Additional Materials: As listed on the Apparatus List

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Shift
Laboratory

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**14**
2	**9**
3	**20**
4	**12**
Total	**55**

This document consists of **16** printed pages and **0** blank page.

For Examiner's Use

1 When an object falls in air, it experiences a drag force which opposes the motion of the object. Larger objects experience greater drag forces. In this experiment, you will investigate how the terminal velocity of a paper cone falling in air depends on the diameter of the cone.

(a) Cut a sector out of a piece of filter paper as shown in Fig. 1.1.

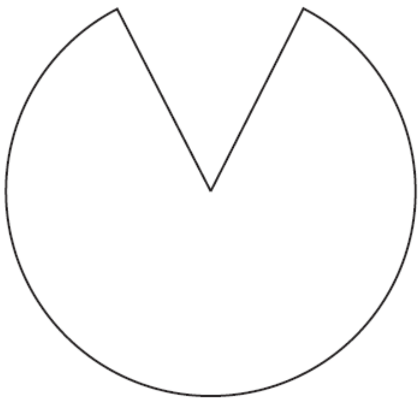

Fig. 1.1

(b) (i) Tape the straight edges of the paper together to produce a cone, as shown in Fig. 1.2.

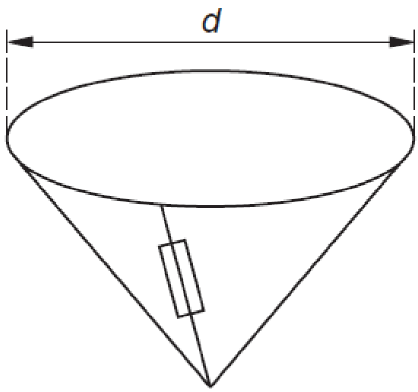

Fig. 1.2

(ii) Measure and record the diameter *d* of the cone.

d = ... [2]

(iii) Estimate the percentage uncertainty in *d.*

Percentage uncertainty in *d* = ... [1]

For Examiner's Use

(c) **(i)** Mount a metre rule vertically using a stand, boss and clamp.

(ii) Release the cone from a short distance above the top of the metre rule, as shown in Fig. 1.3.

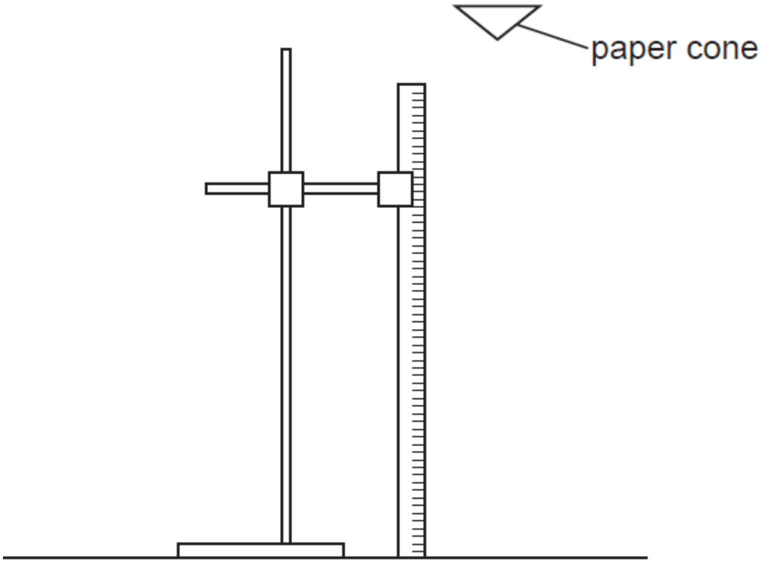

Fig. 1.3

Make and record measurements to determine the time *t* for the cone to fall through a distance *h* from the top of the metre rule.

h = ………………………………… [1]

t = ………………………………… [1]

(d) Calculate the terminal velocity *v* of the cone.

v = ………………………………… [1]

For Examiner's Use

(e) **(i)** Remove the tape from the paper and cut away a larger sector as shown in Fig. 1.4.

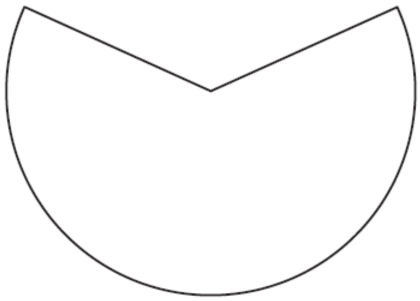

Fig. 1.4

(ii) Repeat step **(b)(i)**.

(f) It is suggested that *v* is inversely proportional to *d*.

Use the cone in step **(e)(ii)** to take further measurements to investigate this suggestion. State and explain whether or not you agree with this suggestion.

Present your measurements and calculated results clearly.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………[5]

For Examiner's Use

(g) Weights such as steel paperclips are loaded into the cone. With a much heavier cone, suggest changes that could be made to the experiment. You are not expected to conduct the experiment.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

[Total: 14 marks]

2 In this experiment, you will investigate the motion of a bent metal wire.

(a) **(i)** Secure the cork in the clamp so that the pin is mounted horizontally.

(ii) Make a sharp bend in the wire at its centre so that the angle θ between the straight parts of the wire is about 100º as shown in Fig. 2.1.

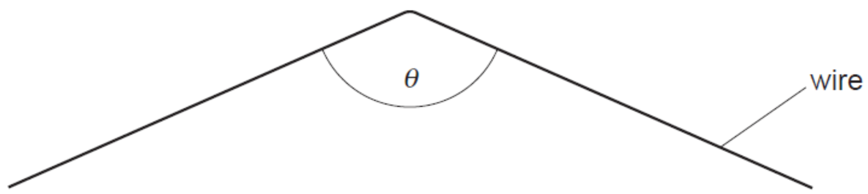

Fig. 2.1

(iii) Measure and record the angle θ.

θ = ……………………………… [1]

(iv) Calculate cos θ.

cos θ = ……………………………… [1]

For Examiner's Use

(v) Justify the number of significant figures which you have given for cos *θ*.

....

....[1]

(b) **(i)** Suspend the wire from the pin so that the arrangement is as shown in Fig. 2.2.

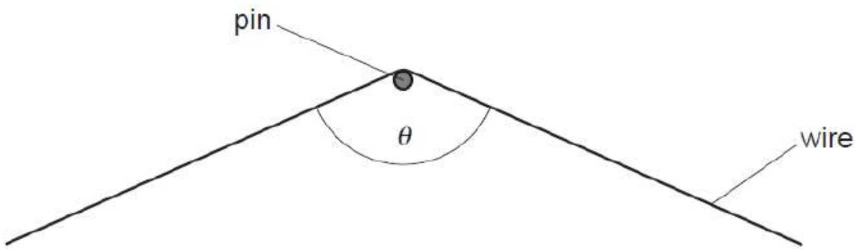

Fig. 2.2

(ii) Displace the wire from its equilibrium position and release it so that it performs small oscillations in a vertical plane, as shown in Fig. 2.3.

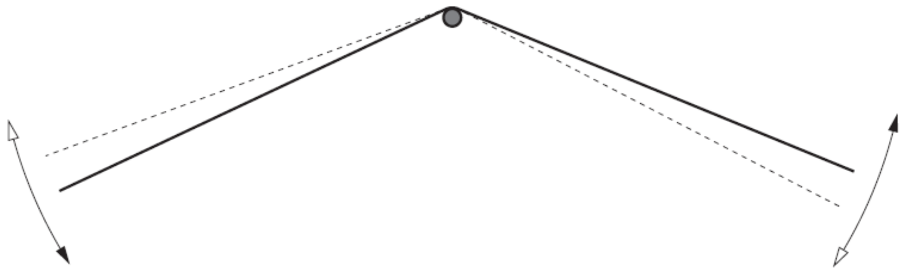

Fig. 2.3

(iii) Make and record the measurements to determine the period *T* of these oscillations.

T = ... [2]

For Examiner's Use

(c) It is suggested that the relationship between T and θ is

$$\frac{1}{T^4} = A(\cos\theta + 1)$$

where A is a constant.

Using your data, calculate the value of A.

A = ………………………………… [1]

(d) A theoretical treatment of this oscillator shows that

$$A = \frac{1}{2}\left(\frac{3g}{4\pi^2 L}\right)^2$$

where L is the total length of the wire.

By making one further measurement, and using the results of your experiment, calculate a value of g, the acceleration of free fall.

g = ………………………………… [3]

[Total: 9 marks]

For Examiner's Use

3 In this question you will investigate how the resistance of a light-dependent resistor (LDR) depends on the number of holes made in an aluminium foil placed above the LDR. The LDR is contained in a tube.

(a) (i) A lamp has been mounted above the tube containing the LDR. You should **not** adjust the position of the lamp or the tube during the experiment.

(ii) Connect the LDR in series with a 1.0 kΩ resistor, milliammeter and a power supply as shown in Fig. 3.1. A voltmeter is to be placed in parallel with the LDR. Connections to the LDR may be made using crocodile clips attached to the wires leading from the tube.

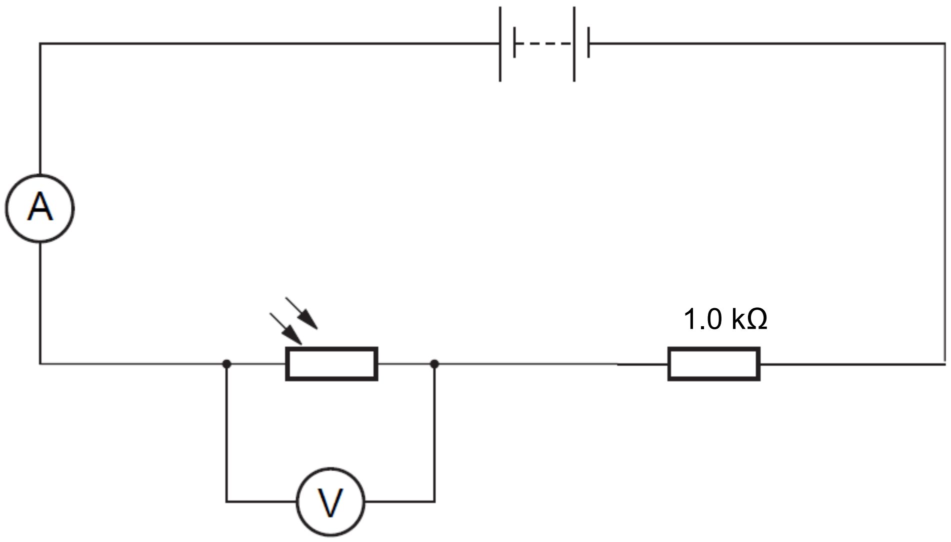

Fig. 3.1

(b) (i) Use the pin to make a small hole near the centre of the aluminium foil as shown in Fig. 3.2. The diameter of the hole should be the same as the diameter of the pin. Remove the pin.

For Examiner's Use

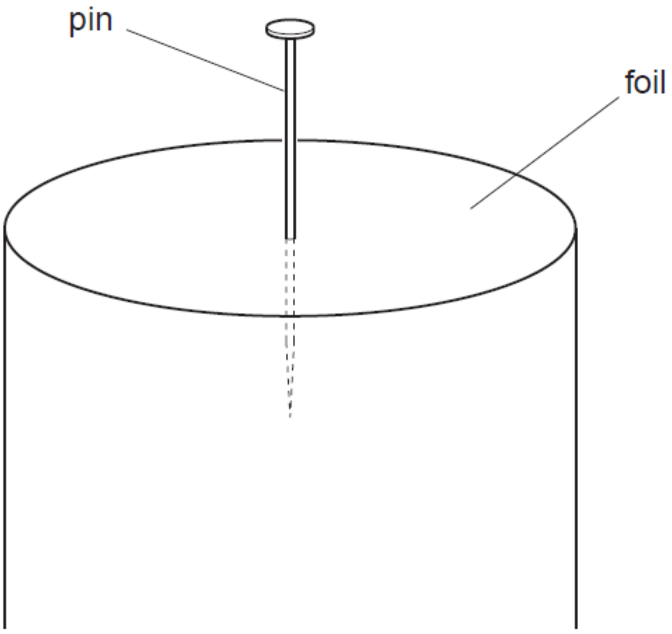

Fig. 3.2

(ii) Record the current I in the circuit and the potential difference V across the LDR.

V = ……………………………

I = …………………………… [1]

(iii) Calculate the resistance R of the LDR.

R = …………………………… [1]

For Examiner's Use

(c) Make another, separate pinhole close to the centre of the foil. Repeat **(b)(ii)** and **(iii)** until you have six sets of readings for R and the number N of pinholes in the foil where $1 \leq N \leq 6$. [6]

(d) Theory suggests that

$$R = aN^b$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b.

a = ……………………………

b = …………………………… [8]

For Examiner's Use

For Examiner's Use

(e) **(i)** Use a micrometer screw gauge to measure the diameter of the pin.

diameter of pin = ... [1]

(ii) Hence determine the cross-sectional area A_p of one pinhole.

A_p = ... [1]

(iii) Use the rule to measure the diameter of the tube containing the LDR, and hence determine the cross-sectional area A_T of the tube.

A_T = ... [1]

(iv) Use your values from **(ii)** and **(iii)** to find the number of holes equivalent to the cross-sectional area of the tube.

number of holes = ...

(f) Use your answers from **(d)** and **(e)** to determine a value for the resistance of the LDR if the foil were to be removed from the end of the tube. It is **not** necessary to check this value experimentally.

R = ... [1]

[Total: 20 marks]

4 One type of radiation detector known as Geiger – Müller tube is shown in Fig. 4.1.

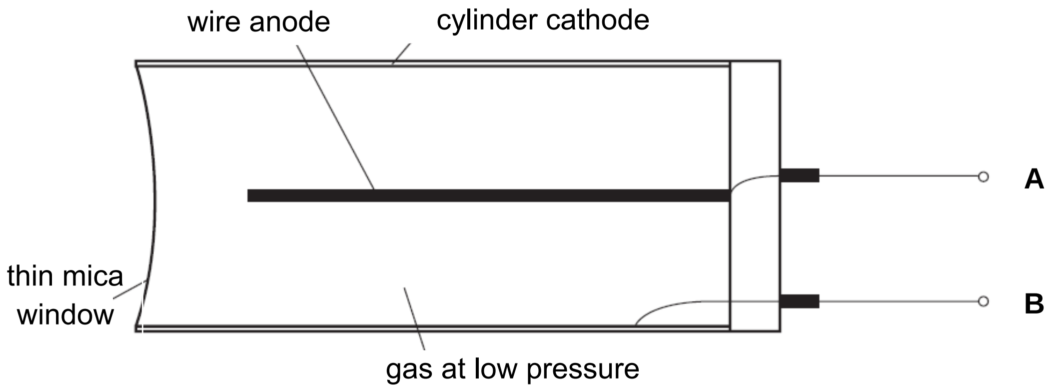

Fig. 4.1

In order for the tube to function, a potential difference V_{AB} has to be applied between **A** and **B**. The count rate registered by an instrument connected to the tube depends on several factors such as the activity of the source and V_{AB}. The tube can detect *α, β* and *γ*–radiation.

Design a laboratory experiment to investigate how the count rate due to *γ*– radiation **only** depends upon the potential difference V_{AB}. You have access to three different radioactive sources only. Information relating to each of these sources is given in the table below.

Source	Type of radiation emitted	Half-life of source
Radium – 226	*α, β* and *γ*	1600 years
Bismuth – 214	*β* and *γ* only	20 minutes
Cobalt – 60	*β* and *γ* only	5 years

You may assume that the following equipment is available, together with any other apparatus that may be found in a school or college science laboratory.

Aluminium plates of different thickness
Geiger – Müller tube
Lead plates of different thickness
Ratemeter

You should draw a diagram showing the arrangement of your apparatus. In your account you should pay particular attention to

(a) which source you would use, giving a reason for your choice,
(b) the procedure to be followed, including how the count rate would be measured,
(c) the control of variables,
(d) any safety precautions you would take.

For Examiner's Use

Diagram

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For Examiner's Use

For Examiner's Use

[12]

Dunman High School 2018 Year 6 Prelim Exam H2 Physics Answers

Paper 1

1 **C**	2 **D**	3 **A**	4 **D**	5 **D**	6 **D**	7 **C**	8 **C**	9 **C**	10 **C**
11 **A**	12 **A**	13 **C**	14 **D**	15 **C**	16 **D**	17 **B**	18 **A**	19 **D**	20 **A**
21 **B**	22 **B**	23 **B**	24 **B**	25 **B**	26 **B**	27 **A**	28 **C**	29 **C**	30 **B**

Paper 2

1 (a) (i) atmospheric pressure = 9.10×10^4 Pa A1
(ii) $(9.15 - 9.10) \times 10^4 = \rho_m \times 9.81 \times (0.17 - 0.10)$ C1
$\rho_m = 728 \text{ kg m}^{-3}$ A1

(b) (i) pressure at top surface of cube = 9.135×10^4 Pa (from graph)
pressure at bottom surface of cube = 9.180×10^4 Pa (from graph) C1
Upthrust = $(9.180 - 9.135) \times 10^4 \times (0.051)^2$ C1
= 1.17 N A1
(ii) force = 4 – 1.17 = 2.83 N A1

(c) Remove the cube and check if spring returns to original length B1
(d) (i) free body diagram of upper ball, three forces: 1. weight, 2. horizontal force by wall on ball and 3. force by lower ball on upper ball.
Angle is 45° between horizontal and the dotted line.
So tan(45°) = (horizontal force) / (weight) C1
Horizontal force = weight = 1.67 N A1
OR taking moment about axis through point of contact between the balls:
Same moment arm C1
Hence *F* = weight of ball = 1.67 N A1

(ii) $F = \sqrt{(1.67^2 + 1.67^2)}$ C1
= 2.36 N A1

2 (a) $g = (6.1 \pm 0.1)$ N m^{-1} C1
Force = $mg = 6.1 \times 20000$
= (122 000 ± 2000) N A1
(b) $F = \frac{mv^2}{r}$ or $g = \frac{v^2}{r}$ C1
$v = \sqrt{(6.1 \times (8.2 \times 10^6)}$
= $(7.1 \pm 0.1) \times 10^3$ m s^{-1} A1
(c) (i) The gravitational potential at a point is defined as the <u>work done per unit mass</u> in bringing a <u>small test mass</u> from infinity to that point. B1
(ii) $\phi = -\frac{GM}{r} = -gr$ C1
= – $(4.0 \pm 0.1) \times 10^7$ J kg^{-1} A1
OR
recognizes that this is the <u>area under the graph</u> <u>from point to infinity</u> B1
counting squares gives total area = – $(4.0 \pm 2.0) \times 10^7$ J kg^{-1} B1

3 (a) (i) *g* and *r* are constant, so *a* is proportional to *x* B1
negative sign shows *a* and *x* are in opposite direction B1
(ii) $\omega^2 = \frac{g}{r}$ and $\omega = \frac{2\pi}{T}$ C1
$\omega^2 = \frac{9.81}{0.28} = 35$

$T = 1.06$ s M1

$\tau = 0.53$ s A1

(b) Sketch: time period constant (or increases very slightly) B1

drawn lines always 'inside' given loops, up to given time duration B1

successive decrease in peak height B1

4 **(a)** **(i)** $\tan\theta = \frac{38}{165}$

$\theta = 13°$ C1

$d \sin\theta = n\lambda$

$d = 2.82 \times 10^{-6}$ m C1

number per metre = $\frac{1}{d} = 3.6 \times 10^5$ m^{-1} A1

(ii) Lines further apart in second order, B1

Lines fainter in second order, B1

(if differences stated but without reference to the orders, max 1 mark)

(b) **(i)** P remains in same position B1

X and Y rotate through 90° B1

(ii) either screen not parallel to grating or grating not normal to incident light B1

5 **(a)** **(i)** a region in which a charge will experience a force B1

electric force exerted per unit positive charge placed at that point B1

(ii) $E = \frac{Q}{4\pi\varepsilon_o r^2} = \frac{5.2 \times 10^{-7}}{4\pi\ \varepsilon_o\ (0.25)^2}$ B1

$= 7.48 \times 10^4$ A1

unit: N C^{-1} or V m^{-1} B1

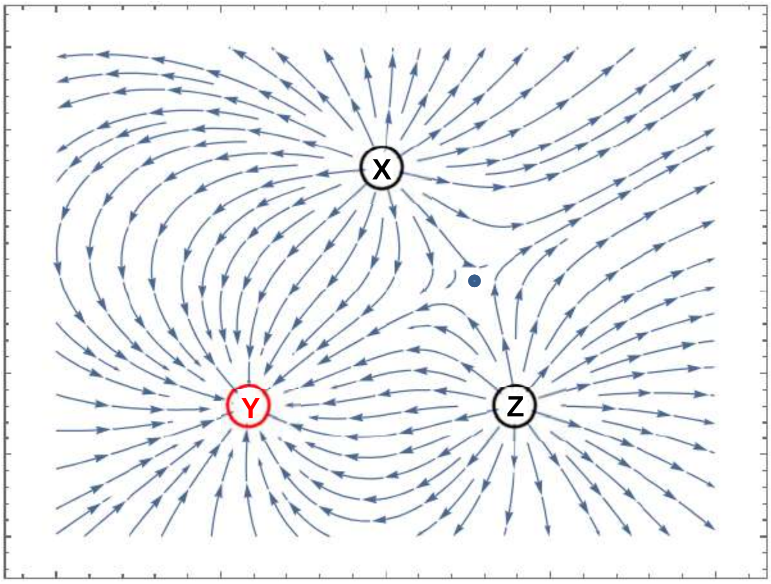
(b) lines perpendicular to surface going into negative charge and leaving positive charge for all charges B1

neutral point indicated consistent with field lines B1

basic pattern correct (field lines near each charge are radial spherically symmetrical) and fills rectangle B1

no crossing/joining of lines B1

max 3



6 **(a)** Magnetic field due to current in wire B is normal to the current in wire A, and pointing into plane of paper. By Fleming's left hand rule, this causes a magnetic force to be exerted on wire A towards wire B. B1

Based on Newton's 3rd law, a magnetic force is also exerted on wire B by wire A which is of the same magnitude but opposite in direction, giving rise to an attractive force between both wires. B1

(b) (i) $B = \dfrac{\mu_0 I_A}{2\pi d}$

$= \dfrac{4\pi \times 10^{-7}(90)}{2\pi(0.50)}$

$= 3.6 \times 10^{-5}$ T M1

$Bqv \sin 90^0 = \dfrac{mv^2}{r}$ M1

$r = \dfrac{mv}{Bq} = \dfrac{(1.67\times10^{-27})(1.0\times10^{3})}{(3.6\times10^{-5})(1.6\times10^{-19})}$

$= 0.29$ m A1

(ii) As proton is nearer to wire A, B increases ($B \alpha \dfrac{1}{r}$**)** and radius decreases due to the increasing magnetic force ($F = Bqv \sin\theta$). B1

Eventually at the nearest location to wire, the velocity of proton is parallel to wire, therefore force is directed away from wire, radius is smallest and proton is turned back. B1

B decreases further from wire A and radius increase due to decreasing *F*. B1

7 (a) (i) EM produced whenever charged particle is suddenly accelerated/ decelerated at the metal target (and wavelength depends on magnitude of acceleration) M1

Electrons hitting the metal target have a range/distribution of accelerations A1

(ii) All kinetic energy of one electron given up in one collision to produce a single X-ray photon. B1

Minimum wavelength for maximum energy Or $\lambda_{min} = hc/E_{max}$ B1

So independent of target metals (only depend on accelerating voltage) A0

(b) (i) More likely (higher probability) for electrons at the next higher level to drop down to fill up the hole, so higher intensity for K_α A1

(ii) At low voltages, the energy of electrons (25 keV) is not sufficient B1

to knock electrons out of the inner shells of the tungsten atom B1

So no characteristic X-rays produced by de-excitation. A0

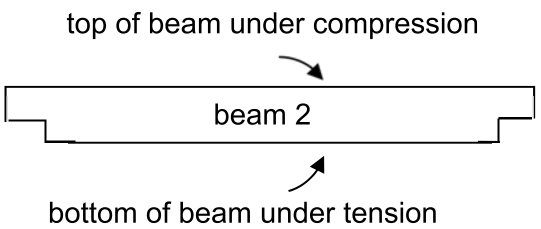
(c) $E = \dfrac{hc}{e\lambda} = \dfrac{(6.63\times10^{-34})(3\times10^{8})}{(1.6\times10^{-19})(6.6\times10^{-11})}$ M1

$= 1.88 \times 10^4$ eV A1

8 (a) It is the number of trains arriving at a station per unit time. A1

(b) Aluminium alloy has high strength-to-weight ratio, thus reduces the amount of friction by reducing the weight of the trains. It has high corrosion resistance. Aluminium's natural passivation process in which a thin aluminium oxide layer forms when the metal is exposed to oxygen, reduces the possibility of further oxidation. A1

(c) (i)



Correct labelling of compression and tension A1

(ii) Total normal reaction forces = $(350 + 380) \times 10^3$
$= 730 \times 10^3$ N — A1

(iii) Total load column 1 has to take = 730×10^3 N — A1

(iv) Total load ground has to take = $(730 + 100) \times 10^3$ — M1
$= 830 \times 10^3$ N — A1

(d) **(i)** Coordinate (4.3, 922) is treated as anomaly. Best fit line drawn through the rest of the seven points. — A1

(ii) Gradient of line $= \dfrac{1040 - 916}{5.00 - 4.40}$ — M1
$= 207 \times 10^3$ N m^{-2} — A1

(iii) Factor of safety = $\dfrac{645 \times 10^3}{207 \times 10^3}$
$= 3.12$ — M1
Since factor of safety is greater than 2.9, it is safe. — A1

(e) **(i)** Applied load = $(207 \times 10^3)\pi(\dfrac{2.5}{2})^2$ — M1
$= 1016 \times 10^3$ N — A1

(ii) Total allowable weight of passengers = $(1016 - 830) \times 10^3$
$= 186 \times 10^3$ N — A1

(iii) Total allowable number of passengers per car = $(\dfrac{186 \times 10^3}{60 \times 10})$ — M1
$= 310$ — A1

(f) Number of passengers a car can take when train arrives at station
$= 0.25 \times 310 = 77.5$ — C1
Total number of passengers train can take = 77.5×6
$= 465$ — M1
Longest time interval between train arrivals = $(\dfrac{465}{240})$
$= 1.94$ minutes — A1

Paper 3

1 Consider a ream (500 sheets) of A4 papers (70 or 80 gsm).
Thickness of 1 ream ≈ 5 cm, so thickness of one piece ≈ 0.01 cm ≈ 0.1 mm.
Area of A4 paper ≈ 200 x 300 = 60,000 mm^2 = 0.06 m^2

(a) **(i)** 0.05 – 0.15 mm — A1
(ii) 4 – 5 g — A1

(b) time = $\dfrac{0.15 \times 10^{12}}{3.00 \times 10^8}$ — C1
= 500 s = 8.3 min — A1

(c) **(i)** SI units for *T*: s, *R*: m and *M*: kg (or seen in formula) — C1
$K = \dfrac{T^2 M}{R^3}$ units of $K = \dfrac{s^2 kg}{m^3}$ — A1

(ii) $K = \dfrac{(86400)^2(6 \times 10^{24})}{(4.23 \times 10^7)^3} = 5.918 \times 10^{11}$ — C1
$\dfrac{\Delta K}{K} = 2\dfrac{0.5}{100} + 3\dfrac{1}{100} + \dfrac{2}{100} = 0.06$ — C1
$\Delta K = 0.355 \times 10^{11}$

$K = (5.9 \pm 0.4) \times 10^{11}$ (SI units) A1
(incorrect % value, then max 1 mark)
OR, $K_{max} = 6.283 \times 10^{11}$, $\Delta K = K_{max} - K = 0.365 \times 10^{11}$
$K_{min} = 5.57 \times 10^{11}$, $\Delta K = \frac{1}{2}(K_{max} - K_{min}) = 0.355 \times 10^{11}$
(iii) *R*, as this has the largest fractional uncertainty. B1

2 **(a)** 15 m s^{-1} A1
(b) constant gradient (straight line graph) A1
(c) **(i)** 1.55 s A1
(ii) distance = area under the graph from 0 to 1.55 s
=½ (15)(1.55) M1
= 11.6 m
= 12 m A0
(iii) distance = ½ (25)(4.1 – 1.55) – 11.6 C1
= 31.875 – 11.6
= 20 m A1

(d) displacement is the straight line / minimum distance between the start and finish points in that direction. B1
distance is the actual total path travelled by the ball. B1

(e) Smooth curve with decreasing gradient until zero at terminal velocity B1
gradient of the curve at x-intercept (0 m s^{-1}) = gradient of the straight line and the curve crosses the x-axis before 1.55 s. B1

3 **(a)** **(i)** force is the rate of change of momentum B1

(ii) Force from B on body A is equal in magnitude but opposite in direction to force on B from A (forces act on different bodies) B1
Forces are of the same type B1

(b) **(i)** maximum force = $(210 \times 10^{-9}) \times (138 \text{ to } 145) \times 9.81$ C1
= 2.84×10^{-4} to 2.99×10^{-4} N A1
(ii) Initial speed ~ 0 C1
Maximum speed = the area under the *a* – *t* graph C1
= 1.20 to 1.32 m s^{-1} A1
(iii) ground (and Earth) gain momentum M1
In equal and opposite to the change for the flea, so momentum conserved B1

4 **(a)** **(i)** angle subtended at centre of circle B1
(by) arc equal in length to the radius B1
(ii) arc = $r\theta$ and for one revolution, arc ≡ π (diameter) = π(2*r*) M1
so, $\theta = \pi(2r) / r = 2\pi$ A0
(b) **(i)** point S shown vertically below C B1
(ii) [(max) force / tension – weight] provides the centripetal force C1
$18 - 3 = m r \omega^2 = (3 / 9.81)(0.85)\omega^2$ C1
$\omega = 7.6$ rad s^{-1} A1
(c) **(i)** vertically no net force, $T \cos 35^o = 3.0$, $T = 3.7$ N A1
(ii) resultant is horizontal component of tension
$3.7 \sin 35^o = 2.1$ N A1
horizontally towards the left B1
5 **(a)** **(i)** obeys the law pV/T = constant or any two named gas laws M1
at all values of *p*, *V* and *T* A1
or two correct assumptions of kinetic theory of ideal gas B1

third correct assumption B1

(ii) ($pV = nRT$ gives) $(1.00 \times 10^5)(750 \times 10^{-6}) = n(8.31)(300)$ B1

$n = 0.030$ A1

(b)

	work done on gas / J	heat supplied o gas / J	increase in internal energy of gas / J
A to B	+360	0	+360 &
B to C	0 $	+670	+670 $
C to D	-810 &	0	-810
D to A	0 @	-220 @	-220 #

&: first and third line correct B1

$: second line correct B1

#: −220 correct in right hand column B1

@: other two figures correct in last line B1

(c) the gas molecules bounce off the receding piston at lower <u>speeds</u> B1

there is a decrease in <u>kinetic energy</u> of the molecules B1

6 (a) $V_{r.m.s.} = \sqrt{\dfrac{2^2(0.002) + 1^2(0.002)}{0.01}}$ M1

$= 1.0$ V A1

Steady voltage of 1 V will produce the same heating effect as $V_{r.m.s.}$ of 1 V.

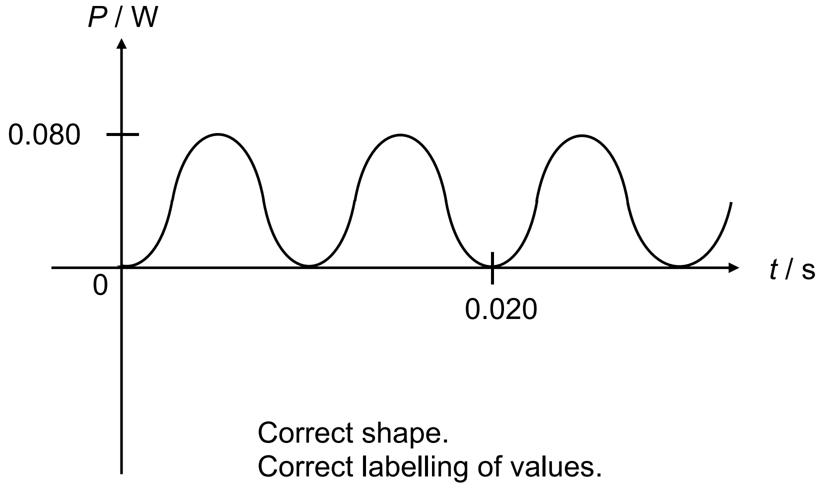
(b) Transmission of electrical energy at high voltage means that the current is low according to $P = IV$. B1

Power loss through joule heating (I^2R) is hence lowered as less electrical energy is dissipated as heat in the cables of resistance R. B1

(c) (i) $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$

$V_s = 71 \times 6.5 \times 10^{-3} = 0.46$ V A1

(ii)



Correct shape. B1

Correct labelling of values. B1

(iii) 1. In the forward biased direction, the diode has no resistance. <u>Current flows downwards through resistor R</u>. A1

In the reverse biased direction, diode has infinite resistance. There is no current flowing through resistor R. A1

2. In the forward biased direction, there is a half-wave sinusoidal voltage output across resistor R, having the same frequency as that of the input voltage. In the reverse biased direction, there is no voltage output across resistor R. A1

7 (a) Electromotive force is the work done in transforming non-electrical energy into electrical energy per unit charge passing through the terminals of the source. B1
Potential difference is the amount of electrical energy transformed per unit charge to some other forms of energy when the charge passes from one point to the other. B1

(b) (i) Since $I = I_1 + I_2$,

$$I = \frac{V}{R} + \frac{V}{R_V} \quad \text{M1}$$

$$\frac{1}{R} = \frac{I}{V} - \frac{1}{R_V}$$

$$R = \frac{R_V V}{IR_V - V} \quad \text{A1}$$

(ii) $V = IR + IR_A$ M1

$$\frac{V}{I} = R + R_A$$

$$R = \frac{V}{I} - R_A \quad \text{A1}$$

(iii) For $R = \dfrac{V}{I}$, $R_V >> R$ and $R_A << R$. Hence, R_V should be infinite, A1

and R_A should be equal to zero. A1

(c) (i) $R = \rho \dfrac{l}{A}$

$$R = 1.4 \times 10^{-6} \times \frac{1.1}{\pi(0.304 \times 10^{-3})^2} \quad \text{M1}$$

$R = 5.30\ \Omega$ A1

(ii) 1. $\dfrac{l}{110} \times \dfrac{5.3}{5.3 + 0.30 + 0.50} \times 2.2 = \dfrac{1.2}{1.2 + 1.1} \times 1.8$ M1

$l = 54.0$ cm A1

2. E.m.f. of cell is larger than the terminal p.d. of cell M1
length AC will increase. A1

(iii) 1. $I = \dfrac{V}{R} = \dfrac{2.2}{(0.3 + 5.3)}$ M1

$= 0.3929$ A

$P = I^2 R = (0.3929)^2 (5.30) = 0.818$ W A1

2. $I = Anve$

$0.3929 = \pi(0.304 \times 10^{-3})^2 (10^{29}) v (1.6 \times 10^{-19})$

$v = 8.46 \times 10^{-5}$ m s^{-1} A1

(d) **(i)** $R = \dfrac{3.4}{1.125}$ = 3.02 Ω A1

(ii) As the potential difference (p.d.) increases from 0 V to 3.4 V, the ratio of *V* to *I* decreases, hence resistance decreases. B1
As the p.d. increases from 3.4 V to 6.0 V, the ratio of *V* to *I* increases. Hence, resistance increases during this interval. B1

8 **(a)** smaller deviation (not zero deviation) M1
acceptable path wrt position of N A1

(b) **(i)** mass of alpha particle = $4 \times 1.66 \times 10^{-27}$ kg B1
(kinetic energy = $0.5 \times 4 \times 1.66 \times 10^{-27} \times (1.30 \times 10^{7})^2$ J A1

(ii) all the kinetic energy becomes electrical potential energy B1
$5.61 \times 10^{-13} = Q_\alpha Q_{Au} / 4\pi\varepsilon_0 r = (2e)(79e) / 4\pi\varepsilon_0 r$ C1
$r = 6.48 \times 10^{-14}$ m A1

(c)
- emission from radioactive daughter products
- self-absorption in source
- absorption in air before reaching detector
- detector not sensitive to all radiations
- window of detector may absorb some radiation
- background radiation

Any two points. B2

(d) **(i)** curve is not smooth or curve fluctuates/curve is jagged B1
(ii) clear evidence of allowance for background B1
half-life determined at least twice B1
half-life = 1.5 hours A2
(2 marks if in range 1.4 – 1.6; 1 mark if 1.6 < half-life ≤ 2.0)

(e) **1.** half-life: no change M1
because decay is spontaneous/independent of environment A1
2. count rate (likely to be or could be) different / is random / cannot be predicted B1

(f) activity = $(3.8 \times 10^4)\, e^{(-\ln 2 / 15)(36)}$ C1
or activity = $(3.8 \times 10^4)\,[1 / 2^{2.4}]$ (C1)
= 7200 Bq A1
volume = $(7200 / 1.2) \times 5.0 = 3.0 \times 10^4$ cm^3 A1
or activity of 5.0 cm^3 = $1.2 \times 2^{2.4}$ (C1)
= 6.3336 Bq (C1)
volume = $(3.8 \times 10^4 / 6.3336) \times 5.0 = 3.0 \times 10^4$ cm^3 (A1)

Paper 4

Qns			Skills Assessed and Marking Instructions	M
1	**b**	**(ii)**	Value of *d* to nearest mm.	1
		(ii)	Evidence of repeated measurements of *d*.	1

		(iii)	Absolute uncertainty in the range of 2 mm to 10 mm (1 s.f.). Percentage uncertainty calculated correctly. Percentage uncertainty in 2/3 s.f.	1
	c	**(ii)**	Value of h to nearest mm.	1
			Value of t in s and must be between 0.1 to 10 s	1
	d		Terminal velocity calculated correctly with unit	1
	f		Measurement and record of second value of d_2. Value of second t (t_2). Correct calculation of second v_2. Quality of result: smaller d gives greater v. Determination of a constant of proportionality k (two values of k where $k = vd$) Draw conclusion based on the calculated values of k. Candidate must test against a specified criterion (e.g. 20% difference in values of k, with reference to the uncertainty calculated *(b)(iii)*).	1 1 1 1 1
	g		Terminal velocity may not be reached at short distance, - Increase height - Measure velocity at two points to check terminal velocity reached Much faster velocity - Use light gate to trigger stopwatch to eliminate human reaction error in timing Take more readings and plot a graph to check relationship Or other valid improvement. Max: 3 marks.	 1 1 1 1

Qns			Skills Assessed and Marking Instructions	M
2	**a**	**(iii)**	Value of θ to the <u>nearest degree</u>, with unit.	1
		(iv)	cos θ calculated correctly	1
		(v)	Answer must relate sf in θ to sf in cos θ Do not allow vague answers that are given in terms of 'raw data'	1
	b	**(iii)**	Value of T with unit. The number of oscillations n taken such that $n\ T_1 > 10$ s. Evidence of repeats.	1 1

	c		Value of *k* calculated correctly with correct unit, s^{-4}.	1
	d		Measurement of L, the value should be in the range 40 cm ± 2 cm.	1
			Correct method of working to give a value of *g* in the range 7.5 to 12.5 m s^{-2}.	1
			Correct unit of *g*	1

Qns			Skills Assessed and Marking Instructions		M
3	b	(i)	*V* and *I* recorded with unit.		1
		(ii)	Resistance of LDR calculated correctly And greater than 1 kΩ and less than 100 kΩ.		1
	c		• Award 2 marks if student has successfully collected 6 or more sets of data (*V, I*) without assistance/intervention. 5 sets one mark. 4 or fewer sets zero mark. • Deduct 1 mark if minor help from supervisor, deduct 2 if major help. • Deduct 1 mark if wrong trend in *I* (or *R*).	C1	2
			Each column heading must contain a quantity and a unit where appropriate. Ignore units in the body of the table. There must be some distinguishing mark between the quantity and the unit i.e. solidus is expected, *I*/mA. Allow lg(*R*), lg(*R*/Ω) but not lg*R*/Ω.	C2	1
			Consistency of raw readings, *I* in mA and *V* in V only.	C3	1
			For each calculated value of *lg,* the number of d.p in calculated value should reflect the number of s.f. in the raw readings. All values must be given to an appropriate number of s.f. for this mark to be awarded.	C4	1
			Correctly calculated values of *R*, *lg(R) and lg(N)*.	C5	1
	d		Linearising equation and deriving expressions that equate e.g. gradient to b and *y*-intercept to lg(*a*), lg(*R*) = lg(*a*)+*b* lg(*N*).	D1	1
			Graph: Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. Scales must be labeled with the quantity which is being plotted.	D2	1
			All observations must be correctly plotted. Work to an accuracy of half a small square. Diameter of the plotted point must be less than half the small square.	D3	1
			Line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line. Allow only one anomalous point if clearly indicated (i.e. labelled or circled) by the student.	D4	1
			Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Check for Δ*y*/Δ*x* (i.e. do not allow Δ*x*/Δ*y*). The value must be negative.	D5	1
			y-intercept – must be read off to nearest half a small square or determined from *y=mx+c* using a point on the line.	D6	1
			Values of *a* and *b* calculated correctly	D7	1
			Unit of *a*, no units of *b*	D8	1

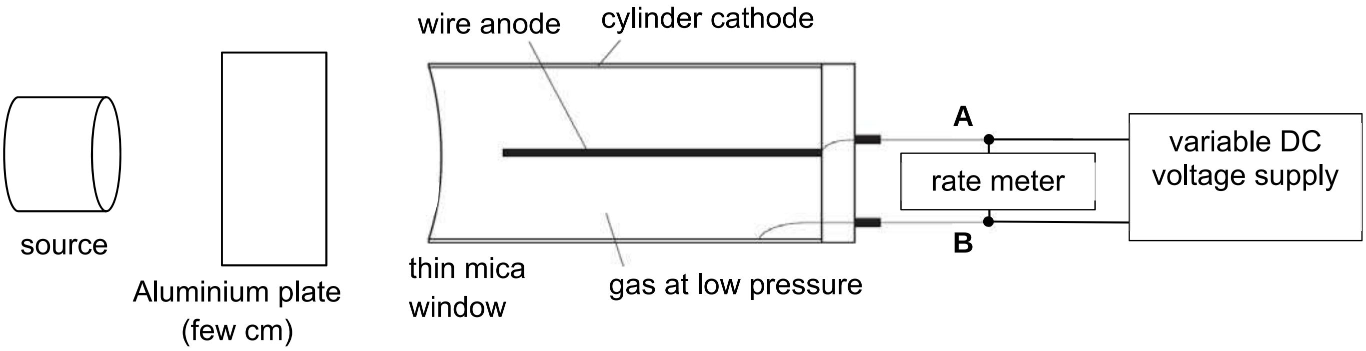
	e	**(i)**	Value of diameter, d = 1.10 mm ± 0.1 mm. Correct d.p. and unit.		1
		(ii)	Area is calculated correctly with unit.		1
		(iii)	Repeated readings of diameter of tube		1
	f		Value of R in range 100 – 1000 Ω.		1

4

Code	Description		
A	*Basic Procedure* ✓ Procedure OK (i.e. measure count rate and p.d.; change p.d. and measure new count rate for at least 6 sets of readings).	1	A1
	✓ Voltmeter shown in parallel with the GM tube or the variable DC power supply.	1	A2
	✓ Method of removing α or β radiation (depending on source used). Appropriate absorber is expected. ✓ Accept 'aluminium' or thin (a few mm) lead. ✓ Could be shown on the diagram. ✓ Allow electric or magnetic deflection.	1	A3
B	*Method of measuring Independent Variable/ source used* ✓ Radium or Cobalt source used	1	B1
B	*Method of measuring Dependent Variable* ✓ Ratemeter/scaler/datalogger-(connected to PC) connected to terminals A and B of GM.	1	B2
B	*Processing and Analyzing Experimental Data* ✓ Appropriate graph of the dependent variable (count rate) against the independent variable (potential difference V_{AB}) is to be plotted. (i.e. lg count rate against lg V_{AB})	1	B3
C	*Method of keeping Variables Constant (note: do NOT use control of variables)* ✓ Keep distance from source to GM tube constant/fixed/same, etc. ✓ Keep orientation of source to GM tube constant/same, etc.	1	C1
C	*Safety Aspect* ✓ use source handling tool/long tweezer/long tong. ✓ store source in lead lined box when not in use. ✓ do not point source at people/do not look directly at source. ✓ **Do not** allow 'protective clothing', 'lead suits', 'lead gloves', 'goggles', etc.	Max 2	C2 C3 C4
D	*Details in Procedure* ✓ Reason for choice of the source used. Answer must relate to half-life. This mark cannot be scored if B1 = 0 ✓ Repeat and take average readings (need to give reason: to allow for randomness of activity) ✓ Sensible value of p.d. applied to GM tube (i.e. 50 V to 1000 V). ✓ Subtract count rate due to background radiation. ✓ Aluminium sheets must be mm or cm thickness, Lead must be few mm ✓ Count-rate must be an order of magnitude higher than background count (preliminary / initial measurements)	Max 3	D1 D2 D3 D4 D5 D6
	Total	**12**	

Aim: To investigate how the count rate due to γ-radiation depends on the potential difference V_{AB}

Independent variable: Potential difference V_{AB}
Dependent variable: count rate due to γ-radiation



Procedure

1. Set up apparatus as shown in the diagram above.
2. Use the Cobalt-60 source source
    a. Half-life is sufficiently long to avoid a large change in activity during the experiment and is approximately constant
    b. Does not emit α-radiation, which is highly ionizing and hence toxic on close contact
    c. Place in front of the thin mica window at about 3 cm away.
    d. Place an aluminium plate of a few centimetre thickness between source and window to prevent α- and β- radiation from reaching the detector
3. Vary the potential difference supplied across points A and B
    a. Connect the output ends of a variable DC voltage supply to points A and B
    b. Obtain the supplied potential difference by reading off the output settings.
4. Measure the count rate across points A and B
    a. Connect the rate meter to points A and B.
    b. Read off the count rate from the display of the rate meter, *C*.
5. Repeat steps 3 and 4 for different outputs of potential differences, each time performing averaging for each potential difference.

Control variables:

1. Distance between source and mica window
    a. Secure the 2 in position using retort stands
2. Activity of source
    a. Keep to the same source so that the age of the source is approximately constant

Analysis

1. Assume $C = kV_{AB}^n$,
   where *C* is the count rate measured by the rate meter,
   V_{AB} the potential difference between points A and B,
   k and *n* are constants.
2. Taking logarithm on both sides of the equation, we obtain $\lg C = \lg k + n \lg V_{AB}$
3. The graph of against will be a straight line graph with y-intercept and gradient *n* if the equation is valid.

Safety

1. Handle the source with long tweezer.
2. Store source in lead-lined box when not in use.

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

PHYSICS

9749/01

Paper 1 Multiple Choice

20 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use paper clips, glue or correction fluid.
Write your name, civics group and registration number on the Answer Sheet in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **18** printed pages and **0** blank page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\,\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T/K = T/{}^{\circ}C + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$
	$= \pm \omega\sqrt{(x_o^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 Measurements are subject to both systematic error and random error.

Which measurements have high accuracy and low precision?

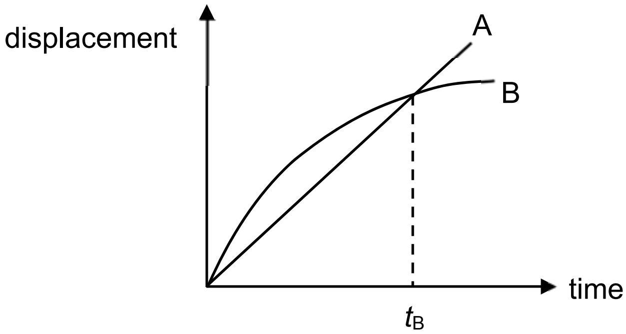
A High random error and high systematic error

B High random error and low systematic error

C Low random error and high systematic error

D Low random error and low systematic error

2 The diagram below shows the variation of displacement with time for 2 trains, Train A and Train B, running on parallel tracks.



Which of the following statements is correct?

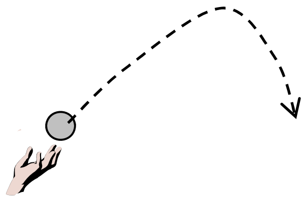
A At time t_B, both trains have the same velocity.

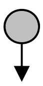
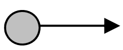
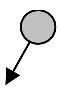
B Both trains speed up all the time.

C Both trains have the same velocity at some time before t_B.

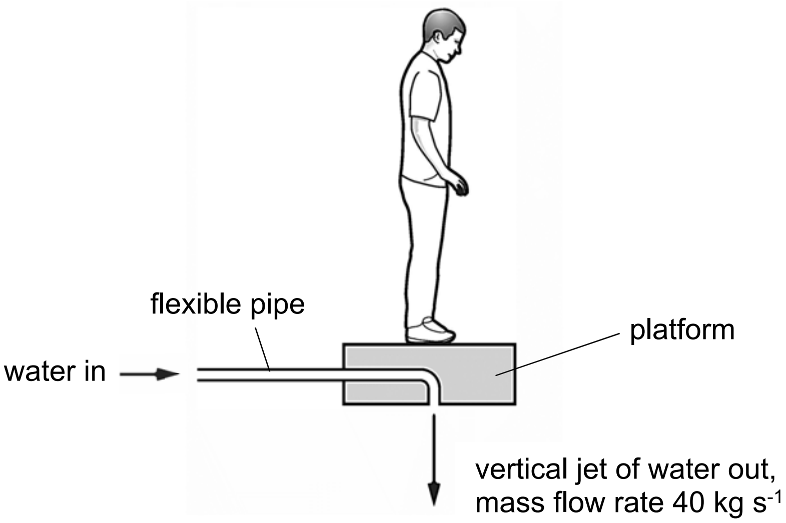
D Somewhere on the graph, both trains have the same acceleration.

3 A ball thrown at an angle travels in a trajectory as shown below. When the ball is at the top of its flight, which of the following shows the direction its resultant acceleration?



A  **B**  **C**  **D** 

4 The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg. The mass of water that is discharged vertically downwards from the platform each second is 40 kg.

What is the speed of the water leaving the platform?

A 2.4 m s^{-1} **B** 6.9 m s^{-1} **C** 24 m s^{-1} **D** 47 m s^{-1}

5 Two objects A and B collide head-on on a horizontal, frictionless surface. The velocities of the objects before the collision and after the collision are shown in the diagram below.

Which of the following statements is correct?

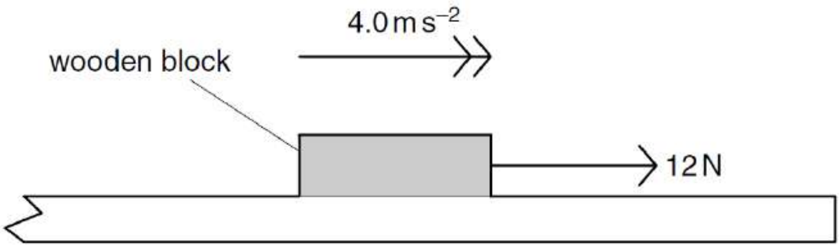
A The sum of the kinetic energies of A and B is conserved.

B The collision is possibly inelastic.

C The total momentum of the two objects cannot be conserved since no net external force acts on them.

D The momentum of each object is conserved.

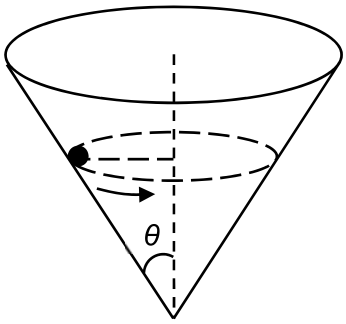
6 A wooden block of mass 1.0 kg is on a rough horizontal surface. A force of 12 N is applied to the block and it accelerates at 4.0 m s^{-2}.



What is percentage of work done is used to overcome frictional force when the block is being moved a distance of 10 m?

A 33.3% **B** 66.7% **C** 75.0% **D** 100%

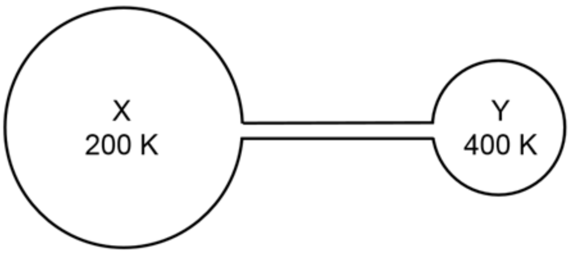
7 A small bead is set into circular motion in a horizontal plane within a smooth conical cone as shown below.



If the bead is moving with a centripetal acceleration of *g*, what is the angle *θ*?

A 30° **B** 45° **C** 55° **D** 70°

8 In the diagram below, the volume of bulb **X** is twice that of bulb **Y**. The system is filled with an ideal gas and a steady state is established with the bulbs held at 200 K and 400 K.

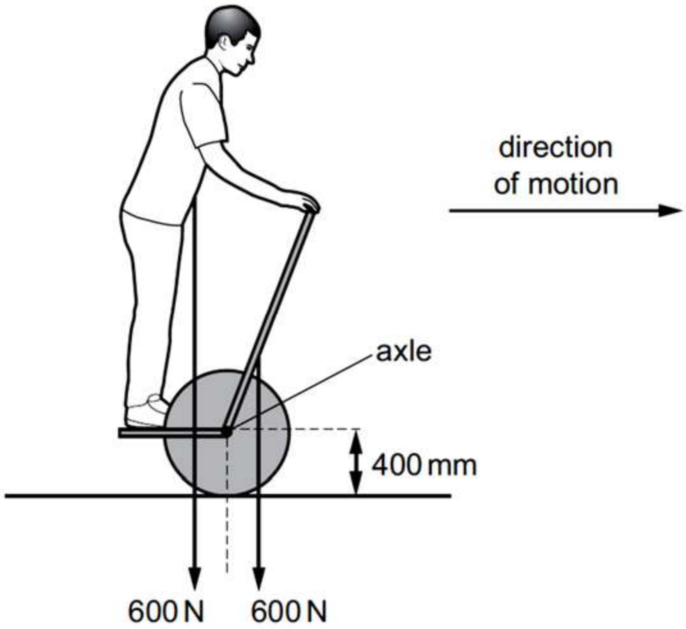


There are *b* moles of gas in **X**.

How many moles of gas are there in **Y**?

A *b* / 4 **B** *b* / 2 **C** *b* **D** 2*b*

9 The diagram below shows a motorised vehicle for carrying one person.



The vehicle has two wheels on one axle. The passenger stands on a platform between the wheels.

The weight of the machine is 600 N. Its centre of mass is 200 mm in front of the axle. The wheel radius is 400 mm.

When stationary, a passenger of weight 600 N stands with his centre of mass 200 mm behind the axle to balance the machine.

The motor is now switched on to provide a horizontal force of 90 N at the ground to move the vehicle forwards.

How far and in which direction must the passenger move his centre of mass to maintain balance?

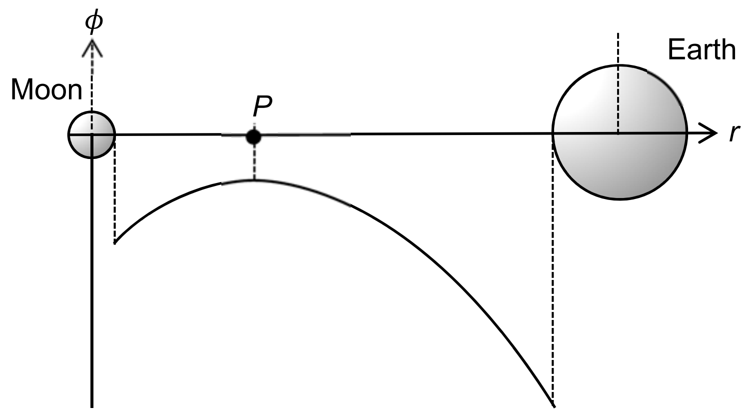
A 60 mm backward

B 60 mm forward

C 140 mm backward

D 140 mm forward

10 The gravitational potential ϕ as it varies with distance r from the centre of the Moon to the centre of Earth as shown in the diagram below.



Which of the following statements is **not** true?

A The gravitational field strength at *P* is zero.

B The gravitational field strength at *P* is the scalar sum of the individual field strengths of the Moon and the Earth at point *P*.

C The gravitational field strength at *P* is the vector sum of the individual field strengths of the Moon and the Earth at point *P*.

D The gravitational field strength at *P* is given by the rate of change of ϕ with respect to *r*.

11 A fixed amount of ideal gas undergoes the following changes:

Process 1: The gas is heated at constant volume.
Process 2: The gas is compressed at constant pressure.

How does the internal energy of the gas for each process change?

	Process 1	**Process 2**
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

12 Which of the following statements is **false** in describing a mass moving in simple harmonic motion?

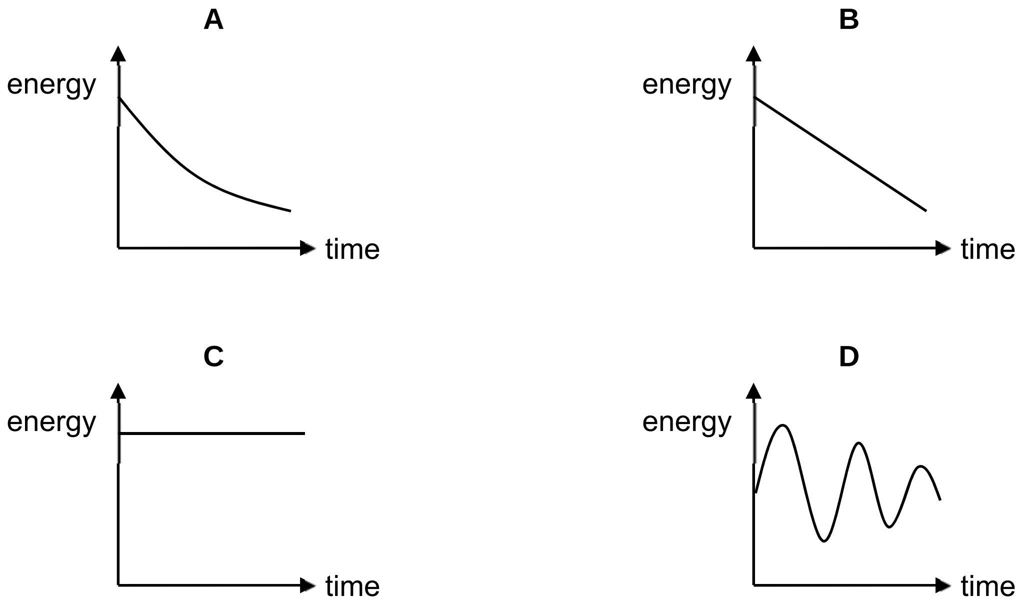
A The maximum kinetic energy is dependent on the frequency of the oscillation.

B The time taken for the system to change from maximum kinetic energy to maximum potential energy is a quarter of the period of the oscillation.

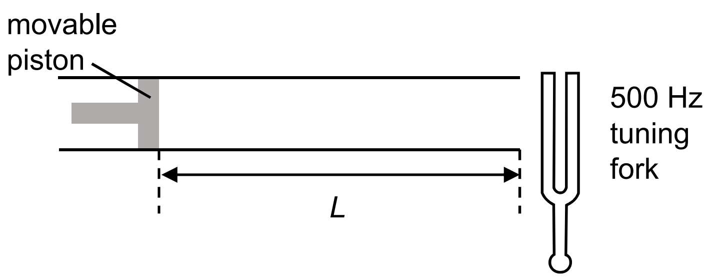
C An oscillating system with larger amplitude will have a longer period.

D An oscillating system with larger amplitude will have a greater maximum velocity.

13 Which of the following graphs show the variation in the total energy of an object under light damping as time passes?



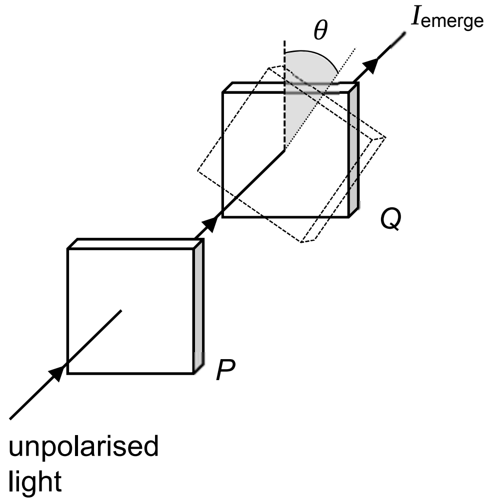
14 A 500 Hz tuning fork is held at the open end of an air-filled glass tube, which is closed at the other end by a movable piston.



Resonance is achieved when L = 82.5 cm. Given that the speed of sound in air is 330 m s^{-1}, which of the following other values of L will **not** result in resonance?

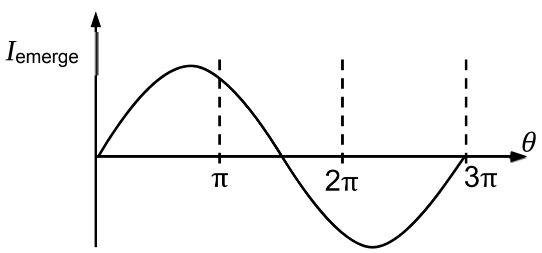
A 16.5 cm **B** 49.5 cm **C** 99.0 cm **D** 115.5 cm

15 Unpolarised light is incident normally on a linear polarizer *P* and subsequently on a second linear polarizer *Q* as shown below.

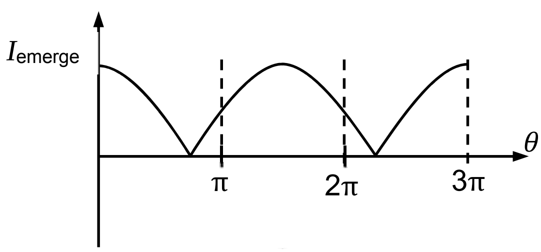


Which graph best represents the relationship between the emergent light intensity I_{emerge} and the angle of rotation of *Q* about the axis of light transmission *θ*?

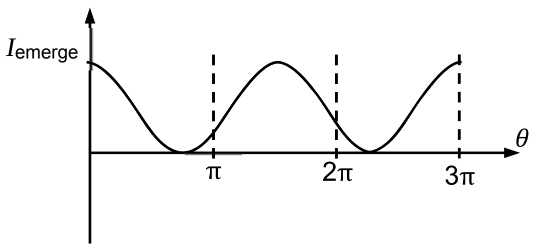
A



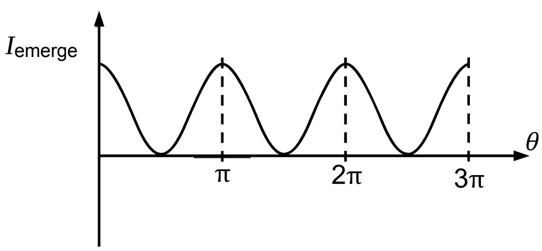
B



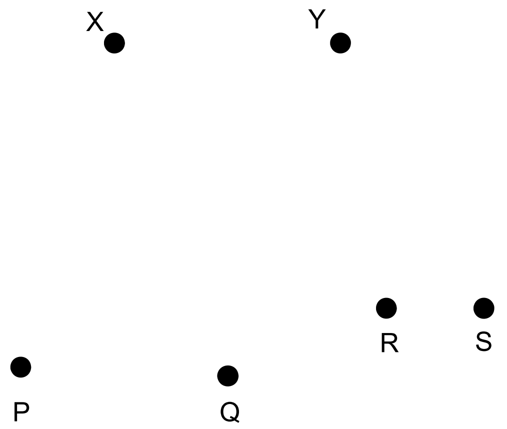
C



D



16 In the diagram below (drawn to scale), X and Y are identical point sources of waves that exhibit a constant phase difference of π at source. The waves have a wavelength of 1.0 cm.



Which of the following statements is true?

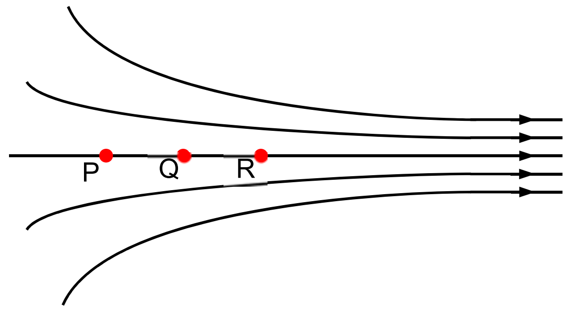
A P is a point of destructive interference.

B $XQ - YQ = m\frac{\lambda}{2}$, where m is an odd integer.

C $XR - YR = n\lambda$, where n is an integer.

D S is a point of destructive interference.

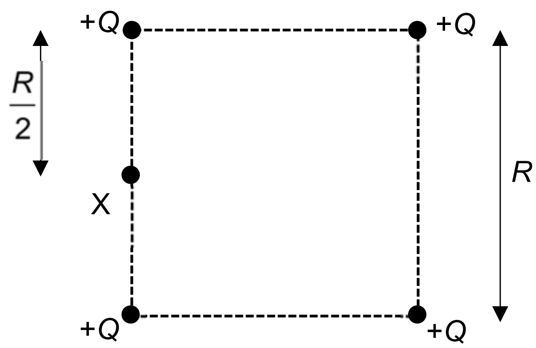
17 The diagram below shows electric field lines with points P, Q and R on one of the field lines. The distance between PQ is equal to the distance between QR.



If the potential at P and Q are 0 V and – 200 V, respectively, which of the following can be a possible value of the potential at R?

A - 450 V **B** - 400 V **C** + 200 V **D** + 250 V

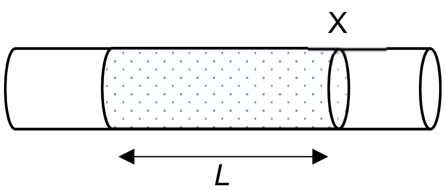
18 Four identical point charges are arranged at the corners of a square of length R as shown below.



What is the magnitude of the electric field strength E and the electric potential V at point X?

	E	V
A	$\frac{12}{5}\;\frac{Q}{\pi\varepsilon_0 R^2}$	$\frac{2}{5}\;\frac{Q}{\pi\varepsilon_0 R}$
B	$\frac{12}{5}\;\frac{Q}{\pi\varepsilon_0 R^2}$	$\left(1+\frac{1}{\sqrt{5}}\right)\;\frac{Q}{\pi\varepsilon_0 R}$
C	$\frac{4}{\sqrt{5}^3}\;\frac{Q}{\pi\varepsilon_0 R^2}$	$\frac{2}{5}\;\frac{Q}{\pi\varepsilon_0 R}$
D	$\frac{4}{\sqrt{5}^3}\;\frac{Q}{\pi\varepsilon_0 R^2}$	$\left(1+\frac{1}{\sqrt{5}}\right)\;\frac{Q}{\pi\varepsilon_0 R}$

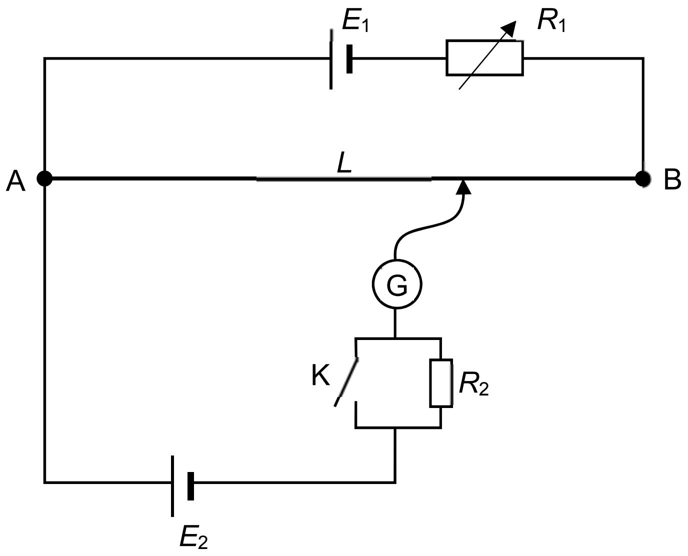
19 A copper wire has a number density of 8.5×10^{28} conduction electrons per cubic metre, and an cross-sectional area of 3.2×10^{-7} m^2. When a potential difference is applied to the ends of the wire, the current is 1.0 A.



If all the electrons within a cylinder of length L pass point X in 60 s, what is the value of L?

A 0.00015 m **B** 0.014 m **C** 0.025 m **D** 0.20 m

20 Which of the following statements is true about the circuit shown?



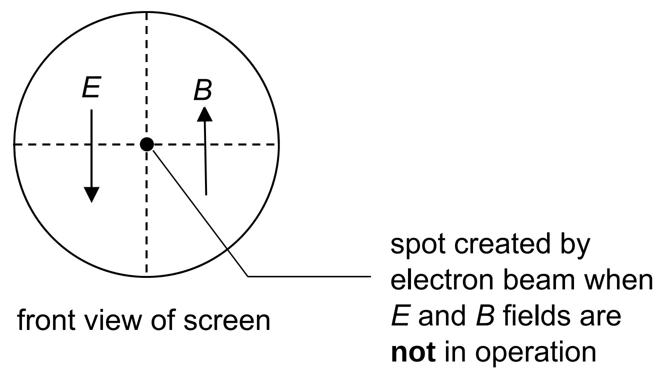
A When switch K is closed, as the resistance R_2 increases, the balanced length L decreases.

B When switch K is open, as the resistance R_2 increases, the balanced length L does not change.

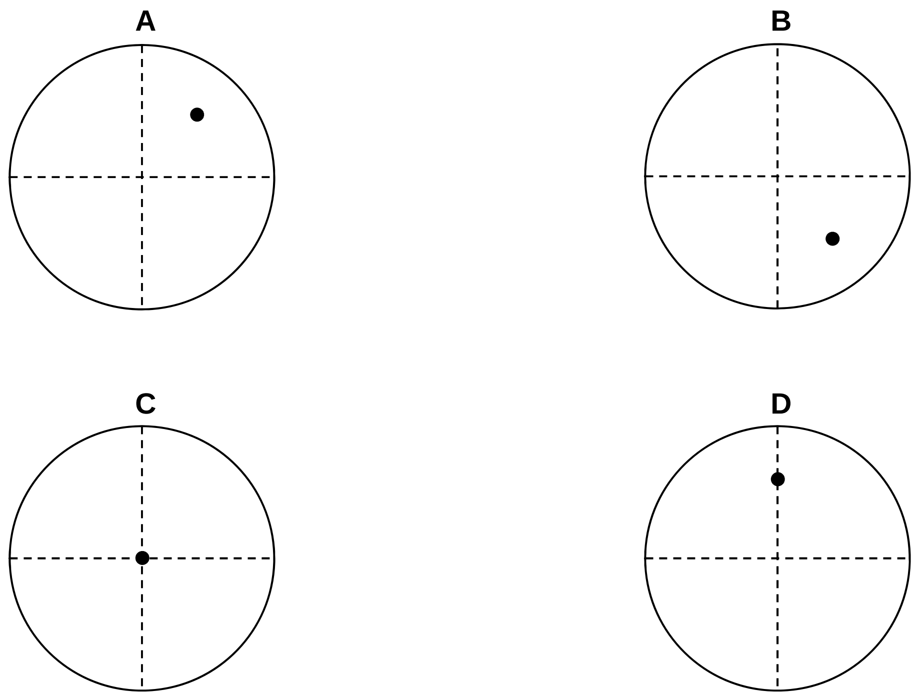
C When switch K is open, as resistance R_1 increases, the balanced length L decreases.

D When switch K is closed, changes in the internal resistance of E_2 will produce an increase in the balanced length L.

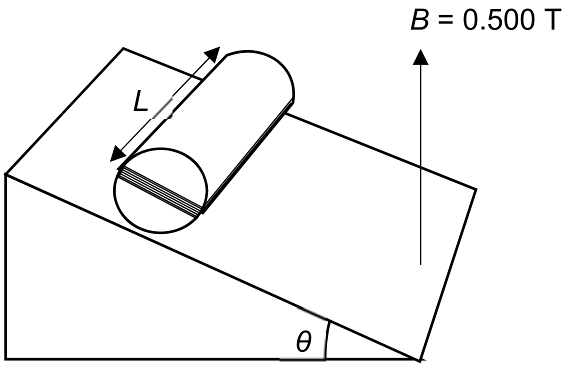
21 In a cathode-ray oscilloscope tube, the electron beam passes through a region where there is an electric field directed vertically downwards and a magnetic field directed vertically upwards as shown in the diagram below.



Which of the diagrams below shows a possible position of the spot on the screen when both fields are operating together?



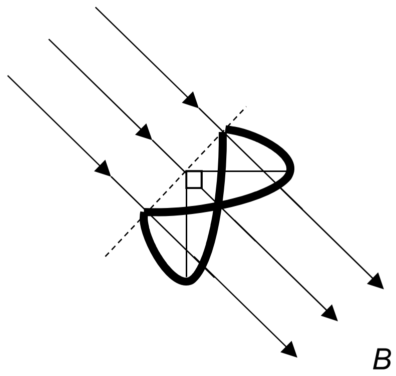
22 A wooden cylinder of mass 0.250 kg and length L of 0.100 m, has 10 turns of wire wrapped around it longitudinally. The cylinder is released on a plane inclined at an angle θ to the horizontal, with the plane of the coil parallel to the incline plane, as shown in the diagram below.



If there is a vertical uniform magnetic field of magnitude 0.500 T acting throughout the plane, what is the least current through the coil that keeps the cylinder from rolling down the plane?

A 1.25 A **B** 2.45 A **C** 6.77 A **D** 11.2 A

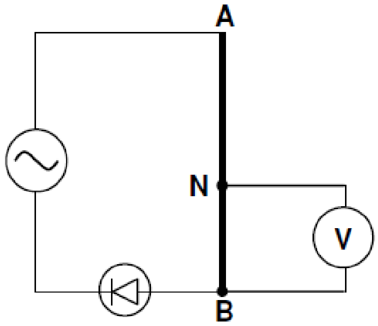
23 A closed circular loop of wire has a radius of 3.7 cm. It is bent along a diameter such that the two halves are perpendicular to each other. A uniform magnetic flux density of B = 76 mT is directed perpendicular to the fold diameter and makes equal angles (45°) with the planes of the semicircle.



If the magnetic flux density B is reduced to zero at a uniform rate during a time interval of 4.5 ms, what is the magnitude of the induced e.m.f in the loop?

A 0.026 V **B** 0.051 V **C** 0.073 V **D** 0.098 V

24 The uniform wire AB has length 1.0 m and resistance of 10 Ω. When NB is 40.0 cm, the a.c. voltmeter reads a steady r.m.s. voltage of 2.5 V.



What is the instantaneous peak power provided by the supply?

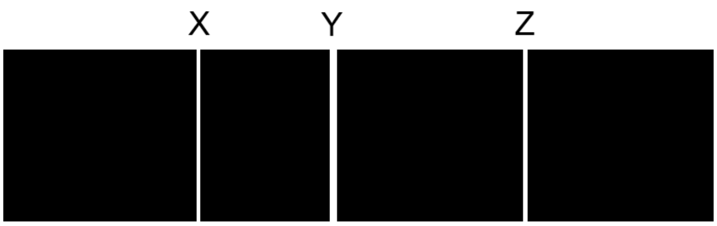
A 0.63 W **B** 3.9 W **C** 7.8 W **D** 16 W

25 When monochromatic light of wavelength 440 nm is incident on a metal surface, electrons are emitted. No electrons are emitted from the surface when the wavelength of the incident light is greater than 550 nm.

What is the minimum de Broglie wavelength of an emitted electron?

A 3.6×10^{-10} m **B** 7.2×10^{-10} m **C** 8.1×10^{-10} m **D** 1.6×10^{-9} m

26 The diagram below shows the line spectrum from a hot gas.



Which of the following statements can account for line Y being much brighter than lines X and Z?

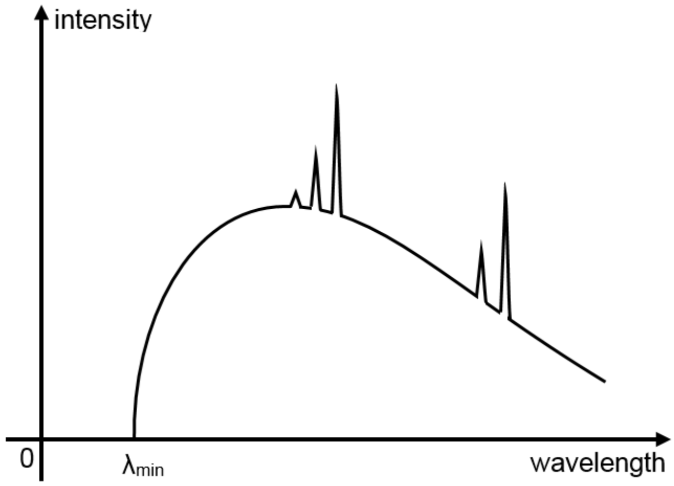
A Line Y has the highest frequency.

B Line Y originates in the hottest part of the gas.

C Line Y is the result of electrons undergoing transition between two states of greatest energy difference.

D Line Y is the result of most electrons undergoing the same transition between the two states involved in the emission.

27 An X-ray spectrum is shown in the diagram below.



What does the value of λ_{min} represent?

A The threshold wavelength of the target metal used to produce X-ray.

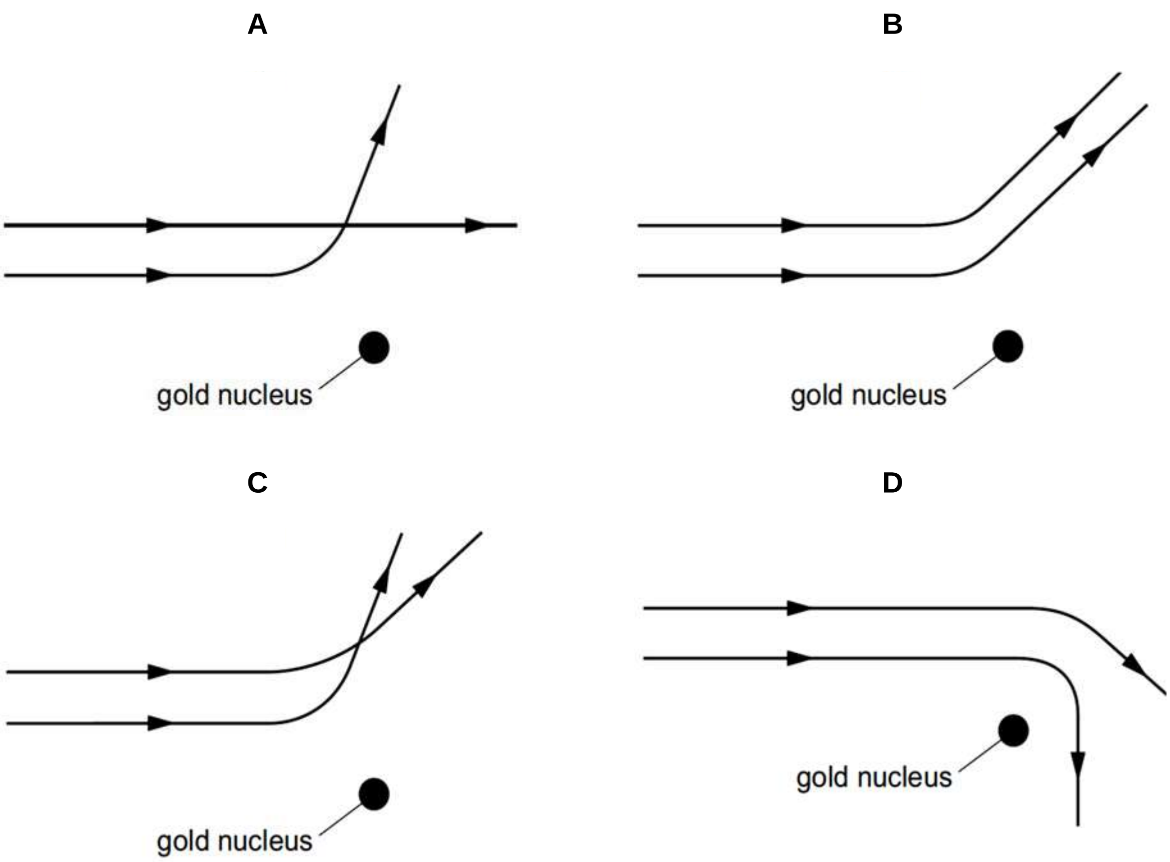
B The wavelength corresponding to the ionization energy of the target metal.

C The de Broglie wavelength of the electron with maximum energy.

D The wavelength corresponding to all the energy supplied to an electron in the accelerating electric field being converted into a single X-ray photon.

28 Two alpha particles with equal energies are fired towards the nucleus of a gold atom.

Which diagram best represents their paths?



29 Uranium-235 undergoes fission in a reaction shown below, releasing 195 MeV of energy. The binding energy per nucleon for uranium-235 is 7.6 MeV, and those for caesium and rubidium are approximately **X** MeV.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{143}_{55}Cs + {}^{90}_{37}Rb + 3\,{}^{1}_{0}n$$

What is the value of **X**?

A 6.7 **B** 6.8 **C** 8.4 **D** 8.5

30 Radon $^{222}_{86}Ra$ is the start of a decay chain that forms bismuth $^{214}_{83}Bi$ by α and β emission.

For the decay of each nucleus of radon, how many α-particles and β-particles are emitted?

	α-particles	β-particles
A	1	1
B	2	1
C	1	2
D	2	2

END OF PAPER

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	1	7	-			REGISTRATION NUMBER		

PHYSICS **9749/02**

Paper 2 Structured Questions

14 September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
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Total	

This document consists of **22** printed pages and **0** blank pages.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\,\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T/\text{K} = T/{}^{\circ}\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$
	$= \pm \omega\sqrt{(x_o^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 **(a)** State Newton’s three laws of motion.

First Law: ....

....

....

Second Law: ....

....

....

Third Law: ....

....

.... [3]

(b) Using the appropriate laws of motion, answer the question for each given situation.

(i) A passenger claimed that he was sitting in the middle of a bus that was moving forward. The driver suddenly applied the brakes and a suitcase that was in the front of the bus flew backwards and hit him.

State and explain if his claim is valid.

....

....

....

.... [2]

(ii) A labourer was tasked with pulling a cart. He reasoned that whatever he exerts on the cart, the cart will exert an equal and opposite force on him. The forces will cancel out and hence it is pointless for him to pull the cart as both he and the cart will not be able to move.

State and explain if his reasoning is correct.

....

....

....

.... [2]

(iii) A man is stranded in the middle of a frozen lake with a heavy bag of gold. As there is no friction between him and the surface of the ice, he is unable to crawl back to shore.

State and explain the action that he can take to get back to shore.

....

....

....

....

.... [2]

(c) A small sedan car makes a head-on collision with a large truck.

(i) State and explain if the force experienced by the car is different from that experienced by the truck.

....

....

.... [1]

(ii) Both drivers are securely fastened to their vehicle seats. State and explain if the driver of the truck is likely to experience more severe injuries as compared to the driver of the car.

....

....

....

....

....

.... [2]

2 Fig. 2.1 shows an archer with a bow.

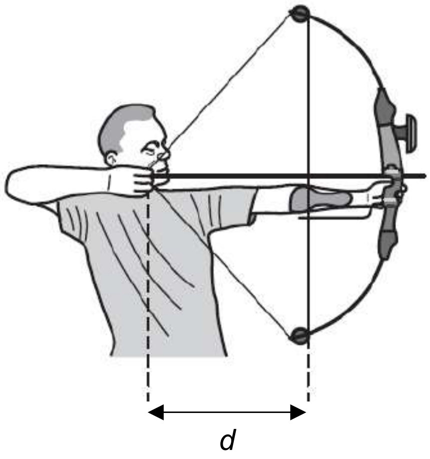


Fig. 2.1

The force *F* required to bend the bow and the corresponding displacement *d* of the arrow are measured. A plot of *F* against *d* is shown in Fig. 2.2.

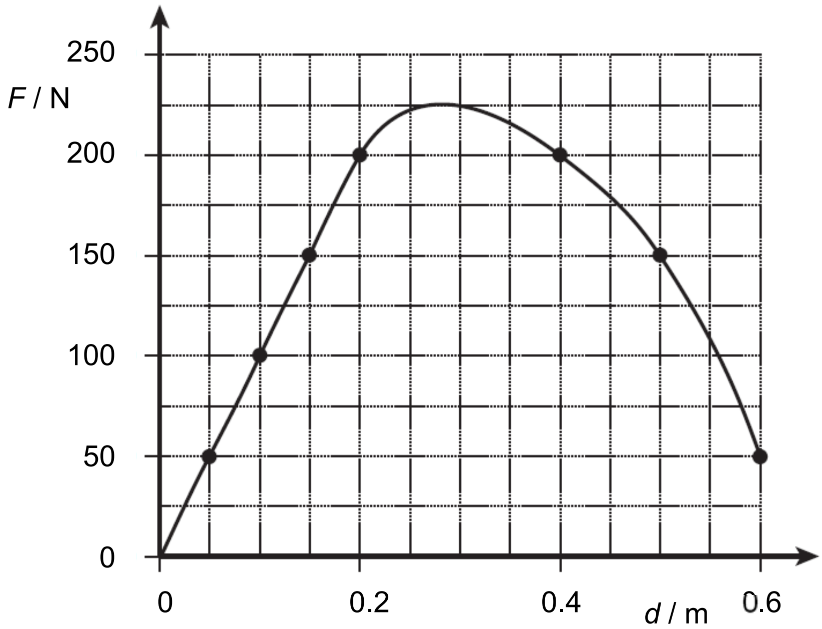


Fig. 2.2

(a) An experienced archer is able to draw an arrow further back, resulting in a greater displacement of arrow, *d*, as compared to a novice archer.

Using Fig. 2.2 and the principle of conservation of energy, suggest an advantage that this extra displacement provides.

....

....

....

....

.... [2]

(b) **(i)** Using Fig. 2.2, estimate the elastic potential energy stored in the bow when an arrow is displaced by 0.50 m.

elastic potential energy = ……………………J [2]

(ii) The arrow in **(b)(i)** is then released by the archer from the bow.

Determine the maximum possible speed of the arrow which has a mass of 3.5×10^{-2} kg.

maximum possible speed = …………………… m s^{-1} [2]

3 **(a)** Define the *tesla*.

....

....

.... [1]

(b) Charged particles, of speed 4500 m s^{-1} and mass 2.66×10^{-26} kg, are travelling in a narrow beam in a vacuum as shown in Fig. 3.1.

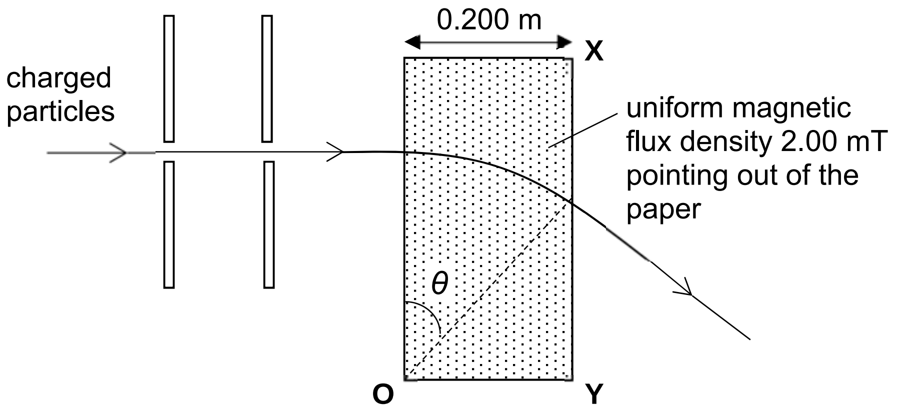


Fig. 3.1

The charged particles enter a region of uniform magnetic flux density which is 0.200 m wide. The direction of the magnetic flux is pointing out of the paper.

(i) Using Newton's Law of motion, state and explain the speed of the particles as they exit the uniform magnetic field.

....

....

....

.... [2]

(ii) Given that the magnitude of the charge on the particles is *e*, calculate the radius of the circular motion of the charged particles in the uniform magnetic field.

radius = ……………………m [2]

(iii) Hence, calculate the angular velocity of the charged particles in the uniform magnetic field.

angular velocity = …………………… rad s^{-1} [1]

(iv) Point **O** is the centre of the circular motion of the charged particles as shown in Fig. 3.1. Show that the angle θ is 0.564 rad. [2]

(v) In another experiment, similar charged particles are now fired into the magnetic field in Fig. 3.1 with different momentum.

1. Determine the maximum momentum of particles such that the particles will not exit the magnetic field through XY.

momentum = …………………… kg m s^{-1} [2]

2. Show that the time taken for the particle of mass m and charge q in **(b)(v)1** to complete a semi-circle within a region of magnetic flux density B is given by:

$$\frac{\pi m}{Bq}$$ [2]

4 **(a)** State the *principle of superposition*.

....

....

.... [1]

(b) Noise-cancelling headphones use both Active Noise Control and passive sound-proofing to reduce undesired ambient sounds reaching the ears of the user. In Active Noise Control, a microphone detects ambient noise and a noise-cancellation speaker emits a corresponding "anti-noise" that undergoes destructive interference with the noise.

Suggest the features that the "anti-noise" should have in order to achieve the optimal noise-cancelling effect.

....

....

....

.... [2]

(c) A student measured the waveforms of the noise and the anti-noise. The following observations were made:

1. There is a 1.0 ms time-lag between the noise and the anti-noise.
2. The amplitudes of the noise and anti-noise were effectively similar.

A sample noise waveform is shown in Fig. 4.1.

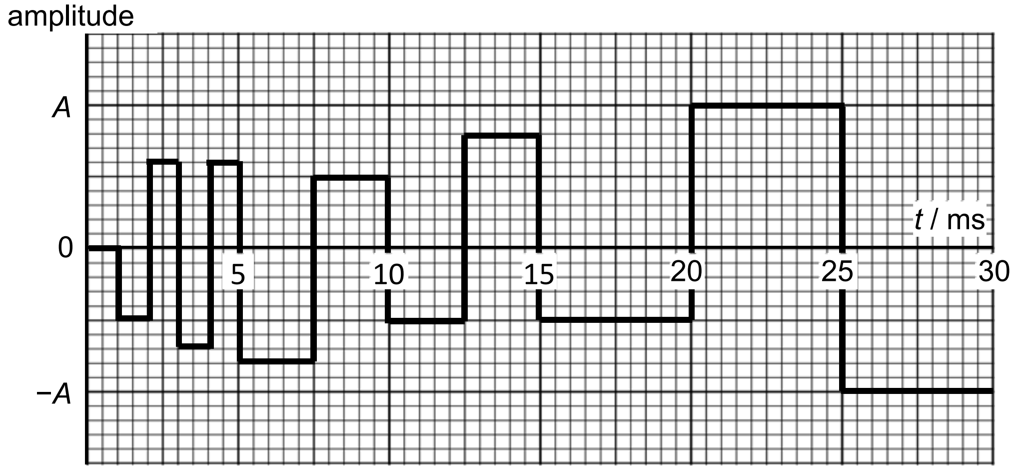


Fig. 4.1

(i) On Fig. 4.2, sketch the anti-noise waveform for 15 ms < t < 30 ms. [2]

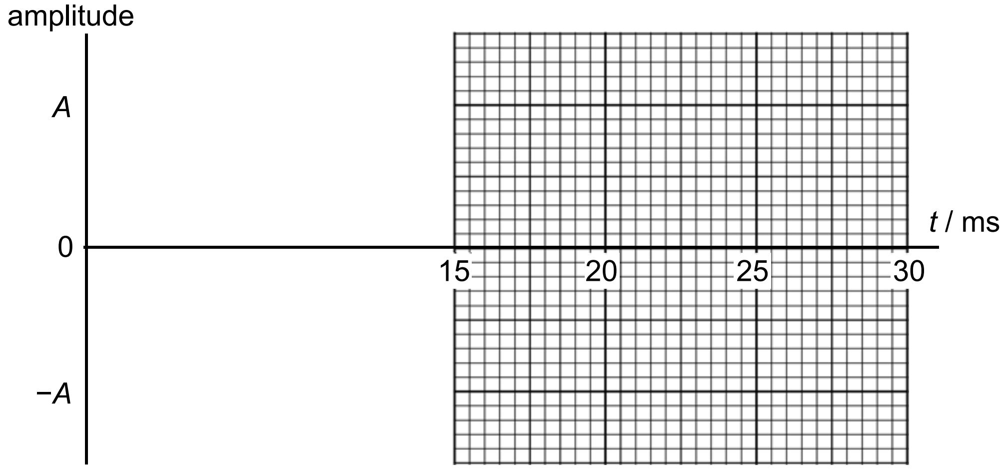


Fig. 4.2

(ii) The final resultant waveform reaching the ears is shown in Fig. 4.3.

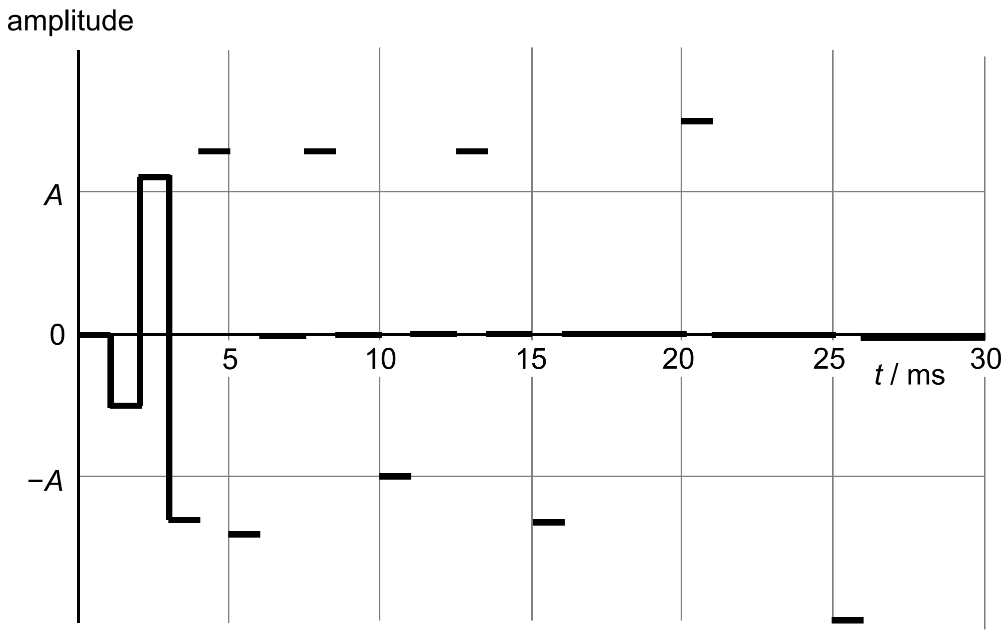


Fig. 4.3

Using Fig. 4.3, suggest if Active Noise Control is better suited for noises of higher or lower frequencies.

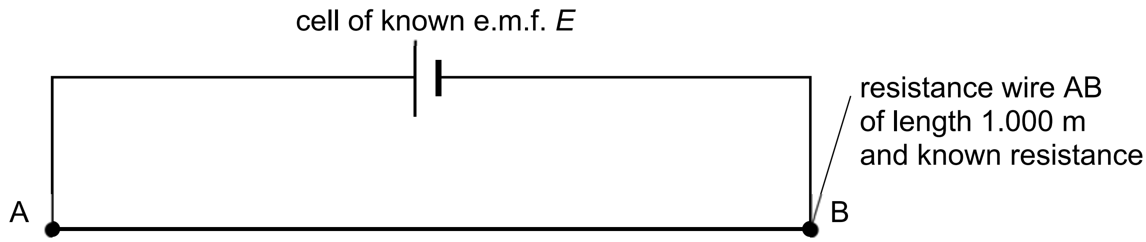
....

....

.... [2]

5 **(a)** You are provided with a galvanometer, a switch, a 100 Ω fixed resistor, and some connecting wires.

By completing the potentiometer circuit diagram in Fig. 5.1, explain how the internal resistance of an unknown cell ε may be determined.



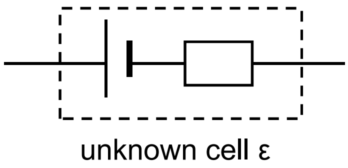


Fig. 5.1

....

....

....

....

....

.... [3]

(b) Fig 5.2 shows a potentiometer circuit in which the resistance wire is made up of 7 identical strands of unshielded constantan wire.

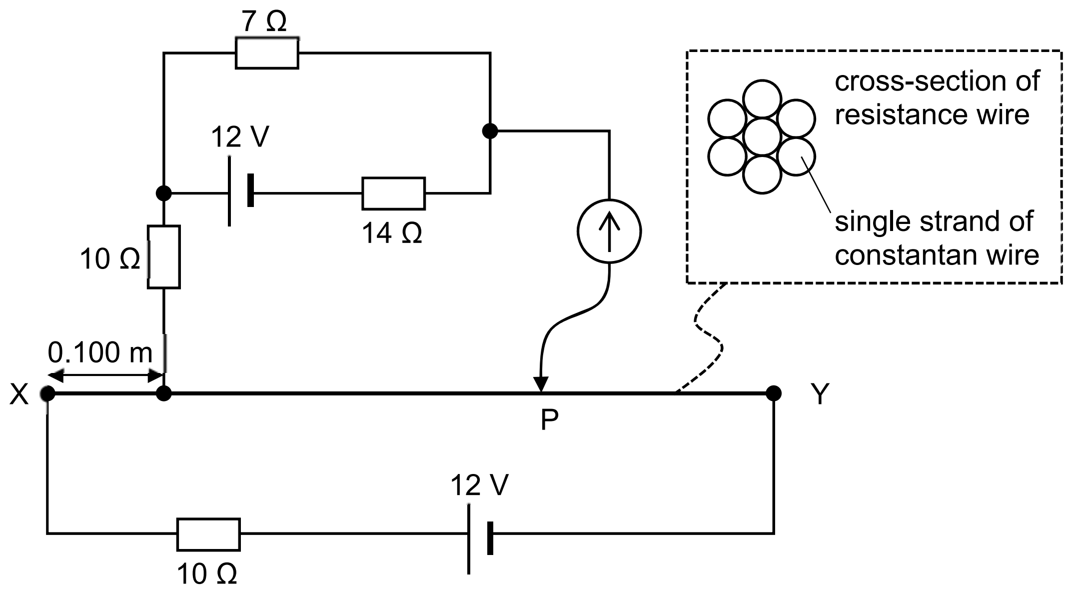


Fig. 5.2

(i) Each constantan strand has a diameter of 0.15 mm. Given that XY is 1.00 m long, show that XY has a resistance of 4.0 Ω.(Resistivity of constantan is 4.90×10^{-7} Ω m.) [2]

(ii) The cells have negligible internal resistances. Explain quantitatively whether a balance length can be found. [3]

6 Radiation of wavelength 4.0×10^{-7} m is incident on the photo-cathode **C** of a photo-cell. The photo-cell is connected to a potential divider arrangement as shown in Fig. 6.1. The material of **C** has a work function of value 3.0×10^{-19} J.

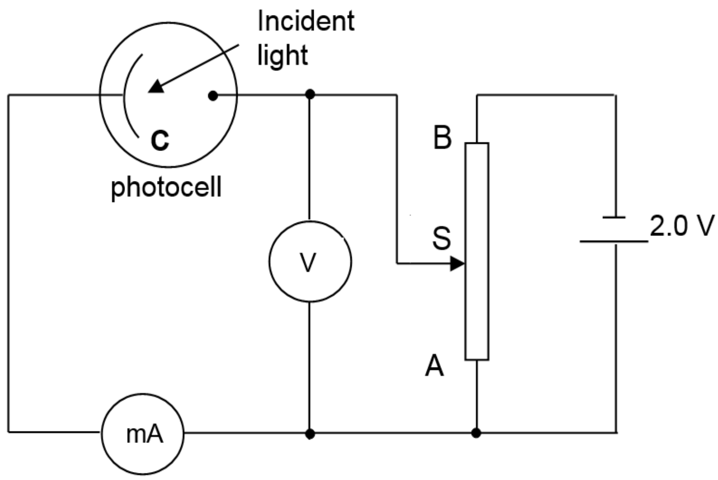


Fig. 6.1

(a) Explain what is meant by *work function*.

....

....

.... [1]

(b) (i) Calculate the maximum kinetic energy of the electrons emitted from the photo-cathode.

maximum kinetic energy = ... eV [3]

(ii) Suggest a reason why not all photoelectrons have this maximum energy.

....

....

.... [1]

(iii) Calculate the minimum reading of the voltmeter when the milli-ammeter registers no current flowing through it.

voltmeter reading = …………………… V [1]

(c) The sliding contact S is moved from A towards B.

On Fig. 6.2, sketch a graph of current registered by milli-ammeter against potential difference *V* measured across the analog voltmeter. [2]

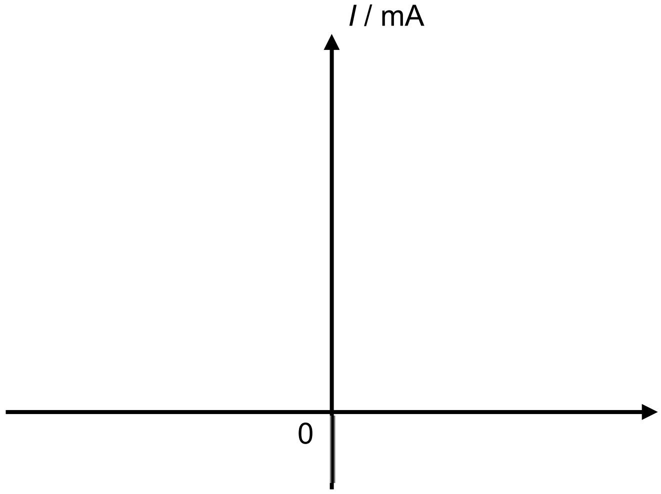


Fig. 6.2

(d) The polarity of the battery is now reversed. Explain why the milli-ammeter will always register a current flowing through it, regardless of the position of the sliding contact S on AB.

....

....

....

.... [2]

(e) In an actual experiment using the setting in **(d)**, the frequency of the irradiating photons is equal to the threshold frequency. However, there is no photocurrent registered by the milli-ammeter regardless of the position of the sliding contact S on AB.

Suggest a reason for this observation.

....

.... [1]

7 (a) For a steady and streamline flow of an incompressible and non-viscous fluid, the total hydraulic head H of the flow through a particular cross-section of a pipe is given by the expression

$$H = \frac{P}{\rho g} + \frac{v^2}{2g} + h$$

where P is the pressure of the fluid at the cross-section,
ρ is the density of the fluid,
v is the velocity of the fluid at the cross-section, and
h is the height of the centreline of pipe above a reference level.

H is related the energy in the fluid.

Suggest the type of energy associated with the following terms:

(i) $\frac{v^2}{2g}$

.... [1]

(ii) h

.... [1]

(b) Fig. 7.1 shows a steady and fully developed flow through a horizontal pipe of varying diameter. The inlet has an inner pipe diameter D_A and fluid velocity V_A while the outlet has an inner pipe diameter D_B and fluid velocity V_B.

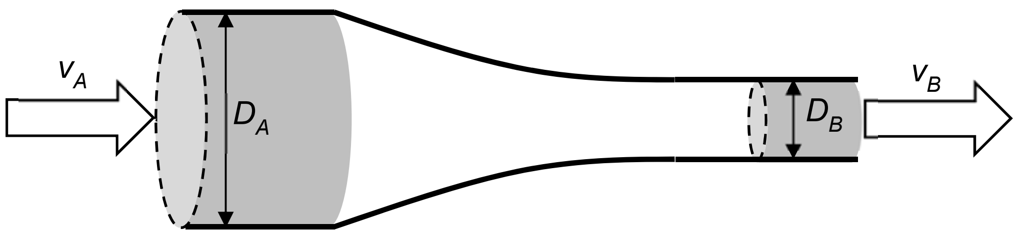


Fig. 7.1

(i) Assuming there are no energy losses within the pipe, state how the total hydraulic head at the inlet and at the outlet are related.

.... [1]

(ii) If the fluid can be considered incompressible, show that v_A and v_B are related by the expression

$$\frac{v_A}{v_B} = \frac{{D_B}^2}{{D_A}^2}$$ [2]

(iii) The inner diameter of the inlet is 0.100 m and the inner diameter of the outlet is 0.050 m. Water flows into the inlet at a speed of 8.0 m s^{-1}.

Using the hydraulic head expression given in **(a)** and your answers to **(b)**, determine the pressure difference between the inlet and outlet. (Density of water is 1000 kg m^{-3}.)

pressure difference = ………………………… Pa [3]

(c) In a typical flow between 2 cross-sections of a pipe, there will be energy losses due to frictional forces between the walls of the pipe and the fluid. This is accounted for by including an additional head loss term,

$$H_{Loss} = f_D \frac{v^2 L}{2gD}$$

where f_D is the friction factor,
L is the length of the pipe, and
D is the inner diameter of the pipe.

(i) State how this additional term will affect your answer to **(b)(iii)**.

....

.... [1]

(ii) If the pipe in **(b)** has a length of 10 m and a friction factor of 0.0038, estimate the magnitude of the difference to your answer in **(b)(iii)** if frictional losses are considered.

difference = ………………………… Pa [2]

(d) A student suggests using water flow in rigid pipes to model blood flow in blood vessels.

(i) State a difference between water flow in rigid pipes and blood flow in blood vessels.

....

....

.... [1]

(ii) The accumulation of fat and cholesterol deposits along the arterial walls has an effect of narrowing the arteries leading to an increase in blood pressure.

State and explain if the modelling proposed by the student will able to correctly predict this observation.

....

....

....

....

....

.... [3]

8 The International Space Station (ISS) is a habitable artificial satellite. It is maintained at 340 km above the Earth's surface, in what is known as a Low Earth Orbit (LEO). The radius of the Earth is 6.37×10^6 m. Fig 8.1 shows how the gravitational field strength of the Earth, g, varies with distance from the Earth's surface.

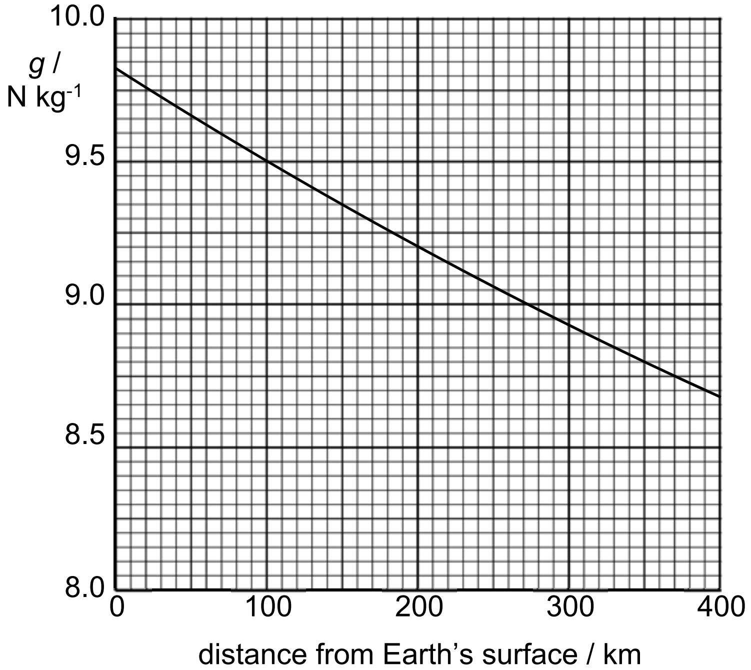


Fig. 8.1

(a) Using Fig 8.1, explain why an astronaut experiences apparent weightlessness in the ISS despite a non-zero gravitational field strength at LEO.

....

....

....

.... [2]

(b) Astronauts in apparent weightlessness may lose muscle mass. Fig. 8.2 shows a model of a spring system which can be used to monitor changes in mass.

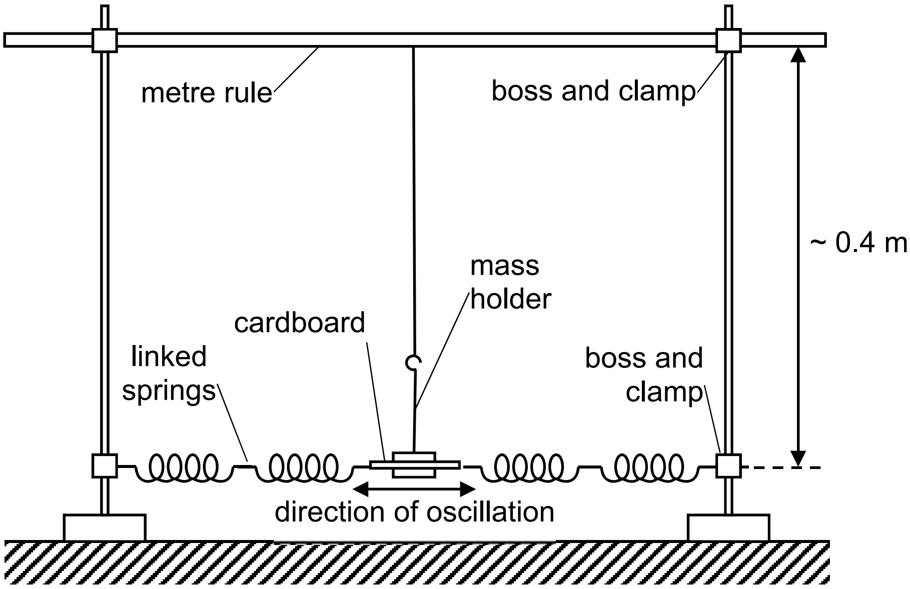


Fig. 8.2

It has been suggested that the relationship between the period of oscillation T and the mass M is given by:

$$\frac{1}{T^2} = \frac{p}{M} + q$$

where p and q are constants.

Fig. 8.3 shows the experimental results obtained using a stopwatch to measure the time taken for oscillations.

M / kg	time taken for 20 oscillations		T / s	$\frac{1}{T^2}$ / s^{-2}	$\frac{1}{M}$ / kg^{-1}
	t_1 / s	t_2 / s			
0.100	10.34	10.38	0.5180	3.727	10.0
0.150	12.07	11.93	0.6000	2.778	6.67
0.200	13.39	13.43	0.6705	2.242	5.00
0.250	14.34	14.32	0.7165	1.948	4.00
0.300	15.23	15.23	0.7615	1.724	3.33
0.350	15.70	15.64	0.7835	1.629	2.86

Fig. 8.3

The corresponding values of $\frac{1}{T^2}$ and $\frac{1}{M}$ are plotted on the graph in Fig. 8.4.

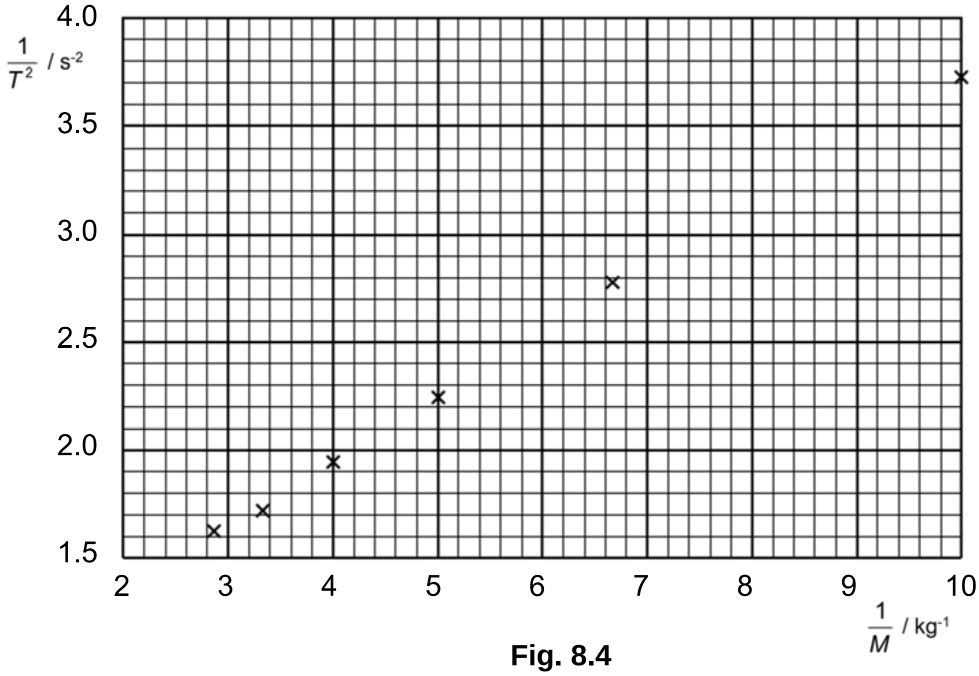


Fig. 8.4

(i) Using Fig. 8.4, determine *p* and *q*.

p = ...

q = ... [3]

(ii) It has been suggested that the variation of period, ∂T, is related to an astronaut's mass loss by $\partial T = \frac{2pT^3}{M} \times (\text{fractional mass loss})$.

Determine ∂T corresponding to an initial mass of M = 0.5 kg and a fractional mass loss of 0.10.

∂T = ...s [2]

(iii) According to medical opinion, a muscular mass loss of 10% is concerning. Taking reference from the data available, discuss if the experiment is able to detect the variation ∂T for a mass as small as 0.5 kg.

....

....

.... [2]

END OF PAPER

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	1	7	-			REGISTRATION NUMBER		

PHYSICS

9749/03

Paper 3 Longer Structured Questions

18 September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only

You are advised to spend one and a half hours on Section A and half an hour on Section B

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
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Total	

This document consists of **25** printed pages and **1** blank page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1} $(1/(36\,\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas,	W	$= p\Delta V$
hydrostatic pressure,	p	$= \rho gh$
gravitational potential,	ϕ	$= -\frac{Gm}{r}$
temperature,	T/K	$= T/{}^{o}C + 273.15$
pressure of an ideal gas,	p	$= \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t$
		$= \pm \omega\sqrt{(x_o^2 - x^2)}$
electric current,	I	$= Anvq$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential,	V	$= \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay,	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided.

1 A spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially supported at a height *h* above the water surface such that the spring is at its natural length, as shown in Fig. 1.1.

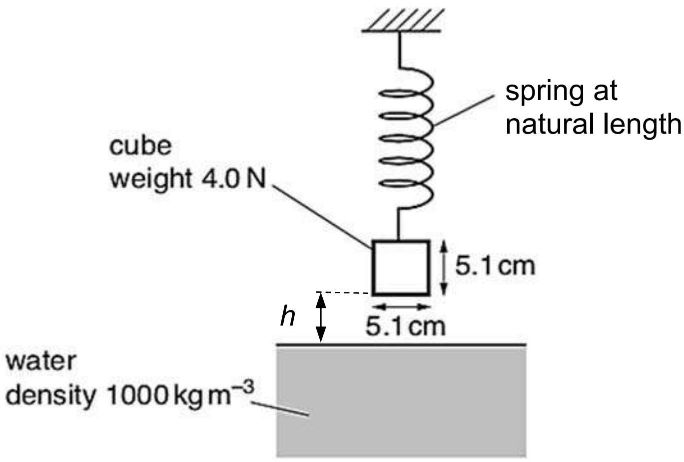

Fig. 1.1

The cube has a weight of 4.0 N and sides of length 5.1 cm. The cube is lowered gently into water. The cube reaches equilibrium with its base at a depth of 7.0 cm below the water surface, as shown in Fig. 1.2. The density of the water is 1000 kg m^{-3}.

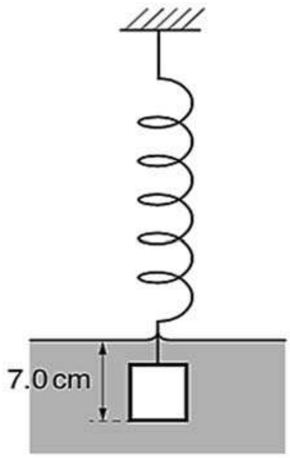

Fig. 1.2

(a) Calculate the difference in the pressure exerted by the water on the bottom face and on the top face of the cube.

difference in pressure = …………………………… Pa [2]

(b) Using your answer in **(a)**, show that the upthrust acting on the cube is 1.3 N. [1]

(c) Determine the force exerted on the spring by the cube when it is in equilibrium in the water.

force = …………………………… N [2]

(d) The spring obeys Hooke's law and has a spring constant of 30 N m^{-1}.

Determine the height *h*.

h = …………………………… m [3]

(e) The cube in the water is suddenly detached from the spring.

(i) Determine the initial acceleration of the cube.

initial acceleration = …………………………… m s^{-2} [2]

(ii) Describe and explain the variation of the acceleration of the cube as it sinks in the water.

....

....

.... [2]

2 **(a)** State what is meant by *simple harmonic motion*.

....

....

.... [2]

(b) A small frictionless trolley is attached to a fixed point **P** by means of a spring. A second spring is used to attach the trolley to a variable frequency oscillator, as shown in Fig. 2.1.

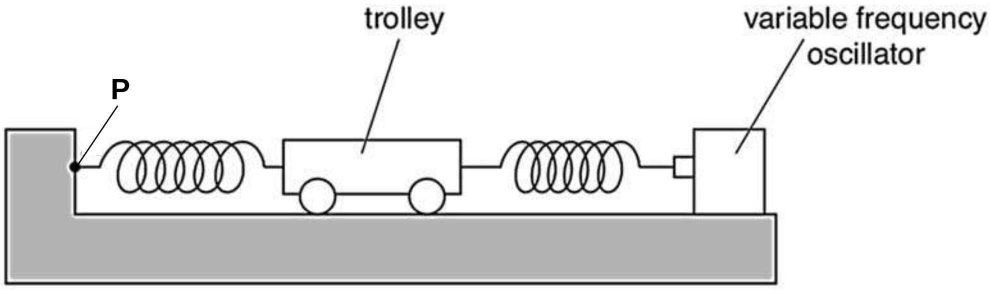

Fig. 2.1

Both springs remain extended within their limits of proportionality. Initially, the oscillator is switched off. The trolley is displaced horizontally along the line joining the two springs and is then released. The variation with time t of the velocity v of the trolley is shown in Fig. 2.2.

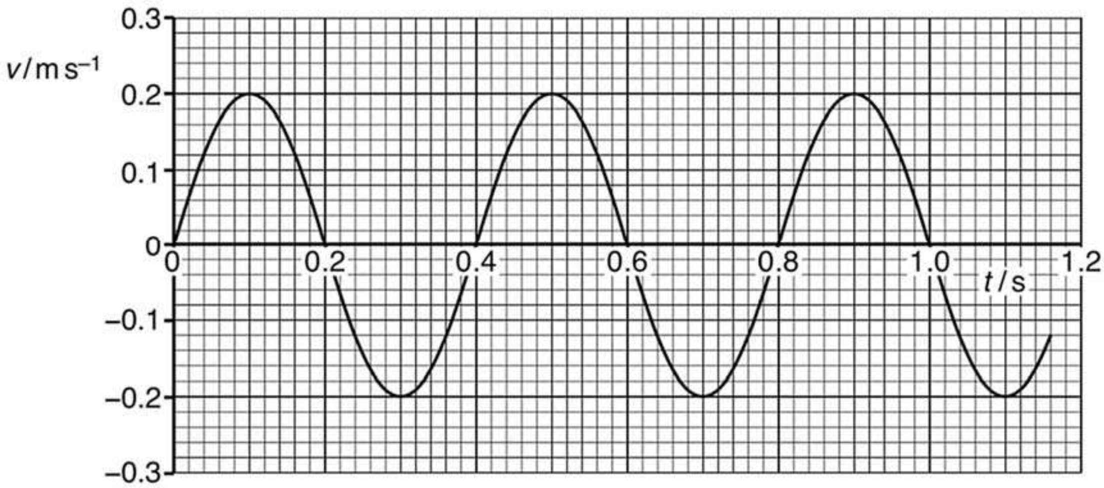

Fig. 2.2

(i) Using Fig. 2.2, state two different times at which

1. the displacement of the trolley is zero,

time = ………………… s and ………………… s [1]

2. the acceleration in one direction is maximum.

time = ………………… s and ………………… s [1]

(ii) Determine the frequency of oscillation of the trolley.

frequency = …………………………….. Hz [1]

(iii) The variation with time of the displacement of the trolley is sinusoidal. The variation with time of the velocity of the trolley is also sinusoidal.

State the phase difference between the displacement and the velocity.

phase difference = …………………………….. ° [1]

(c) The oscillator is now switched on. The amplitude of variation of the oscillator is constant. The frequency *f* of vibration of the oscillator is varied. The trolley is forced to oscillate by means of vibrations of the oscillator.

(i) Distinguish between *free oscillations* and *forced oscillations*

....

....

....

....

.... [2]

(ii) It was observed that the trolley vibrates with different amplitudes as the frequencies of the oscillator changes.

On the axis provided on Fig. 2.3, sketch a possible amplitude-frequency graph for this trolley. [1]

Fig. 2.3

(iii) State the approximate frequency at which the amplitude is maximum.

frequency = ……………………………. Hz [1]

(iv) The amplitude of the oscillations may be reduced without changing significantly the frequency at which the amplitude is a maximum.

State and explain how this may be done. You may draw on Fig. 2.1 to support your answer.

....

....

....

.... [2]

3 **(a)** Define *electric potential* at a point.

....

....

.... [1]

(b) Two similar positive point charges of magnitude e are set up along the line XY as shown in Fig. 3.1.

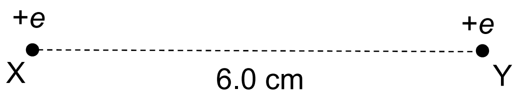

Fig. 3.1

(i) On Fig 3.2, sketch how the electric potential varies over XY. [2]

Fig. 3.2

(ii) Describe how the electric force acting on a known charge q placed at a point along XY could be obtained from Fig 3.2.

....

.... [2]

(c) **(i)** A negative point charge of – e is now placed at the midpoint of XY.

State the magnitude of electric force experienced by the point charge

electric force = ………………………………. N [1]

(ii) The negative point charge at the midpoint in XY in **(c)(i)** is moved to the position Z as shown in Fig 3.3.

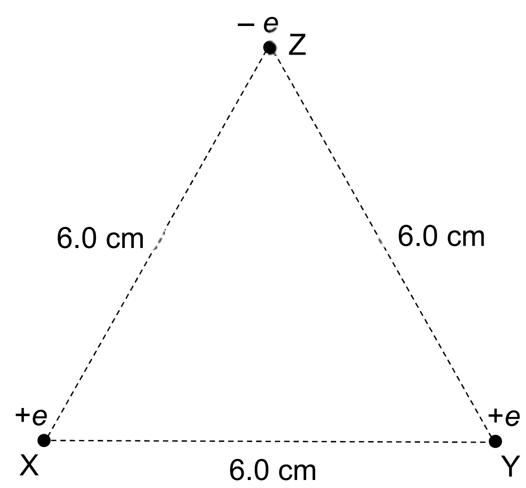

Fig. 3.3

Within the bounded region of Fig 3.4, sketch the resultant electric field lines of the 3 point charges. [3]

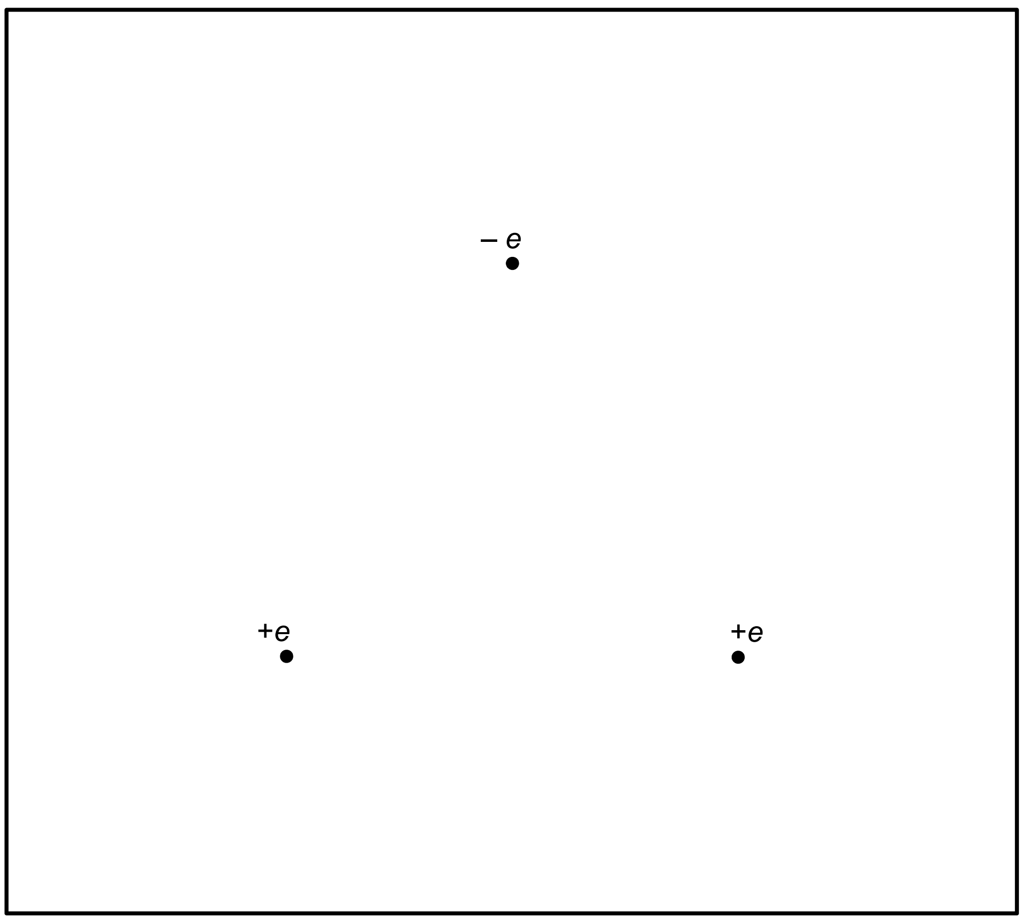

Fig. 3.4

(iii) Determine the work done by the electric field to completely separate the 3 point charges in Fig 3.3.

work done = ……………………………. J [3]

4 **(a)** State the *First Law of Thermodynamics*.

....

....

.... [1]

(b) 0.050 moles of an ideal gas is contained within an uninsulated cylinder with a movable piston as shown in Fig. 4.1.

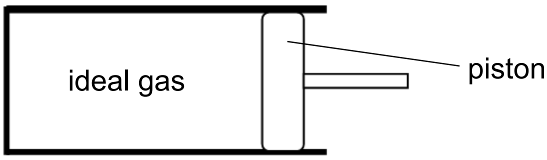

Fig. 4.1

The piston moves slowly outwards, resulting in the variation of pressure shown in Fig. 4.2

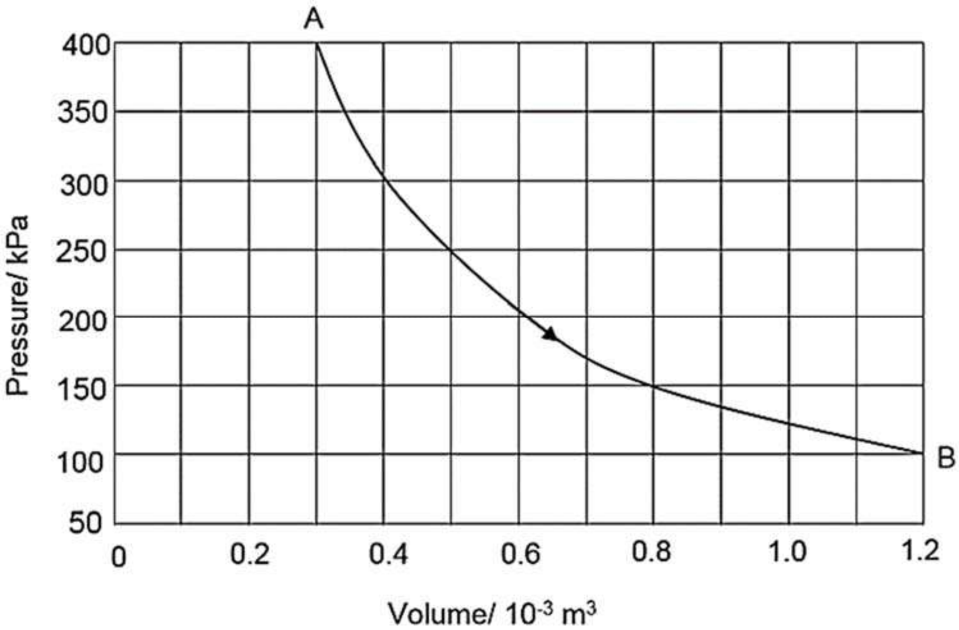

Fig. 4.2

(i) The process A to B occurs along an isotherm.

Determine the temperature along this isotherm.

temperature = ... K [2]

(ii) Calculate the total kinetic energy as a result of the random motion of the gas molecules in the cylinder.

total kinetic energy = …………………………… J [1]

(iii) Estimate the amount of work done by gas as it expands from A to B

work done = …………………………… J [2]

(iv) A student states that no heat flows into or out of the gas during the process A to B as the temperature of the gas did not change.

State and explain the validity of his statement.

....

....

....

.... [3]

(c) In another set up with the same starting point as the one shown in Fig. 4.1, the piston is moved very quickly outwards expanding the gas to a volume of 1.2×10^{-3} m^3. As a result, the temperature of the gas decreases to 144 K.

On Fig. 4.2, sketch the variation with volume of the pressure of the gas. [2]

5 Fig. 5.1 shows the structure of a geophone which is used by geophysicists to determine the speed of seismic waves traveling within the ground layer.

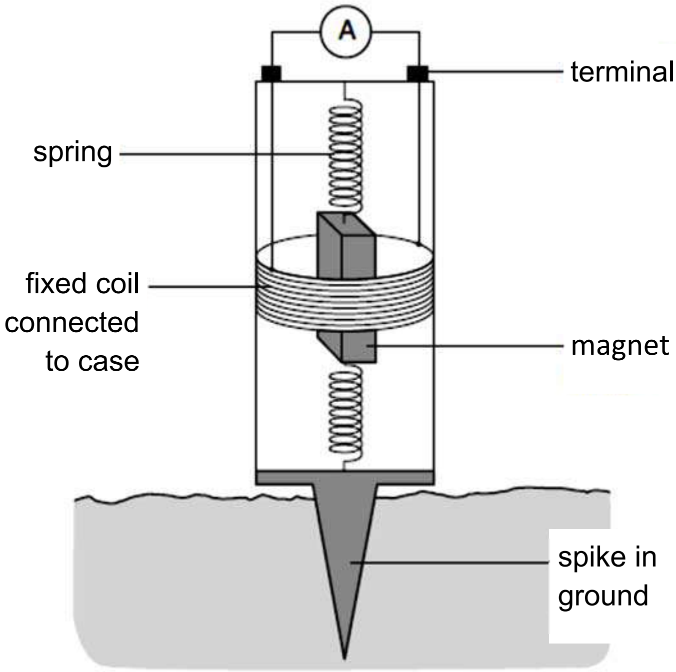

Fig. 5.1

The spike of the geophone is inserted into the ground. When a seismic vibration moves the case and coil, the magnet remains stationary due to its inertia.

(a) State Faraday's law of electromagnetic induction.

....

.... [1]

(b) Using Faraday's law, explain how an e.m.f. is generated between the terminals when seismic waves pass through the ground.

....

....

....

.... [2]

(c) A coil of 50 turns generates a maximum e.m.f. of 85 mV in a geophone.

Calculate the rate of change of magnetic flux needed to generate this e.m.f.

rate of change of magnetic flux = ………………………… Wb s^{-1} [2]

(d) Suggest 2 changes to the geophone which will make it more sensitive to the seismic vibrations.

1. .... [1]

2. .... [1]

6 In the hairdryer shown in Fig. 6.1, an alternating current passes through the heating coil when the switch is closed.

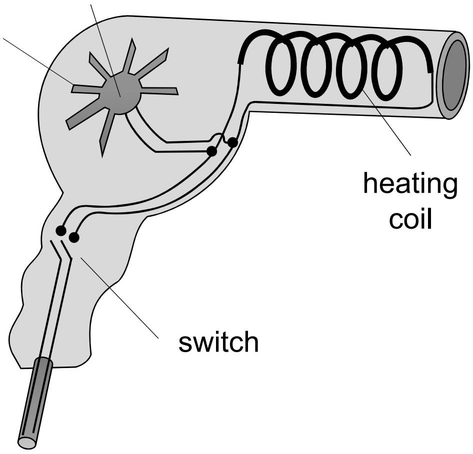

Fig. 6.1

(a) By reference to heating effect, explain what is meant by the root-mean-square (r.m.s) value of an alternating current.

....

.... [1]

(b) The hair dryer is connected to the mains supply of 120 V r.m.s. and frequency 50 Hz. The heating coil delivers a power of 1200 W.

(i) Calculate the peak current through the heating coil.

peak current = …………………………… A [2]

(ii) Write an equation, in terms of the elapsed time *t*, for the current that passes through the heating coil, given that the instantaneous power output is zero at *t* = 0 s. [1]

(c) The primary coil of a transformer is connected to a 2.4 kV r.m.s. supply. The secondary coil is connected to the hair dryer and the current flowing through the heating coil has the same value as that calculated in **(b)(i)**.

The transformer is non-ideal and electrical energy is converted to thermal energy in the transformer at a rate of 600 W.

Determine the r.m.s. current in the primary coil.

r.m.s. current = …………………………… A [2]

Section B

Answer any **one** question in this Section in the spaces provided.

7 **(a)** **(i)** Explain what is meant by an *alternating current*.

....

....

.... [1]

(ii) Fig. 7.1. shows a metal wire held taut between a knife edge X and a smooth pulley P. The wire passes between opposing poles of permanent bar magnets.

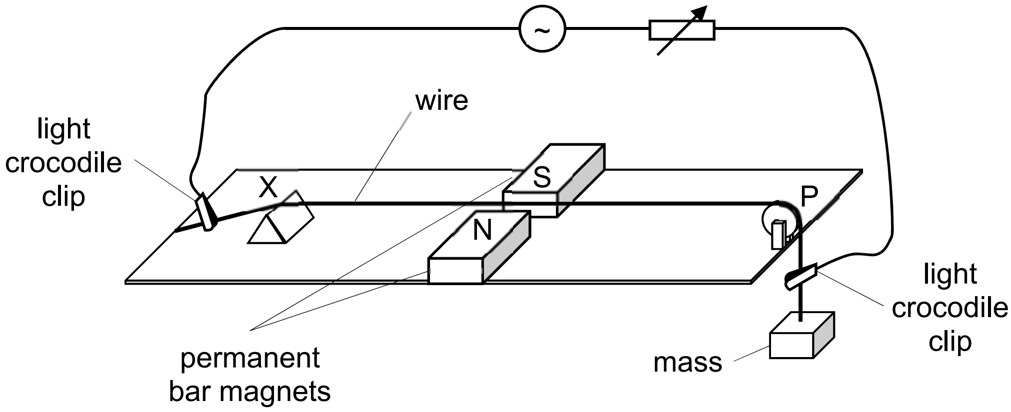

Fig. 7.1

The wire vibrates when a sinusoidal alternating source is connected across the wire. Explain how these vibrations are created. Describe the properties of these vibrations.

....

....

....

....

....

....

....

....

.... [4]

(iii) When the frequency of the alternating source is 120 Hz, a standing wave wire in its fundamental mode is observed in the wire. XP is 2.0 m in length.

1. Calculate the speed of the wave in the wire.

speed of wave = …………………………… m s^{-1} [2]

2. Explain, with reference to the formation of a stationary wave, what is meant by the speed calculated in **(a)(iii)1**.

....

....

....

....

....

....

....

....

....

.... [4]

(iv) When the mass hanging below pulley P is doubled, the fundamental mode standing wave is observed to occur when the frequency of the alternating source is 170 Hz. When the mass was triple that of the original set up, the fundamental mode frequency is 208 Hz.

Suggest if the relationship

$$v \propto \sqrt{T}$$

is valid, where v is the wave velocity in the metal wire, and
T is the tension in the metal wire. [3]

(b) (i) State what is meant by the *diffraction* of a wave.

....

.... [1]

(ii) Light of wavelength 633 nm from a laser is directed normally at a diffraction grating, as illustrated in Fig. 7.2.

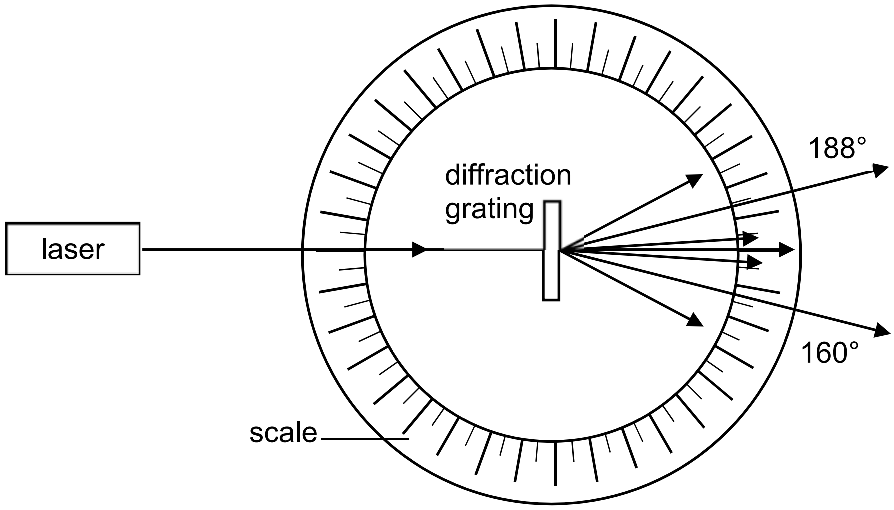

Fig. 7.2

The diffraction grating is situated at the centre of a circular scale, marked in degrees. The readings on the scale for the second order diffracted beams are 160° and 188°.

Calculate the number of lines per unit length of the slits in the diffraction grating.

number of lines per unit length = …………………………… m^{-1} [4]

(iii) Suggest why the non-central fringes produced by light passing through a diffraction grating is brighter than that from the same source with a double slit.

....

.... [1]

8 **(a)** In an α-particle scattering experiment, an α-particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 8.1.

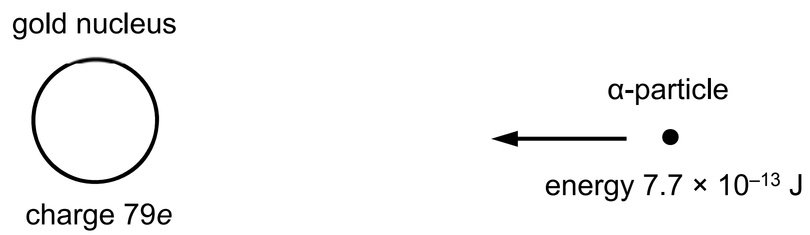

Fig. 8.1

The gold nucleus has a charge 79*e*. At a large distance from the gold nucleus, the α-particle has energy 7.7 × 10^{-13} J.

(i) The α-particle does not collide with the gold nucleus.

Show that the radius of the gold nucleus must be less than 4.7 × 10^{-14} m. [2]

(ii) The results of the α-particle scattering experiment provide evidence for the structure of the atom.

result 1: The vast majority of α-particles pass straight through the metal foil or are deviated by small angles.

result 2: A very small minority of α-particles are scattered through angles greater than 90° and up to 180°.

State what may be inferred from

1. result 1,

....

.... [1]

2. result 2.

....

....

....

.... [2]

(b) One nuclear reaction that can take place in a nuclear reactor may be represented, in part, by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{95}_{42}Mo + ^{139}_{57}La + 2\,^{1}_{0}n + \text{..........} + \text{ energy}$$

Data for a nucleus and some particles are given in Fig. 8.2

nucleus or particle	mass / u
$^{139}_{57}La$	138.955
$^{1}_{0}n$	1.00863
$^{1}_{1}p$	1.00728
$^{0}_{-1}e$	0.000549

Fig. 8.2

(i) Complete the nuclear reaction shown above. [1]

(ii) Calculate the binding energy per nucleon, in MeV, of lanthanum-139 $\left(^{139}_{57}La\right)$.

binding energy per nucleon = ... MeV [3]

(iii) State and explain whether the binding energy per nucleon of uranium-235 $\left({}^{235}_{92}U\right)$ will be greater, equal to or less than your answer to **(b)(ii)**.

....

....

....

.... [2]

(c) A radiation detector is placed close to a radioactive source as shown in Fig. 8.3.

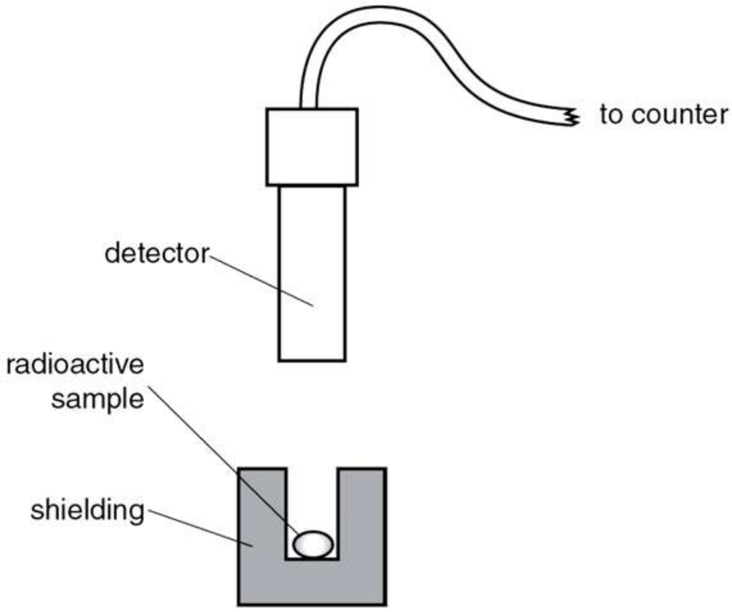

Fig. 8.3

The emissions from the radioactive source include both β-particles and γ-ray photons.
The β-particles emitted have energies up to a maximum of 0.61 MeV.

(i) Suggest two reasons why the activity of the source and the measured count rate may be different.

1. ....

.... [1]

2. ....

.... [1]

(ii) Explain why the emitted β-particles have a range of energies.

....

.... [1]

(iii) The γ-ray photons emitted have specific energies. Suggest why this is so.

....

.... [1]

(d) The variation with time t of the measured count rate in **(c)** is as shown in Fig. 8.4.

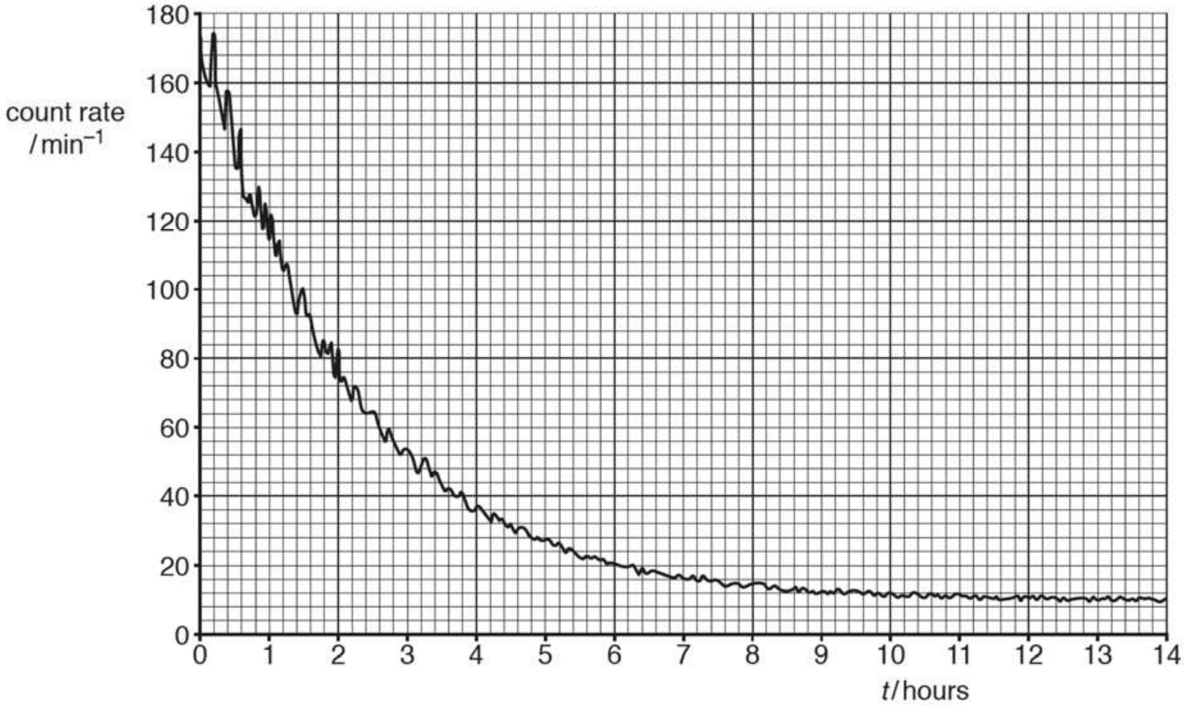

Fig. 8.4

(i) Use Fig. 8.4 to determine the half-life of the radioactive source.

half-life = …………………………… hours [3]

(ii) The readings in Fig. 8.4 were obtained at room temperature.

A second sample of this radioactive source is heated to a temperature of 500 °C. The initial count rate at time t = 0 is the same as that in Fig. 8.4. The variation with time t of the measured count rate from the heated source is determined.

State and explain if there are any differences in

1. the half-life,

....

.... [1]

2. the measured count rate for any specific time.

....

.... [1]

END OF PAPER

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EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	1	7	-			REGISTRATION NUMBER			

PHYSICS

9749/04

Paper 4 Practical

24 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper.
Additional Materials: as listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

Shift
Laboratory

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
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This document consists of **17** printed pages and **1** blank page.

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1 In this experiment you will investigate how the motion of a paper strip depends on its width.

(a) **(i)** Measure and record the width *x* of the paper strip, as shown in Fig. 1.1.

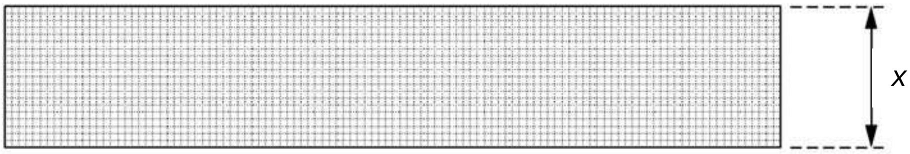


Fig. 1.1

x = ………………………… [1]

(ii) Connect the clips to the strip as shown in Fig. 1.2.

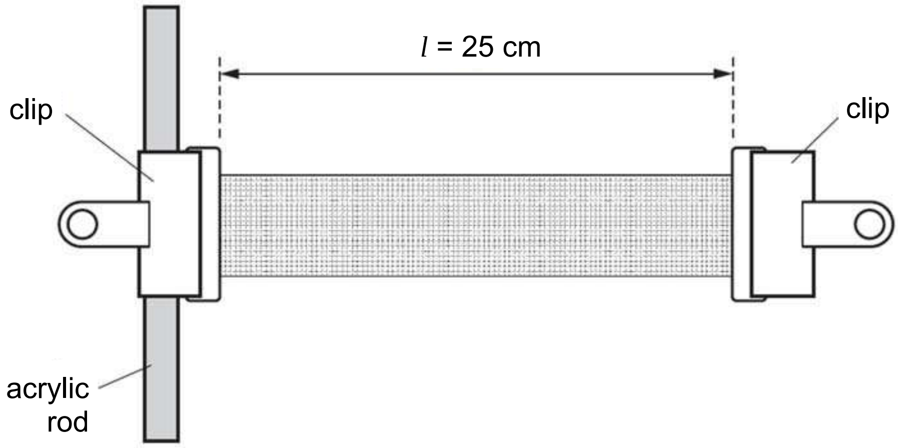


Fig. 1.2

(iii) Measure and record the length *l* of the paper strip between the 2 clips.

l = …………………………

(b) (i) Set up the apparatus with the top clip supported on the nail, as shown in Fig. 1.3.

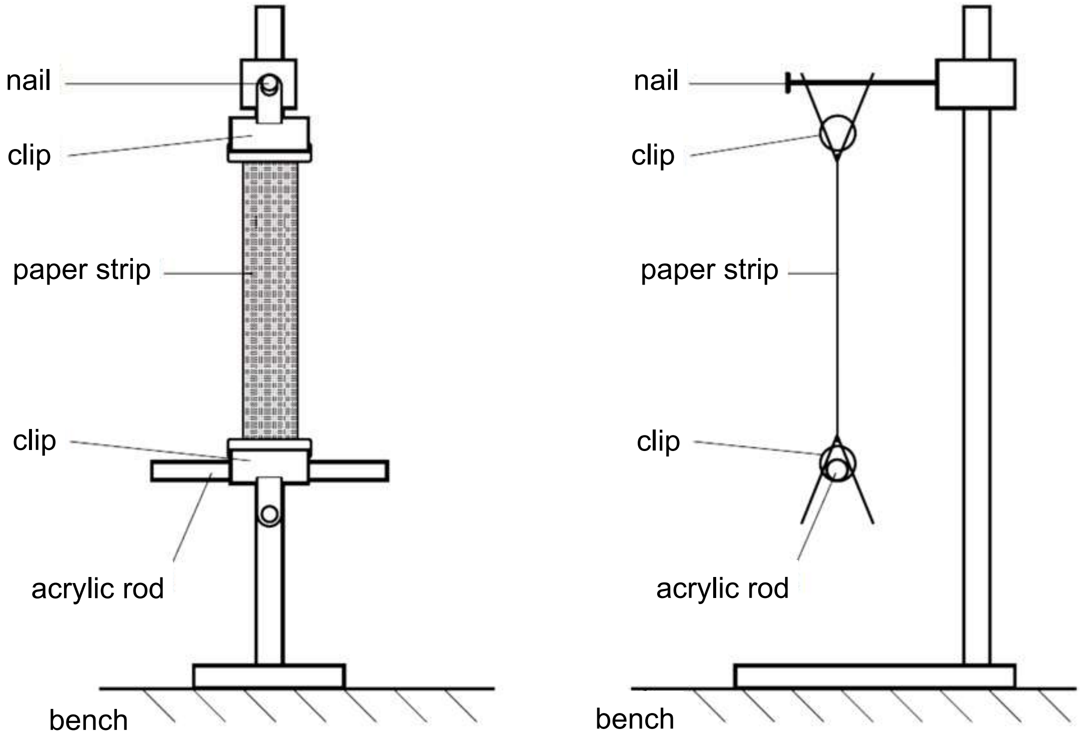


Fig. 1.3

(ii) Twist the acrylic rod through an angle of approximately 45° in a horizontal plane, as shown in Fig. 1.4.

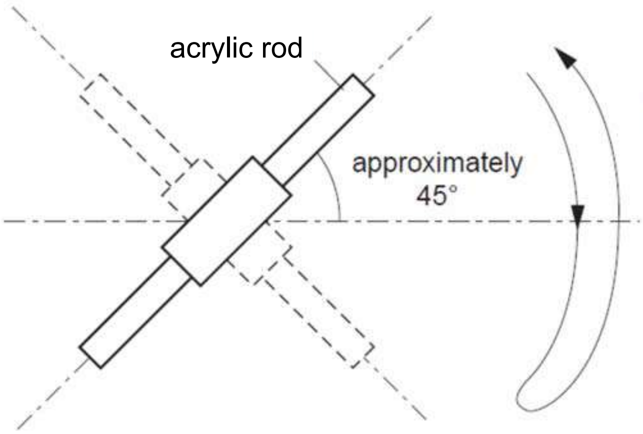


Fig. 1.4 (top view)

Release the rod and observe its movement.
The rod completes one swing by twisting one way and then back the other way, as shown in Fig. 1.4.
The time taken for each complete swing is T.
By timing several of these complete swings, determine an accurate value for T.

T = ………………………… [2]

(c) By cutting the given strip, repeat **(a)** and **(b)** until you have six sets of values of x and T. Values of x should be in the range 1 cm ≤ x ≤ 6 cm.

[9]

(d) **(i)** Plot a graph of T against $\frac{1}{x}$. [3]

(ii) Determine the gradient and y-intercept of this line.

gradient = ………………………………… [1]

y-intercept = ………………………………… [1]

(e) It is suggested that the relationship between T and x is

$$T = \frac{a}{x} + b$$

where a and b are constants.

Using your answers from **(d)(ii)**, determine the values of a and b.

a = ……………………………………

b = ……………………………………
[1]

(f) State one problem with determining an experimental value of T for x = 15 cm

[1]

(g) Paper manufacturers uses a similar setup and set of procedures to determine the quality of their products.

Other than the length l of the paper, suggest two other quantities of the paper that will affect the values of a or b.

1.

2. [2]

[Total: 21 marks]

2 In this experiment, you will measure the potential difference across a resistor R_2 as the resistance of the circuit is varied.

(a) (i) Connect the circuit shown in Fig. 2.1 using one of the resistors in the chain.

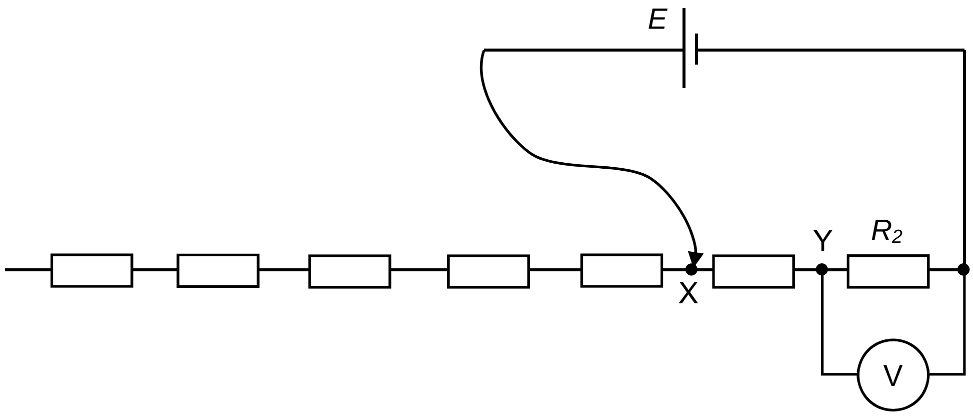


Fig. 2.1

(ii) Record the value of the potential difference V across R_2.

V = ...

(b) Change the number n of resistors between X and Y and repeat **(a)(ii)** until you have six sets of readings for V and n.

[4]

(c) *V* and *n* are related by the equation

$$\frac{1}{V} = \frac{nR_1}{ER_2} + \frac{1}{E}$$

where R_1 is the resistance of each of the resistors in the chain and *E* is the e.m.f. of the battery.

Suggest how you would use the data collected in **(b)** to determine values of *E* and the ratio of $\frac{R_1}{R_2}$

[3]

[Total: 7 marks]

3 When an object falls in air, it experiences a drag force which opposes the motion of the object. Larger objects experience greater drag forces. In this experiment, you will investigate how the terminal velocity of a paper cone falling in air depends on the diameter of the cone.

(a) Cut a sector of a piece of filter paper as shown in Fig. 3.1.

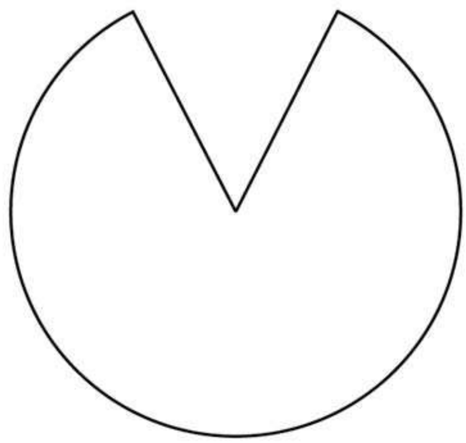


Fig. 3.1

(b) (i) Tape the straight edges of the paper together to produce a cone, as shown in Fig. 3.3.

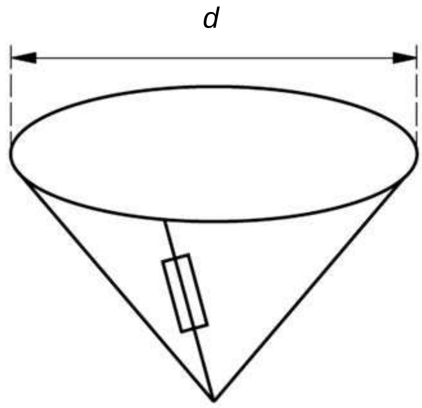


Fig. 3.2

(ii) Measure and record the diameter *d* of the cone.

d = …………………………………… [1]

(c) **(i)** Mount a metre rule vertically using a retort stand, boss and clamp.

Explain how you ensured that the metre rule was mounted vertically.

....

....

.... [1]

(ii) Release the cone from a short distance above the top of the metre rule, as shown in Fig. 3.3.

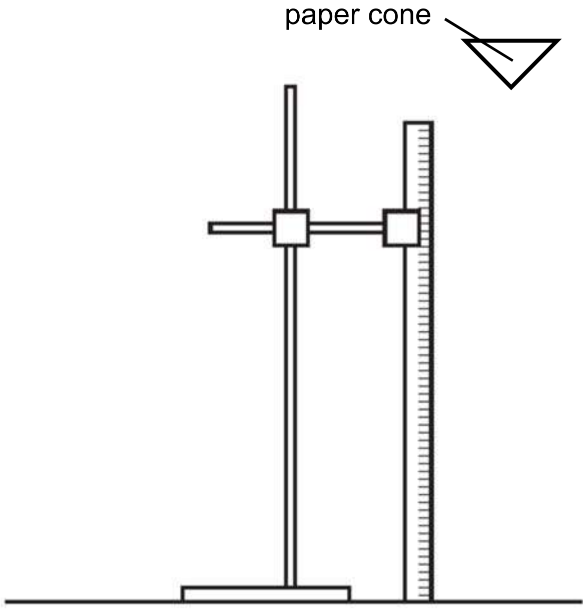


Fig. 3.3

Make and record measurements to determine the time *t* for the cone to fall through a distance *h* from the top of the metre rule.

h = ... [1]

t = ... [1]

(d) Estimate the percentage uncertainty in *t*, showing your working.

percentage uncertainty in *t* = ... [1]

(e) Calculate the terminal velocity *v* of the cone.

v = ………………………………… [1]

(f) **(i)** Remove the tape from the paper and cut away a larger sector as shown in Fig. 3.4.

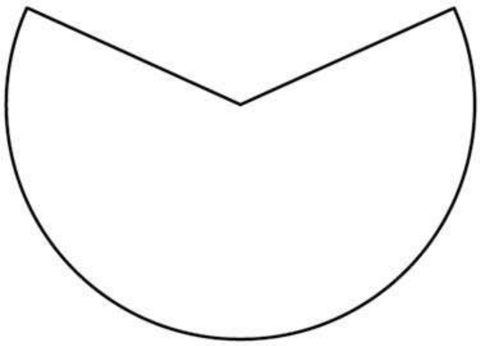


Fig. 3.4

(ii) Repeat **(b)**, **(c)(ii)** and **(e)**, recording your results below.

d = …………………………………

h = …………………………………

t = …………………………………

v = …………………………………

[2]

(g) It is suggested that v is inversely proportional to d. Explain clearly if the results of your experiment support this suggestion.

[2]

(h) **(i)** State three significant sources of error or limitations of the procedure in this experiment.

1.

2.

3.

[3]

(ii) Suggest three improvements that could be made to the experiment to address the errors identified in **(h)(i)**. You may suggest the use of other apparatus or a different procedure.

1. ____

____

____

2. ____

____

____

3. ____

____

____ [3]

[Total: 16 marks]

4 A student is investigating the absorption of sound by foam.

It is suggested that the absorption *A* of the sound is related to the density *d* and thickness *t* of the foam by the relationship

$$A = K\ d^{p}t^{q}$$

where *K*, *p* and *q* are constants.

You are provided with rectangular foam boards of different thicknesses and unknown densities.

Design a laboratory experiment to determine the values of *p* and *q*.

You should draw a diagram to show the arrangement of your apparatus and you should pay particular attention to

(a) the equipment to be used,

(b) the procedure to be followed,

(c) the measurements to be taken,

(d) the control of variables,

(e) the analysis of the data,

(f) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

[11]

[Total: 11 marks]

Paper 1 Answer Key

1	2	3	4	5	6	7	8	9	10
B	C	C	C	A	B	B	A	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	C	A	C	D	D	A	D	B	B
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	B	B	D	D	D	D	C	D	B

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

PHYSICS 9749/02

Paper 2 Structured Questions
MARK SCHEME
Maximum Mark: 80

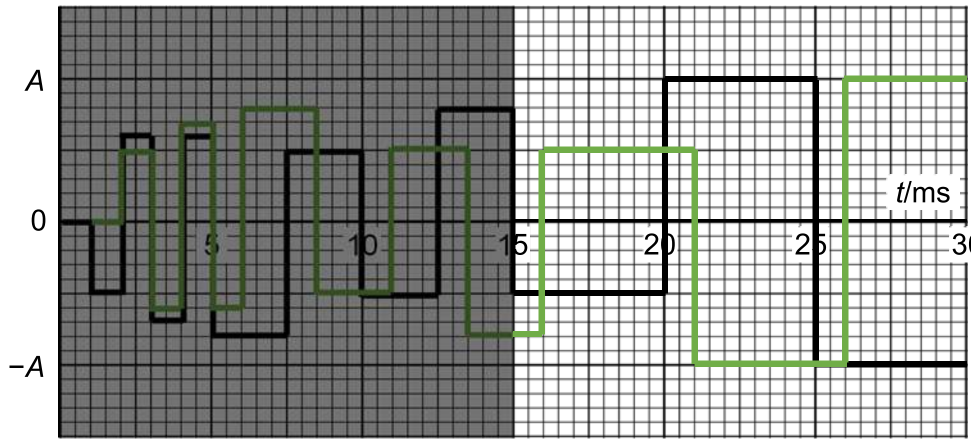
14 September 2018

Question		Marks
1(a)	N1L: An object at rest will remain at rest and an object in motion will remain in motion at constant velocity in the absence of an external resultant force.	B1
	N2L: The rate of change of momentum of a body is directly proportional to the resultant force acting on the body and occurs in the direction of the resultant force.	B1
	N3L: If body A exerts a force on body B, then body B exerts a force of the same type that is equal in magnitude and opposite in direction on body A.	B1
1(b)(i)	Initially, suitcase moving with **same velocity as bus** before braking	B1
	By N1L, suitcase will continue to move forward in the absence of external force acting on it because not secured (or small frictional force between when the suitcase was still in contact with the bus that is not sufficient to stop it from moving forward) when brakes applied	B1
	Claim invalid	A0
1(b)(ii)	The two equal and opposite forces act on cart and labourer separately	B1
	Cart pulled forward by the force applied by the labourer on the cart. Labourer moved forward by the frictional force between feet/shoes and ground.	B1
	Reasoning false	A0
1(b)(iii)	Throw bag of gold in direction away from shore	B1
	By N3L, man experiences a force equal in magnitude and opposite in direction from the force he exerted on the bag of gold. This forces accelerates the man towards shore during pushing, thereafter he will glide over ice at constant speed	B1
1(c)(i)	By N3L, force experienced by car same as force experienced by truck	B1
1(c)(ii)	Total mass of truck and its driver larger than total mass of car and its driver, hence the truck and its driver experiences smaller change in velocity over same duration of time	B1
	Safety belt exert smaller force on truck driver in stopping his forward velocity	B1
	Truck driver likely less injured than car driver	A0

Question		Marks
2(a)	Area under F-x graph is w.d. in stretching bow. More potential energy is stored	B1
	Arrows gain more KE, has less deviation from intended flight path **OR** Arrows gain more KE, has farther range	B1
2(b)(i)	By counting squares under F-x graph, Elastic potential energy = area under F-x graph = 1.25 J × 64.5 (±2 squares) = 81 J (78.1 J to 83.1J)	M1 A1
2(b)(ii)	By Conservation of Energy, Loss in elastic PE = Gain in KE for arrow $81=\frac{1}{2}\left(3.5\times10^{-2}\right)v^{2}$ v = 68.0 m s^{-1} (66.8 J to 68.9 J)	M1 A1
3(a)	The tesla is the uniform magnetic flux density which when acting at right angle to a straight conductor carrying a current of 1 ampere produces a force per unit length of 1 Newton per metre on the conductor. Or If a conductor carrying a current of 1 ampere is placed at right angles to a uniform magnetic field of flux density 1 Tesla, then the force per unit length on the conductor is 1 newton per metre.	B1
3(b)(i)	Charged particles moving perpendicular to a magnetic field will experience a resultant magnetic force perpendicular to its motion. Hence no work is done. By Newton's 2nd Law, the acceleration of the particles is in the same direction as the resultant force. The direction of the particles changes but not its speed. By Newton's 1st law, upon exit, the particles will move in a straight line with a speed of 4500 ms^{-1}.	B1 B1
3(b)(ii)	Magnetic force provides centripetal force for particle's circular motion $F=Bqv=\frac{mv^{2}}{r}$ $r=\frac{mv}{Bq}$ $=\frac{\left(2.66\times10^{-26}\right)(4500)}{\left(2\times10^{-3}\right)(1.6\times10^{-19})}$ = 0.374 m	B1 A1
3(b)(iii)	$v=r\omega$ $\omega=\frac{v}{r}=\frac{4500}{0.374}$ = 12030 rad s^{-1}	M1 A1

Question		Marks
3(b)(iv)	$\sin\theta = \dfrac{OX}{r}$	M1
	$\theta = \sin^{-1}\left(\dfrac{0.2}{0.374}\right)$	
	= 0.564 rad	A1
3(b)(v)1.	$r = \dfrac{mv}{Bq} = \dfrac{P}{Bq}$	M1
	$P = rBq = (0.2)(2\times10^{-3})(1.6\times10^{-19})$	
	= 6.4 x10^{-23} kg m s^{-1}	A1
3(b)(v)2.	magnetic force F provides centripetal force for the particle's circular motion	M1
	$F = Bqv = mr\omega^2$	
	$Bq(r\omega) = mr\omega^2$	
	$Bq = m(\dfrac{2\pi}{T})$	
	$T = 2\pi\dfrac{m}{Bq}$	
	For semicircle, $t = \dfrac{T}{2} = \dfrac{\pi m}{Bq}$	A1

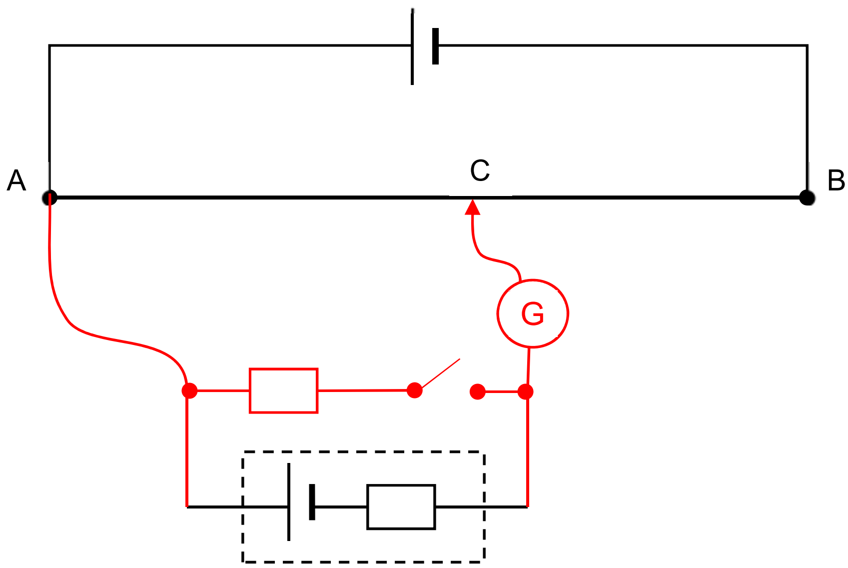
4(a)	Two or more waves of the same kind meet at a point at the same time, displacement of the resultant wave is vector sum of the displacements of the individual waves at that point at that time.	B1
4(b)	constant phase difference of **π** (rad)	B1
	same amplitude	B1
4(c)(i)	Amplitude	



	phase difference (shown by reflection in x-axis)	B1
	time lag (shown by translation of 2 small squares to right)	B1

Question		Marks
4(c)(ii)	longer durations of destructive interference	M1
	for noise waves of longer periods; correspond to lower frequencies	A1

5(a)



- Correct drawing with switch in the correct position. B1

Turn off the switch. Find balance length when galvanometer shows null reading. B1

Find ε using $\varepsilon = V_{AC} = kL_{AC}$ and $V_{AB} = E = kL_{AB}$

Turn on the switch.

Find the new balance length, L_{AC}'

B1

To find r:

Compare $V_{AC}' = kL_{AC}'$ and $V_{AB} = E = kL_{AB}$

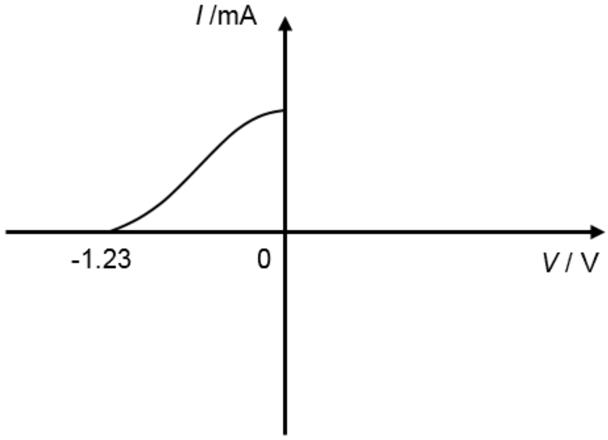
$V_{AC}' = kL_{AC}' = (R/R+r).\ \varepsilon$

Solve r.

Question		Marks
5(b)(i)	For single strand: $R = \frac{\rho L}{A}$ $= \frac{(4.9\times10^{-7})(1)}{\pi\left(\frac{0.15\times10^{-3}}{2}\right)^2}$ (= 27.7 Ω)	M1
	For 7 strands: $\frac{1}{R_{eff}} = 7\left(\frac{1}{R}\right)$ $R_{eff} = \frac{R}{7}$ $= \frac{(4.9\times10^{-7})(1)}{\pi(7)\left(\frac{0.15\times10^{-3}}{2}\right)^2}$ = 3.96 Ω = 4.0 Ω	A1
5(b)(ii)	Potential difference across the 7 Ω resistor = $\frac{7}{14+7}\times 12 = 4\ V$	B1
	By potential divider rule, potential difference across 0.9 m potentiometer = $\frac{0.9\times 3.96}{3.96+10}\times 12 = 3.06\ V$	B1
	Since the potential difference across the potentiometer is less than the potential difference across the 7 Ω resistor, balance length cannot be achieved.	B1
6(a)	Work function is the minimum amount of energy required for an electron to escape from the surface of a metal.	B1
6(b)(i)	Using conservation of energy,	
	$KE_{\max} = hf - \phi$	M1
	$= \frac{6.63\times10^{-34}\times3.0\times10^{8}}{4.0\times10^{-7}} - 3.0\times10^{-19}$	
	$= 1.97\times10^{-19}$ J	C1
	$= \frac{1.97\times10^{-19}}{1.60\times10^{-19}} = 1.23$ eV	A1
6(b)(ii)	Some of the electrons in material C may <u>need energy greater than the work function energy to be liberated as photoelectrons as they are beneath the metal surface</u>. Hence, not all photoelectrons have this maximum kinetic energy.	B1

Question		Marks
6(b)(iii)	p.d. = 1.23 V	B1

6(c)



Correct shape of curve (Only in 1 quadrant of graph) — B1
Stopping potential clearly and correctly labelled numerically. — B1

6(d) When the polarity is being reversed, C will always be at a lower potential compared to D. Photoelectrons released from C will therefore always be attracted to D and close the circuit for current to flow through the milliammeter. — M1, A1

6(e) Metal surface is oxidized. — B1
OR
The intensity of the radiation is not sufficiently high enough to liberate enough photoelectrons for them to be measureable by the milliammeter.

Any one of the above points.

7(a)(i)	kinetic energy (of the fluid)	B1
7(a)(ii)	gravitational potential energy (of the fluid)	B1
7(b)(i)	They are the same/ equal.	B1
7(b)(ii)	mass flow (rate) at inlet = mass flow (rate) at outlet	B1

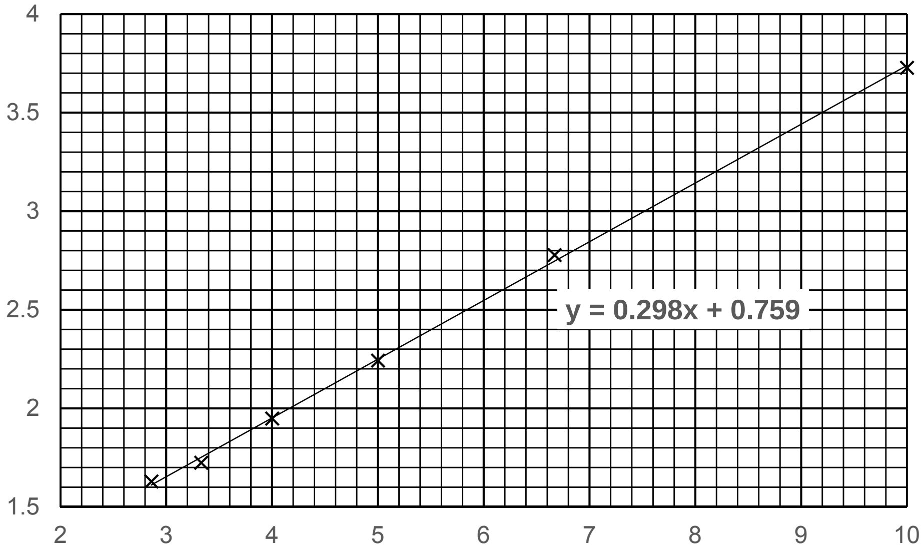
$$\frac{m_A}{t} = \frac{m_B}{t}$$

$$\frac{\rho \frac{\pi D_A{}^2}{4} l_A}{t} = \frac{\rho \frac{\pi D_B{}^2}{4} l_B}{t}$$ B1

$$D_A{}^2 v_A = D_B{}^2 v_B$$

$$\frac{v_A}{v_B} = \frac{D_B{}^2}{D_A{}^2}$$

Question		Marks
7(b)(iii)	$\frac{v_{out}}{v_{in}} = \frac{D_{in}^{\ 2}}{D_{out}^{\ 2}}$ $v_{out} = \left(\frac{0.100}{0.050}\right)^2 v_{in}$ $= 4v_{in}$	C1
	$\frac{P_{in}}{\rho g} + \frac{v_{in}^{\ 2}}{2g} + h_{in} = \frac{P_{out}}{\rho g} + \frac{v_{out}^{\ 2}}{2g} + h_{out}$ $\frac{P_{out} - P_{in}}{\rho g} = \frac{v_{in}^{\ 2} - v_{out}^{\ 2}}{2g}$ $\Delta P = \frac{\rho\left(v_{in}^{\ 2} - v_{out}^{\ 2}\right)}{2}$ $= \frac{\rho\left(v_{in}^{\ 2} - (4v_{in})^2\right)}{2}$	M1
	$= -480 \text{ kPa}$	A1
7(c)(i)	The pressure difference will be higher.	B1
7(c)(ii)	$v_{ave} = 2.5v_{in}$ $D_{ave} = 0.075 \text{ m}$ (or any other appropriate averaging done)	C1
	$p_{Loss} = H_{Loss} \times \rho g$ $= f_D \frac{v_{ave}^{\ 2} L}{2gD_{ave}} \times \rho g$ $= 0.0038 \times \frac{(2.5\times 8)^2 \times 10}{2\times 0.075} \times 1000$ $= 101 \text{ kPa}$	A1
7(d)(i)	✓ Blood vessels are flexible ✓ (Higher) friction factor / viscosity of blood ✓ Blood is a suspension rather than a pure fluid. ✓ Capillary action due to the small diameter of blood vessels.	B1
7(d)(ii)	As the arteries narrow, the model predicts that the <u>velocity of the flow</u> at this cross section will be <u>higher</u>.	M1
	From the expression in (a), the <u>pressure of the blood</u> at the narrow cross-section will be <u>lower</u>.	M1
	Thus, this model proposed by the student <u>will not be able to correctly predict</u> this observation.	A1

Question		Marks
8(a)	gravitational force provides (just enough) centripetal acceleration of 8.825 m s^{-2} on both ISS and astronaut to keep them in circular orbit around Earth	
	OR	
	both ISS and astronaut experience 8.825 ms^{-2} of acceleration directed to the centre of the earth due to gravity	M1
	no contact force by ISS on astronaut.	A1
8(b)(i)		
	best fit straight line with line thickness not comparable to half sq	B1
	p = 0.298 kg s^{-2}	B1
	q = 0.759 s^{-2}	B1
8(b)(ii)	For $\frac{1}{T^2}=\frac{p}{M}+q \rightarrow T=\sqrt{\left(\frac{p}{M}+q\right)^{-1}}$	
	For M = 0.5 kg, $T=\sqrt{\left(\frac{0.298}{0.5}+0.759\right)^{-1}}=0.859$ s	C1
	$\partial T=\frac{2(0.298)(0.858)^3}{0.5}\times(10\%)=0.08$ s (1 s.f.)	A1
8(b)(iii)	Yes. Period has more precision that what is required of variation	B1
	from table of values (Fig. 8.3), the period is to 4 decimal points while the variation which is to 2 d.p.	B1

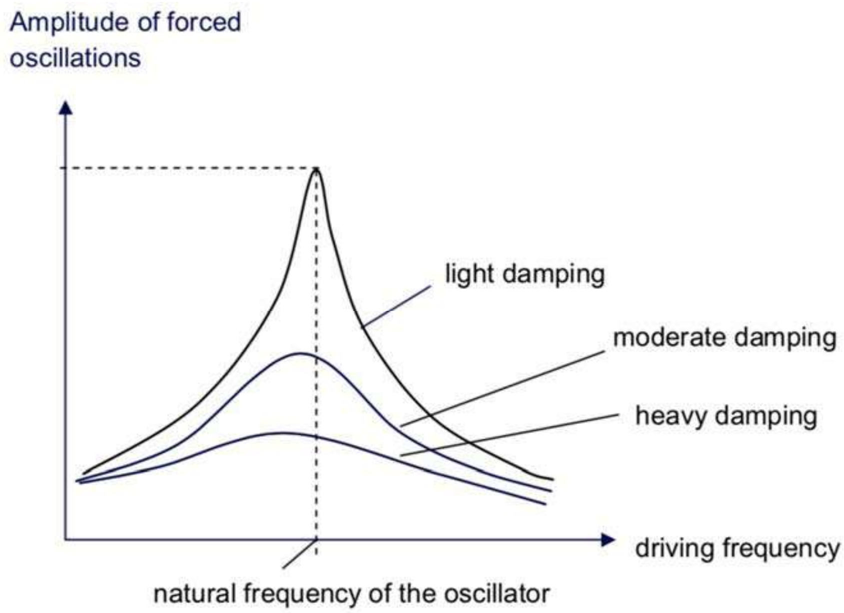
EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

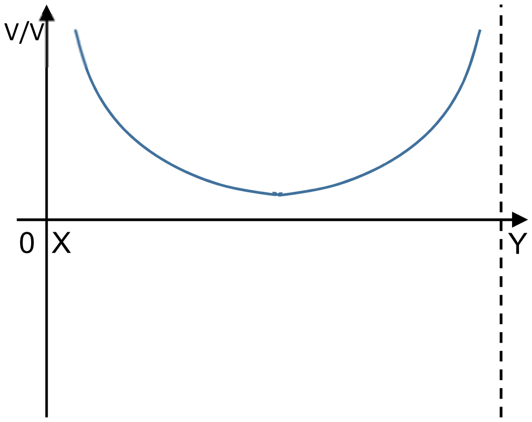
PHYSICS 9749/03

Paper 3 Longer Structured Questions
MARK SCHEME
Maximum Mark: 80

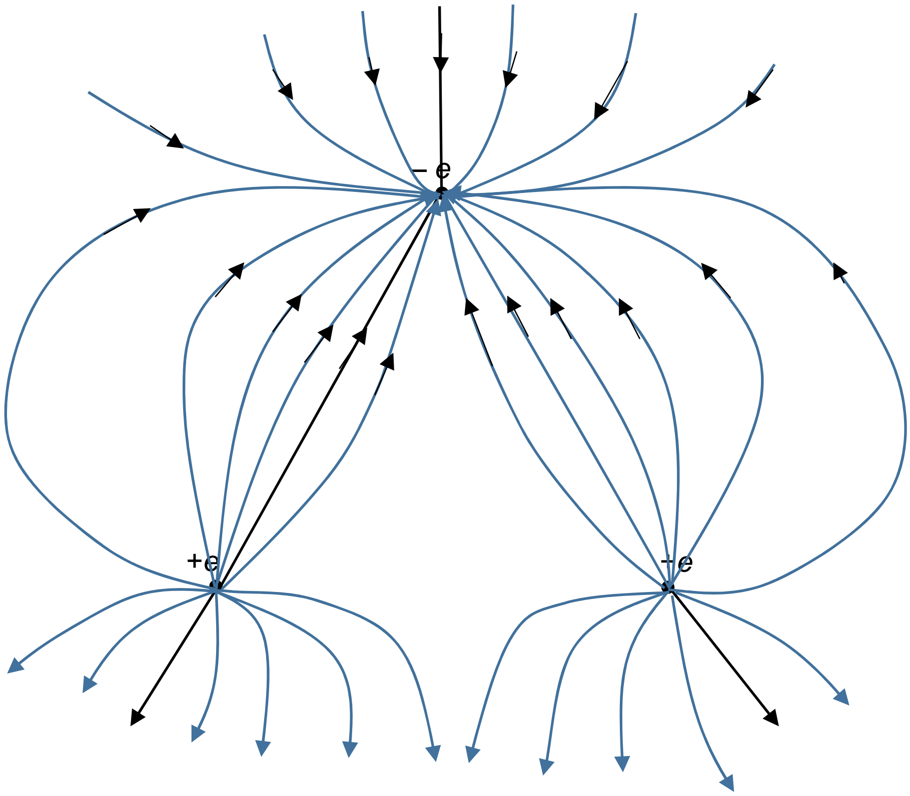
18 September 2018

Question		Marks
1(a)	Difference in pressure **Δp = ρ g Δh**	
	= 1000 x 9.81 x 0.051	M1
	= 500.31 Pa	
	= 500 Pa	A1
1(b)	Upthrust U = **Δp x 5.1 x 5.1 x 10^{-4}**	M1
	= 1.3005 = 1.3 N	A0
1(c)	U + T = W	M1
	1.3 + T = 4.0	
	T = 2.7 N	
	By N3L Force on spring by cube is 2.7 N downwards.	A1
1(d)	Let the extension of the spring be x.	
	T = k x	
	2.7 = 30 x	M1
	x = 0.090 m = 9.0 cm	A0
	initial height above surface, h = 9.0 – 7.0	M1
	= 2.0 cm	
	= 0.020 m	A1
1(e)(i)	2.7 = 4.0/9.81 x a	M1
	a = 6.62 m s^{-2} (Downwards)	A1
1(e)(ii)	Viscous force is proportional to speed. Resultant force downwards = Weight – Viscous Force (- Upthrust if considered not negligible) ***a*** decreases as velocity increases.	B1
	When viscous force = weight, ***a*** = 0 m s^{-2}	B1

Question		Marks
2(a)	acceleration / force proportional to displacement (from a fixed point)	B1
	either acceleration and displacement in opposite directions or acceleration always directed towards a fixed point	B1
2(b)(i)1.	0.1 s, 0.3 s, 0.5 s, etc (any two)	B1
2(b)(i)2.	either **0 s, 0.4 s, 0.8 s, 1.2 s** or **0.2 s, 0.6 s, 1.0 s** (any two)	B1
2(b)(ii)	period = 0.4 s frequency = 2.5 Hz	B1
2(b)(iii)	phase difference = 90^{o}	B1
2(c)	free: (body oscillates) without any loss of energy / no resistive forces / no external forces applied	B1
	forced: continuous energy input (required) / body is made to vibrate by an (external) periodic force / driving oscillator	B1
2(d)(i)		
	Any of these shapes and max peak at natural frequency	B1
2(d)(ii)	frequency = 2.4 - 2.5 Hz	B1
2(d)(iii)	e.g. (1) attach sheet of card to trolley bigger than the cross section of the trolley	M1
	increases damping / frictional force	A1
	e.g. (2) reduce oscillator amplitude	M1
	reduce power / energy input to system	A1

Question		Marks
3(a)	<u>the work done per unit positive charge</u> <u>by an external agent</u> in bringing a small test charge from <u>infinity to that point</u>, without any change in the kinetic energy of the charge.	
3(b)(i)		B1 B1
3(b)(ii)	The electric field strength (*E*) at a point between X and Y can be found finding the <u>negative of the gradient of the tangent drawn at that point</u> on the graph in 3(b)(i).	B1
	The electric force acting on the known charge q can be found by <u>multiplying the electric strength *E* at that point with the known charge *q*</u>.	B1
3(c)(i)	Zero	

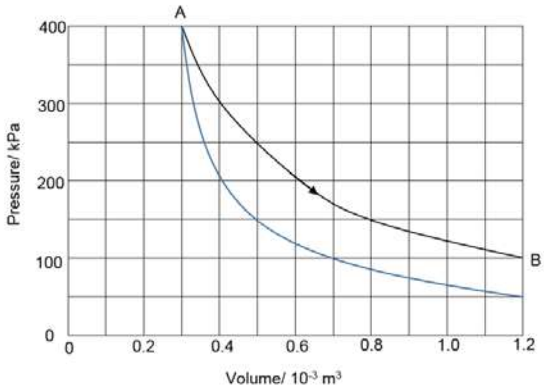
Question	Marks
3(c)(ii)	



Electric field lines from positive charge to negative charge shown with arrows. B1

- Lines do not intersect B1
- Line start and end with charge
- Line are closer near the centre line B1
- Symmetrical in shape

Question		Marks
3(c)(iii)	<u>To move the positive charge q at X to infinity:</u> Total electric potential at X due to the charges at Z and Y, Vx = 0 Work done by external agent to move +e from X to infinity, Wx = e.(0-Vx) = e.0 = 0	B1
	<u>To move – e at Z to infinity:</u> Total electric potential at Z (Vz) is due to the electric charge at Y = +e/4πε$_o$(0.06)	B1
	Work done by external agent to move -e from Z to infinity, Wz = -e.(0-Vz) = -e. (0 - e/4πε$_o$(0.06)) = e^2/4πε$_o$(0.06) = 3.837 x10^{-27} J	
	No work is needed to move the last charge at Y to infinity.	
	Hence total work done by external agent to separate the 3 charges completely = 0+3.837 x10^{-27} +0 = 3.84 x10^{-27} J	B1
	Work done by electric field to separate the 3 charges totally from one another = - 3.84 x10^{-27} J	
	OR	
	Other variation of method	
	Work done by external agent to assemble charges one at a time = - work done by external agent to separate the 3 charges totally from one another = work done by electric field to separate the 3 charges totally from one another.	
4(a)	The <u>increase in the internal energy</u> of a system is the sum of the external <u>work done on</u> the system and the <u>heat supplied to</u> the system.	B1
4(b)(i)	Using $T = \frac{pV}{nR}$	M1
	Taking any point: Point A: $T_A = \frac{(400\times10^3)(0.3\times10^{-3})}{(0.050)(8.31)} = 289\ K$ Point B: $T_B = \frac{(100\times10^3)(1.2\times10^{-3})}{(0.050)(8.31)} = 289\ K$	
	Therefore, temperature is 289 K.	A1
4(b)(ii)	Kinetic energy = $\frac{3}{2}nRT = \left(\frac{3}{2}\right)(0.050)(8.31)(289) = 180\ J$ -	M1 A0

Question		Marks
4(b) (iii)	Work done by gas = area under the *p*-*V* graph = (25 squares+9 missing squares) (50×10^3) (0.10×10^{-3}) = 170 J (allow 165 to 175J)	M1 A1
4(b) (iv)	temperature unchanged, no increase in the internal energy. $\Delta U = 0J$ When the gas expands from A to B, work done on the gas is w = - 170 J. Using 1st Law of Thermodynamics: $\Delta U = w + q$ 0 = - 170 + q Heat supplied, q = +170 J q is positive → heat is supplied to the gas during the expansion of the gas to ensure that there is no increase in the internal energy of the gas. Therefore, the student claim is false.	 M1 A1
4(c)	 Downwards sloping curve below AB Ends at (1.2, 50)	B1 B1
5(a)	The induced e.m.f. is directly proportional to the rate of change of magnetic flux linkage.	B1
5(b)	As the seismic waves passes, the vibrations moves the case (and coil) and causes the movement of the case (and coil) relative to the magnet. This results in a change of magnetic flux linkage through the coil, and by Faraday's law, an e.m.f. will be induced across the coil.	B1 B1
5(c)	$\varepsilon = \frac{dN\phi}{dt} \Rightarrow \frac{d\phi}{dt} = \frac{\varepsilon}{N}$ $= \frac{85 \times 10^{-3}}{50}$ $= 1.7 \times 10^{-3}$ -	C1 A1
5(d)	✓ magnet with stronger magnetic field ✓ coil with many turns ✓ spring with a lower spring constant. (any two of the above)	B1 B1

Question		Marks
6(a)	The r.m.s value of an <u>a.c</u>. will give the same <u>heating effect on a resistor</u> as due to <u>a d.c. current</u> of the <u>same value.</u>	B1
6(b)(i)	Power = VI = 1200 W r.m.s current I = 1200 / 120 = 10 A Peak Current $I_o = 10\sqrt{(2)}$ = 14.1 A	 C1 A1
6(b) (ii)	$I = I_o \sin(2\pi f\, t)$ $= 14.1 \sin(2\pi \times 0.50t)$ $= 14.1 \sin(100\,\pi t)$	 B1
6(c)	Secondary power = 600 + 1200 = 1800 W By conservation of energy, Input power = 1800 W I_pV_p = 1800 $I_p = 1800/(2.4\times10^3)$ = 0.75 A	 C1 A1
7(a)(i)	an electric current that periodically reverses its direction in a circuit (with a frequency)	B1
7(a)(ii)	- wire carries a current that is perpendicular to the magnetic field between the magnet poles - (by Fleming's LHR) wire experiences a force that is normal to both the current and magnetic field - force experienced is directed up and down vertically - since current reverses direction periodically, vibration is the same frequency as the AC	B1 B1 B1 B1
7(a)(iii)1.	recognising $\lambda = 2(L_{XP})$ $v = f\lambda = (120)(4) = 480$ m s^{-1}	M1 A1
7(a) (iii)2.	- <u>meeting</u> of (waves) - waves of same type, same frequency, opposite direction (characteristics) - incident waves from force on AC-carrying wire in magnetic field reflected off X and P (Origin of standing waves) - speed of incident / reflected wave in wire (concluding with correct answer)	B1 B1 B1 B1

Question		Marks
7(a) (iv)	$v = f\lambda$, therefore $v \propto f$ because λ is fixed by length of XP	B1
	tension is provided by weight, $T = mg$ therefore $T \propto m$	B1
	Need to show that $f \propto \sqrt{m}$ Take ratio:	
	$\frac{f_1}{f_0} = \frac{170}{120} \approx 1.42$, $\sqrt{\frac{2m}{m}} = \sqrt{2} \approx 1.41$ $\frac{f_2}{f_0} = \frac{208}{120} \approx 1.73$, $\sqrt{\frac{3m}{m}} = \sqrt{3} \approx 1.73$	M1
	Likely valid	A0
7(b)(i)	waves spread at edge or slit changes direction and spreads into geometric shadow	B1
7(b)(ii)	$\theta = \frac{1}{2}(188 - 160) = 14°$	C1
	$d \sin\theta = n\lambda \rightarrow d \sin(14°) = 2(633 \times 10^{-9})$	M1
	$d = 5.23 \times 10^{-6}$ m	C1
	$d = \frac{1}{N} \rightarrow N = \frac{1}{d} = 1.91 \times 10^5$	A1
7(b) (iii)	each bright fringe is constructive interference from multiple points of diffracted waves (vs two points in double slit)	B1

8(a) (i)	loss in E_K = gain in electric E_P	M1
	$7.7 \times 10^{-13} = \frac{Qq}{4\pi\varepsilon_o r}$	
	$= \frac{(79 \times 1.60 \times 10^{-19})(2 \times 1.60 \times 10^{-19})}{4\pi(8.85 \times 10^{-12})r}$	M1
	$r = 4.72 \times 10^{-14}$ m Since *r* is the distance of closest approach, the radius of gold must be less than this.	
8(a) (ii)	**1.** most of the atom is empty space **or** the size of the nucleus is very small compared to the size of the atom	B1
	2. the nucleus is positively charged	B1
	the mass is concentrated in the nucleus	B1
8(b)(i)	$7\ {}^{0}_{-1}e$	A1

Question		Marks
8(b)(ii)	mass defect = [(82 × 1.00863) + (57 × 1.00728) – 138.955]*u* = 1.16762*u* binding energy per nucleon $= \dfrac{1.16762 \times 1.66 \times 10^{-27} \times \left(3.0 \times 10^{8}\right)^2}{139 \times \left(1.60 \times 10^{-19}\right)}$ $= 7.84$ MeV	C1 M1 A1
8(b)(iii)	Since the fission reaction releases energy, the binding energy of uranium must be lower than for the products **OR** Above A = 56, binding energy per nucleon decreases as A increases. Since U-235 has a larger nucleon number (compared to La-139), it must have a higher binding energy per nucleon.	M1 A1 M1 A1
8(c)(i)	✓ radiation emitted in all directions ✓ background radiation ✓ emission from radioactive daughter products ✓ window of detector may absorb some radiation ✓ self-absorption in source	Any 2 B1 each
8(c)(ii)	the energy is shared with a(n) (anti)neutrino	B1
8(c)(iii)	energy levels in the nuclei are discrete	B1
8(d)(i)	Background count = 10 min^{-1} After 3 T_{half}, count rate will be 30 min^{-1} Hence 3 T_{half} = 4.5 hours T_{half} = 1.5 hours (1.4 to 1.6 hours)	B1 M1 A1
8(d)(ii)	1. <u>no change</u> as radioactive <u>decay is spontaneous</u> / independent of environment. 2. likely to be <u>different</u> as radioactive <u>decay is random</u> (and cannot be predicted).	B1 B1

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

PHYSICS 9749/04

Paper 4 Practical
MARK SCHEME
Maximum Mark: 55

24 August 2018

Question		Marks
1(a)(i)	Evidence of averaging of *x* (along the length of the strip) seen.	[1]
1(b)(ii)	Calculation of *T* from raw readings of *t* seen.	[1]
	Value of *T* within 1.3 s ± 0.2 s.	[1]
1(c)	**Data Collection** If candidate successfully collected: 6 sets of readings – award 3 marks 5 sets of readings – award 2 marks 4 sets of readings – award 1 mark If substantial assistance was rendered by supervisor – deduct 1 mark. If data trend is incorrect – deduct 1 mark.	max [3] min [0]
	Range of *x* To include 1 cm and 6 cm	[1]
	Column Headings Each column heading must contain a quantity and a unit. There must be some distinguishing mark between the quantity and the unit. Ignore POT errors. Ignore units in the body of the table.	[1]
	Presentation of Raw Readings All values of *x* must be to nearest 1 mm. All values of *t* must be to nearest 0.1 s and ≥ 10 s	[1]
	Raw Readings of *t* (or *T*) Evidence of repeated measurements seen.	[1]
	Significant Figures of Calculated Readings Significant fig. for every row of 1/*x* same as, or one more than, raw *x*. (Significant fig. for every row of *T* same as, or one more than, raw *t*. Number of oscillations needs to be recorded)	[1]
	Calculation 1/*x* (and *T*) calculated correctly. Tick if correct.	[1]

Question		Marks
1(d)(i)	**Axes** Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points on the grid occupy at least half the graph grid in both *x* and *y* directions. Scales must be labelled with the quantity (and unit) which is being plotted. Scale markings should not be more than three large squares apart.	[1]
	Plotting of Points All observations in table must be plotted. Check first and last points are plotted correctly. Tick if correct. Points are plotted to an accuracy of half a small square. Do not accept 'blobs' (points with diameter greater than half a small square).	[1]
	Line of Best Fit Judge by the balance of all the points (at least five) about candidate's line. (Point(s) not considered by candidates need to be clearly labelled as anomalous) There must be an even distribution of points either side of the line along the whole length. If mark is not awarded indicate rotation or direction of best fit line. Lines must not be kinked.	[1]
1(d)(ii)	**Gradient** The hypotenuse of the triangle must be at least half the length of the drawn line. Read-offs must be **accurate** to half a small square. Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$). If incorrect, write in the correct value(s).	[1]
	***y*-intercept** _Either_ Correct read-off from a point on the line and substitute into straight line equation $y = mx + c$. Read-off must be **accurate** to half a small square. Allow ecf of gradient value. _Or_ Read-off of intercept directly from graph. Read off must be **accurate** to half a small square.	[1]
1(e)	*a* is the value of candidate's gradient with consistent unit (mm s or cm s or m s). *b* is the value of candidate's y-intercept with consistent unit (s).	[1]
1(f)	✓ strip too wide (for the clips / causes significant drag / tear paper) ✓ time for 1 oscillation too short for clear observation.	Max [1]
1(g)	✓ thickness of paper ✓ density of paper or mass per unit area (**not** mass / weight) ✓ Young's modulus ✓ Shear modulus	Max [2]

[Total: 21 Marks]

Question		Marks
2(b)	**Data Collection** If candidate successfully collected: 6 sets of readings – award 2 marks 5 sets of readings – award 1 marks If substantial assistance was rendered by supervisor – deduct 1 mark. If data trend (i.e. *V* decreases as *n* increases) is incorrect – deduct 1 mark.	max [2] min [0]
	Column Headings Each column heading must contain a quantity and a unit. There must be some distinguishing mark between the quantity and the unit. Ignore Power-of-Ten errors. Ignore units in the body of the table.	[1]
	Presentation of Raw Readings All values of *V* must be to nearest 0.001 V.	[1]
2(c)	Stated appropriate graph (1/*V* against *n*) to be plotted.	[1]
	E is determined by the inverse of the *y*-intercept	[1]
	Ratio R_1/R_2 is determined by dividing the gradient with the *y*-intercept	[1]
		[Total: 7 Marks]
3(b)(ii)	Value of *d* to nearest 0.1 cm or 1 mm	[1]
3(c)(i)	Use the set square to align metre rule to benchtop in 2 perpendicular directions.	[1]
3(c)(ii)	Value of *h* in range of 50 cm to 100 cm	[1]
	Averaging of at least 3 measurements of *t* seen.	[1]
3(d)	Absolute uncertainty must be in the range of 0.1 s to 0.3 s. Correct calculation. Final answer to 1 or 2 significant figures.	[1]
3(e)	First value of *v* calculated correctly. Calculations must be checked. Write in correct value if wrong.	[1]
3(f)(ii)	Smaller *d* gives greater *v*.	[1]
	Second value of *v* calculated correctly. Calculations must be checked. Write in correct value if wrong.	[1]
3(g)	Correct calculation to check proportionality. Possibilities include: ✓ Two calculations of *vd*. Ratio of *v* values and inverse ratio of *d* values both calculated.	[1]
	Sensible comments relating to proportionality calculations and percentage uncertainty calculated in **(d)**.	[1]

Question		Marks
3(h)(i)	Relevant points can include: a) Two sets of readings insufficient to draw valid conclusion. b) Cone may have not reached terminal velocity. c) Hard to see when cone strikes floor. d) Cone falls at an angle due to imbalance of cone. e) Human error in timing/reaction time. f) Difficult to measure diameter because cone flexible. g) Parallax error in reading positions of the cone.	Max [3]
3(h)(ii)	Corresponding points to **(h)(i)** can include: a) Take more readings and plot a graph. b) Ensure terminal velocity by increasing release height or measure velocity at two intervals to check terminal velocity reached. c) Use a pressure (or other appropriate) sensor placed on the floor to stop timer. d) Balance the cone using extra strip of tape. e) Use light gate to trigger stopwatch or use video camera / high speed camera placed in front of the apparatus or measure time over greater distance. f) Measure diameter of cone in two directions and average or use a string to measure the circumference and calculate the diameter g) Drop in front of rule/read at eye level.	Max [3]
	[Total: 16 Marks]	
4	**Basic Procedure** Diagram shows in-line placement of apparatus, including foam board (not "floating")	[1]
	Viable selection of sound source (eg signal generator connected to a loudspeaker) and corresponding sensor (eg microphone connected to a pre-amplifier to a CRO, or microphone connected to a data-logger, or a decibel meter). Speaker must be switched on.	[1]
	Repeats experiment by changing foam boards of the <u>same *d*</u> but <u>different *t*</u>. Mention how t is changed (board with different thickness) AND by changing foam boards of the <u>same *t*</u> but <u>different *d*</u>. (need to see eg different materials)	[1]
	Measuring and Quantifying Dependent Variable Defines absorption appropriately ($1 - x/x_o$). x_o is measured without any foam boards in place	[1]
	Measuring and Quantifying Independent Variable(s) *t* is measured using metre rule / vernier calipers / micrometer screw gauge.	[1]
	Length and width of foam boards measured using metre rule. Mass of foam boards is measured using a pan / spring balance. Density of foam board is calculated appropriately.	[1]

Question		Marks
	Processing and Analysing Experimental Data Appropriate graph of *A* against *t* to be plotted (i.e. lg *A* against lg *t*) If a straight line graph is obtained, the gradient of the graph is *q*.	[1]
	Appropriate graph of *A* against *d* to be plotted (i.e. lg *A* against lg *d*) If a straight line graph is obtained, gradient of the graph is *p*.	[1]
	Safety Any suitable precautions to mitigate effects of loud sounds.	1
	Additional Details ✓ *t* is measured at least twice at different positions to find average ✓ Sound source of same frequency and/or amplitude is used ✓ Distance between sound source and sensor is kept constant by making measurements and placing markers. ✓ Repeat measurements by flipping the foam boards. ✓ Any suitable precautions to reduce effects of diffraction of sound (i.e. frequency of sound to be significant different from dimensions of foam board / placing microphone right behind foam board, surface area of foam board significantly larger than loudspeaker) ✓ Any suitable method to reduce reflection of sound. (i.e. use of barrier or tube) ✓ Carries out experiment in room with low ambient sound to reduce external effects. ✓ Preliminary trials for suitable initial loudness so that appreciable signal can be detected even when using thickest, most dense foam board	Max [2]
		[Total: 11 Marks]

HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		**CT GROUP**	**17S**
TUTOR NAME			

PHYSICS **9749/01**

Paper 1 Multiple Choice **20 Sep 2018**

1 hour

Additional Materials: Optical Mark Sheet

INSTRUCTIONS TO CANDIDATES

Write in soft pencil.

Write your name, CT, NRIC or FIN number on the optical mark sheet (OMS). Shade your NRIC or FIN in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the OMS.

Each correct answer will score one mark. A mark will **not** be deducted for a wrong answer.

Any rough working should be done in this booklet.

Data
speed of light in free space, $c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1} $\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge, $e = 1.60 \times 10^{-19}$ C
the Planck constant, $h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant, $u = 1.66 \times 10^{-27}$ kg
rest mass of electron, $m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton, $m_p = 1.67 \times 10^{-27}$ kg
molar gas constant, $R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant, $k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant, $G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall, $g = 9.81$ m s^{-2}

Formulae	
uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\,\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/\,^{\circ}\text{C} + 273.15$
pressure of an ideal gas	$P = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$ $= \pm \omega \sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 Which of the following statements is correct?

A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Speed is distance travelled per second.

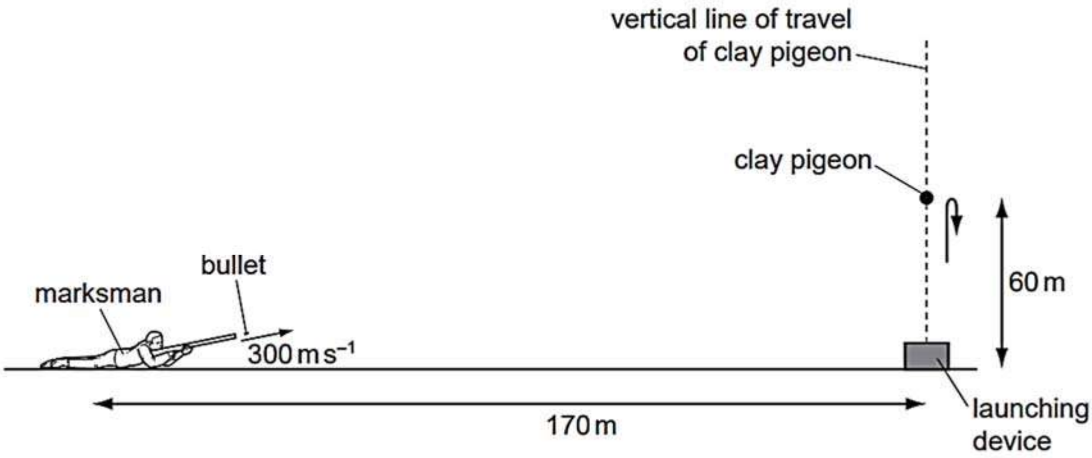
D Pressure is force per unit area.

2 An elevator is moving downwards with an acceleration of 5.8 m s^{-2}. A ball, held 2.0 m above the floor of the elevator and at rest with respect to the elevator, is released.

How long does it take for the ball to reach the floor of the elevator?

A 0.51 s **B** 0.64 s **C** 0.83 s **D** 1.00 s

3 A clay pigeon is launched vertically into the air from the ground.



(diagram not to scale)

A marksman lies at a horizontal distance of 170 m away from the launching device. When the clay pigeon reaches its maximum height of 60 m, the marksman aims his rifle at the clay pigeon and fires a bullet at it. The bullet leaves the rifle with a speed of 300 m s^{-1}.

At which time after the bullet is fired, does the bullet hit the clay pigeon? Assume air resistance is negligible.

A 0.17 s **B** 0.57 s **C** 0.60 s **D** 1.66 s

4 A projectile of mass m is fired at ground level with velocity u from a point A, as shown below.

Neglecting air resistance, determine the magnitude of the change in momentum of the mass between leaving point A and arriving back at ground level.

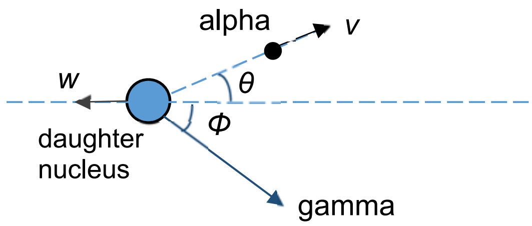
A zero **B** ½ mu **C** mu **D** $2mu$

5 An empty truck has a mass of 5000 kg. Regardless of the mass of load it has, it experiences a fixed retarding force of 70000 N when it decelerates from a speed of 50 m s^{-1} to 30 m s^{-1}. The duration for the empty truck to decelerate is t_1. The duration for it to decelerate when it has a full load of 1300 kg is t_2.

What is the difference ($t_2 - t_1$)?

A 0.37 s **B** 0.56 s **C** 0.93 s **D** 1.43 s

6 A stationary nucleus of mass number A undergoes a radioactive decay by emitting an alpha particle with velocity v and a gamma radiation of wavelength λ. The daughter nucleus moves off with velocity w.



Which of the following equations is correct?

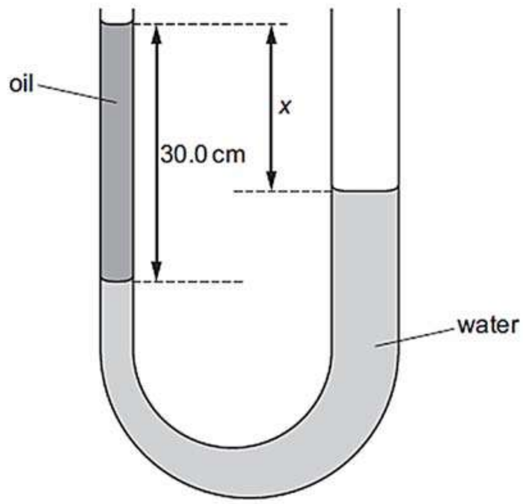
A $(A - 4)w = 4v \cos \theta$

B $(A - 4)uw = 4uv \cos \theta + \dfrac{hc}{\lambda} \cos \phi$

C $4uv \sin \theta = \dfrac{hc}{\lambda} \sin \phi$

D $4uv \sin \theta = \dfrac{h}{\lambda} \sin \phi$

7 A U-tube has one arm of cross-sectional area *A* and the other arm of cross-sectional area 4*A*. The tube contains water of density 1000 kg m^{-3} and oil of density 850 kg m^{-3}, as shown.



The column of oil on top of the water in the left-hand arm is of length 30.0 cm.

What is the difference in height *x* between the levels in the two arms of the tube?

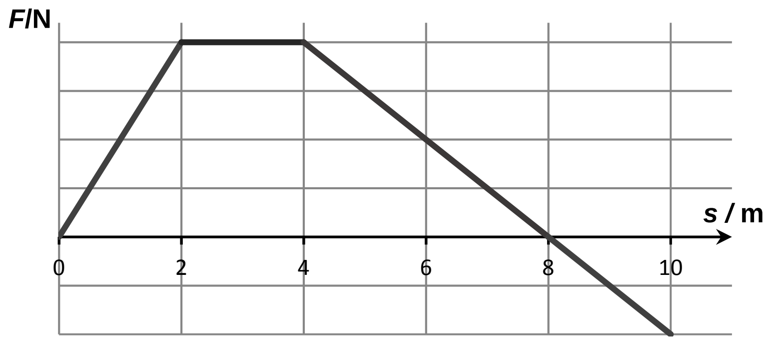
A 4.5 cm **B** 6.2 cm **C** 23.8 cm **D** 23.5 cm

8 When a horizontal force *F* is applied to a trolley over a smooth horizontal surface of distance *x*, its kinetic energy changes from 2 J to 6 J.

If a force 2*F* is applied to the trolley over a distance of 2*x*, what will be the final kinetic energy of it? Assume the original kinetic energy of the trolley is 2 J.

A 12 J **B** 16 J **C** 18 J **D** 24 J

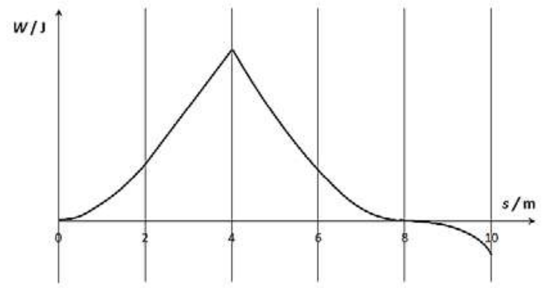
9 The figure below shows the variation the force *F* applied to an object with the displacement *s* of it.



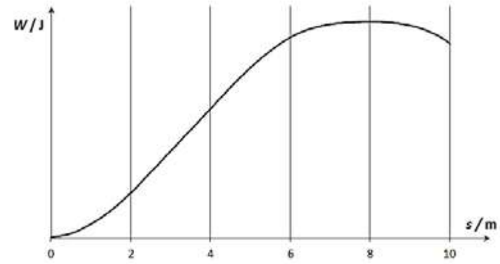
Which of the following graphs correctly shows the variation of the work done by *F* on the object with respect to displacement?

(Note the graphs in the following options may not have the same scale for their vertical axes.)

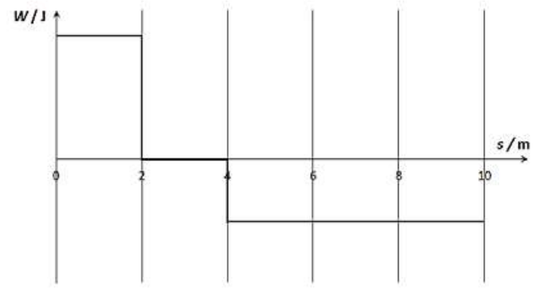
A



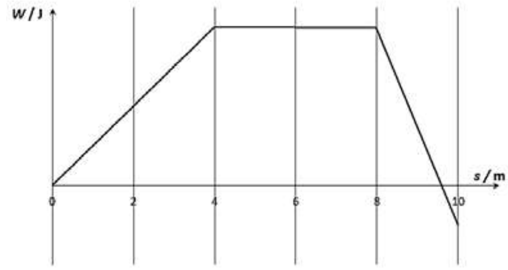
B



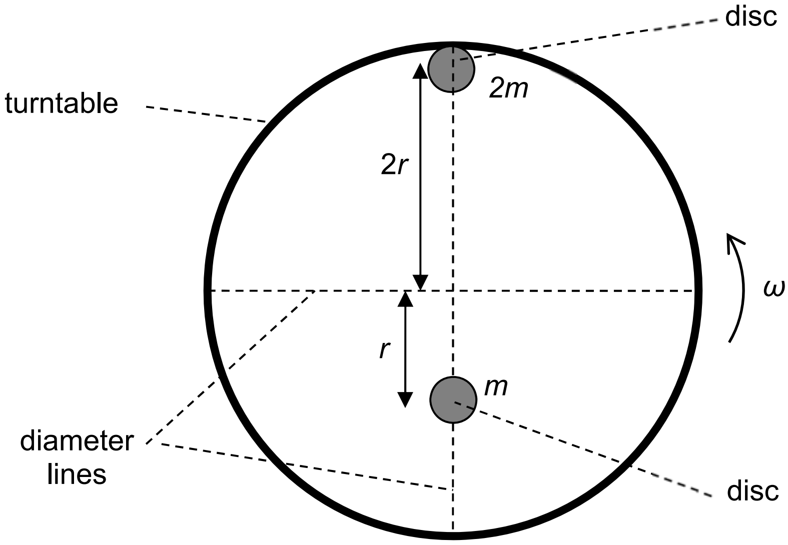
C



D



10 Two rough discs of mass m and $2m$ are placed on a rough, horizontal and level turntable as shown in the diagram. The turntable starts rotating from rest with gradually increasing angular velocity ω. Eventually, both discs will slip off the turntable.



Given that the maximum frictional force acting on mass m is half of that on mass $2m$, which of the following is correct?

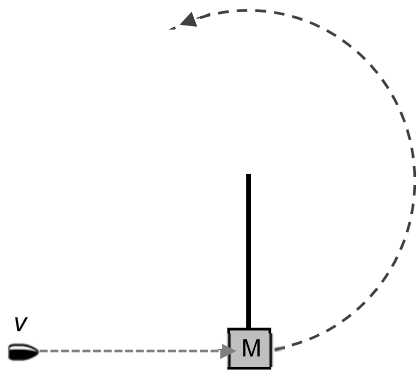
A Disc of mass m experiences maximum frictional force first.

B Disc of mass $2m$ experiences maximum frictional force first.

C Both discs experience maximum frictional force at the same time.

D Neither disc will experience maximum frictional force

11 A bullet of mass m and speed v hits a pendulum bob of mass M horizontally. Subsequently, it embeds into the bob. The pendulum bob is suspended by a stiff rod of length L and negligible mass.



Determine the minimum value of v such that the pendulum bob will just swing through a complete vertical circle.

A $v = \frac{4(m+M)gL}{m}$

B $v = \frac{5(m+M)gL}{m}$

C $v = \frac{(m+M)\sqrt{4gL}}{m}$

D $v = \frac{(m+M)\sqrt{5gL}}{m}$

12 A satellite of mass m is orbiting a planet of mass M at a radius of R. How much energy must be provided to bring the satellite to an orbit of radius $2R$?

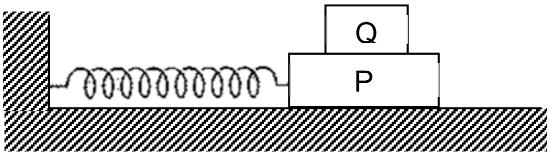
A 0

B $\frac{GMm}{2}\left(\frac{1}{2R}-\frac{1}{R}\right)$

C $\frac{GMm}{2}\left(\frac{1}{R}-\frac{1}{2R}\right)$

D $GMm\left(\frac{1}{2R}-\frac{1}{R}\right)$

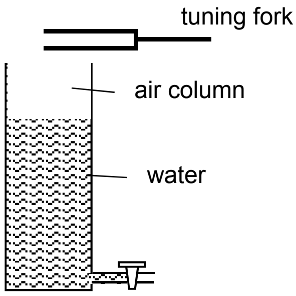
13 A system consisting of a large block P with a smaller block Q resting on it, oscillates on a frictionless surface with a frequency of 1.5 Hz. The maximum static friction between the two blocks is 5.0 N.



If the mass of P is 2.00 kg and the mass of Q is 0.20 kg, what is the maximum amplitude of oscillation of the system in order that block Q does not slip?

A 0.28 m **B** 0.056 m **C** 0.028 m **D** 0.026 m

14 The diagram shows a setup in which a stationary wave is produced in an air column. A tuning fork, placed above the tube, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of water in the tube.



Initially, water is filled to the brim of this tube. The water is allowed to run out of it. Resonance occurs when the air column lengths are 18 cm and 30 cm. Which of the following lengths of air column will **not** result in resonance?

A 6 cm **B** 24 cm **C** 42 cm **D** 54 cm

15 Light of wavelengths 400 nm and 600 nm are incident normally on a diffraction grating. It was observed that the 400 nm light in one order of the spectrum appears at the same angle as the 600 nm light in the adjacent order.

Given that the angle is 30°, calculate the spacing between the slits in the grating.

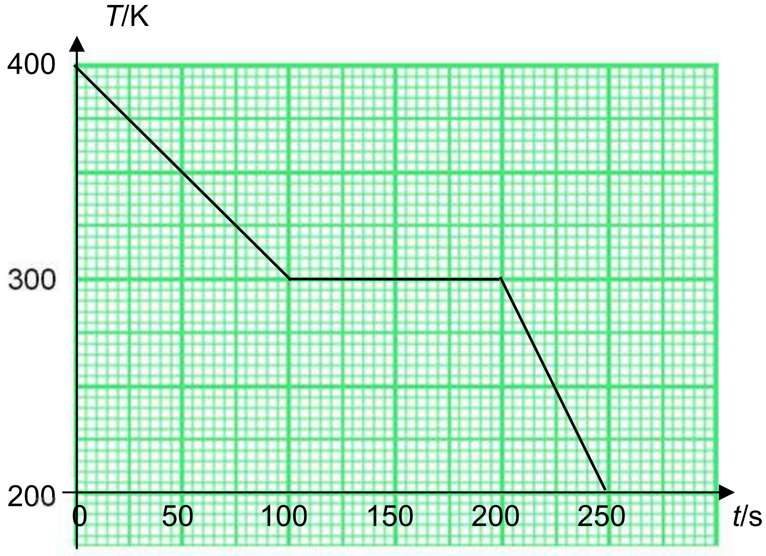
A 1.2 μm **B** 1.8 μm **C** 2.4 μm **D** 3.6 μm

16 Two vessels X and Y contain ideal gases at the same temperature T. The pressures of ideal gases in X and Y are P and $P/4$ respectively. The volume of X is 1.5 times that of Y. The vessels are connected by a narrow tube with a tap. The tap is initially closed. The temperature of the gas is maintained at the constant temperature T.

What is the pressure of the gas at equilibrium when the tap is opened?

A 0.50 P **B** 0.70 P **C** 0.75 P **D** 1.50 P

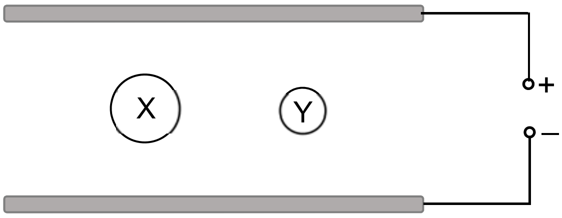
17 The graph shows the variation of temperature T against time t of a certain substance. Originally, it is in a liquid state at t = 0 s. Heat is removed from it at a constant rate until it becomes a solid.



Which of the following could be correct?

	specific heat capacity of liquid / J kg^{-1} K^{-1}	specific heat capacity of solid / J kg^{-1} K^{-1}
A	1500	3000
B	1800	900
C	2500	2500
D	4500	3000

18 The figure below shows two charged oil drops, X and Y, of masses 2*m* and *m* respectively, which are just prevented from falling under gravity by the application of a voltage between the two parallel metal plates.



Which of the following correctly describes what will happen if the plates are moved further apart?

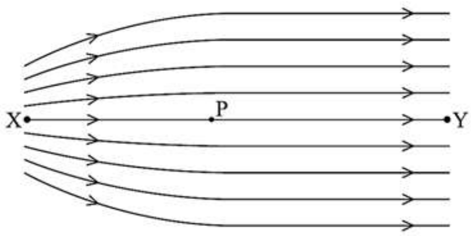
A Both X and Y will move up with the same acceleration.

B Both X and Y will move down with the same acceleration.

C X will begin to move down with an acceleration greater than that of Y.

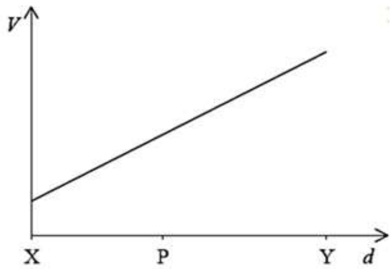
D X will begin to move down with an acceleration smaller than that of Y.

19 The diagram below shows the electric field lines in a region of space.

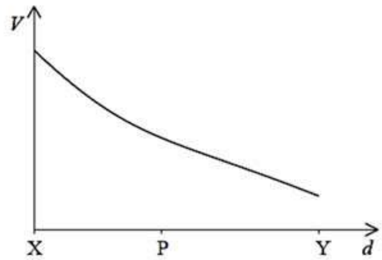


Which of the following diagrams shows the variation with distance *d* of the potential *V* along the line XY?

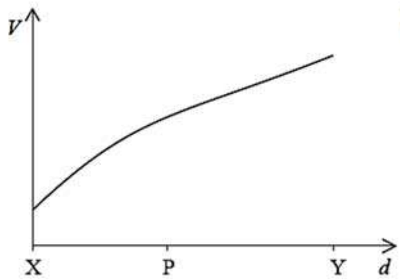
A



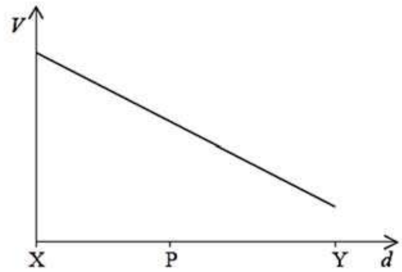
B



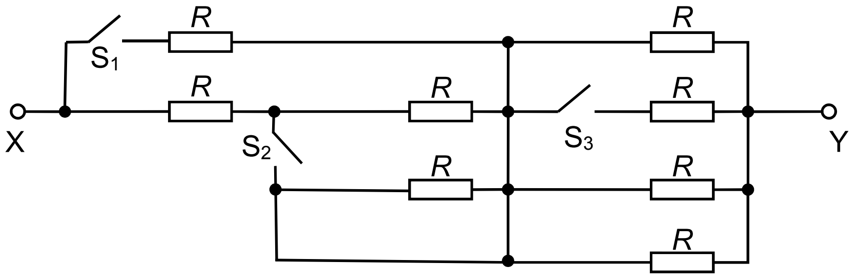
C



D



20 A network is constructed using eight resistors, each of resistance R, and three switches S_1, S_2 and S_3.



Which of the following combination will give rise to the minimum total resistance between points X and Y?

	S_1	S_2	S_3
A	closed	closed	closed
B	closed	open	closed
C	open	closed	closed
D	open	open	open

21 A row of 30 decorative lights, connected in series, is connected to a mains transformer. When the supply is switched on, the lights do not work. The owner uses a voltmeter to test the circuit. When the voltmeter is connected across the fifth bulb in the row, a reading of zero is obtained.

Which of the following scenarios described is **not** possible?

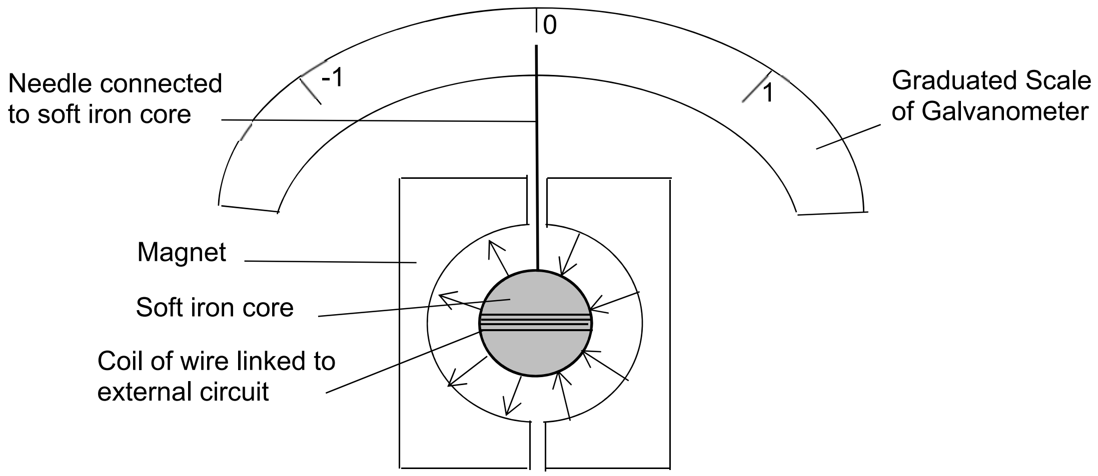
A Only the filament of the fifth bulb has broken.

B The fuse in the mains transformer has blown.

C The filament of at least one of the other bulbs has broken.

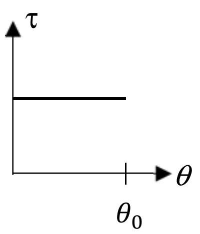
D There is a break in the wire from the supply to the transformer.

22 The diagram below illustrates one of the earliest designs of a galvanometer. A coil of wire is wound around a circular iron core which is placed between two magnets with circular surfaces such that the magnetic field (indicated by the arrows) on the surface of the iron core is directed perpendicularly onto the surface and of the same magnitude across the surface of the iron core as shown in the diagram.

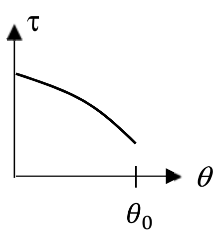


When a constant current flows in the coil, the needle will be deflected to an angle θ_0 from the vertical direction. Which of the following graphs show the variation of the torque on the soft iron core τ, due to magnetic forces acting on the coil, with the angular displacement θ of the needle as the needle rotates from 0 to θ_0?

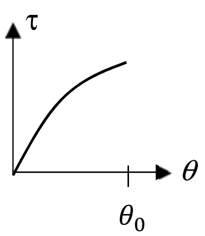
A



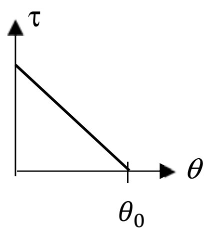
B



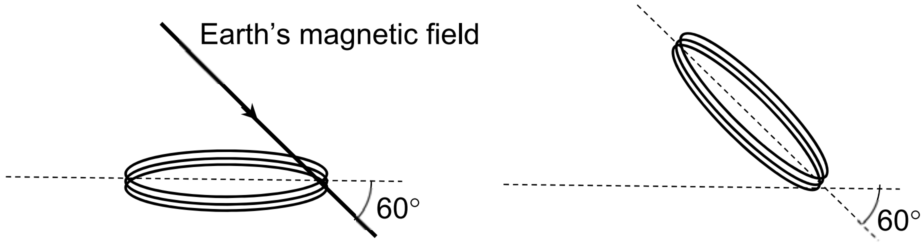
C



D



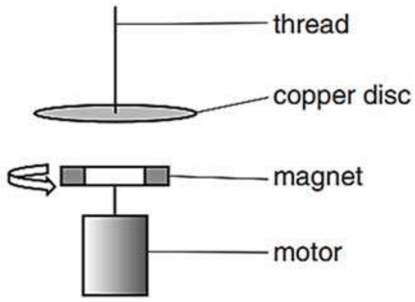
23 A coil of wire of 3 turns and cross sectional area of 0.30 m^2 is placed on the ground. Earth's magnetic field is 0.045 T and is directed at an angle of 60° below horizontal.



What is the magnitude of the change in magnetic flux linkage of the coil of wire if it is lifted on one side such that it is now parallel to the Earth's magnetic field?

A 0.020 Wb turns **B** 0.035 Wb turns **C** 0.040 Wb turns **D** 0.070 Wb turns

24 A magnet is attached to a motor and rotates below a freely-suspended copper disc as shown below.



Which of the following statements is correct?

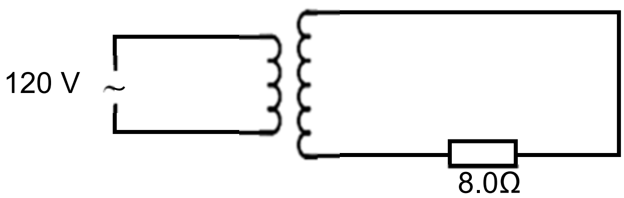
A The disc remains stationary as copper is not magnetic.

B The disc rotates in the same direction as the magnet as copper is magnetic.

C The disc rotates in the same direction as the magnet as eddy currents are induced in the disc.

D The disc rotates in the opposite direction as the magnet as eddy currents are induced in the disc.

25 A non-ideal transformer with an efficiency of 0.75, is connected to a 120 V a.c. supply and a 8.0 Ω resistor. The secondary coil of the transformer has twice as many turns as the primary coil.



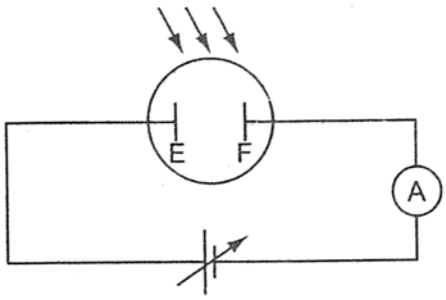
Assuming there is no flux leakage between the primary and secondary coils, what is the current in the primary coil?

A 15 A **B** 30 A **C** 60 A **D** 80 A

26 It is written on a label attached to a kettle that the power consumption of the kettle is 2.0 kW for 240 V r.m.s. alternating supply. The kettle is connected to an alternating mains supply of 120 V r.m.s.. How much energy is consumed if the kettle is used for 1.5 hours?

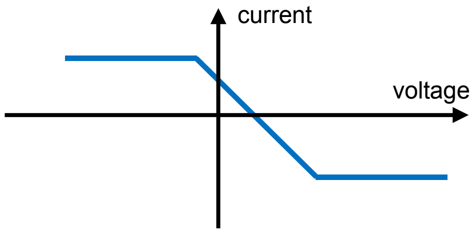
A 0.50 kWh **B** 0.75 kWh **C** 1.5 kWh **D** 3.0 kWh

27 The diagram shows a circuit used for the investigation of photoelectric emission. The two electrodes E and F are made of different metals. The work function of electrode E is higher than that of electrode F.

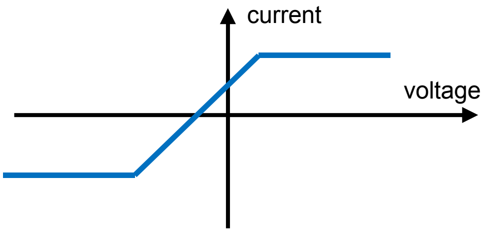


Which of the following graphs show the variation the current (flows from E to F) versus voltage (of E with respect to F) when the two electrodes are illuminated with a uniform monochromatic light? Assume the magnitude of the saturation current for either electrode is same during this experiment.

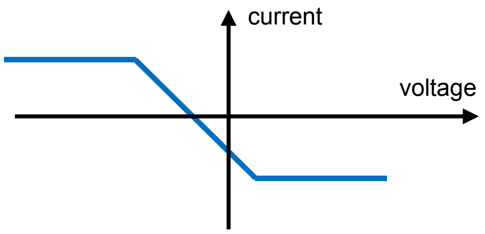
A



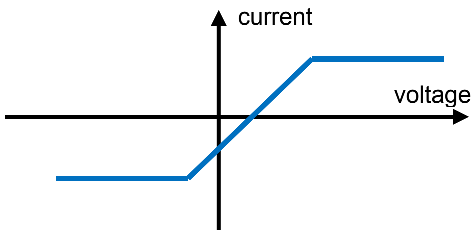
B



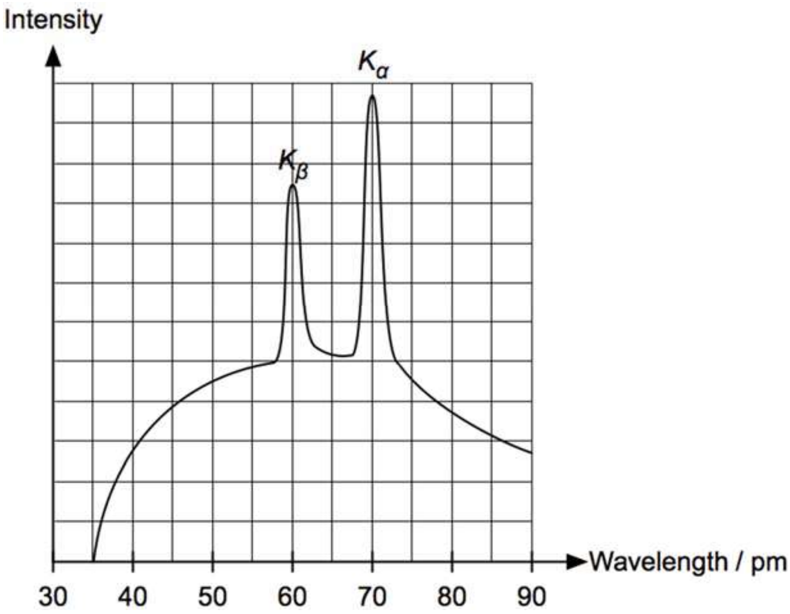
C



D



28 The X-ray spectrum obtained by bombarding a molybdenum target with electrons is shown in the figure.



The two peaks K_α and K_β are produced when the electrons in the lowest energy level of the molybdenum atoms are knocked out by the incident electrons and electrons in the next two higher energy levels of the atom made the transition to the lowest energy level.

What is the energy difference of the two higher energy levels?

A 21 keV **B** 18 keV **C** 13 keV **D** 3 keV

29 Which of the following combinations of radioactive decay results in the formation of an isotope of the original nucleus?

A one α and four β decays

B one α and two β decays

C two α and two β decays

D four α and one β decays

30 A radioactive source consists of a mixture of two isotopes P and Q.

P has a half-life of 60 minutes and Q has a half-life of 30 minutes. The initial activity recorded by a suitable counter is 800 min^{-1}. After 120 minutes, the counter registers an activity of 80 min^{-1}.

What is the initial contribution of P to the count rate?

A 160 min^{-1} **B** 240 min^{-1} **C** 270 min^{-1} **D** 480 min^{-1}

END OF PAPER

HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		**CT GROUP**	17S
CENTRE NUMBER		**INDEX NUMBER**	

PHYSICS 9749/02

Paper 2 Structured Questions **14 September 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your **Centre number**, **index number, name** and **CT class** clearly on all work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paperclips, highlighters, glue or correction fluid.

Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.
You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
1		10
2		9
3		11
4		11
5		11
6		7
7		21
Deductions		
Total		80

Data

speed of light in free space,
$c = 3.00 \times 10^{8}$ m s^{-1}

permeability of free space,
$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}

permittivity of free space,
$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}
$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}

elementary charge,
$e = 1.60 \times 10^{-19}$ C

the Planck constant,
$h = 6.63 \times 10^{-34}$ J s

unified atomic mass constant,
$u = 1.66 \times 10^{-27}$ kg

rest mass of electron,
$m_e = 9.11 \times 10^{-31}$ kg

rest mass of proton,
$m_p = 1.67 \times 10^{-27}$ kg

molar gas constant,
$R = 8.31$ J K^{-1} mol^{-1}

the Avogadro constant,
$N_A = 6.02 \times 10^{23}$ mol^{-1}

the Boltzmann constant,
$k = 1.38 \times 10^{-23}$ J K^{-1}

gravitational constant,
$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}

acceleration of free fall,
$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\,\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/\,^\circ\text{C} + 273.15$
pressure of an ideal gas	$P = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$ $= \pm\omega\sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o nI$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[BLANK PAGE]

Answer **all** questions in the spaces provided.

1 **(a)** A spring, which has an unstretched length of 0.650 m, is attached to a fixed point. A mass of 0.400 kg is attached to the spring and gently lowered until equilibrium is reached. The spring has then stretched elastically by a distance of 0.200 m.

Calculate, for the stretching of the spring,

(i) the loss in gravitational potential energy of the mass,

loss = ………………………… J [1]

(ii) the elastic potential energy gained by the spring.

gain = ………………………… J [2]

(b) Explain why the two answers to **(a)** are different.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(c) The mass on the spring is now set into simple harmonic motion by pulling it downwards by an additional 0.100 m and released from rest.

The angular frequency ω of a spring-mass system is given by $\omega = \sqrt{\frac{k}{m}}$, where k is the force constant and m is the mass of the load.

(i) Calculate the maximum speed of the mass,

maximum speed = ………………………… m s^{-1} [2]

(ii) The velocity-displacement graph of the mass is shown in Fig. 1.1. Label on the graph the point **P** when the mass is first released and point **Q** when it first returns to its equilibrium position. Include numerical values on the axes. Take upwards to be positive. [1]

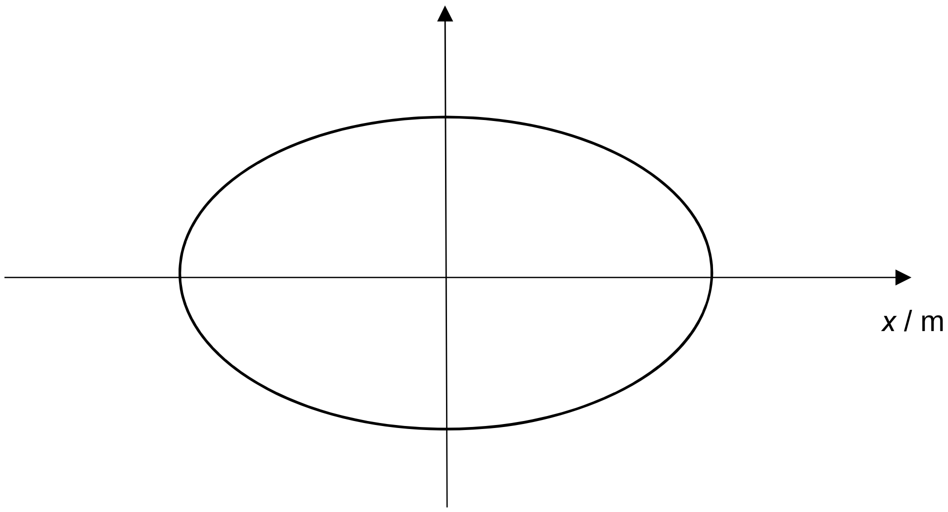


Fig. 1.1

(iii) The mass is now lowered into a container of water until it is completely submerged. The mass is again displaced downwards from its equilibrium position by 0.100 m and released from rest. Throughout the oscillations, the mass remains under water.

Sketch on Fig. 1.1 the variation of velocity with respect to displacement for one complete oscillation of the mass. [2]

2 **(a)** State the principle of conservation of linear momentum.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(b) A light and long string (string 1), runs over two smooth and light pulleys (pulleys A and B). One end of the string is fixed to the ceiling and the other end is attached to mass M_1. Pulley A is fixed to the ceiling while pulley B is movable and is attached to mass M_2 via another light string (string 2).

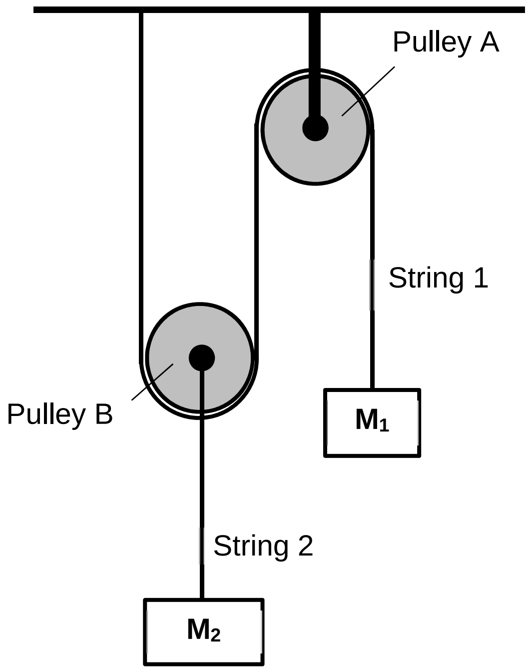


Fig. 2.1

(i) Given that M_1 = 4.0 kg and M_2 = 8.0 kg and they are both at rest, determine the tension in string 1 and string 2.

tension in string 1 = ………………………… N

tension in string 2 = ………………………… N [2]

(ii) A little disturbance is made to the system and M_1 starts to move upward with speed v_1 while M_2 starts to move downwards with v_2. By considering linear momentum, express v_2 in terms of v_1.

v_2 = ……………………… [2]

(iii) Hence, determine the energy introduced to the system due to the disturbance in terms of v_1.

energy = …………………………… [2]

(iv) After some time, the masses move with constant speed. Show that total energy of the system is conserved. Explain your working clearly. [2]

3 **(a)** A commonly used quantity in astronomy is *luminosity*. The luminosity of a star is the total energy radiated by the star per second.

(i) The luminosity of our sun is 3.826×10^{26} J s^{-1}. The mean distance of the Earth from the sun is 1.496×10^{8} km. Determine the intensity of light reaching the Earth.

intensity = …………………….. W m^{-2} [2]

(ii) A student, using a photometer that measures the intensity of visible light, measures the intensity of sunlight at noon to be less than the value calculated in **(a)(i)**. Suggest a reason for this observation.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

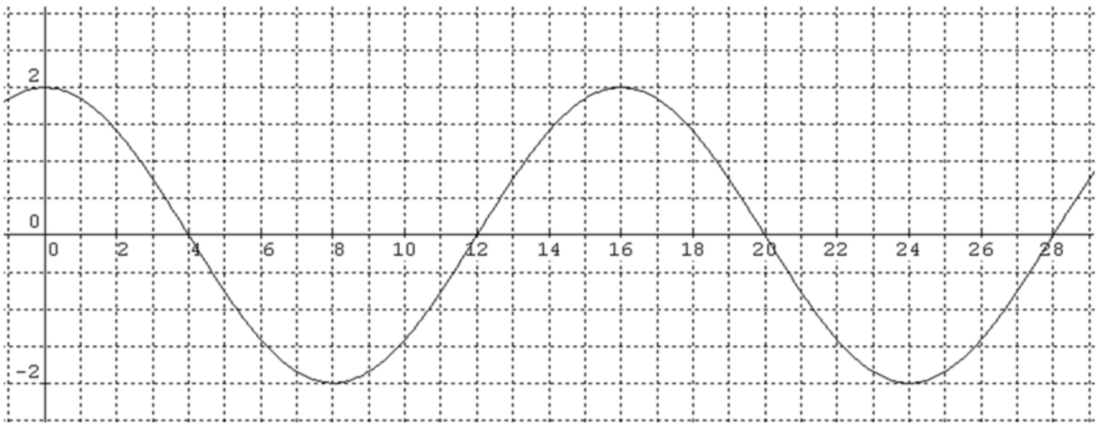
…………………………………………………………………………………………………….. [1]

(iii) A photometer of area 4.00 x 10^{2} cm^{2} is aimed directly at the sun at the top of a building. Determine the maximum power incident on the photometer.

maximum power = …………..………….. W [2]

(b) Fig. 3.1 shows the displacement *y* of a particle in a sinusoidal wave as a function of time *t*.

y / cm



t / s

Fig 3.1

(i) Using Fig. 3.1, write an equation that represents the displacement *y* of the particle in terms of *t*.

y = ………………………… [2]

(ii) A second particle is situated nearer to the source of the wave, at a distance $\frac{\lambda}{4}$ from the first. Determine the phase difference between the vibrations of the two particles.

phase difference = ………………………….. [2]

(iii) Sketch in Fig. 3.1 to illustrate the variation with time of the displacement of the second particle. [2]

4 **(a)** State what is meant by an electric field.

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….. [1]

(b) Fig. 4.1 below shows a set of equipotential lines of a region of an electric field.

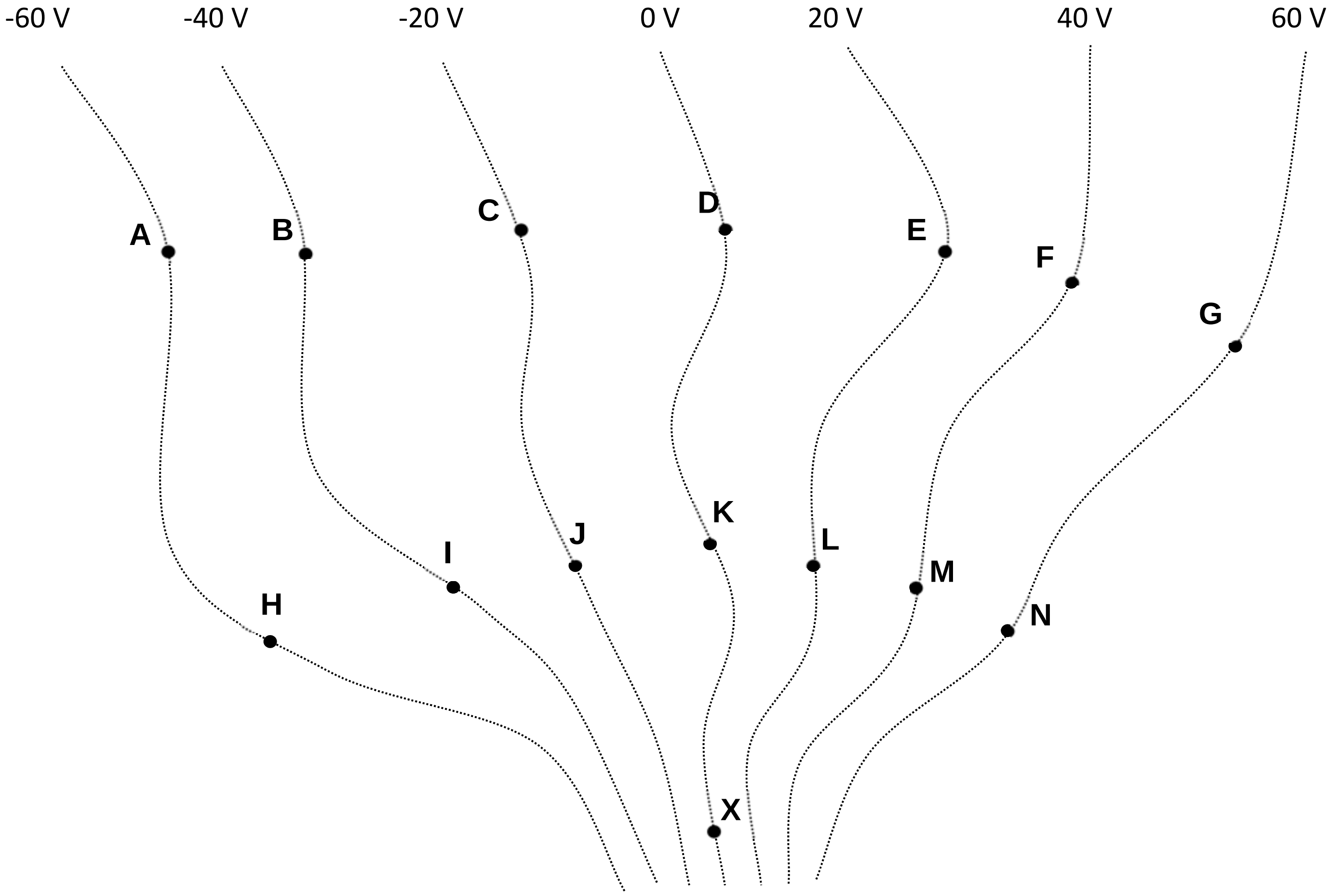


Fig. 4.1 (drawn to scale)

(i) Given that the same field line passes through the points **A,B,C,D,E,F** and **G,** draw in Fig. 4.1, this field line, clearly indicating the direction of the field. [2]

(ii) Explain whether the field is stronger at **D** or at **X**.

…………………………………………………………………………………………………….

……………………………………………………………………………………………………. [1]

(iii) A charge Q_1 of - 5.0 μC is placed at the point **L**. Calculate the electric potential energy of the charge Q_1 at point **L**.

electric potential energy = ………………………….. J [2]

(iv) Charge Q_1 is now released from rest. Given that work done on it *by the electric field* is 1.0 x 10^{-4} J, identify the point(s) that can represent the final location of Q_1.

Point(s): ……………………………. [2]

(v) Charge Q_1 is now removed, and Q_2 of - 15.0 μC is now placed at the point **X**. By making *direct measurements* from the Fig 4.1, determine the electric force experienced by the charge.

Indicate on Fig. 4.1 the direction of the force experienced by Q_2 at **X**.

electric force = …………………………. N [3]

5 **(a)** The variation with temperature of the resistance R_T of a thermistor is shown in Fig. 5.1.

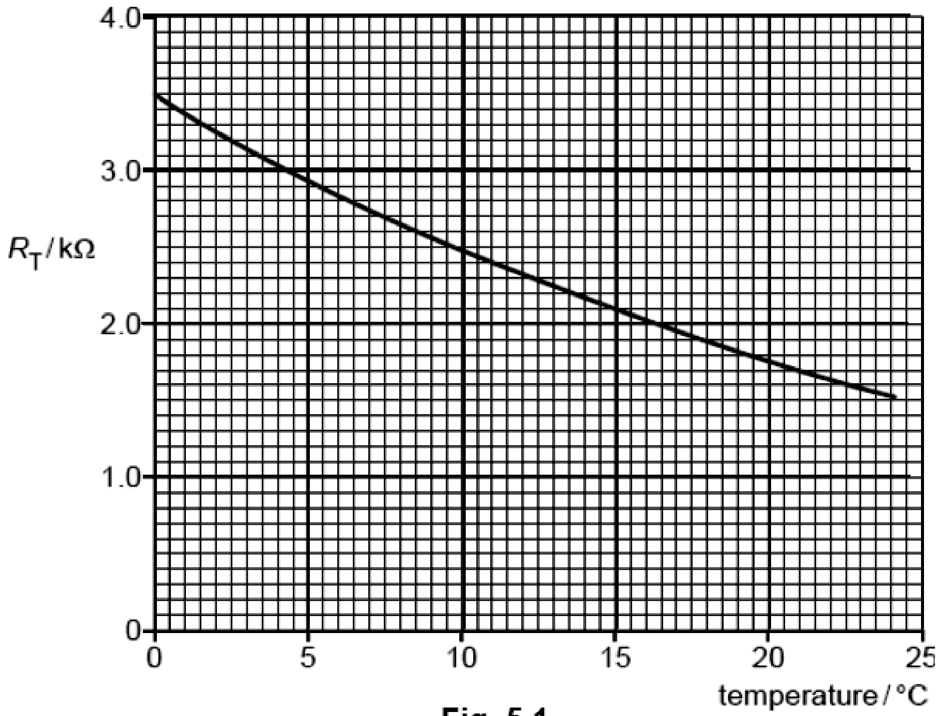


Fig. 5.1

The thermistor is connected in series with a resistor R as shown in the circuit in Fig. 5.2.

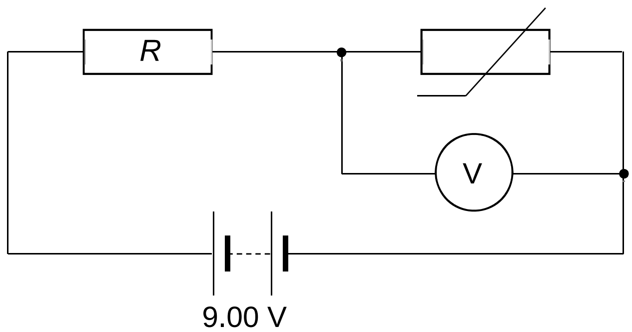


Fig. 5.2

The battery has e.m.f. 9.00 V and negligible internal resistance. The voltmeter has infinite resistance.

(i) For the thermistor at 22.5 °C, determine the resistance of the thermistor.

R_T = ……..……………………… Ω [1]

(ii) Given that the voltmeter reading is 2.70 V, determine the resistance of resistor R.

resistance of R = ……..……………………… Ω [2]

(b) The voltmeter is now removed from the original circuit and the rest of the circuit is connected to a potentiometer as shown in Fig. 5.3.

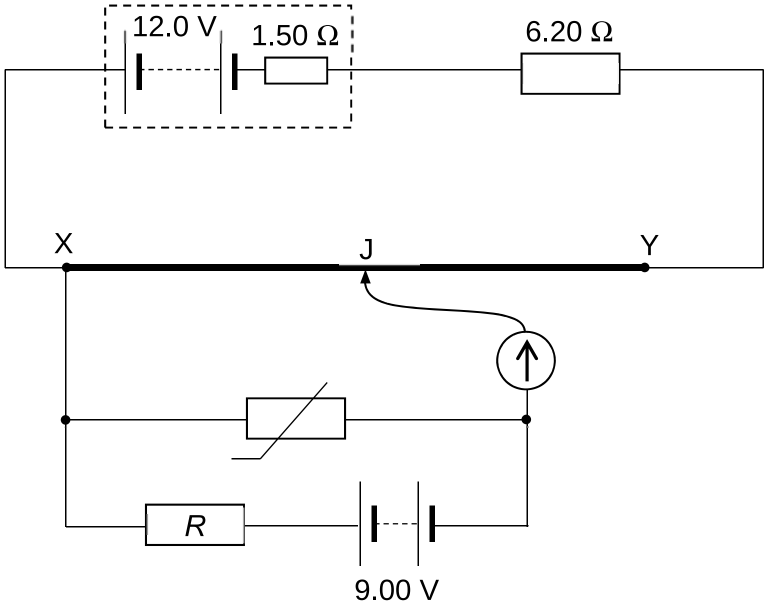


Fig. 5.3

The potentiometer has a driver cell of e.m.f. 12.0 V with internal resistance of 1.50 Ω. It is connected in series with a resistor of resistance 6.20 Ω and a uniform resistance wire XY, of length 120 cm and radius 0.250 mm. The resistivity of the wire is 1.10×10^{-6} Ω m.

(i) Determine the resistance of the wire XY.

resistance of wire XY = ………………………….. Ω [2]

(ii) For the thermistor at 22.5 °C, determine the balance length XJ where there is no deflection in the galvanometer.

XJ = ………………………….. m [2]

(iii) Explain what will happen to the position of the balance point J if the thermistor is at a temperature of 0 °C.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

(iv) Supposed the 6.20 Ω resistor is replaced by a resistor of smaller resistance, explain what will happen to the position of the balance point J.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

6 **(a)** Fig. 6.1 shows the variation of binding energy per nucleon with the number of nucleons in nucleus.

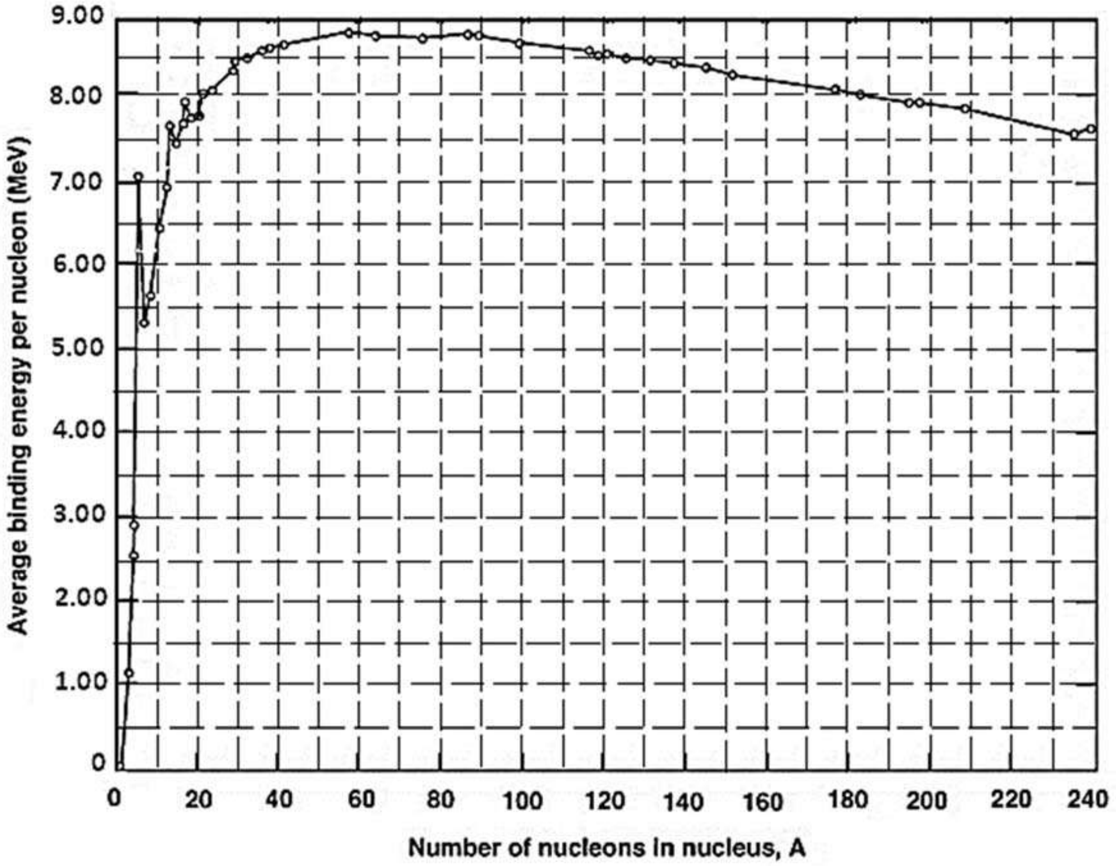


Fig. 6.1

(i) Define binding energy of a nucleus.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Using Fig. 6.1, estimate the binding energy of the nucleus Iridium-170, ${}^{170}_{77}\text{Ir}$.

binding energy of ${}^{170}_{77}\text{Ir}$ =……………….……. MeV [1]

(iii) Hence calculate the mass defect of ${}^{170}_{77}\text{Ir}$.

mass defect of ${}^{170}_{77}\text{Ir}$ =……….……………… u [2]

(b) Stellar nucleosynthesis is a collective term for nuclear reactions taking place in stars. These reactions create nuclei of elements heavier than hydrogen.

The "triple" alpha process is a nuclear fusion reaction that occurs in stars where three alpha particles combine to form carbon-12, $^{12}_{6}C$.

(i) Determine the energy released in this reaction.

Given:

mass of alpha particle = 4.002603 u

mass of $^{12}_{6}C$ = 12.000000 u

energy released =…………………… J [2]

(ii) "Silicon" burning is the final stage of fusion in massive stars. This process involves silicon-28, $^{28}_{14}Si$ capturing multiple alpha particles, until the sequence terminates at $^{56}_{28}Ni$. At this point the star can no longer release energy via nuclear fusion. This eventually results in a catastrophic collapse of the star.

Suggest a reason why the star can no longer release energy via nuclear fusion.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

7 Read the following article and then answer the questions that follow.

Physics of Microwave Oven

Microwaves are electromagnetic (e.m.) waves that have frequencies ranging from 300 MHz up to 300 GHz. Following international conventions, microwave ovens operate at frequencies at around 2.45 GHz.

Fig. 7.1. depicts a typical microwave oven. Microwaves are generated in magnetron which feeds via a waveguide into the cooking chamber. The cooking chamber has metallic walls which are able to perfectly reflect the microwaves fed into the cooking chamber, whilst the front door of the microwave is made of glass and is covered by metal grids. The holes in the metal grids are usually 100 times smaller than the wavelength of the microwaves, hence the walls and the grids act like a Faraday's cage.

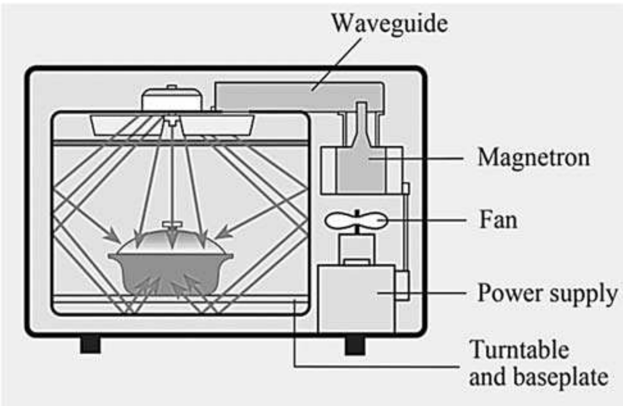


Fig.7.1. Schematic diagram of a typical microwave.

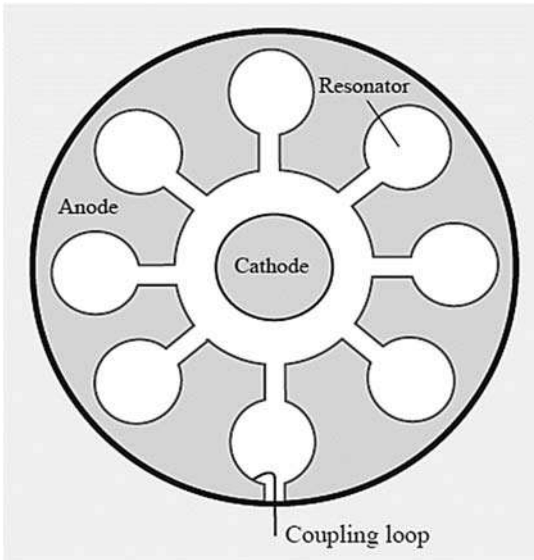


Fig.7.2. Schematic diagram of a magnetron

Fig. 7.2 shows the schematic diagram of a magnetron. A cylindrical cathode is at the central axis, several millimetres from a hollow circular anode. Inside the anode there are a number of cavities known as resonators which allows for resonance at 2.45 GHz. A voltage of 5.00 kV is applied between the electrodes and a magnetic field is applied parallel to the axis such that the electric and magnetic fields are perpendicular to each other. In the magnetron, the combined effect of electric and magnetic fields causes the electrons emitted from the hot cathode to travel in curved paths.

So how does the interaction of the molecules in food with the microwaves produce a heating effect to cook food? The water molecules in food oscillate in the alternating electric field of the microwaves. As the individual molecules oscillate, the work done against the forces between neighbour molecules increases their kinetic energy in a random manner, raising the temperature of the food. Fat, sugar and salt in food are able to heat up through a similar mechanism though they often play a smaller role as they are less abundant than water.

The absorption of microwaves by water molecules in the food, is often described as resonance, but this is not true: free water molecules resonate at 22 GHz and 183 GHz. Microwaves with a frequency of 22 GHz would be totally absorbed in the surface of the food without penetrating. If waves with a frequency as low as 100 MHz were used, they would pass straight through the food, and it would not heat up. The choice of 2.45 GHz is a compromise.

Upon entering foods, the intensity of microwaves is gradually reduced along its path according to the relationship:

$$I = I_0 e^{-\mu z}$$

where I_o is the intensity of the microwave incident on the surface of the food, I is the microwave intensity in the food at a distance z below the surface and μ is a constant known as the attenuation coefficient.

Another method to characterise the penetration of microwaves in food is using a quantity known as *penetration depth* δ_p. It is a quantity that is dependent on the frequency of microwaves incident on the food and is defined as the distance at which the microwave intensity is reduced to 1/e (e = 2.718) from the intensity at the point of entry.

Passage extracted and adapted from "Physics of Microwave Oven" by Michael Volmer and OCR Jan 2004 Paper 2865.

(a) **(i)** Suggest what is the function of a 'Faraday's cage'.

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(ii) Estimate a suitable spacing for the holes in the metal grids used in the front door of a microwave oven.

spacing = ... m [2]

(b) Fig. 7.3 shows a simplified model of part of the magnetron. The electric field between the cathode and anode is illustrated.

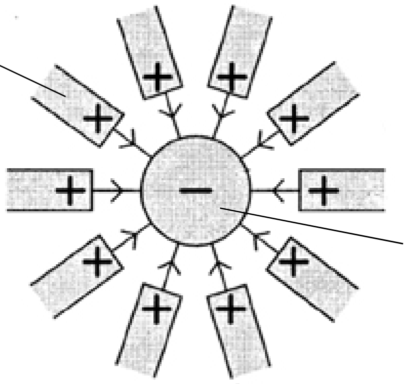


Fig. 7.3

(i) Show that the maximum kinetic energy that an electron can gain when moving to the anode is 8.0×10^{-16} J. [1]

(ii) Hence, if the microwave power output of the magnetron is about 1 000 W, determine the least number of electrons that must be emitted by the cathode each second.

least number of electrons per second = ... [1]

(iii) Suggest one reason why the actual number of electrons emitted is likely to be larger than your answer to **(b)(ii).**

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [1]

(iv) Fig. 7.4 shows the trajectory of an electron of mass *m* and charge *q* moving at a speed *v* in the magnetic field of flux density *B* inside a magnetron.

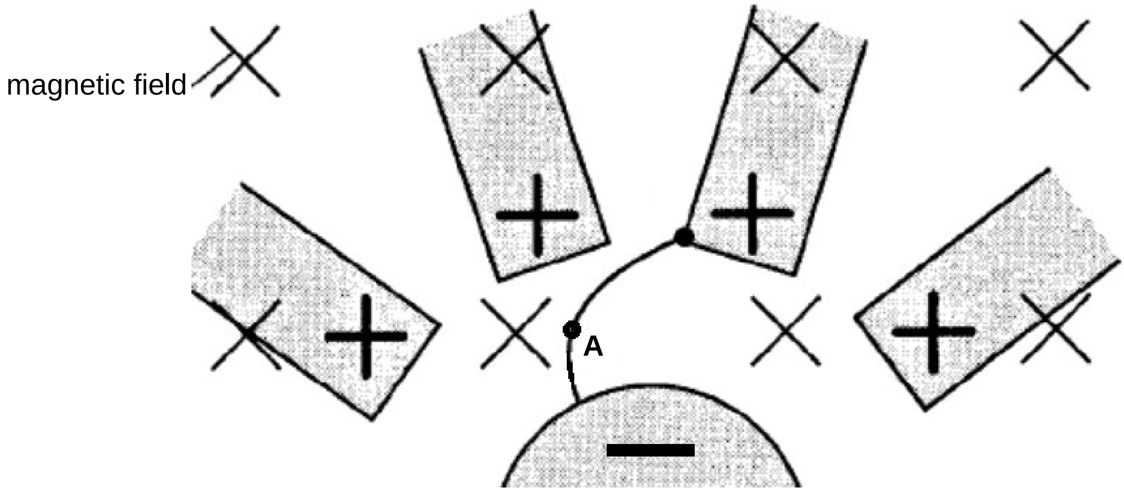


Fig. 7.4

1. On Fig. 7.4, draw and label the forces acting on the electron at A. [2]

2. State and explain how the introduction of the magnetic field will affect the maximum kinetic energy gained by an electron when moving to the anode calculated in **(b)(i).**

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) An experiment is conducted to investigate penetration of microwaves of frequency 2.45 GHz for a sample of potato mash.

Fig. 7.5 shows the readings obtained for the experiment.

depth into food z / mm	intensity of microwaves at depth z I / A.U.	ln (I / A.U.)
0	24	3.18
4	19	2.94
8	15	
12		2.49
16	10	2.30

Note that intensity I is measured in arbitrary units (A.U.)

Fig. 7.5

(i) Complete Fig. 7.5 for z = 8 mm and z = 12 mm. [1]

(ii) A graph of ln (I / A.U.) with (z / mm) is shown in Fig. 7.6.

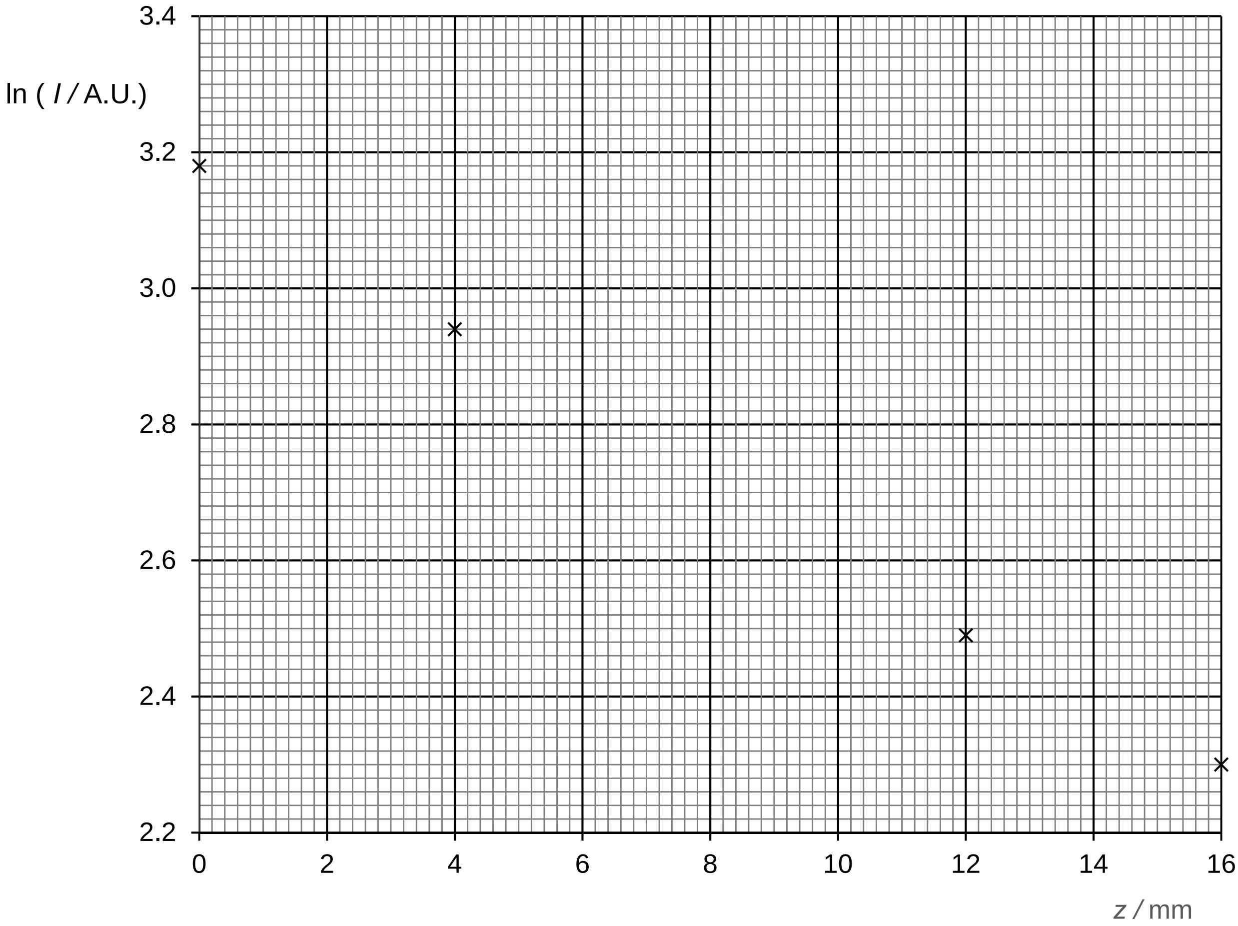


Fig. 7.6

1. On Fig. 7.6, plot the point corresponding to z = 8 mm.

2. Draw the best fit line for all the points. [2]

(iii) Determine the gradient of the line you have drawn.

gradient = …………………….. [2]

(iv) Hence, determine the penetration depth δ_p for the potato mash.

δ_p = ...mm [3]

(v) The experiment is then repeated with a potato mash of higher water content.

1. Suggest and explain how the penetration depth will differ from that found in **(c)(iv).**

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

2. Sketch on Fig. 7.6, the new graph of ln(I / A.U.) with (z / mm) for this experiment. Label this graph **N**. [1]

END OF PAPER

HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		**CT GROUP**	17S
CENTRE NUMBER		**INDEX NUMBER**	

PHYSICS — 9749/03

Paper 3 Longer Structured Questions

19 September 2018

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your **Centre number**, **index number, name** and **CT class** clearly on all work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paperclips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question only. **Circle** the question number of the cover page.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
SECTION A		
1		**10**
2		**9**
3		**11**
4		**11**
5		**8**
6		**11**
SECTION B		
7		**20**
8		**20**
Deductions		
Total		**80**

Data

speed of light in free space,
$c = 3.00 \times 10^{8}$ m s^{-1}

permeability of free space,
$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}

permittivity of free space,
$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}
$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}

elementary charge,
$e = 1.60 \times 10^{-19}$ C

the Planck constant,
$h = 6.63 \times 10^{-34}$ J s

unified atomic mass constant,
$u = 1.66 \times 10^{-27}$ kg

rest mass of electron,
$m_e = 9.11 \times 10^{-31}$ kg

rest mass of proton,
$m_p = 1.67 \times 10^{-27}$ kg

molar gas constant,
$R = 8.31$ J K^{-1} mol^{-1}

the Avogadro constant,
$N_A = 6.02 \times 10^{23}$ mol^{-1}

the Boltzmann constant,
$k = 1.38 \times 10^{-23}$ J K^{-1}

gravitational constant,
$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}

acceleration of free fall,
$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\,\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	T/K = T/ °C + 273.15
pressure of an ideal gas	$P = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$ $= \pm \omega \sqrt{(x_o{}^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o nI$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

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Section A

Answer **all** questions in the spaces provided.

1 Fig. 1.1 is a diagram of a human arm lifting an object.

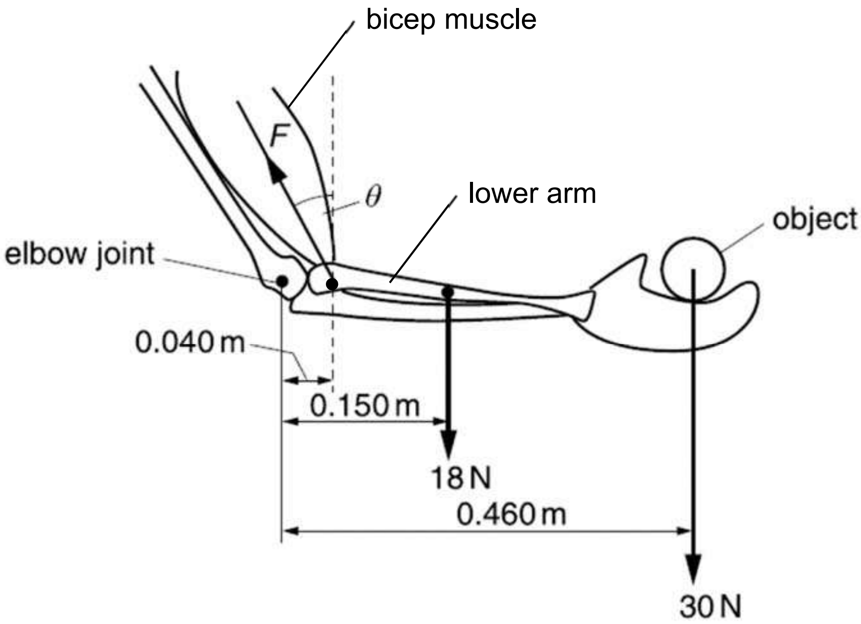


Fig. 1.1

The lower arm is horizontal and its centre of gravity is 0.150 m from the elbow joint. The weight of the lower arm is 18 N. The bicep muscle exerts a force F at an angle of θ to the vertical.

The horizontal distance between the elbow joint and the point of attachment of the muscle to the lower arm bone is 0.040 m. The weight of the object held in the hand is 30 N and its centre of gravity is 0.460 m from the elbow joint. The arm is in equilibrium.

(a) Define *centre of gravity*.

....

.... [1]

(b) Determine the value of F when $\theta = 15^{o}$.

F = ... N [2]

(c) For the lower arm to be in equilibrium, the elbow joint also needs to exert a force *R* on the lower arm bone.

(i) Draw a labelled arrow on Fig. 1.1 to represent the force *R* that the elbow exerts on the lower arm. [1]

(ii) Explain the direction of this force *R*.

....

....

....

....

....

.... [2]

(d) As the lower arm is slowly moved away from the body in the horizontal direction, the angle θ increases.

(i) Sketch in Fig. 1.2 the graph of how *F* varies with θ. (You may assume that the lower arm remains horizontal and is in equilibrium at all times.)

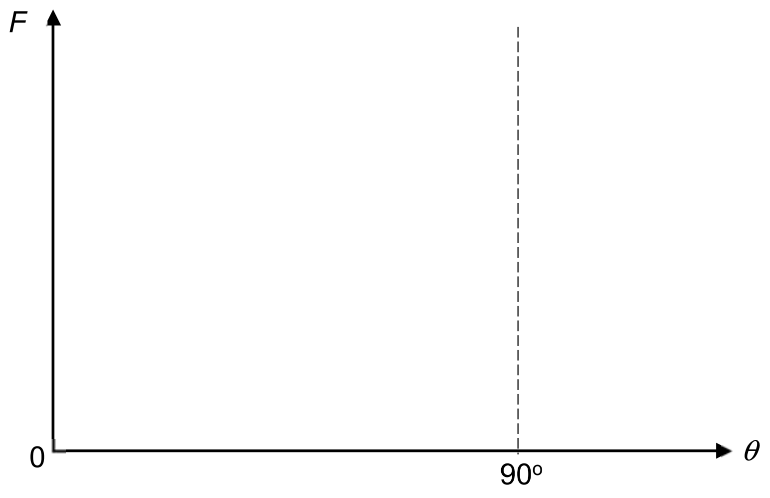


Fig. 1.2

[2]

(ii) Explain the shape of your graph in Fig. 1.2.

....

....

.... [2]

2 **(a)** Explain what is meant by the internal energy of a system.

....

....

.... [2]

(b) Dry air is enclosed in an air-tight cylinder fitted with a piston, as shown in Fig. 2.1.

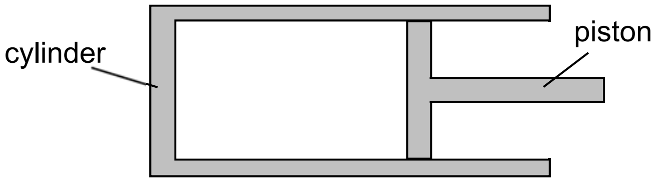


Fig. 2.1

The piston moves to compress the air and the variation with volume *V* of the pressure *p* of the air during the process from A to B is shown in Fig. 2.2.

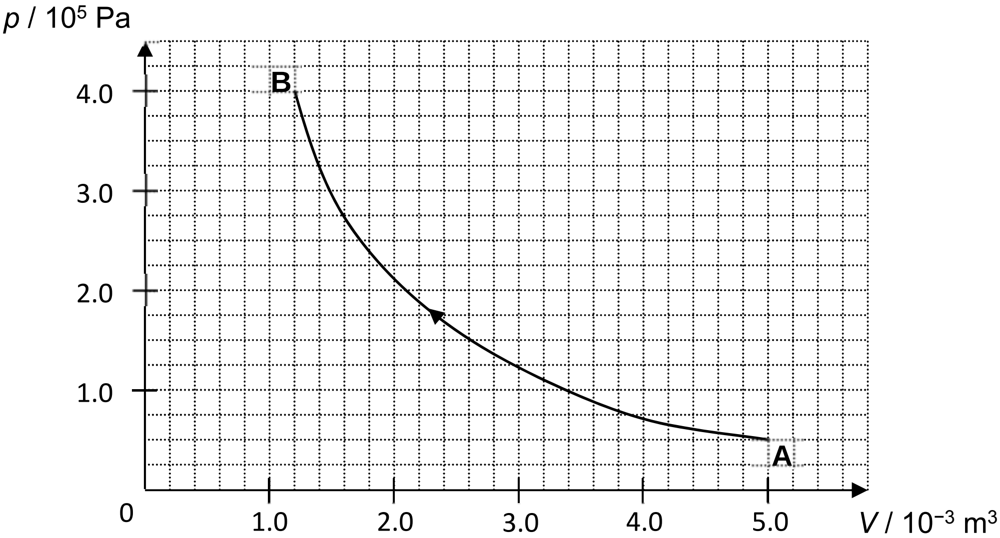


Fig. 2.2

It may be assumed that the dry air behaves as an ideal gas.

(i) Assume the dry air is a monoatomic gas. Calculate the internal energy of the dry air just before the start of process from A to B.

internal energy = …………….……… J [2]

(ii) The dry air then goes through two more processes.

Process 2: The air is cooled while keeping the piston at the same position.

Process 3: The air then expands, while kept at constant temperature, to return to its original state.

1. Calculate the pressure of the air at the end of the process 2.

pressure = …………………… Pa [2]

2. On Fig. 2.2, draw accurately and label on the *p*-*V* graph of the two processes 2 and 3. [3]

3 **(a)** State the principle of superposition.

....

....

....

.... [2]

(b) A source of microwaves is placed on a table at a fixed distance from a detector. A vertical reflecting plate is placed a distance *y* from the source and the detector. Reflection at the reflector causes a phase change of π rad to the microwave.

Fig 3.1 shows the **view from above**.

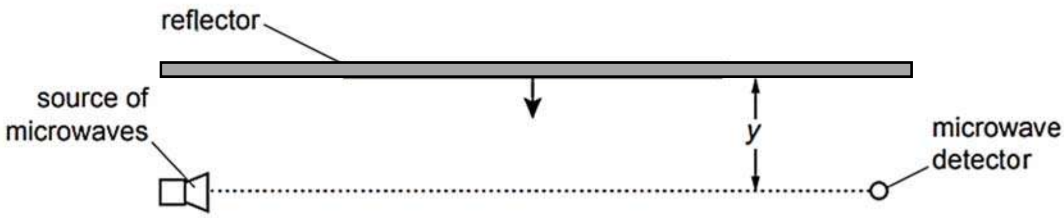


Fig 3.1 (top view)

The reflector is moved gradually towards the source and the detector, in the direction indicated by the arrow on the reflector in Fig 3.1. The intensity measured by the detector alternates between high and low.

Explain these observations.

....

....

....

....

.... [3]

(c) The reflector is fixed at a position y = 2.5 m and the detector is at a distance 5.0 m away. The wavelength of the microwave is 0.59 m.

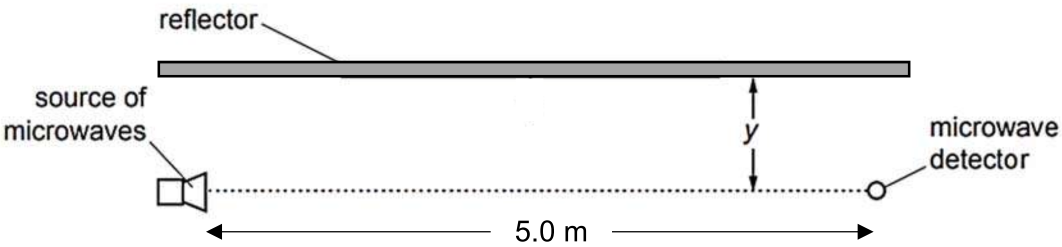


Fig. 3.2

(i) Explain whether the intensity at the detector is a maximum or a minimum.

....

....

....

.... [3]

(ii) Describe how the intensity of reception varies as the detector is moved towards the source along the dotted line until it reaches the source.

....

....

....

....

....

.... [3]

4 This question is about an experiment to estimate the resolution of the human eye.

Two vertical parallel lines are drawn on a piece of card. The separation between the lines *y* is 2.0 ± 0.5 mm. The card is fixed to a wall at head level.

A group of students look at the card whilst each covering one eye. They walk back from the card until they can no longer separate the two lines. The distance *L* between the eye and the card is measured.

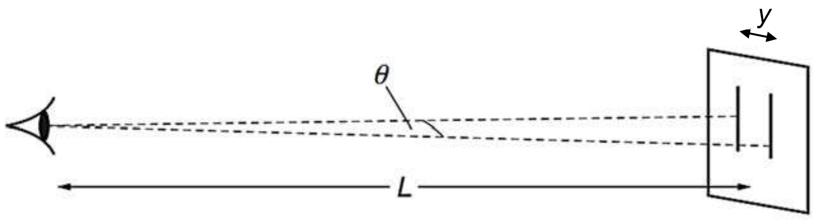


Fig 4.1

Here are the results from the five students:

student	A	B	C	D	E
maximum distance *L* / m	6.2	5.8	6.1	5.9	6.1

(a) **(i)** State the uncertainty of the distance *L* based on students' results.

uncertainty = ………………………….. m [1]

(ii) A student suggests that the uncertainty in the distance *L* can be ignored when calculating the minimum angle *θ* that can be resolved because of the uncertainty in the separation of the lines *y* on the card.

Comment on this suggestion, explaining whether or not you agree.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(iii) Calculate a value for the minimum angle (with its corresponding uncertainty) that can be resolved.

minimum angle that can be resolved = …………………. ± ……………… rad [3]

(b) The diameter of the pupil of the eye is estimated to be 3 mm. The two lines are marked using red ink.

(i) Explain what is meant by the Rayleigh criterion for the resolution of two patterns.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(ii) Estimate the minimum angle using the Rayleigh criterion.

minimum angle = ……………………… rad [2]

5 **(a)** Ernest Rutherford proposed a planetary model for the hydrogen atom. In the model, a single electron is treated as a point-like charged particle, moving in circular motion around a stationary proton (the nucleus) as shown in Fig. 5.1.

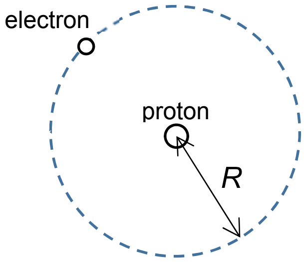


Fig. 5.1 (not to scale)

(i) State two forms of energy that the system possesses and state whether each form is by convention, positive or negative.

....

.... [2]

(ii) Explain why the total energy of the system is conventionally taken to be negative when the electron is orbiting the nucleus.

....

....

....

.... [2]

(b) In quantum mechanics, it is not possible to model the path of the electron in the hydrogen atom to be a well-defined circle around the proton.

(i) Using Heisenberg uncertainty principle for position and momentum, explain why the path of the electron inside the atom is not well-defined.

....

....

....

.... [2]

(ii) Despite not knowing the path of the electron, we are certain that the electron remains bound to the nucleus. By considering your answer to **(a)**, show that the maximum kinetic energy of the bound electron is given by $E_k = \dfrac{e^2}{4\pi\varepsilon_0 R}$. Explain your working clearly. [2]

6 **(a)** A student writes three incorrect statements as shown in the table below. Each statement has an error either in the unit or number. **Circle** the error in the statement and write the correct answer.

Incorrect statement	**Correct number or unit**
The weight of a person is about 700 kg.	
The atmospheric pressure at sea level is about 1.0 x 10^5 N m^2.	
1 GW is 10 times bigger than 1 MW.	

[3]

(b) For over a century, the standard kilogram has been defined by a small platinum-iridium cylinder housed at the International Bureau of Weights and Measures in France. This is the last remaining human-made material object on which a measurement standard is based.

Suggest why the use of a physical sample as the standard became inadequate with the advancement in Science.

....

....

.... [1]

(c) It was proposed at the turn of this century that mass be defined in terms of the Planck constant *h* rather than in terms of a physical standard mass. This can be done using a watt balance, an electromechanical mass measuring instrument that measures the mass of a test object very precisely by the strength of an electric current and a voltage.

Fig 6.1 shows a simplified version of the watt balance.

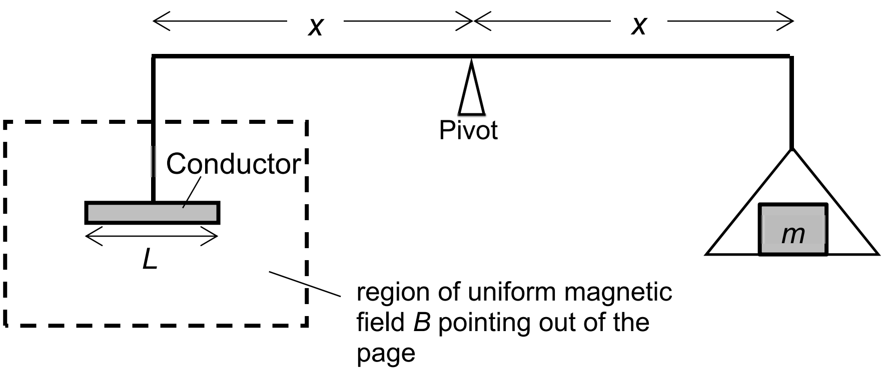


Fig 6.1

The mass *m* on the right arm of the balance is the mass to be measured. On the left arm, a conductor of length *L* is placed in a uniform magnetic field with flux density *B* pointing out of the page.

The process of finding *m* involves two stages.

(i) Stage 1: To balance the mass, a constant current I is passed through the conductor such that a magnetic force is exerted on the conductor. Using the principle of moments, the balancing condition is

$$mgx = BILx$$

where *g* is the gravitational field strength and can be treated as a constant.

Indicate the direction of the conventional current through the conductor by drawing an arrow on it in Fig. 6.1. [1]

(ii) Stage 2: The mass *m* is removed from the balance and the conductor is made to travel at a constant speed *u* through the same magnetic field as shown in Fig. 6.2.

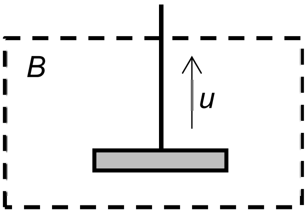


Fig. 6.2

1. Explain how a potential difference is set up aross the ends of the conductor.

....

....

....

.... [2]

2. Hence, show that the potential difference *V* set up is given by *BLu*. [2]

(iii) Very precise and accurate values of V and I can be determined using $V = \frac{hC}{2e}$ and $I = \frac{kne}{2}$, where e is the elementary charge, n is an integer and C and k are known constants.

Using **(c)(i)** and **(ii)**, show how the mass m can be defined in terms of the Planck constant h. [2]

Section B

Answer **one** question from this Section in the space provided.

7 **(a)** State and define the unit for magnetic flux.

....

....

.... [2]

(b) The plan view (from top down) of a train braking system is illustrated in Fig 7.1. The train carriage of mass *m* is mounted on a rectangular metal frame ABCD of length *L* and width *w*, the effective resistance of the frame is *R.* The train carriage is initially moving at a constant speed along the rails.

A uniform magnetic field *B* is directed perpendicularly into the ground over a rectangular region of length *L*. Line P denotes the start of this region while line Q denotes the end of the region. After passing through the magnetic field, the train speed is expected to be reduced to a very low speed after which brakes can be applied to stop it completely. You may assume that friction is negligible.

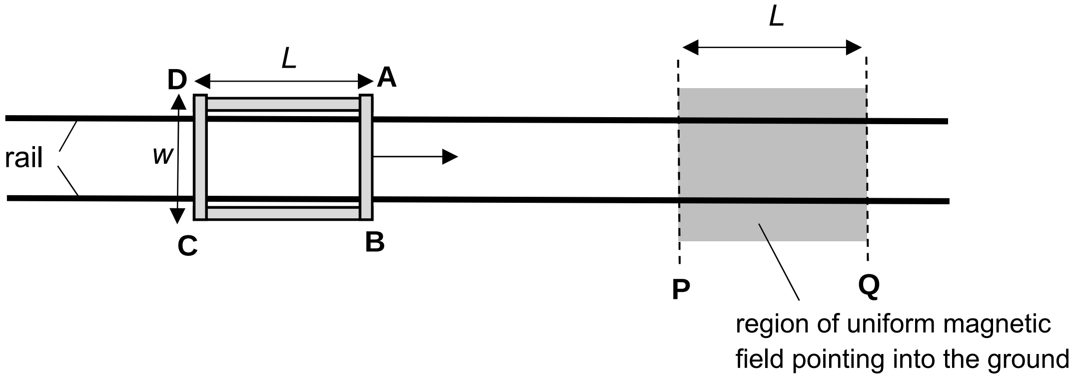


Fig 7.1 (top view)

(i) Explain how the train carriage is slowed as AB moves through the magnetic field from P to Q.

....

....

....

....

.... [3]

(ii) Show that the emf induced in the frame *E* is given by *Bwv* where *v* is the speed of the train carriage. Explain your working clearly. [2]

(iii) Hence, deduce an expression for the magnitude of the acceleration of the train carriage as it moves through the magnetic field in terms of *B*, *w*, *v*, *m* and *R*.

acceleration = ………………………….. [3]

(c) The graph in Fig 7.2 shows the velocity of the train carriage as it moves through the magnetic field, from the instant AB crosses line P to the instant CD crosses line Q.

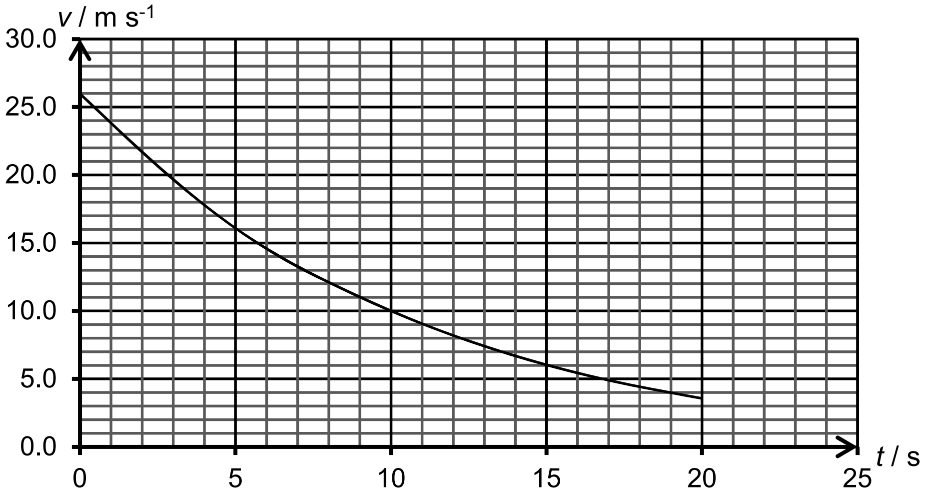


Fig 7.2

(i) Use Fig 7.2 to estimate the distance PQ.

PQ = …………………………… m [3]

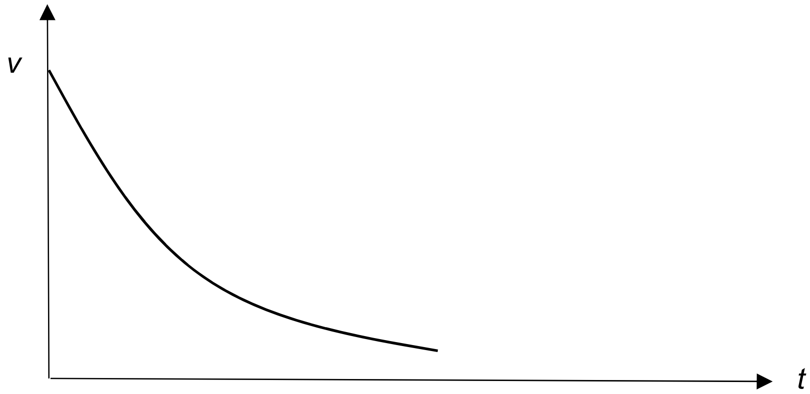
(ii) Comment on how increasing the region of magnetic field (distance between P and Q) would affect the exit speed of the train after passing through it.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(iii) Sketch on Fig 7.3 the variation of the velocity of the train carriage as it passes through the magnetic field if distance PQ is now reduced.



[3]

Fig 7.3

(iv) Suggest and explain one modification that can be incorporated into the train braking system so that in the event of a train malfunction which causes the train to be moving at a speed that is much higher than expected, the system can still slow the train down to an acceptable speed.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

8 **(a)** State Newton's law of gravitation.

………

………

………

……… [2]

(b) Earth rotates about its axis with a period of 24 hours. Assume Earth has a uniform density.
Radius of Earth = 6.37 x 10^6 m
Mass of Earth = 5.97 x 10^{24} kg

(i) Calculate the centripetal acceleration of a man standing at Earth's equator.

centripetal acceleration = …………………….. m s^{-2} [2]

(ii) Hence, calculate the acceleration of free fall at the equator of Earth, and explain why this value may be different from that at the poles.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [4]

(c) The International Space Station (ISS) revolves the Earth in a circular orbit at a height of just 408 km above Earth's surface.

(i) Show that the period of the ISS is 1.5 hours.

[2]

(ii) For a circular orbit, the radius, r, and period, T, are related by the relationship

$$T^2 \propto r^3$$

This result is also known as Kepler's Third Law.

A student noted that a point on Earth's equator rotates with a period of 24 hours but the ISS in **(c)(i)** orbits with a period of just 1.5 hour.

Comment the apparent discrepancy between the student's observation and Kepler's Third Law.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(iii) An astronaut on the ISS deduced that he must be weightless since he was floating. Comment on his deduction.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(d) The table shows data relating the Moon orbiting the Earth and an electron orbiting the nucleus of a hydrogen atom.

	Moon orbiting Earth	electron orbiting nucleus
mass / kg	7×10^{22}	9×10^{-31}
speed / m s^{-1}	1×10^{3}	2×10^{7}
orbital radius / m	4×10^{8}	5×10^{-11}

Fig. 8.1

(i) Using the data from Fig 8.1, determine

1. the de Broglie wavelength of the Moon orbiting the Earth,

wavelength = …………………………….. m

2. the de Broglie wavelength of the electron orbiting the nucleus.

wavelength = …………………………….. m [3]

(ii) Hence, explain why it is reasonable to treat the Moon in orbit around the Earth as a "particle" but it is not reasonable to treat the electron in orbit around the nucleus as a "particle".

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

END OF PAPER

Apparatus List

LEFT SIDE	RIGHT SIDE	
Question 1	**Question 2**	**Question 3**
• 2 retort stands • wooden board with paper attached • carbon paper • wooden block • marble • metre rule • 30 cm ruler • ramp • pendulum bob with string • Sellotape • Blue-tack • scissors	• Bunsen burner • tripod • metal gauze • thermometer • wooden stirrer • retort stand • lighter • stopwatch • 250 ml beaker • 100 ml measuring cylinder	• 2B pencil • sharpener • 3 1.5V dry cell • DMM (voltmeter) • DMM (micro-ammeter) • 2 probes • 1 long wire

2018 H2 Physics Preliminary Examinations Paper 4 Mark Scheme

Question 1	Pt	Marking point	Mark
(b)(ii)	1	Value of *x* in range 0.250 m ≤ x ≤ 0.310 m. Precision of 1 mm (but see point 3 below).	1
	2	Value of *y* in range 0.550 m ≤ y ≤ 0.650 m. Precision of 1 mm.	1
	3	Evidence of repeated readings for *x* (Including table in part (c)). Average *x* value calculated correctly. Allow for 1 more d.p than least for averaged value.	1
	4	*x* and *y* have the correct units.	1
(c)	5	At least 6 sets of data. Data set in (b) must be included within this set.	1
	6	Range of $y \geqslant 30$ cm.	1
	7	Column headings with units including lg or ln e.g. ln (x/cm)	1
	8	Raw data given to correct d.p. Precision of *x* and *y* 1 mm (consistent with part (b)).	1
	9	Processed data given to correct s.f. (least or one more).	1
	10	Correctly calculated values of processed data.	1
(d)	11	Equation **<u>correctly</u>** linearized & suitable **<u>linear</u>** graph plotted, e.g. y/x vs. x or y/x^2 vs. $1/x$.	1
	12	Gradient calculated correctly. Hypotenuse of the dotted triangle greater than half the length of the drawn line. Read-offs accurate to half a small square.	1
	13	Vertical intercept must be read off to the nearest half small square or determined from $y = mx + c$ using a point on the best-fit line.	1
	14	Value & unit of *u* calculated correctly (allow 2 to 4 s.f. inclusive). Unit: m s^{-1} or cm s^{-1}.	1
	15	Value and unit of *k* calculated correctly (allow 2 to 4 s.f. inclusive). No unit.	1
Graph	16	Axes labelled with the quantity (and unit, if applicable) which is being plotted. Acceptable scales are 1:1, 1:2, 1:2.5, 1:4, 1:5. The horizontal range and vertical range for the plotted points occupy at least half the horizontal range and vertical range, respectively, of the graph paper.	1
	17	All observations plotted to an accuracy of half a small square.	1
	18	Acceptable best-fit line and correct trend, e.g. graph of *y*/*x* vs. *x* should give a straight-line graph of positive gradient. (The shape of the curve or the gradient of the straight line must be consistent with the equation given.)	1

(e)	**19 – max 1 mark**	**20 – max 1 mark**
	(e)(i) - Source of error	**e(ii) - Suggested improvement**
A	Wooden board may not be exactly horizontal / may not be parallel to the ground / may slant at an angle / may not be perpendicular to the plumb line.	Place a **spirit level** on the board to *ensure* that the board is horizontal *Ensure* the two distances from the floor of opposite ends of the board are equal **using a metre rule.** Use a **set square** to *ensure* the board is perpendicular to the plumb line.
B	**B1** The marble may be released with some (varying) initial speed.	Rest the ball on the ramp with a piece of cardboard blocking it first and then lift off the cardboard.
	B2 The marble is not released at the same location at the top of the ramp.	Make markings on the marble and on the ramp. Align the marking on the marble with that on the ramp at the point of release.
	B3 One cannot ensure that the marble starts rolling at the same location.	
C	The marble did not shoot out of the ramp in a direction parallel to the ramp.	Reduce the width/diameter of the ramp.
	The ramp is not perpendicular to the edge of the table.	Use a **set square** to *ensure* that the ramp is perpendicular to the edge of the table.
	The plumb line and the ramp are not in the same plane as the marking left by the ball.	Draw a line from the edge of the board to the marking such that this line is parallel to the ramp when viewed from the top. The distance *x* is the distance from the edge of board to the marking.

Question 2	Marking point
1	Column headings with units
2	≥ 8 sets of data (only check table) Student must start experiment at 80 degrees and conduct experiment correctly according to question Temperature to fall to at least 65 degrees
3	Temperature given to 0.1 °C; consistent dp for time
4	**All observations must be plotted** to an accuracy of half a small square.
5	Smooth curve through the points.
6	Tangent properly drawn, touching the curve at θ = 70.0 °C.
7	Gradient – the hypotenuse of the triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square.
8	Appropriate and correct calculation of *P (ecf given)*
9	Possible modification: ● Replace beaker with Styrofoam cup ● Beaker with appropriate lagging method and material
10	Control variable: Mass of water kept at 100 g or 100 ml
11	For an appropriate comparison, allow the temperature to drop over the same range and take the **gradient of the temperature-time graph at 70.0 °C** again, compute the new *P*.
12	**NOTE: To study the effects of insulation, students should have the awareness that there must be a few data points so the challenge will be in quantifying the amount of insulation.** Difficult to quantify the amount of insulation → solution: measure surface area and thickness of insulation and calculate its total volume of insulation.

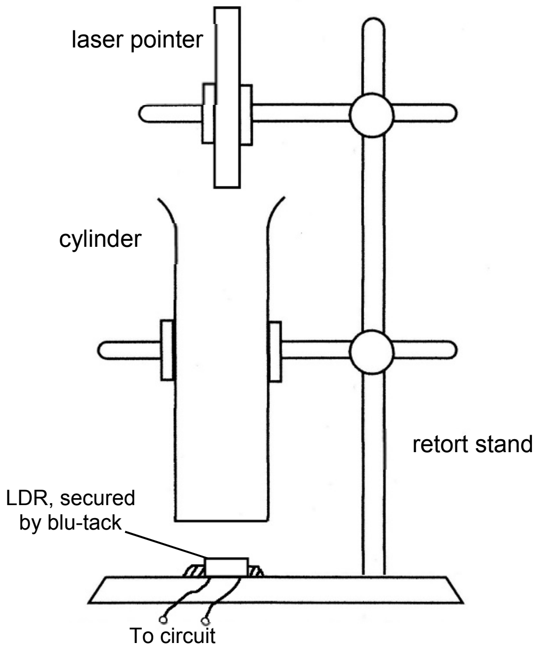
Question 3	Marking points
1	*I* recorded to correct precision (1 dp in microns); correct conversion from mA to A; suitable range Repeated readings of *I*
2	*V* recorded to correct precision (2 dp), correct units and correct range (2.80 – 5.10 V)
3	x recorded to appropriate units (allow mm, cm and m) with correct appropriate dp
4	appropriate Δ*I* , given to 1 sf percentage uncertainty given to 1 or 2 sf
5	Correct calculation of *R*
6	Correct estimation of ΔV
7	Correct uncertainty formula and calculation of Δ*R*
8	Δ*R* given to 1 sf and *R* written to correct precision
9	Correct calculation
10	Correct calculation (check area **divide by 6mm**) with correct units -Wrong concept (zero marks)
11	Correct calculation

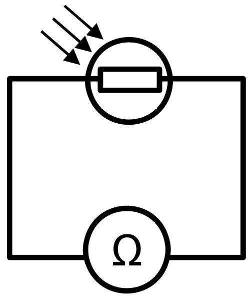
Question 4 Mark Scheme

	Marks	Marking Points
Diagram	2	**D1** Labelled diagram with laser pointing at LDR and beam directed through the liquid column; secure both LDR and laser in place (no floating apparatus) **D2** Ohmmeter connected to LDR; or other workable circuit arrangement
Variables	6	**Procedure to measure and vary independent variable: *m*** **V1** Volume of water using measuring cylinder, *V*; Mass of powder using electronic weighing balance, *M* **V2** $m = M / V$ **V3** How to vary *m* to obtain at least 6 readings?
		Procedure to measure dependent variable: μ **V4** Measure resistance of LDR with the empty cylinder, R_0 **V5** Use the calibration graph to determine corresponding intensities I_0 and *I,* and find μ using the equation given
		V6 Control for depth of liquid the laser passed through. Or Control for intensity of light incident on LDR.
Analysis	1	**Method of Analysis** **A1** Propose power law: $\mu = pm^q$, linearise: $\lg\mu = \lg p + q\lg m$.
Reliability and further good details	Max 2	**Any further design details that will improve reliability and accuracy.** **R1** Stir the suspension before taking every reading. **R2** Do pre-experiment to determine a suitable range of mass of power to add that will result in resistance values that maximizes the range given in calibration graph. **R3** Do the experiment in a dark room; or other ways that minimizes the effect of ambient light. **R4** Other valid points.
Safety	1	Any relevant safety precaution **S1** Avoid pointing the laser at others or looking directly into the laser beam.
Total	**12**	

Suggested Solution

Diagram





1. Set up apparatus as above. Take note to align and secure the top side of the LDR to the laser beam.
2. Conduct the experiment in a dark room.
3. Turn on the laser. Measure the resistance of the LDR using the ohmmeter. Read off the intensity value from the intensity calibration curve for this value of resistance.
4. This is the intensity of the laser as it passes through air, I_{air}.
5. Fill up the cylinder to about ¾ full using a measuring cylinder.
6. Pre-experiment: by adding increasing amount of talcum powder and take their corresponding resistance readings, determine the mass of powder for the intensity to fall to about 20% of I_{air}.
7. Clear out the contents of the cylinder and perform step 5 again. Record the volume as V.
8. Starting with the lower limit of mass of talcum powder, weigh out a small portion of talcum powder using electronic weighing balance.
9. Calculate m = (cumulative mass of powder added) / *V*.
10. Add this powder to the cylinder. Stir with a glass rod to mix the content well.
11. Prior to clamping the cylinder back into the setup, turn on the laser to shine directly on the LDR. Perform this step in each iteration of varying m to check that the power of laser remains constant.
12. Check that the depth of the suspension column had remained the same.
13. Clamp the cylinder back into the same position. Perform step 3 and obtain intensity of laser as it passes through liquid, I_{liquid}.
14. Calculate μ. Tabulate m with the corresponding μ.
15. Obtain 9 further sets of readings of I_{liquid} and μ by adding further portions of the powder into the suspension (up till the amount determinded in step 6).
16. It is hypothesized that the relationship between μ and m can be expressed as a power law:

$$\mu = pm^q$$

linearising: $\lg \mu = \lg p + q \lg m$

Plot a graph of lg μ against lg m. If a straight line is obtained with gradient q and y-intercept lg p, then the relationship proposed is valid.

Safety: Avoid pointing the laser at others or looking directly into the laser beam.

HWA CHONG INSTITUTION
C2 Preliminary Examinations
Higher 2

A

CANDIDATE NAME		CT GROUP	17S
CENTRE NUMBER		INDEX NUMBER	

PHYSICS **9749/04**

Paper 4 Practical **27 August 2018**

2 hr 30 min

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your name and CT class and tutor's name clearly in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.

You may use a HB pencil for any diagrams, graphs or rough working. Do not use paperclips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given at the end of each question or part question.
You are reminded of the need for good English and clear presentation in your answers.

Shift
Laboratory

For Examiner's Use	
1	

1 In this question you will investigate the trajectory of a small ball as it rolls off a surface which is inclined to the horizontal. Set up the ramp at the edge of the bench as shown in Fig 1.1.

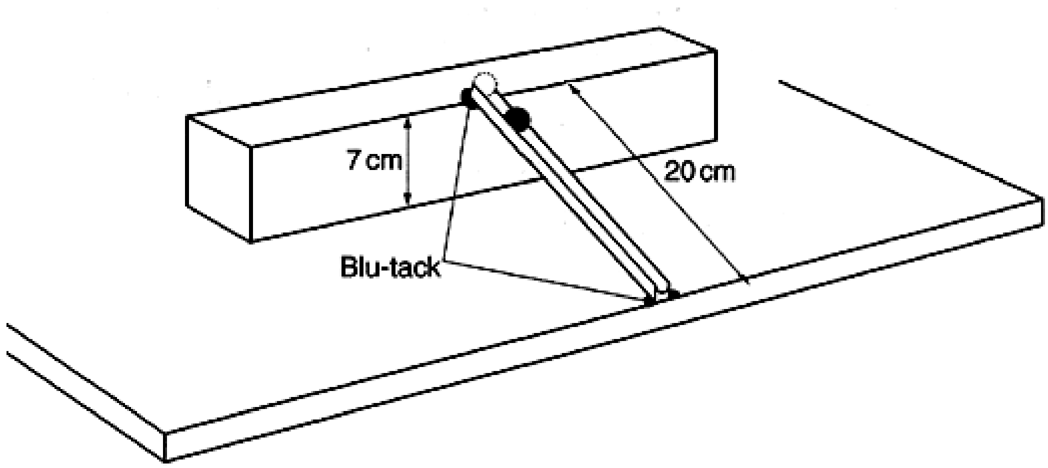


Fig 1.1

(a) (i) Suspend a plumb-line from the edge of the bench using Sellotape as shown in Fig 1.2.

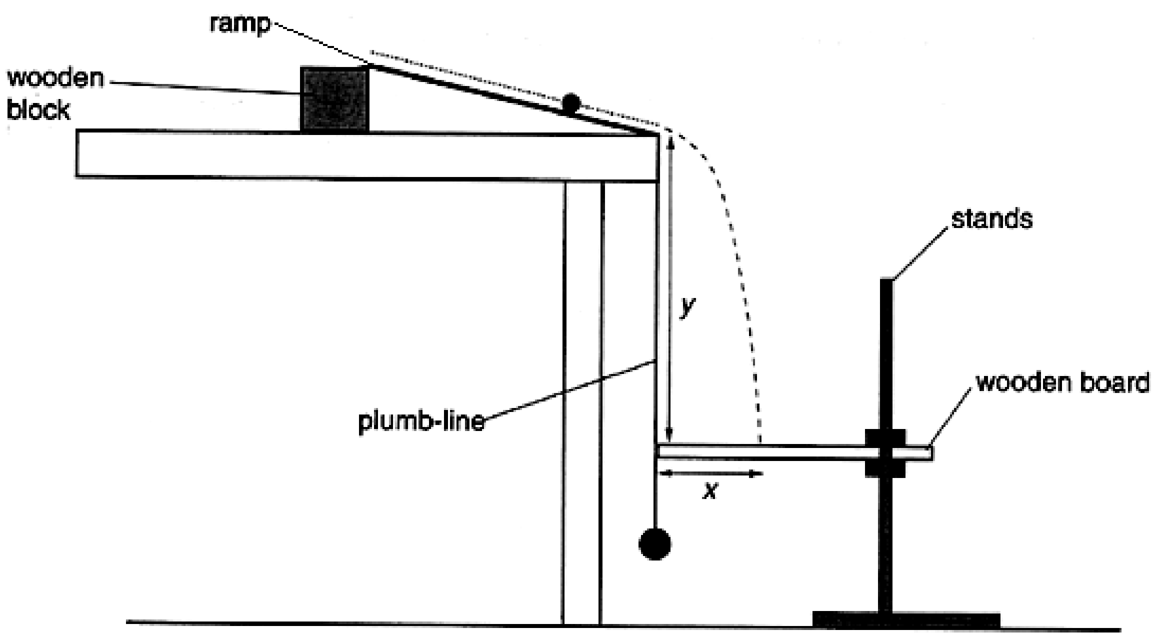


Fig. 1.2

(ii) Mount a wooden board horizontally using two clamps so that the board is situated about 60 cm below the bottom of the ramp. The side of the board which has blank sheets of paper attached to it should be facing **upwards** and the narrower edge of the board should just be touching the plumb-line as shown in Fig 1.2.

(iii) A sheet of carbon paper is placed on top of the blank paper. The ink-covered side of the carbon paper should be facing **down**.

(b) **(i)** Position the ball at the top of the ramp. Release the ball so that it rolls down the ramp and into the board below.

(Caution: as the ball hits the board, it will rebound and subsequent impacts will create unwanted markings. Thus, be ready to catch the ball after the first bounce.)

Lift up the carbon paper and observe that the ball makes a small mark on the blank paper.

Submit the paper with markings with your scripts at the end of the exam.

(ii) Measure and record the vertical distance *y* (between the bottom of the ramp and the top of the board) and the average horizontal distance *x* (between the plumb-line and the mark on the paper).

x = ...

y = ...

1	
2	
3	
4	

(c) Reduce the value of *y* and repeat steps **(i)** and **(ii)** in part **(b)** to obtain further sets of readings for *x* and *y*.

5	
6	
7	
8	
9	
10	

(d) The equation which relates x and y is

$$2u^2y = g\left(1+k^2\right)x^2 + 2u^2kx$$

where g = 9.81 ms^{-2}

u is the speed of the ball as it leaves the ramp and

k is a constant.

Plot a suitable graph to determine the values of u and k. Include appropriate units with your values.

11	
12	
13	
14	
15	

u = ……………….………….

k = …………………………...

(e) **(i)** State and explain one significant source of error in this experiment.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

19	

(ii) Suggest an improvement that could be made to the experiment to address the error identified in **(e)(i)**.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

20	

[Total: 20 marks]

16	
17	
18	

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NAME | CLASS 17S | Q2 | Q3 | **B**

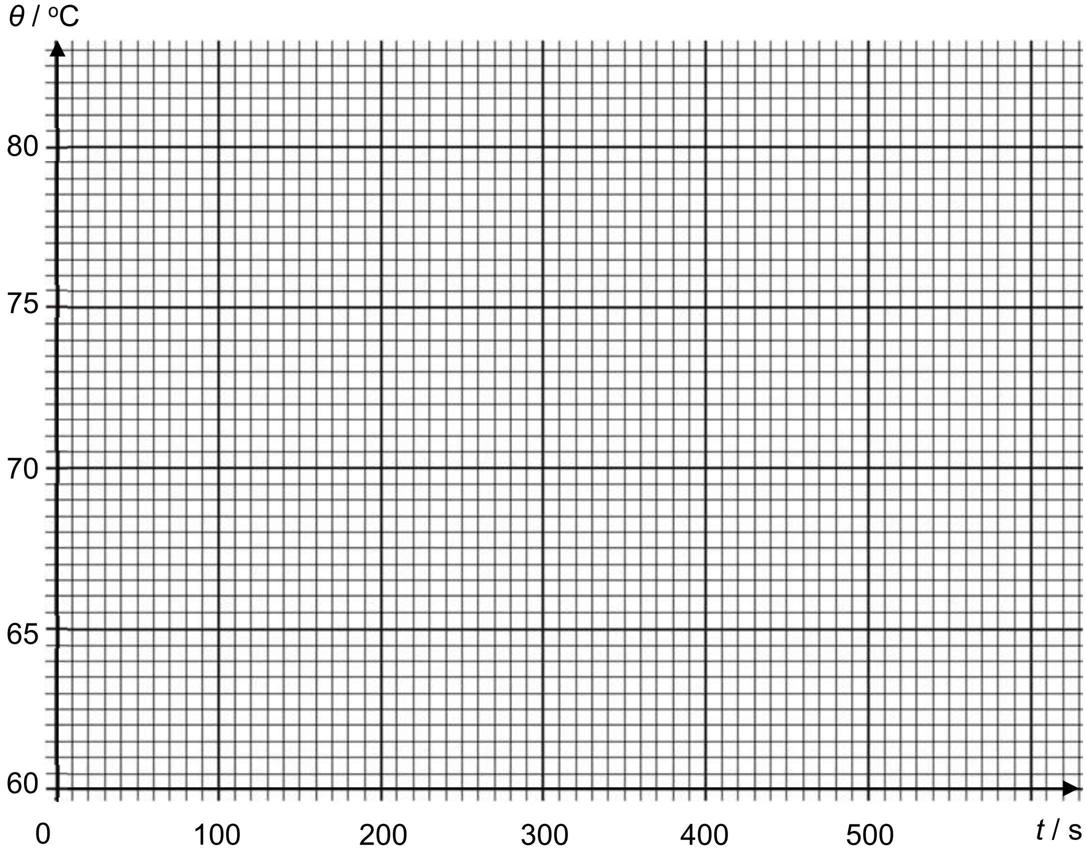
2 **(a)** **(i)** Measure 100 cm^3 of water, using the measuring cylinder, and pour the water into the beaker provided. Heat the water using the Bunsen burner.

Switch off the Bunsen burner, observe the temperature of the water in the beaker and start the stopwatch when the temperature reaches 80.0 °C. Record the temperature θ at regular intervals as a function of the time t.

Tabulate your readings in the space below.

1	
2	
3	

(ii) Plot a graph of θ against time t. Draw a curve through your points.



4	
5	

(iii) Draw tangent to the curve at θ = 70.0 °C.

6	

(iv) Hence, determine the rate at which the water is losing energy when θ = 70.0 °C, given that the density of water is 1.0 g cm^{-3}, its specific heat capacity is c = 4.2 J g^{-1} K^{-1} and the rate of losing energy is given by

$$P = -mc\frac{d\theta}{dt}$$

where m is the mass of the water.

7	
8	

P = ... J s^{-1}

(b) Insulation is expected to have a significant effect on the rate of energy loss of water.

Explain how you would adapt the experiment to study the effects of insulation. State one challenge you would expect to encounter and how this might be overcome.

....

....

....

....

....

....

....

....

9	
10	
11	
12	

[Total: 12 marks]

3 In this experiment, you will investigate how the resistance *R* of a wide pencil line varies with the length of the line, and use your results to determine the thickness of this line.

(a) You are provided with the outline of three rectangular boxes of length 120 mm and width 6 mm on page 13.

Use the pencil provided to **shade one of the boxes heavily**. **You should try to ensure that the shading is as uniform as possible.** The other 2 boxes may be used if necessary.

Submit the shading with your script at the end of the examination.

(b) Set up the circuit shown in Fig. 3.1. When the probes are in use in the circuit, they must be held by the insulated sections and **not** the exposed metal parts.

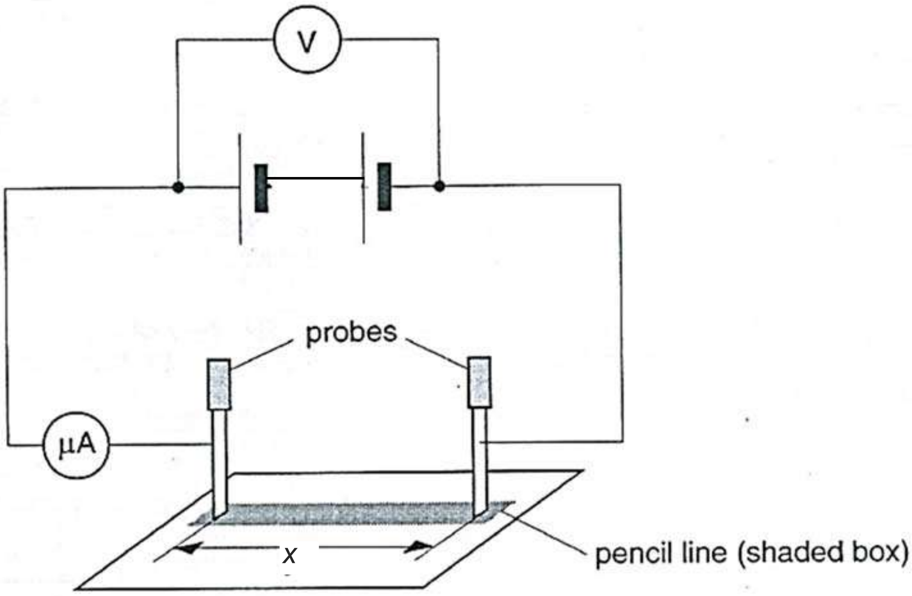


Fig. 3.1

(c) To check the uniformity of the shading:

Placing the probes at different positions on the pencil line at a separation of 40 mm each time. Note the reading of the microammeter in each case. If any of the readings are more than about 10% below the maximum reading, continue shading the parts of the box which give low readings.

(d) **(i)** Place the probes on the pencil line so that their separation x is 80 mm and around the center region of the box.

(ii) Measure and record the current I, potential difference V and separation x.

I = ... A

V = ...

x = ...

1	
2	
3	

(iii) Estimate the percentage uncertainty of current I.

Percentage uncertainty = …………………………

4	

(iv) Determine the resistance R and its corresponding uncertainty.

5	
6	
7	
8	

R = ………………. ± …………….. Ω

(e) Theory suggests that

$$R = \frac{\rho x}{A}$$

where ρ is the resistivity of pencil lead = 1.5×10^{-4} Ω m and A is the **cross-sectional area (normal to the current)** of the pencil line.

(i) Using **(d)(iv)**, determine a value for *A*.

A = ... m^2

9	

(ii) Hence calculate the thickness of the line.

thickness = ...

10	

(iii) Given that atomic diameters are of the order of 10^{-10} m, use your answer in **(e)(ii)** to estimate how many atoms could be placed on top of each other to make up the thickness of the pencil line.

number of atoms = ...

11	

[Total: 11 marks]

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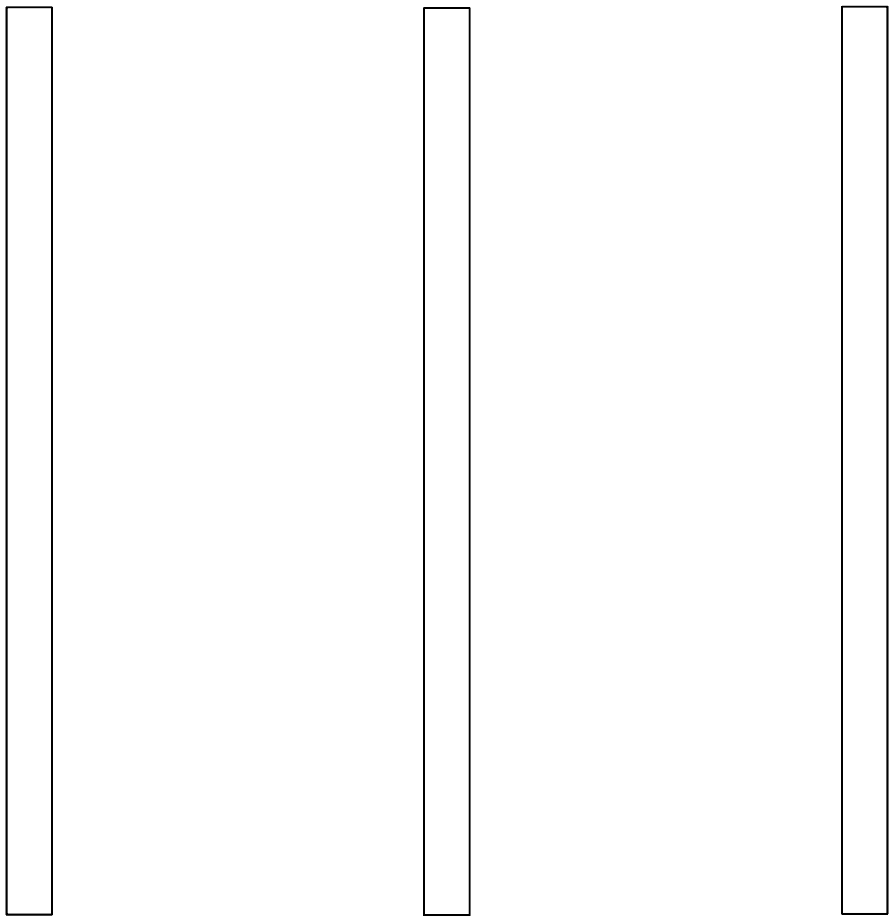
NAME : ………………………………………….. **CLASS: …………….**



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C

NAME | | CLASS | 17S | SCORE |

4 Turbidity is a measure of the degree of cloudiness in water. Clear water has low turbidity while muddy water has high turbidity. The various methods to measure turbidity involved the determination of how much a beam of light is scattered off its incident path.

The turbidity of a liquid is reflected by a scattering ratio μ, where

$$\mu = 1 - \frac{\text{Intensity of light that passaged through liquid}}{\text{Intensity of light that passaged through air}}$$

A turbid suspension can be made by adding talcum powder to water. You are also provided with a transparent glass cylinder (height 50cm), a handheld laser pointer and a light dependent resistor (LDR) with its intensity calibration curve.

Design a laboratory experiment to investigate the relationship between the scattering ratio μ and mass of suspended particulates (talcum powder) per unit volume, *m*.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to the following:

(a) the equipment you would use,

(b) the procedure to be followed,

(c) the method to determine μ,

(d) the control of variables,

(e) how the data will be analysed,

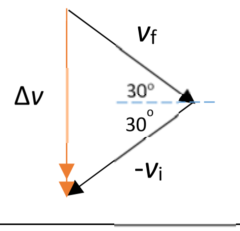
(f) any precautions that would be taken to improve the accuracy and safety of the experiment.

[12]

Diagram:

Hwa Chong Institution

2018 Prelim C2 H2 Paper 1 Suggested Solution

Qn	Ans	Explanation
1	**D**	A quantity is defined with quantities and not units.
2	**D**	Distance travelled by ball $s_b = 0 + \frac{1}{2}(9.8)t^2$, Distance travelled by elevator $s_e = 0 + \frac{1}{2}(5.8)t^2$, $2.0 = \frac{1}{2}(9.8)t^2 - \frac{1}{2}(5.8)t^2 \quad \Rightarrow t = 1.00$ s
3	**C**	$\theta = tan^{-1}\frac{60}{170}$ Consider horizontal motion: $t = \frac{s_x}{u_x} = \frac{170}{300\,cos\,\theta} = 0.60$ s
4	**C**	Change in momentum = mass x change in velocity. Change in velocity = final velocity – initial velocity. However, velocity is a vector and vectors cannot be “simply” subtracted. Thus, the subtraction has to be changed into an addition: $\Delta v = v_f - v_i = v_f + (-v_i)$. From the vector addition diagram, since $\lvert v_f \rvert = \lvert v_i \rvert = \lvert u \rvert$ $\Delta v = 2u \sin 30^o = u$ $\Delta p = m\,\Delta u = mu$ 
5	**A**	When the truck is **empty**, by Newton’s second law, $F_{net} = m\,a$ (-70 000) = (5 000) a a = (-70 000) / (5 000) = -14.0 m s^{-2} $t_1 = (v - u) / a$ = (30 – 50) / (-14.0) = 1.43 s. When the truck is **full**, by Newton’s second law, $F_{net} = m\,a$ (-70 000) = (5 000 + 1 300) a a = (-70 000) / (6 300) = 11.1 m s^{-2} $t_2 = (v - u) / a$ = (30 – 50) / (11.1) = 1.80 s. The difference $(t_2 - t_1)$ = 1.80 – 1.43 = 0.37 s.

6	**D**	The equation is for the conservation of linear momentum in the vertical direction.
7	**A**	Pressure at the boundary between the oil and water in the left arm is the same as the pressure at the same height due to water on the right arm. $30.0\rho_{oil}g = (30.0 - x)\rho_{water}g \Rightarrow x = 4.5$ cm
8	**C**	By conservation of energy, work done by the force W = gain in kinetic energy ΔK $\frac{\Delta K'}{\Delta K} = \frac{W'}{W} = \frac{(2F)(2x)}{Fx} = 4 \Rightarrow \Delta K' = (4)(6\text{J-}2\text{J}) = 16$ J New kinetic energy $K' = 16 + 2 = 18$ J
9	**B**	Area under the F – x graph = work done by force. The work done keeps increasing until the force becomes negative.
10	**B**	When maximum friction force is experienced for each of the discs: For m: $friction, f = mr\omega_1^2$, where ω_1 is the angular velocity just as disc slips off $\omega_1^2 = \frac{f}{mr}$ For 2m: $friction, (2f) = (2m)(2r)\omega_2^2$, where ω_2 is the angular velocity just as disc slips off $\omega_2^2 = \frac{f}{2mr}$ As the angular velocity is gradually increased, it will reach ω_2 before ω_1. Hence the 2m disc will experience maximum friction
11	**C**	Applying conservation of linear momentum to the collision: $mv = (m + M)v_1$ To complete the vertical circle, the speed at the top can just be zero, unlike the case for string. Applying conservation of energy to the top and bottom of the circle: $(m + M)\, g\, (2L) = \frac{1}{2} (m + M)\, v_1^2$ $v_1 = \sqrt{4gL}$ Therefore $v = \frac{(m+M)\sqrt{4gL}}{m}$
12	**C**	For a satellite that is in orbit, the gravitational force provides for the centripetal force, $G\frac{Mm}{r^2} = m\frac{v^2}{r}$ $mv^2 = G\frac{Mm}{r}$ The initial energy is the total energy of the satellite in orbit at radius R $TE_{initial}$ = KE + GPE = $\frac{1}{2}mv^2 - \frac{GMm}{R} = \frac{GMm}{2R} - \frac{GMm}{R} = -\frac{1}{2}\frac{GMm}{R}$ The final energy is the total energy of the satellite at radius $2R$ is

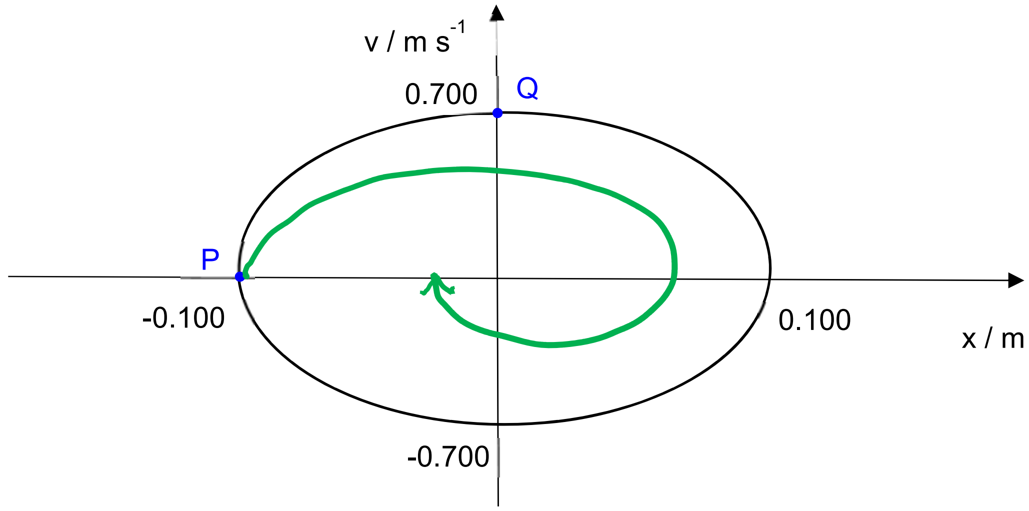
		$$TE_{final} = -\frac{1}{2}\frac{GMm}{2R}$$ Energy needed = final energy – initial energy $$= -\frac{1}{2}\frac{GMm}{2R} - \left(-\frac{1}{2}\frac{GMm}{R}\right) = \frac{GMm}{2}\left(\frac{1}{R} - \frac{1}{2R}\right)$$
13	**A**	The frictional force is the restoring force. $\sum F = ma = m\omega^2 x$ $5.0 = 0.20 \times (2\pi \times 1.5)^2 x_0$ $x_0 = 0.28$ m
14	**B**	For a closed pipe, the resonant lengths are odd multiples of the shortest length. Taking the ratio of the 2 given lengths 30/18 gives 5/3. Hence 30 is the 5th resonance length while 18 is the third resonance length, and the shortest length is 6 cm. All odd multiples of 6 cm produces resonance.
15	**C**	Since the orders overlap at the same angle: $n_1\lambda_1 = n_2\lambda_2$ $\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{400}{600} = \frac{2}{3}$ Therefore the second order 600 nm is overlapping with the third order 400 nm. Using $d = \frac{n\lambda}{sin\theta} = \frac{2(600 \times 10^{-9})}{sin 30^o} = 2.4 \times 10^{-6}$ m
16	**B**	Initial state, X: P x 1.5 V = n_1RT ----- (1) Y: $\frac{P}{4}$ x V = n_2RT ----- (2) Final state, conserving the mass (number of moles): P' (2.5V) = 1.5PV + $\frac{PV}{4}$ P' = 0.7 P
17	**B**	Heat was removed from it at a constant rate. m(specific heat capacity of liquid)(400 - 300)/(100) = m(specific heat capacity of solid)(300 - 200)/(50) (specific heat capacity of liquid) = 2 X(specific heat capacity of solid)
18	**B**	Since both X and Y are stationary and the mass of X is twice of Y, we can conclude that the charge on X is twice of Y. When the plates are moved further apart, the electric field strength decreases, hence there is a net force acting downwards on both X and Y. Applying Newton's second law: X: 2mg – 2qE = 2ma Y: mg – qE = ma

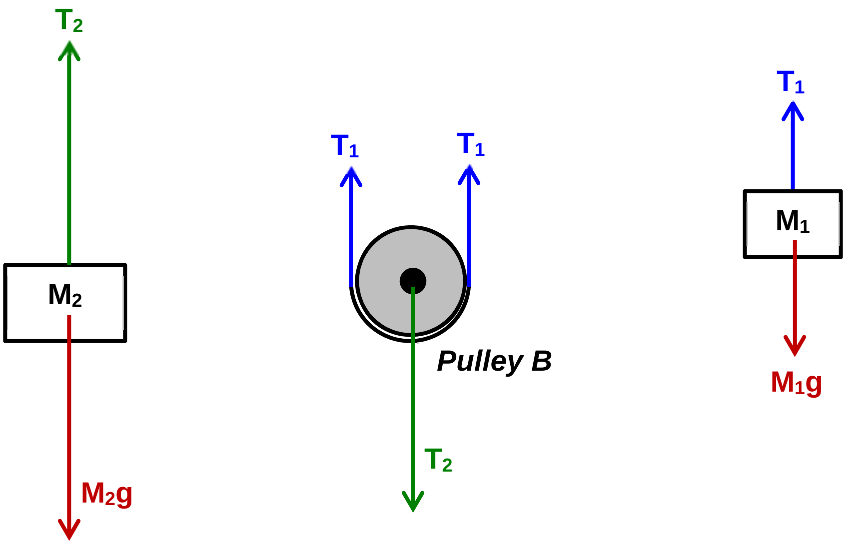
19	**B**	$E = -\frac{dV}{dr}$ As indicated from the slope of the V-d graph, $E_X > E_P = E_Y$
20	**A**	The more the number of parallel connections for the resistors, the lower is the resistance. Short-circuiting any resistance will also reduce the net resistance.
21	**A**	If only the filament of the fifth bulb has broken, the voltmeter will register a non-zero voltage across the transformer.
22	**A**	Since the force on the coil is given by $F = B_{\perp}IL$, the force is constant even as the coil rotates hence the torque is also a constant.
23	**B**	Magnetic flux linkage is given by $\Phi = NBAsin60°$
24	**C**	From the perspective of the copper disc, the magnet seems to rotating so by Lenz's law, in order to 'oppose' the change (which in this case is the rotation of the magnet), the disc will tend to rotate in the same direction as the magnet (so that the magnet will appear 'stationary' from the disc's perspective)
25	**D**	Since transformer has turn ratio of 2, secondary voltage is 240V. Hence power consumed is $P = \frac{(240)^2}{8} = 7200W$ Since transformer has efficiency of 0.75, power drawn from a.c. supply is $P_{ac} = \frac{7200}{0.75} = 9600W$ Hence current in primary coil is given by $I = \frac{P_{ac}}{V} = \frac{9600}{120} = 80A$
26	**B**	Since $P{\sim}V^2$, if kettle is connected to mains voltage that is half the recommended value, its power consumption will be only a quarter, ie 0.5kW. Hence energy consumed in 1.5h is 0.75 kWh.
27	**B**	When p.d. across E and F are zero, the electrode with a lower work function will emit more electrons upon illumination – electrode F. When there is a net electron flowing from F to E, a current flows from E to F will be positive in graph. To have a zero current, the voltage of electrode F with lower work function should be made more positive with respect to electrode E; i.e. voltage of E with respect to F is negative when current is zero.
28	**D**	ΔE = [$hc/(60X10^{-12})$ - $hc/(70X10^{-12})$] / (1.6 $X10^{-19}$) = 3 keV
29	**B**	Isotopes have the same number of protons but different number of neutrons. By emitting one α and two βparticles, the number of protons of the element will be conserved (while the number of neutrons changes).
30	**A**	Initially: P + Q = 800 After 120 min, ¼ P + 1/16 Q = 80 Therefore P = 160

Hwa Chong Institution

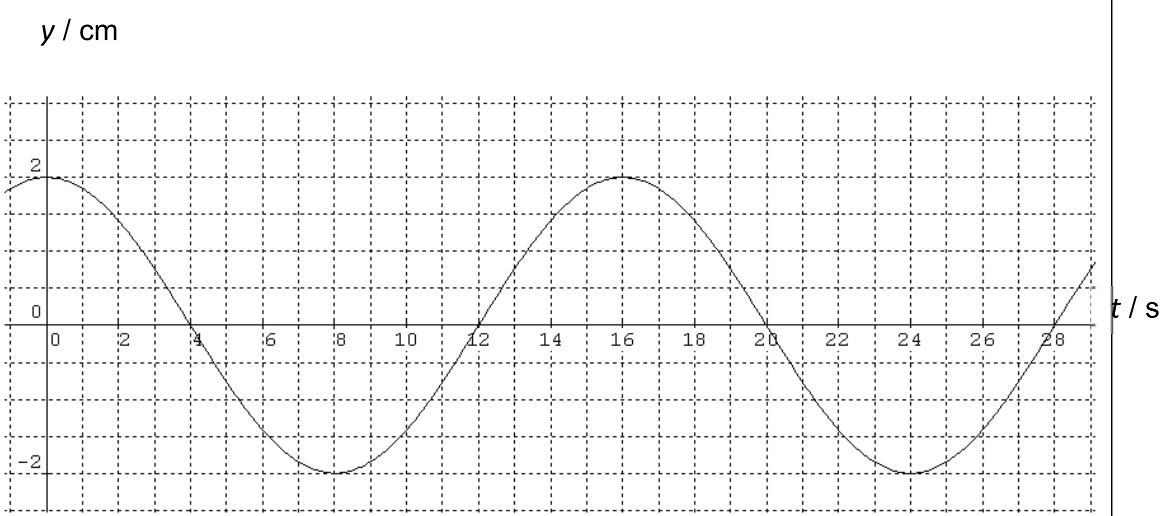
2018 Suggested Solution to Prelim H2 Physics Paper 2

Question	Answer	Marks
1(a)(i)	Loss in gravitational potential energy $\Delta GPE = mg\Delta h$ = (0.400) (9.81) (0.200) = **0.785 J**	 1
(a)(ii)	<u>Method 1:</u> By Newton's second law, taking upwards as positive, $F_{net} = m a$ $F_{spring} - W = 0$ $k x = m g$ $k = m g$ = (0.400 x 9.81) / (0.200) = **19.62 N m^{-1}** The elastic potential energy stored $\Delta EPE = ½ k x^2$ = ½ (19.62) (0.200)^2 = **0.392 J** <u>Method 2:</u> In equilibrium, the spring force is equal to the weight of the object, $F_{spring} = W$ $k x = m g$ $k = m g$ = (0.400 x 9.81) / (0.200) = **19.62 N m^{-1}** The elastic potential energy stored $\Delta EPE = ½ k x^2$ = ½ (19.62) (0.200)^2 = **0.392 J**	 1 1 1 1
(b)	The difference is **work done against the external force** needed to support the mass while lowering it gently. This force is the **difference between the mass's weight and the tension in the spring**. OR A **variable external upward force is required** when the spring mass is stretched gently downwards towards its equilibrium point. Thus **some gravitational potential energy is lost due to the negative work done by the external force**, while the remainder is converted to elastic potential energy.	1 1
(c)(i)	Angular frequency of mass-spring system $\boldsymbol{\omega = \sqrt{k/m} = \sqrt{19.62/0.400}}$ = **7.00 rad s^{-1}** Maximum speed $v_0 = \omega x_0$ = 7.00 x 0.100 = **0.700 m s^{-1}**	 1 1
(c)(ii) & **(iii)**	Both P and Q are labelled correctly (indicated with a dot or a cross) Correct axes labels of v_{max} and amplitude. A curve starting at a displacement of -0.100 m and spiralling with smaller v and x in clockwise direction.	1 1 1

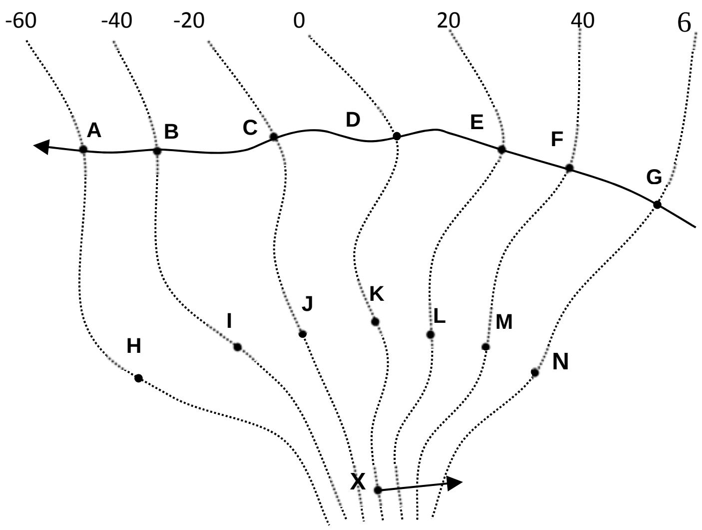
		
	Max Marks	**10**

Question	Answer	Marks
2(a)	The **total** linear momentum of a system is conserved if **no net external force** acts on the system.	1
2(b)(i)	 $T_1 = M_1g = (4.0)(9.81) = $ **39.2 N** $T_2 = M_2g = (8.0)(9.81) = $ **78.5 N**	1 1
(b)(ii)	Since the disturbance is small and the net force on the system can be taken to be zero, hence total momentum remains at zero throughout. $M_1v_1 + M_2(-v_2) = 0$ $v_2 = \frac{1}{2} v_1$ *Note that v is defined as speed in this question (i.e. no negative values for v)*	1 1
(b)(iii)	The disturbance results in the increase of total kinetic energy of the system. Energy introduced $= \frac{1}{2}(4)(v_1^2) + \frac{1}{2}(8)(v_2^2) = \mathbf{3v_1^2}$	1 1
(b)(iv)	There is no change in kinetic energy when the masses were moving at constant speed.	1

	Lost in GPE per unit time of M_1 = $4gv_1$ Gain in GPE per unit time of M_2 = $8gv_2$ = $4gv_1$ Hence the total energy remains the same.	1
	Max Marks	**9**

Question	Answer	Marks
3(a)(i)	Using $I = \frac{P}{4\pi r^2}$ $I = \frac{3.826\times10^{26}}{4\pi(149.6\times10^6\times10^3)^2} = 1360.4\ W\ m^{-2}$ (at least 4 s.f)	1 1
(a)(ii)	• Sun emits light across entire EM spectrum, but the photometer in question detects only visible region • Atmosphere absorbs or reflects some of EM radiation. • Presence of clouds block some of the sunlight. • Angle at which sun's rays strike earth's surface not right angles.	1
(a)(iii)	$I = \frac{P}{A}$ $P_{max} = I_{max}.A = 1360.4(0.0400) = 54.42\ W$ (3 s.f)	1 1
(b)(i)	$y = y_o \cos \omega t$ $y = 0.020 \cos\left(\frac{2\pi}{16}\right)t = 0.020 \cos 0.125\pi t = 0.020 \cos 0.393t$ 1 mark for correct ω	1 1
(b)(ii)	$\Delta\emptyset = \frac{x}{\lambda}\times 2\pi = \frac{\lambda/4}{\lambda}\times 2\pi$ = 0.50 π rad = 1.57 rad (no units deduct one mark)	1 1
(b)(iii)		

	- negative sine graph (correct shape) - with same period of 16 s - smooth and sinusoidal curve (2 marks) Mark by deduction	
	Max mark	**11**

Question	Answer	Marks
4(a)	A region of space where a charged particle will experience an electric force.	1
(b)(i)	Look out for <u>both</u> 1. field line approximately perpendicular to equipotential lines at the points A, B, C, D,E,F,G. 2. direction of field line. From right to left (higher to lower potential)  	1 1
(b)(ii)	Relative field strength (within the same diagram) is represented by the density of equipotential lines. More/closely spaced equipotential lines represent a stronger field as compared to regions where the equipotential lines are more sparse. Hence the electric field is stronger at X.	1
(b)(iii)	Electric potential energy of -5.0μC at L, $U = Vq$ = (20)(-5.0 x 10^{-6}) = **- 1.0 x10^{-4} J**	1 1
(b)(iv)	**work required by external force (= - work done by the field)** = $(V_f - V_i)q$ $\Rightarrow$ -1.0 x 10^{-4} = $(V_f - 20)$(-5.0x10^{-6}) $\Rightarrow$ V_f = **40 V** Thus, possible points are <u>**F & M**</u>.	1 1
(b)(v)	$F = qE = q\frac{\Delta V}{\Delta x}$ = (-15.0 x 10^{-6})$\left(\frac{20-(-20)}{0.01}\right)$ = **- 0.60 N** (1s.f)	1 1

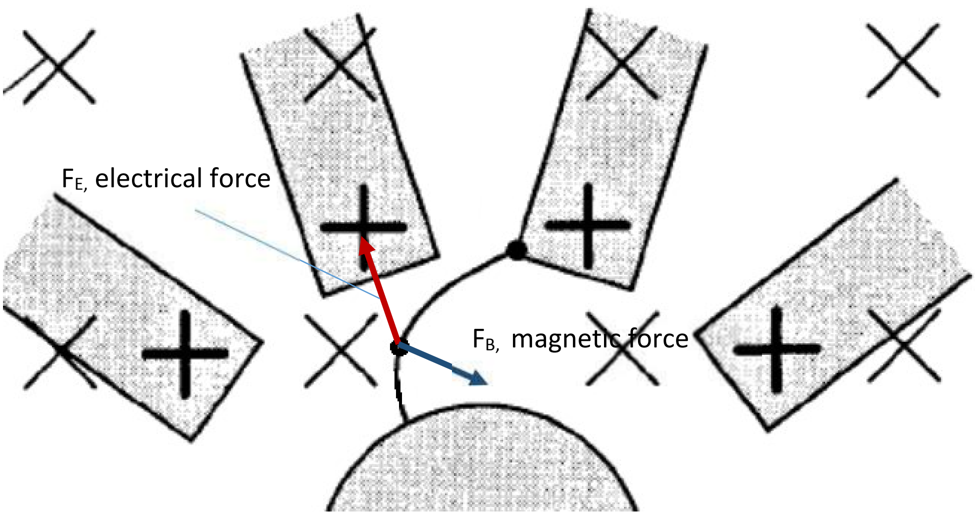
	(-ve sign indicates *F* opposite direction to *E*, which was from right to left. Thus general direction of *F* towards the right, drawn perpendicular to potential line)	1
	Max marks :	**11**

Question	Answer	Marks
5(a)(i)	Reading off graph, at 22.5 °C, R_T = 1600 Ω	1
(a)(ii)	Since p.d. across thermistor, $V_{thermistor}$ = 2.70 V ➔ R_T / (R_T + R) x 9 = 2.70 R = **3730 Ω**	1 1
(b)(i)	Resistance of wire = *ρL / A* = 1.10 x 10^{-6} x 1.20 / [π x (0.250 x 10^{-3})^2] = 6.7227 = **6.72 Ω**	1 1
(c)(ii)	p.d. across XY, V_{XY} = [6.7227 / (6.7227 + 1.50 + 6.20)] x 12.0 = 5.5934 V At balance point, p.d. across thermistor = p.d. across XJ = 2.70 V Therefore, XJ = 2.70 / 5.5934 x 1.2 ➔ XJ = **0.579 m**	1 1
(c)(iii)	When the thermistor is placed at a temperature of 0 °C, the resistance of thermistor increases and hence the potential difference across thermistor will increase. As such, the balance point J will be closer to Y.	1 1
(c)(iv)	When the external resistor becomes smaller in value, by potential divider principle, the potential difference across XY becomes larger. As such, the balance point J will be closer to X.	1 1
	Max Marks	11

Question	Answer	Marks
6(a)(i)	Binding energy is defined as the amount of energy required to separate a nucleus into its individual protons and neutrons or nucleons.	1
6(a)(ii)	At *A*=170, BE/*A* ~ 8.10 MeV (between 8.10 to 8.30 MeV) BE of $^{170}_{77}$Ir = (8.10 to 8.30) x 170 = 1377 MeV to 1411 MeV	1
6(a)(iii)	$B.E = \Delta mc^2$ $\Delta m = \frac{BE}{c^2} = \frac{1377\times10^6\times1.6\times10^{-19}}{(1.66\times10^{-27})(3\times10^8)^2} = 1.475$ u 1377 MeV to 1411 MeV →1.475 u to 1.515 u	1 1

6(b)(i)	Mass Defect = (3 x 4.002603 – 12.000000) u Energy released $E = \Delta mc^2$ $= 0.007809 \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$ $= 1.17 \times 10^{-12}$ J	1 1
6(b)(ii)	After this point, after nickel, the total binding energy of the reactants exceeds that of the products, so no net energy would be released after the reaction.	1
	Max Marks	**7**

Question	Answer	Marks
7(a)(i)	To prevent microwaves/(em) radiation from leaking/escaping **out**/exiting of the cage/microwave oven.	1
(a)(ii)	From the passage, by international convention, wavelength of microwave oven used is given by 2.45 GHz. Wavelength of the microwave = $3.00 \times 10^8 / 2.45 \times 10^9$ Hz = 0.122 m 100 times smaller than 0.122 m or 12.2 cm = 1.22×10^{-3} m or 0.0012 m. Value should be less than 0.00122 m but large enough so that food to be cooked can be viewed through the metal grids e.g. 0.001 m. [M1] mark is awarded for using the information of 2.45 GHz for microwave oven. [A1] spacing < 1/100 of the wavelength of the microwave. First M1 mark must be correct before second mark is given. [-1] Powers of Ten error for conversion of GHz	M1 A1
(b)(i)	Potential difference across the electrodes = 5000 V By conservation of energy, Kinetic energy gained = electrical potential energy loss = (5000)(1.6×10^{-19}) = 8.0×10^{-16} J	1
(b)(ii)	$P = (\text{Energy of the electron}) \times (n/t)$ Each electron has available max. 8.0×10^{-16} J energy (assuming that the electrons start off from cathode with negligible kinetic energy) to be converted to microwave. Least number of electrons per second $= \dfrac{1000 \text{ W}}{8.0 \times 10^{-16}} = 1.25 \times 10^{18}$ (Allow value calculated from (b)(i)) Alternative method: P = IV ⇒ I = 1000 / (5.00×10^3) = 0.200 A I = Q/t = (n/t) (1.60×10^{-19}) = 0.200 A	1

	n/t = 0.200 / (1.60 x 10^{-19}) = 1.25 x 10^{18}	
b(iii)	Not all the (kinetic) energy of the electrons is converted into the **energy of the microwaves** as : • Electrons gives off e.m. radiation of varying wavelengths as it accelerates towards the anode and hence actual energy possessed by electrons are lower when reaching the anode. • some electrons hit the anode, some of its kinetic energy is also converted to heat energy / passed to the molecules (or atoms) in the anode causing thermal agitation/ converted to so less energy is available for conversion to microwave energy Not all the microwaves generated from the energy is fed into the cavity resulting in energy losses due to : • the walls in the cavity of the food chamber may absorb some of the microwave, • microwaves may be fed back / coupled back to the magnetron (resulting in actual useful power of microwave less than the actual energy that can be supplied by the electrons). Answer related must be relate back to the efficiency of **conversion of energy of the electrons to the power output of the microwave; or lost in microwave produced fed into cavity**	1
(b)(iv)1.	 Correct direction of F_E drawn and labelled. (// to electric field line towards anode, see Fig. 7.3 for the electric field between the anode and cathode.) Correct direction of F_B drawn and labelled. (The velocity of the electron should be tangent to trajectory. Apply Fleming's left hand rule to get direction, towards centre of "circular motion" and perpendicular to trajectory) [-1] if F_E and F_B is not defined. Ignore weight if labelled. (Weight is insignificant to the electrical and magnetic forces)	1 1
(b)(iv)2.	As the magnetic force on the electron is acting perpendicular to its motion, (no work is done by the magnetic force on the electron), hence it does not affect the speed of motion as it moves towards the anode. Hence the maximum kinetic **gained** remains unchanged.	1 1

(c)(i)	(table below) Values computed correctly and should follow the same d.p and s.f. of the relevant column	1

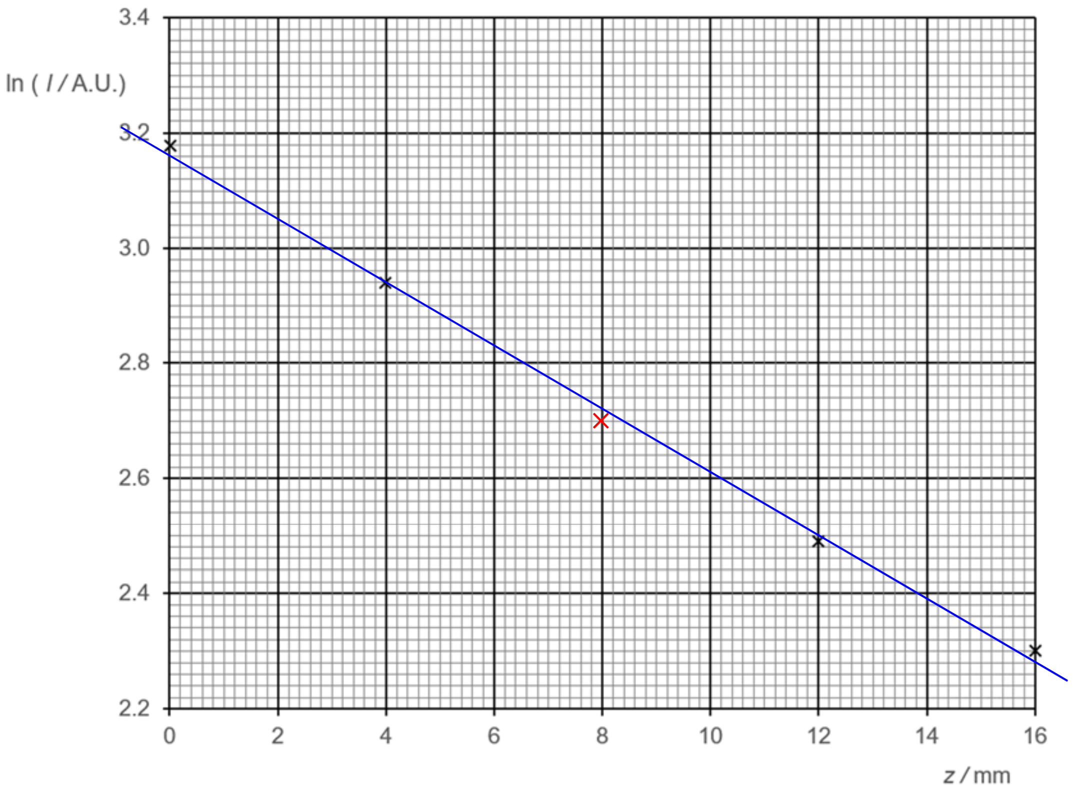
depth into food z / mm	intensity of microwaves at depth z I / A.U.	ln (I / A.U.)
0	24	3.18
4	19	2.94
8	15	2.71
12	12	2.49
16	10	2.30

Values computed correctly and should follow the same d.p and s.f. of the relevant column

(c)(ii)

1.

2.



1. Plot the point accurately to the nearest ½ smallest square. 1
2. Appropriate best fit line drawn. 1

(c)(iii)

Correct computation of the gradient with two points on the best fit line. 1

[-1] if the points are not read to ½ square precision, ½ square off . If more than one square off [0] for whole part. 1

[-1] if the two points chosen are $\Delta z \leq 8$ mm (4 large squares)

No units are required. However if units are incorrect [-1]

E.g. Using (0, 3.16) and (16, 2.28),

$$\text{Gradient} = \frac{3.16 - 2.28}{0 - 16} = -0.055$$

(c)(iv)

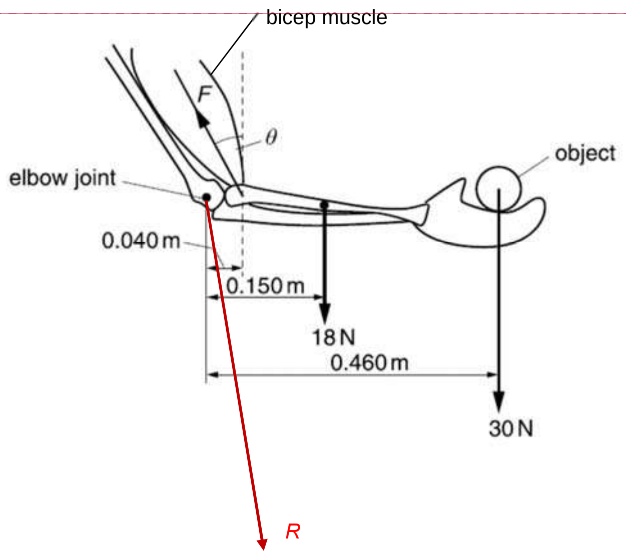
$I = I_o e^{-\mu z} \Rightarrow \ln I = \ln I_o - \mu z$ Hence, gradient of the graph = - μ 1

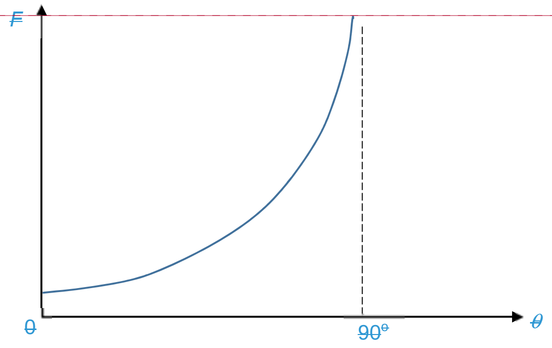
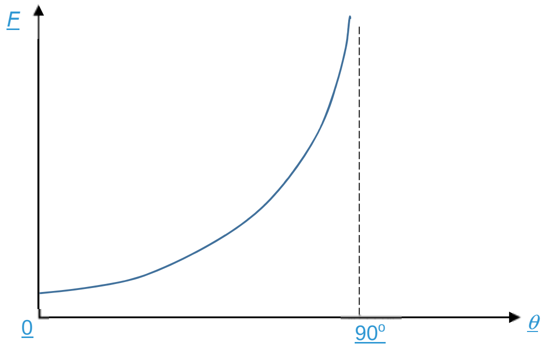
When $z = \delta_p$, $I = I_o/e$ or $\ln(I/I_o) = 1/e$ or $I = 24/e$ 1

	$\Rightarrow \frac{I_o}{e} = I_o e^{-\mu\delta_p}$ $\Rightarrow \delta_P = 1/\mu$ = 1/0.055 = 18.1 mm	1
(c)(v)1.	The potato mash with a higher water content would have more of the microwave (energy) **absorbed at the surface/** more microwave absorbed per unit length/per unit volume by the water molecules the microwave moves through the food, **(**the intensity of the microwaves will then fall to 1/e of its intensity at the surface in a shorter depth). causing the penetration depth to be smaller.	1 1
(c)(v)2.	N – straight line graph with y-intercept unchanged, gradient is steeper. graph must be coherent with conclusion of penetration depth obtained earlier. [This mark is allocated on the page of the graph grids]	1
	Max mark	**21**

Hwa Chong Institution

2018 C2 Prelim H2 Physics Paper 3 Suggested Solution

Qn 1	Answer	Marks
(a)	It is the point where the weight appears to act. Do not accept: "The point where gravity acts" or "point where mass acts/is concentrated"	B1
(b)	Taking moments about the elbow joint, ~~$(F\cos 15.0°)(0.040) = (18)(0.150) + (30)(0.460)$~~ $(F\cos 15.0°)(0.040) = (18)(0.150) + (30)(0.460)$ $\Rightarrow F$ = 427 N	M1 A1
(c)(i)	 Correct direction of *R*~~, the length of *R* is not marked~~.	A1
(c)(ii)	'The rightward horizontal component of *R* is to balance the leftward horizontal component of *F*. Taking moments about the point the muscle is attached to the bone, the vertical component of *R* needs to act downwards to provide an anticlockwise moment to counter the clockwise moment provided by the 18 N and 30 N forces.' OR 'The rightward horizontal component of *R* is to balance the leftward horizontal component of *F*. The net vertical force due to the weights and tension is upwards, hence the vertical component of R must act~~acts~~ downwards so that there is no net vertical force.' OR 'A vector diagram is draw in scale. Using drawn vector diagram in scale, we can deduce the direction of the force R should point rightward~~leftward~~ and downward.' OR 'The forces of 18 N~~18N~~ and 30 N~~30N~~ can be combined to form one downwards force which should be drawn between the two mentioned forces. Since the forces of *R*, *F* and combined force due to 18 N~~18N~~ and 30 N~~30N~~ should intersect at a point, we can deduce the direction of the force *R* should point leftward and downward.'	B1 B1 B1 B1 B1 B1 B1 B1

(d)(i)	  Curve is sloping upwards and does not start from origin, where its asymptote is at 90°	B1 B1
(d)(ii)	Consider moments about the elbow joint. The perpendicular distance between the elbow and the line of action of *F* decreases or the clockwise moment due to the18 N and 30 N forces remain the same and *F* cos θ (or vertical component of *F*) hence remains the constant. Hence, as θ increase, (cos θ reduces), *F* increases. OR F is inversely proportional to cos θ. When θ approaches 90°, F is infinitely large	A1 A1
	Max Marks	10

Question	Answer	Marks
2(a)	The internal energy is the summation of microscopic kinetic energy due to random motion of the molecules and the microscopic potential energy due to intermolecular forces. One mark will be deducted if any one of the four underlined part is missing.	A2
2(b)(i)	$U = \frac{3}{2}nRT$ $U = \frac{3}{2}(PV)$ $U = \frac{3}{2}(0.5 \times 10^5)(5.0 \times 10^{-3})$ $U = 375$ J	C1 A1

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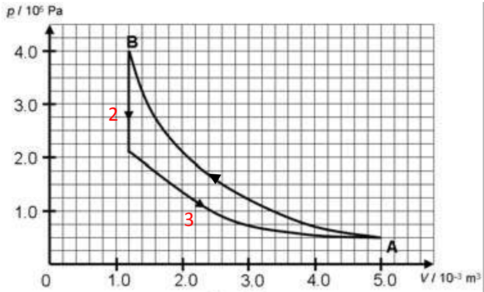
2(b)(ii)	1. Consider process 3 By $PV = constant$ $(0.5\times10^5)(5.0\times10^{-3}) = P(1.2\times10^{-3})$ $P = 2.1\times10^5$ Pa 2.  Fig. 6.2 Vertical line for process 2 curve for process 3 point of intersection of processes 2 and 3 is at $p = 2.1\times10^5$ Pa processes labelled and arrows included [mark by deduction]	 **M1** **A1** **A3**
	Max Marks	**9**

Question	**Answer**	**Marks**
3(a)	When two or more waves of the same kind overlap, the resultant displacement at any point at any instant is given by the vector sum of the individual displacements that each individual wave would cause at that point at that instant.	**B2**
3(b)	As the reflector moves, the path difference between the direct wave from the source and reflected wave to the detector varies. When the 2 waves meet in antiphase and interfere destructively, the detected intensity is low. When the two waves meet in phase and interfere constructively, the detected intensity is high. Accept for analysis using path difference together with phase change at reflection.	**B1** **B1** **B1**
3(c)(i)	path difference = $\sqrt{2}(5)-5=n(0.59)\Rightarrow n=3.5$ $\sqrt{2}(5)-5=n(0.59)\Rightarrow n=3.5$ Since the path difference is odd multiple of half a wavelength and including the phase change due to the reflection, the waves meet in phase/interfere constructively and the detected intensity is a maximum/high.	**B1** **B1** **B1**
3(c)(ii)	To determine maximum order: maximum path difference = $5=n(0.59)\Rightarrow n=8.5$ $5=n(0.59)\Rightarrow n=8.5$ The intensity alternates from maximum to minimum to maximum 5 times.	**B1** **B1** **B1**
	Max Marks	**11**

Question	**Answer**	**Marks**

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4(a)(i)	~~$\frac{1}{2}(6.2-5.8)=0.2$ m~~ $\frac{1}{2}(6.2-5.8)=0.2$ m	A1
4(a)(ii)	Since θ is small, ~~$\theta=\frac{y}{L}$~~ $\frac{\Delta\theta}{\theta}=\frac{\Delta y}{y}+\frac{\Delta L}{L}$ $\theta=\frac{y}{L}$ $\frac{\Delta\theta}{\theta}=\frac{\Delta y}{y}+\frac{\Delta L}{L}$ percentage uncertainty of separation y = ~~$\frac{0.5}{2.0}\times100\%=25\%$~~ $\frac{0.5}{2.0}\times100\%=25\%$ or 30% (1 sf) Average L = ~~$\frac{6.2+5.8+6.1+5.9+6.1}{5}=6.0$ m~~ $\frac{6.2+5.8+6.1+5.9+6.1}{5}=6.0$ m percentage uncertainty of distance L = ~~$\frac{0.2}{6.0}\times100\%=3\%$~~ $\frac{0.2}{6.0}\times100\%=3\%$ The percentage uncertainty of y is almost 10 tens that of L, hence I agree that the uncertainty in L can be ignored.	M1 M1 A1
4(a)(iii)	Since θ is small, ~~$\theta=\frac{y}{L}=\frac{0.0020}{6.0}=0.000333$ rad~~ $\theta=\frac{y}{L}=\frac{0.0020}{6.0}=0.000333$ rad Method 1: From (c)(ii) the %uncertainty of L can be ignored. ~~$\frac{\Delta\theta}{\theta}=\frac{\Delta y}{y}\Rightarrow\Delta\theta=0.25\times0.000333=0.00008$ rad (1 s.f.)~~ $\frac{\Delta\theta}{\theta}=\frac{\Delta y}{y}\Rightarrow\Delta\theta=0.25\times0.000333=0.00008$ rad (1 s.f.) Therefore: 0.00033 ± 0.00008 rad Method 2: $\theta_{max}=\frac{y_{max}}{L_{min}}=\frac{0.0025}{5.8}$ ~~$\theta_{min}=\frac{y_{min}}{L_{max}}=\frac{0.0015}{6.2}$~~ $\Delta\theta=\frac{\theta_{max}-\theta_{min}}{2}=0.00009$ rad (1 s.f.) $\theta_{max}=\frac{y_{max}}{L_{min}}=\frac{0.0025}{5.8}$ $\theta_{min}=\frac{y_{min}}{L_{max}}=\frac{0.0015}{6.2}$ $\Delta\theta=\frac{\theta_{max}-\theta_{min}}{2}=0.00009$ rad (1 s.f.) Therefore: 0.00033 ± 0.00009 rad Accept both cases where uncertainty in L is included and excluded.	B1 B1 A1

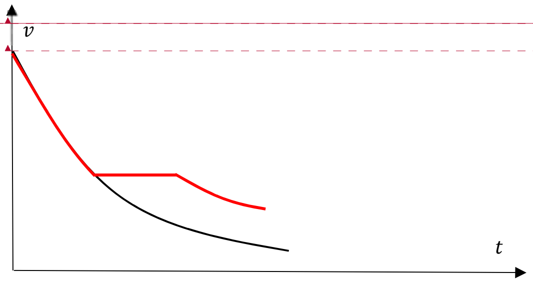
4(b)(i)	The first minimum of pattern 1 coincides with the central maximum for pattern 2	B1
	for the 2 patterns to be just distinguishable.	B1
4(b)(ii)	$\theta = \frac{\lambda}{b} = \frac{700\times10^{-9}}{3\times10^{-3}} = 2\times10^{-4}$ rad $\theta = \frac{\lambda}{b} = \frac{700\times10^{-9}}{3\times10^{-3}} = 2\times10^{-4}$ rad	C1 A1
	Max Marks	11

Question	Answer	Marks
5(a)(i)	Kinetic energy, KE is positive	A1
	Electrical potential energy, EPE is negative	A1
(a)(ii)	Since the electron is orbiting, it means that it is 'confined' to the vicinity of the proton and could not escape on its own.	B1
	Hence the magnitude of KE is less than that of EPE. Since the total energy of the system E is the sum of its KE and EPE, E must be a negative number.	B1
(b)(i)	If the position of the electron at each location is known exactly, by HUP, there is huge uncertainty in its momentum or vice versa.	M1
	Hence the path cannot be well defined if either the position or momentum are unknown.	A1
(b)(ii)	The maximum total energy for the system is zero.	
	TE = EPE + KE = 0	B1
	KE = - EPE = $-\left(\frac{-e^2}{4\pi\varepsilon_0 R}\right) = \frac{e^2}{4\pi\varepsilon_0 R}$ KE = - EPE = $-\left(\frac{-e^2}{4\pi\varepsilon_0 R}\right) = \frac{e^2}{4\pi\varepsilon_0 R}$	B1
	Max Marks	8

Question	Answer	Marks
6(a)	circle unit, N	A3
	circle units, N m^{-2}	
	circle 10, 1000	
6(b)	The advancement in Science will require better precision at the realm of the very small objects. The physical sample has its associate uncertainty in mass. Any mass measuring instrument calibrated from it will inherit this uncertainty. When that mass measuring instrument is measuring very small masses, the percentage uncertainty in mass will increase with the decreasing mass measured.	A1
6(b)(i)	Using Fleming's left hand rule: left to right	A1
6(b)(ii) 1.	The free electrons in the rod move together with the rod as the rod moves upwards. The electrons experience a magnetic force as they move through the magnetic field.	B1
	This force causes the electrons to move to one end of the conductor, leaving a net positive charge on the other end, setting up a potential difference between the ends of the conductor.	B1
	OR	
	As the rod moves upwards, it cuts the magnetic flux or the associated magnetic flux linkages changes.	
	By Faraday's law, an e.m.f.emf (that is proportional to the rate of cutting of magnetic flux) will be induced across the two ends of the rod.	
6(b)(ii) 2.	At equilibrium, the magnetic force on the charge is balanced by the electric force due to the internal electric field set up at the two ends.	B1

	$F_B = F_E$ $Beu = eE = e\frac{V}{L}$ $V = BLu$ OR $V = \frac{d\Phi}{dt} = \frac{d(BLx)}{dt} = BLu$ where x is the change in position of conductor in time dt.	B1
6(b)(iii)	$m = \frac{BIL}{g}$ [from (c)(i)] $= \frac{VIL}{Lug}$ [substitute B using (c)(ii)] $= \frac{\frac{hC}{2e} \times \frac{kne}{2}}{ug}$ $= \frac{nCk}{4ug}h$	B1 A1
	Max Marks	11

Question	Answer	Marks
7a	There is a magnetic flux of 1 **weber** through a surface if a magnetic field of flux density of 1T exists perpendicularly to an area of 1 m^2	B1 B1
7bi	As AB moves from P towards Q, magnetic flux linkage over the area ABCD enclosed by the frame increases resulting in an induced e.m.f. generated in the frame By Lenz's Law, an induced current flows in the anticlockwise direction. This results in a magnetic force that acts on AB towards the left. Alternative: As AB enters the magnetic field, magnetic force acts on the electrons in AB driving them in a clockwise direction around the rectangular frame. The induced current flowing anti-clockwise in the frame results in a magnetic force that acts on AB towards the left.	B1 B1 B1 B1 B1 B1
7bii	The magnetic flux (linkage) is given by $\Phi = BA = B(wx)$ where *x* is the distance AB has moved past P. Hence the induced emf is given by $E = \frac{d\Phi}{dt} = Bw\frac{dx}{dt} = Bwv$	B1 B1
7biii	Induced current is thus $I = \frac{Bwv}{R}$ The braking force that acts on AB is thus $F = -BIw = -\frac{B^2w^2v}{R}$ And the acceleration given by $a = \frac{F}{m} = -\frac{B^2w^2v}{mR}$ OR applying *P* = *Fv*	B1 B1 B1
7ci	Distance 2*L* = Area under *v* – *t* graph = ½ (26 + 16 x 2 + 10 x 2 + 6 x 2 + 3.5)(5) = 233.75 m Range (211, 257) m	B1 B1

	PQ = L = 116.9 m	A1
7cii	The retarding force only acts on the train when there is a changing magnetic flux through the frame. There is no force on the train when the whole frame is within the magnetic field. Increasing the length PQ does not change the exit speed.	M1 A1
7ciii	 Same slope [B1], plateau [B1], takes a shorter time to pass through the field, higher speed as it leaves the magnetic field [B1]	
7civ	To include ***multiple regions of magnetic field*** that can be activated individually when malfunction occurs. Use of electromagnet to generate the magnetic field so that the field can be strengthened by ***increasing the current in the electromagnet*** when malfunction occurs. Do not accept any modifications that relate to the dimensions of the train carriage as it is not possible to vary these during a malfunction.	A1 A1
	Max Marks	**20**

Question	Answer	Marks
8(a)	Every particle attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.	A2
(b)(i)	$a_c = r\omega^2$ $\quad a_c = r\omega^2$ $a_c = (6.37\times10^6)\left(\frac{2\pi}{24\times60^2}\right)^2$ $\quad a_c = (6.37\times10^6)\left(\frac{2\pi}{24\times60^2}\right)^2$ $a_c = 0.0337\text{ m s}^{-2}$ $\quad a_c = 0.0337\text{ m s}^{-2}$	C1 A1
(b)(ii)	$g = \frac{GM}{r^2} = \frac{6.67\times10^{-11}(6.0\times10^{24})}{(6.37\times10^6)^2} = 9.863\text{ m s}^{-2}$ $a_{freefall} = g - a_c$ $a_{freefall} = 9.863 - 0.0337$ $a_{freefall} = 9.83\text{ m s}^{-2}$ $g = \frac{GM}{r^2} = \frac{6.67\times10^{-11}(6.0\times10^{24})}{(6.37\times10^6)^2} = 9.863\text{ m s}^{-2}$ $a_{freefall} = g - a_c$ $a_{freefall} = 9.863 - 0.0337$ $a_{freefall} = 9.83\text{ m s}^{-2}$	B1 A1 A1 A1

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	A small fraction of the gravitational force acted by the earth on any body near the equator is to provide for the centripetal acceleration; at the pole, the centripetal acceleration is zero and the acceleration of free-fall is entirely due to the pull of earth.	
(c)(i)	Gravitational force provides for centripetal force: $\frac{GM_E m}{r^2} = mr\left(\frac{2\pi}{T}\right)^2$ $T^2 = \frac{4\pi^2\left(6.37\times10^6 + 408\times10^3\right)^3}{\left(6.67\times10^{-11}\right)\left(6.0\times10^{24}\right)}$ $T = 5542$ s $T = \frac{5542}{3600} = 1.5$ hr (shown) Gravitational force provides for centripetal force: $\frac{GM_E m}{r^2} = mr\left(\frac{2\pi}{T}\right)^2$ $T^2 = \frac{4\pi^2\left(6.37\times10^6 + 408\times10^3\right)^3}{\left(6.67\times10^{-11}\right)\left(5.97\times10^{24}\right)}$ (Note: use of correct radius) $T = 5556$ s $T = \frac{5556}{3600} = 1.5$ hr (shown) First mark for formulation of relationship Second mark for correct substitution of values and the calculation of the period in seconds.	M1 M1
(c)(ii)	The Kepler's Law holds for scenarios where the gravitational force provides entirely for the centripetal force hence it holds for the satellite in orbit. However, for student on Earth's surface, there are other forces acting on him (normal contact, etc) and the resultant (centripetal) force is not the gravitational force	A1 A1
(c)(iii)	Both astronaut and space station are undergoing circular motion and have the same centripetal acceleration provided by their weights. There is no contact force acting on him by his surrounding and hence he perceived himself to be weightless. Alternative: if a clear account of what true weightlessness mean and how the fact that gravity must have provided the centripetal acceleration, one mark will be awarded.	B1 B1
(d)(i)	**1.** $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{\left(7\times10^{22}\right)\left(1\times10^3\right)} = 9.5\times10^{-60}$ m $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{\left(7\times10^{22}\right)\left(1\times10^3\right)} = 9.5\times10^{-60}$ m **2.** $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{\left(9\times10^{-31}\right)\left(2\times10^7\right)} = 3.7\times10^{-11}$ m $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{\left(9\times10^{-31}\right)\left(2\times10^7\right)} = 3.7\times10^{-11}$ m Both correct – 3 marks One correct – 2 marks Method and substitution correct but answers wrong – 1 mark	B1 A1 A1

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(d)(ii)	For the Moon, its de Broglie's wavelength is very much smaller than the orbital radius. For the electron, its de Broglie's wavelength is comparable to its orbital radius. Thus the wave-like properties for electron cannot be neglected for its motion around the nucleus while that of Moon can be neglected.	**B1** **B1** **B1**
	Max Marks	**20**

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INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS — 9749/01

Paper 1 Multiple Choice

14 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	$= 1.60 \times 10^{-19}$ C
the Planck constant	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton	m_p	$= 1.67 \times 10^{-27}$ kg
molar gas constant	R	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	k	$= 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	G	$= 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	g	$= 9.81$ m s^{-2}

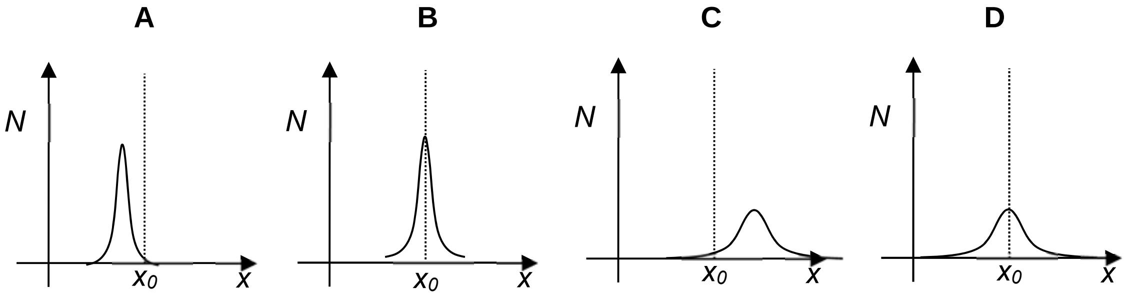
Formulae

uniformly accelerated motion	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on / by a gas	W	$= p\Delta V$
hydrostatic pressure	p	$= \rho gh$
gravitational potential	Φ	$= -\dfrac{GM}{r}$
temperature	T/K	$= T/°C + 273.15$
pressure of an ideal gas	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	$= \dfrac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_0 \sin \omega t$
velocity of particle in s.h.m.	v	$= v_0 \cos \omega t$
		$= \pm\omega\sqrt{\left(x_o^2 - x^2\right)}$
electric current	I	$= Anvq$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	x	$= x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 nI$
radioactive decay	x	$= x_0 \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{½}}$

1 In an experiment, a quantity x is measured many times.

Suppose N is the number of times of measurement which giving a value x and x_0 is the true value of the quantity.

Which of the following graphs best represents measurements of x that are precise but not accurate?



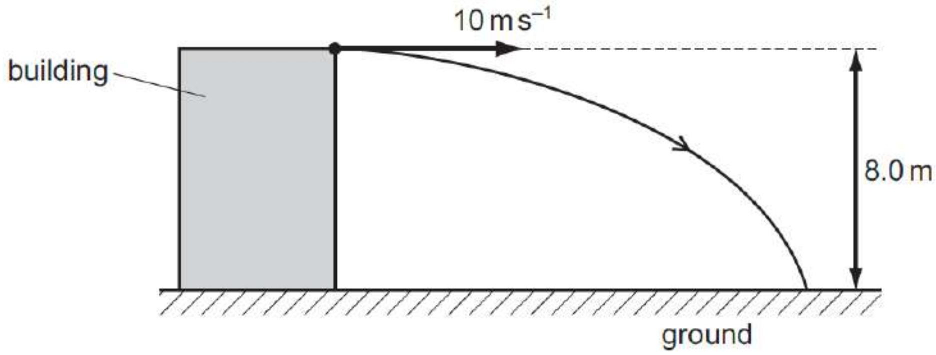
2 A capacitor is a device used to store electric charges. It consists of a pair of conducting plates. The capacitance C of a capacitor is defined as the ratio of the charge Q on either plate to the magnitude of the potential difference V between the plates, as depicted in the formula:

$$C = \frac{Q}{V}$$

Which of the following shows the SI base units for capacitance C?

A $A^2\ s^4\ m^{-2}\ kg^{-1}$ **B** $s^2\ m^{-2}\ kg^{-1}$ **C** $A^2\ m^{-2}\ kg^{-1}$ **D** $C^2\ kg^{-1}\ m^{-2}\ s^2$

3 A boy throws a stone with a horizontal velocity of 10 m s^{-1} from the top of a building. The height of the building is 8.0 m. The stone travels along a curved path until it hits the ground, as shown in the diagram.



Neglecting air resistance, how long does it take the stone to reach the ground?

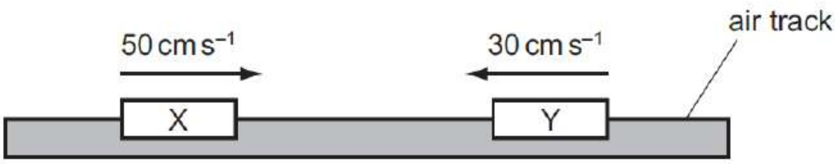
A 0.61 s **B** 0.80 s **C** 1.3 s **D** 1.6 s

4 A firework rocket is fired vertically upwards. The fuel burns and produces a constant upwards force on the rocket. After 5 seconds, there is no fuel left. Air resistance is negligible.

What is the acceleration before and after 5 seconds?

	before 5 seconds	after 5 seconds
A	constant	constant
B	constant	zero
C	increasing	constant
D	increasing	zero

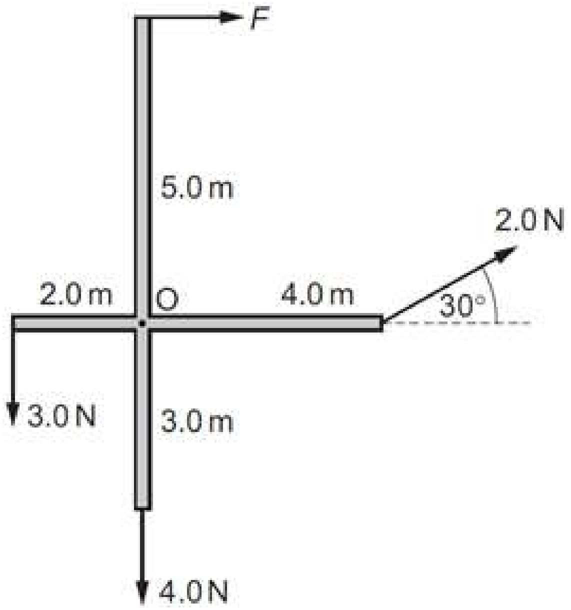
5 Two equal masses X and Y are moving towards each other on a frictionless air track as shown. The masses make an elastic collision.



Which row gives possible velocities for the two masses after the collision?

	velocity of X	velocity of Y
A	zero	20 cm s^{-1} to the right
B	10 cm s^{-1} to the right	10 cm s^{-1} to the right
C	20 cm s^{-1} to the left	zero
D	30 cm s^{-1} to the left	50 cm s^{-1} to the right

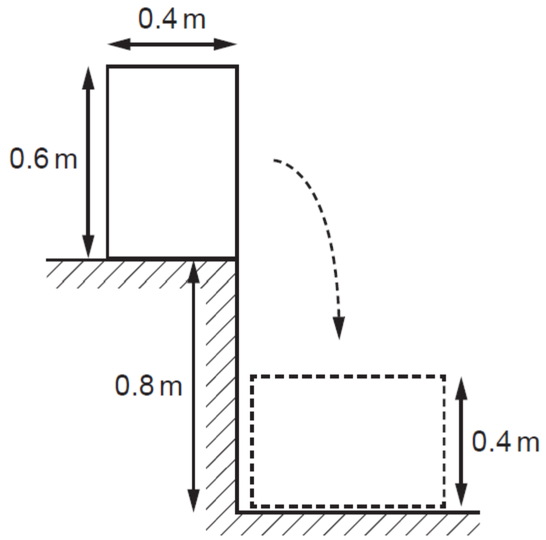
6 A cross-shaped structure, freely pivoted at O, has arms of lengths 5.0 m, 4.0 m, 3.0 m and 2.0 m. It is acted on by forces of 2.0 N, 3.0 N, 4.0 N and an unknown force *F*. The structure is in rotational equilibrium.



What is the magnitude of force *F*?

A 0.40 N **B** 2.0 N **C** 2.6 N **D** 4.4 N

7 A uniform solid block has weight 500 N, width 0.4 m and height 0.6 m. The block rests on the edge of a step of depth 0.8 m, as shown.

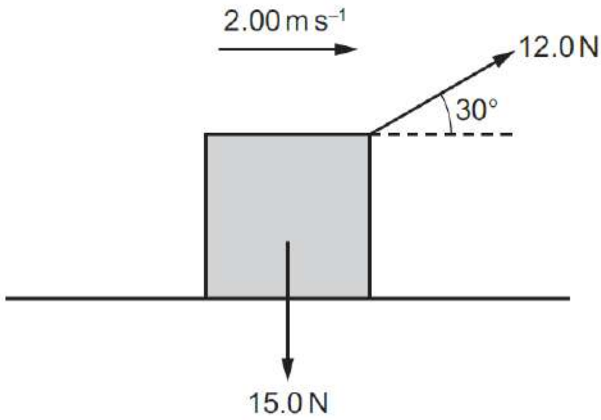


The block is knocked over the edge of the step and rotates through 90° before coming to rest with the 0.6 m edge horizontal.

What is the change in gravitational potential energy of the block?

A 300 J **B** 400 J **C** 450 J **D** 550 J

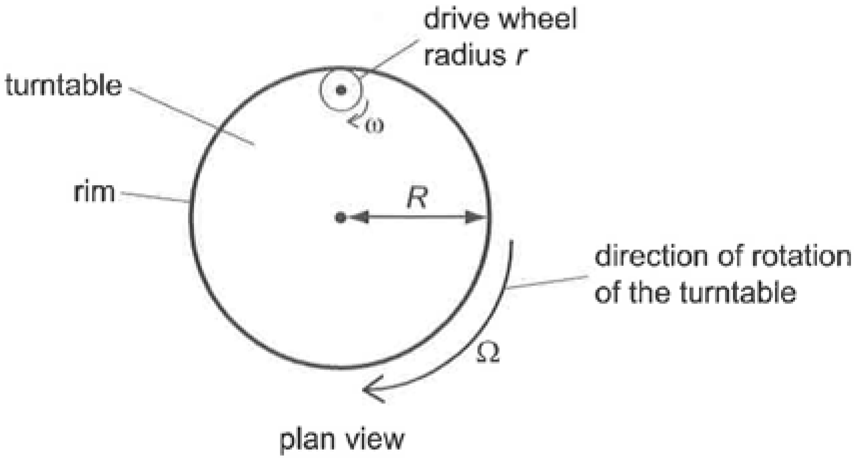
8 An object of weight 15.0 N is pulled along a horizontal surface at a constant velocity of 2.00 m s^{-1}. The force pulling the object is 12.0 N at 30˚ to the horizontal, as shown.



What is the power used to move the object?

A 12.0 W **B** 20.8 W **C** 24.0 W **D** 30.0 W

9 A turntable has radius *R*. It is driven by a rubber drive wheel of radius *r* in contact with the inside of the rim of the turntable, as shown in the plan view diagram.



The turntable rotates with angular velocity Ω and the linear speed of a point on its rim is *V*. The drive wheel rotates with angular velocity ω and the linear speed of a point on its rim is *v*.

Which pair of equations show the relationship between the angular velocities and the linear speeds of the turntable and the wheel?

	angular velocities	linear speeds
A	$\Omega = \omega$	$V = v$
B	$\Omega = \omega$	$V = (r/R)\,v$
C	$\Omega = (r/R)\,\omega$	$V = v$
D	$\Omega = (R/r)\,\omega$	$V = (r/R)\,v$

10 A stationary object is released from a distance 6*R* from the centre of the Earth which has radius *R* and mass *M*.

Which one of the following expressions gives the speed of the object on hitting the Earth?

A $\sqrt{\dfrac{GM}{R}}$ **B** $\sqrt{\dfrac{GM}{5R}}$ **C** $\sqrt{\dfrac{5GM}{2R}}$ **D** $\sqrt{\dfrac{5GM}{3R}}$

11 A satellite is orbiting near the Moon's surface. The acceleration at the Moon's surface due to lunar gravity is *g*/6 and the Moon's radius is *R*/4 (where *g* is the acceleration of the Earth and *R* is the radius of the Earth).

If a satellite orbiting near the Earth's surface has a period of *T*, what is the period of revolution of the Moon's satellite?

A $\dfrac{2}{3}T$ **B** $\sqrt{\dfrac{2}{3}}T$ **C** $\dfrac{4}{9}T$ **D** $\sqrt{\dfrac{3}{2}}T$

12 Two bodies X and Y are in good thermal contact and no net transfer of heat energy from one to the other is observed. Which one of the following statements is certainly correct?

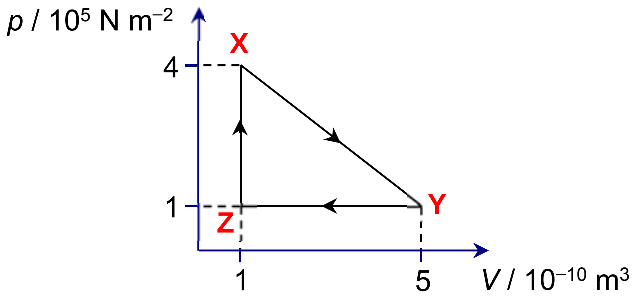
A The mean energies of their molecules are the same.

B The total kinetic energies of their molecules are the same.

C The materials have the same thermal conductivity.

D Their internal energies are equal.

13 A mass of an ideal gas of volume V, at pressure p, undergoes a cycle of changes as shown in the graph.



Which combination is correct?

	work done by gas is negative	heat is
A	Y to Z	added
B	Y to Z	removed
C	X to Y	added
D	X to Y	removed

14 A particle oscillates with undamped simple harmonic motion. Which one of the following statements about the acceleration of the oscillating particle is true?

A It decreases as the potential energy increases.

B It is always in the opposite direction to its velocity.

C It is least when the speed is greatest.

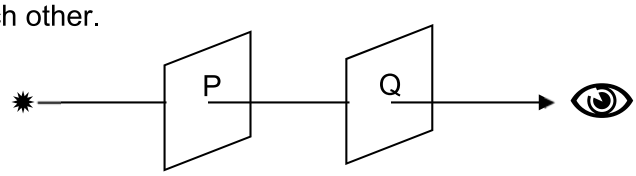
D It is proportional to the frequency.

15 The least distance between two points of a progressive transverse wave which have a phase difference of $\frac{\pi}{3}$ rad is 0.050 m.

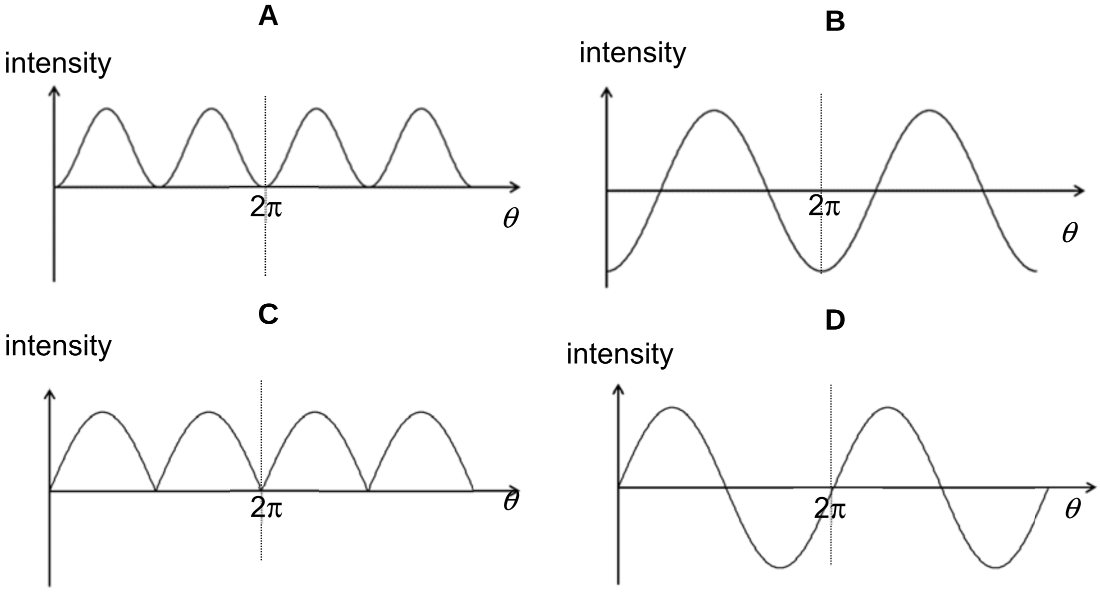
If the frequency of the wave is 500 Hz, what is the speed of the wave?

A 25 m s^{-1} **B** 75 m s^{-1} **C** 150 m s^{-1} **D** 1666 m s^{-1}

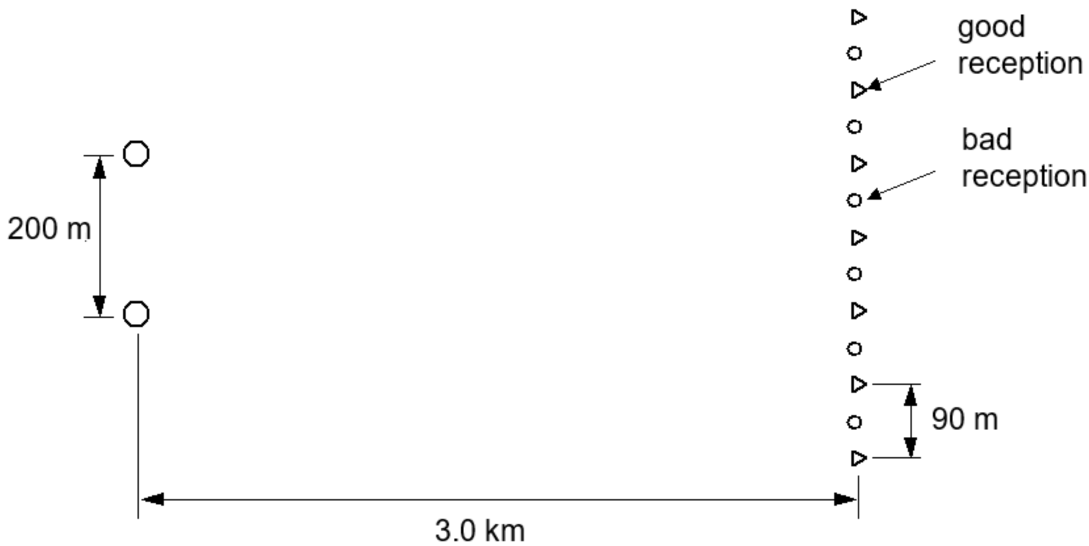
16 A light source is viewed through two pieces of polarizers with their axes initially at ½ π rad from each other.



Which graph correctly shows the variation of intensity reaching the eye with angular displacement of the Q with respect to P when polarizer Q is rotated?



17 Two radio transmitters 200 m apart are transmitting on the same frequency as shown in the diagram below.

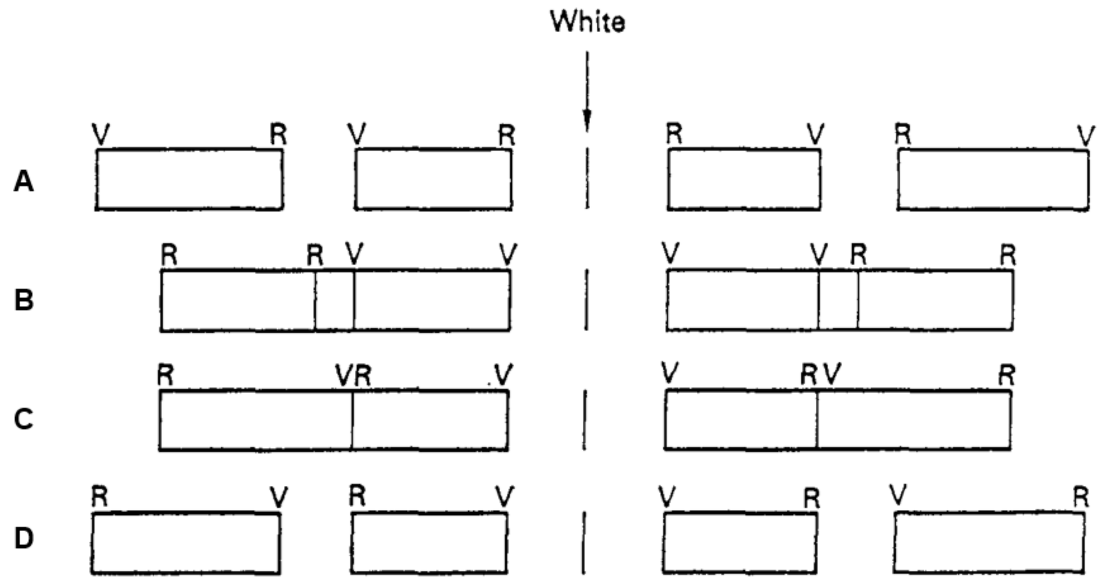


At a distance of 3.0 km away, it was found that there are series of good and poor areas of reception which are 90 m apart. Which one of the following is the wavelength of the radio wave?

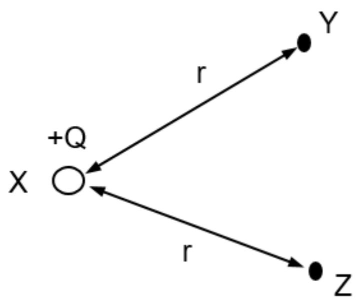
A 0.17 m **B** 6.0 m **C** 670 m **D** 1350 m

18 A narrow shaft of white light (from violet 350 nm (V) to red 700 nm (R)) falls with normal incidence on a diffraction grating, and produces two orders of spectra on a distant screen.

Which of the following diagram shows the appearance of the spectra?



19 The figure below shows a particle of charge +Q at X. The points Y and Z are equidistant from X.



Which one of the following statements with reference to the above figure is **incorrect**?

A No work is done in taking a charge from Y to Z.

B The electric field strength at Z acts along ZX in the direction of Z to X.

C The magnitude of the electric field strength at Y is equal to the magnitude of the electric field strength at Z.

D The potentials at Y and Z are equal.

20 A potential difference of 12 V is applied across a resistor for a time interval of 5.0 s. The current flowing through the resistor is 3.0 A.

Which of the following statements is **incorrect**?

A The resistance of the resistor is 4.0 Ω.

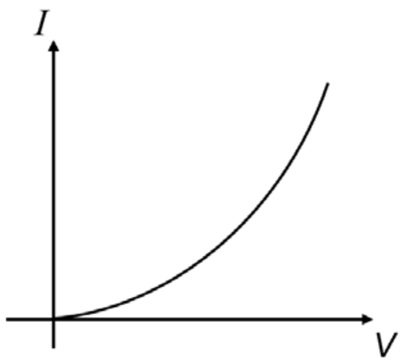
B The energy dissipated in the resistor is 36 J.

C The charge passing through the resistor is 15 C.

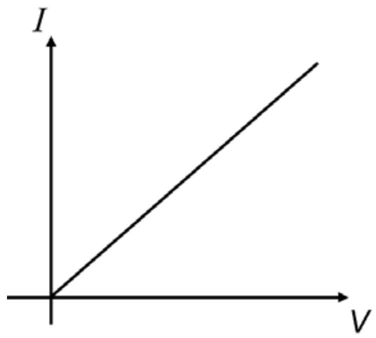
D The potential difference across the resistor is 12 J C^{-1}.

21 Which of the following graphs best represents the relationship between the current I and applied p.d. V for a thermistor?

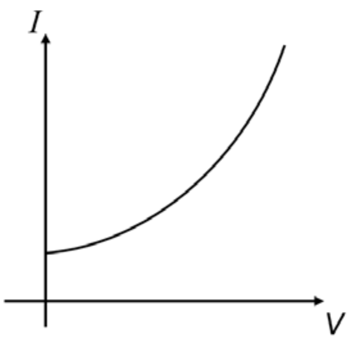
A



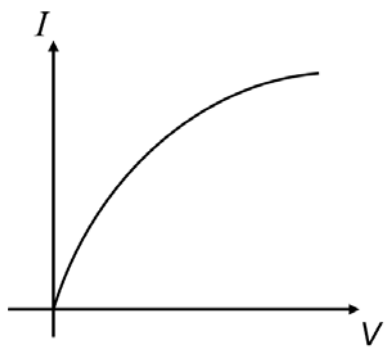
B



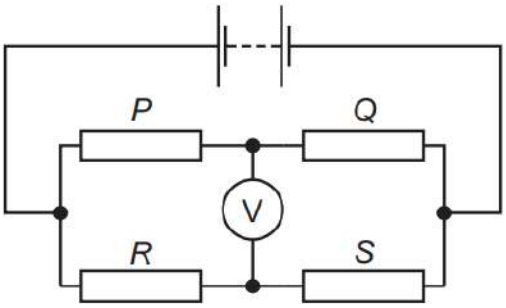
C



D



22 The circuit diagram shows four resistors of different resistances *P, Q, R* and *S* connected to a battery.



The voltmeter reading is zero.

Which equation is correct?

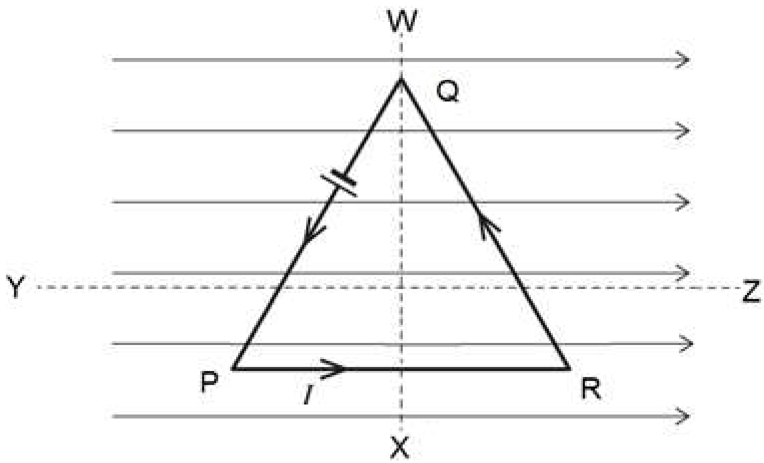
A $P - Q = R - S$

B $P - S = Q - R$

C $PQ = RS$

D $PS = QR$

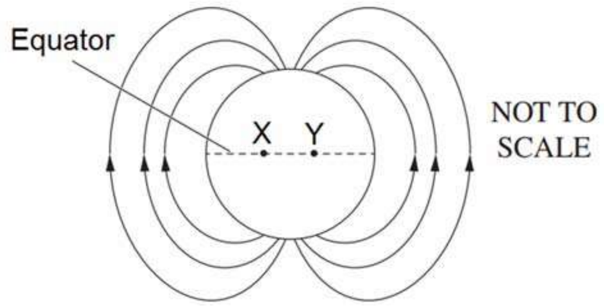
23 A triangular piece of wire frame is placed in a magnetic field as shown below.



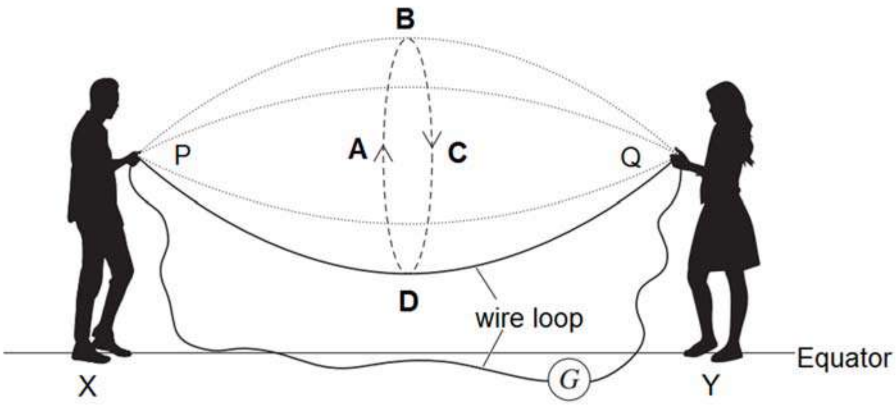
When a current I is supplied as shown, how does the wire frame rotate?

	Axis of rotation	Direction of movement
A	YZ	Q into page
B	YZ	Q out of page
C	WX	R into page
D	WX	R out of page

24 The Earth's magnetic field is a shown in the following diagram.



Two students standing a few metres apart on the equator at points X and Y, where the Earth's magnetic field is parallel to the ground and acting into the page, hold a loop of copper wire between them. Part of the loop is rotated like a skipping rope as shown, while the other part remains motionless on the ground.



At which point **A**, **B**, **C** and **D** during the rotation of the wire does the maximum current flow in the direction from P to Q through the moving part of the wire?

25 A sinusoidal potential difference V_1 as shown in **Fig. A**, is applied across a resistor R and produces heat at a mean rate W.

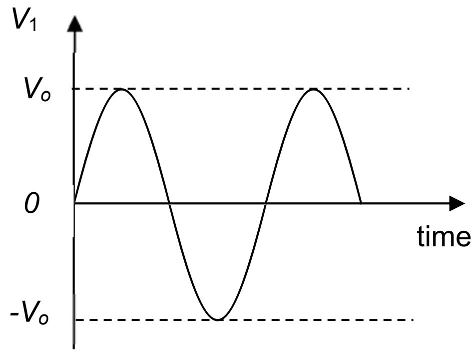


Fig. A

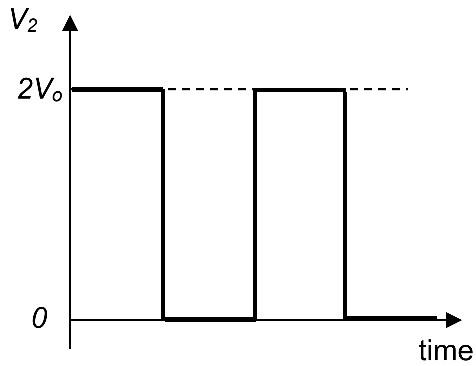


Fig. B

What is the mean rate of heat produced when another potential difference V_2 as shown in **Fig. B** is applied across the same resistor?

A ½ W **B** 2 W **C** 4 W **D** 8 W

26 An electric kettle has the following label:

Power	: 2000 to 2400 W
Voltage	: 220 to 240V
Frequency	: 50 to 60 Hz

Which of the following is a probable expression of the current that passes through the kettle when used in Singapore?

A I = 8.33 sin (315t) **B** I = 10.9 sin (315t)

C I = 14.1 sin (375t) **D** I = 16.0 sin (375t)

27 A photon is emitted from a hydrogen atom by an electron transition between two energy levels. The energy levels have energies X and Y.

Which expression gives the momentum of this photon?

A $\frac{(X-Y)}{h}$ **B** $\frac{(X-Y)}{c}$ **C** $\frac{(X-Y)}{hc}$ **D** $\frac{h(X-Y)}{c}$

28 A proton has a kinetic energy of 1.00 MeV.

If its momentum is measured with an uncertainty of 1.0 %, what is the minimum uncertainty in its position?

A 1.22×10^{-10} m **B** 2.87×10^{-12} m **C** 9.08×10^{-12} m **D** 6.59×10^{-15} m

29 $^{238}_{92}\text{U}$ decays through a series of transformations to a final stable nuclide. The particles emitted in the successive transformations are

$$\alpha \rightarrow \beta \rightarrow \beta \rightarrow \alpha \rightarrow \alpha$$

Which nuclide is not produced during this series of transformations?

A $^{228}_{88}\text{Ra}$ **B** $^{230}_{90}\text{Th}$ **C** $^{234}_{91}\text{Pa}$ **D** $^{234}_{92}\text{U}$

30 The equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{121}_{45}Rh + ^{113}_{47}Ag + 2^{1}_{0}n$$

shows the fission of a uranium−235 nuclide by a slow-moving neutron into a rhodium-121 nuclide, a silver-113 nuclide and two neutrons.

binding energy per nucleon of $^{235}_{92}U$ = 7.59 MeV

binding energy per nucleon of $^{121}_{45}Rh$ = 8.26 MeV

binding energy per nucleon of $^{113}_{47}Ag$ = 8.52 MeV

What is the energy released during this fission process?

A 9.19 MeV **B** 24.4 MeV **C** 73.9 MeV **D** 179 MeV

END OF PAPER

INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS | INDEX NUMBER

PHYSICS 9749/02

Paper 2 Structured Questions

29 August 2018

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
Please write down your answers in the spaces provided.

The number of marks is given in the brackets [ ] at the end of each question or part question.

Marks will be deducted for using inappropriate number of significant figures or wrong value of *g*.

For Examiner's Use	
1	**14**
2	**10**
3	**10**
4	**6**
5	**9**
6	**11**
7	**20**
Penalty	
P2 Total	**80**

This document consists of **21** printed pages and **1** blank page.

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hydrostatic pressure	p	$= \rho gh$
gravitational potential	Φ	$= -\frac{GM}{r}$
temperature	T/K	$= T/°C + 273.15$
pressure of an ideal gas	p	$= \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_0 \sin \omega t$
velocity of particle in s.h.m.	v	$= v_0 \cos \omega t$
		$= \pm\omega\sqrt{\left(x_o^2 - x^2\right)}$
electric current	I	$= Anvq$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	x	$= x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 n I$
radioactive decay	x	$= x_0 \exp(-\lambda t)$
decay constant	λ	$= \frac{\ln 2}{t_{½}}$

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially held so that the spring has zero extension, as shown in Fig. 1.1.

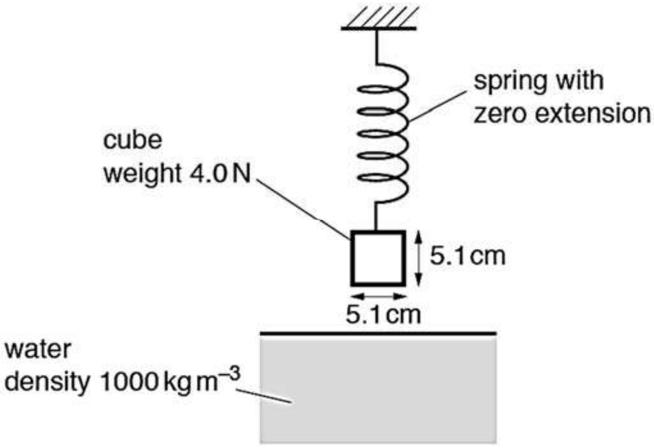


Fig. 1.1

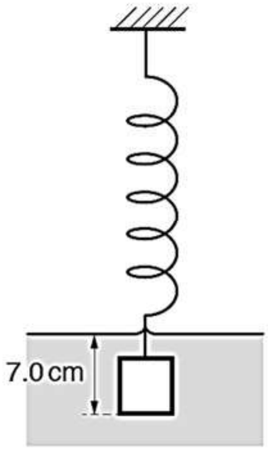


Fig. 1.2

The cube has weight 4.0 N and sides of length 5.1 cm. The cube is released and sinks into water as the spring extends. The cube reaches equilibrium with its base at a depth of 7.0 cm below the water surface, as shown in Fig. 1.2.
The density of water is 1000 kg m^{-3}.

(a) (i) Calculate the difference in the pressure exerted by the water on the bottom face and on the top face of the cube.

difference in pressure = ……………………. Pa [2]

(ii) Use your answer in **(a)(i)** to show that the upthrust on the cube is 1.3 N. Explain your working.

[2]

(iii) Calculate the force exerted on the spring by the cube when it is in equilibrium in the water.

force = ……………………. N [2]

For Examiner's Use

(iv) The spring obeys Hooke's law and has a spring constant of 30 N m^{-1}.

Determine the initial height above the water surface of the base of the cube before it was released.

height above surface = …………………… cm [2]

(b) The cube in the water is released from the spring.

(i) State Newton's second law of motion.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Determine the initial acceleration of the cube.

acceleration = …………………… m s^{-2} [2]

(iii) Describe and explain the variation, if any, of the acceleration of the cube as it sinks further into the water.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

For Examiner's Use

2 Fig. 2.1 shows a simplified heat engine which consists of an insulated cylinder fitted with a perfectly fitting frictionless piston. The cylinder contains a fixed mass of an ideal gas and a heater. When heat is supplied to the gas, it can expand and does work by pushing the piston.

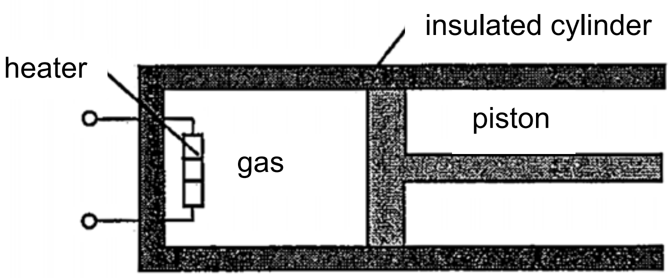


Fig. 2.1

(a) Explain in terms of the motion of the molecules in the gas, how work can be done by the heated gas to move the piston.

....

....

....

....

.... [2]

(b) The efficiency of a heat engine is given by the following equation

$$\text{efficiency} = \frac{\text{useful mechanical work done}}{\text{input heat supplied}}$$

(i) In practice, attaining 100% efficiency is impossible. Suggest two possible reasons.

....

....

....

.... [2]

For Examiner's Use

(ii) Two experiments are performed on the heat engine in Fig. 2.1.

Experiment 1
The heater provides 150 J of thermal energy with the piston held in a fixed position. The temperature rise of the gas is 30 K.

Experiment 2
The heater again supplies 150 J of thermal energy with the piston free to move so that the gas expands at a constant pressure of 1.0×10^5 Pa and does some useful work *W*. In this case, the temperature rise is 18 K and the efficiency is 40%.

1. Explain why there is a difference in the temperature rise in each case.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

………………………………………………………………………………… [2]

2. In the first experiment, calculate the gain in internal energy of the gas.

gain in internal energy = …………………….. J [1]

3. In the second experiment, calculate the work done *W* by the expanding gas.

work done = …………………….. J [2]

4. In the second experiment, calculate the gain in internal energy of the gas.

gain in internal energy = …………………….. J [1]

For Examiner's Use

3 **(a)** State the principle of superposition.

....

....

.... [2]

(b) A ship at X is equidistant from two shore-based radio transmitters P and Q. The stations are 60 km apart, and each behaves as a point source of electromagnetic waves which radiate circular wavefronts. Both transmitters operate with a frequency of 1.0 MHz and radiate signals of equal amplitude.

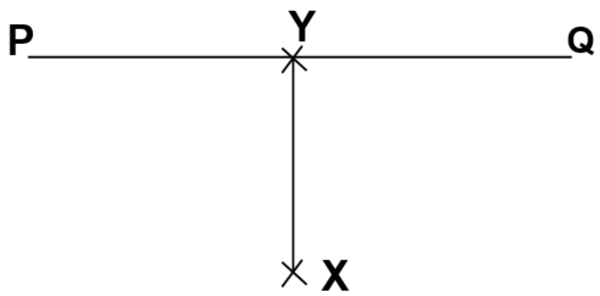


Fig. 3.1

(i) When the ship is at position **X** as shown in Fig. 3.1, the ship detects zero signal amplitude. State what can be deduced about the signals from P and Q.

....

.... [1]

(ii) The ship moves in a straight line from **X** to **Y**. Explain why, throughout the journey, the amplitude of the signal detected by the ship is zero.

....

....

....

.... [2]

For Examiner's Use

(iii) The ship moves in the direction **YQ** until the signal detected has an amplitude twice that from either transmitter alone. Determine the distance that the ship has moved. Explain your answer.

distance = ………………………… m [3]

(iv) When the ship sails from **Y** to the harbour alongside transmitter **Q** the detected signal rises and falls in amplitude. Calculate how many dips in intensity will be passed.

number = ………………………… [2]

4 In order to investigate the variation of the current I in a variable resistor with the potential difference V across it, a student set up the following circuit.

For Examiner's Use

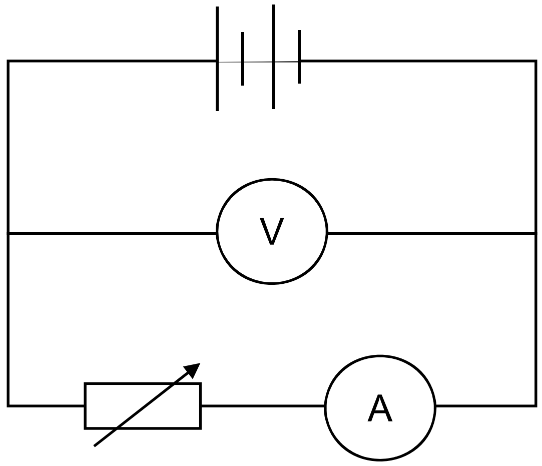


Fig. 4.1

The variation of V with I is shown below.

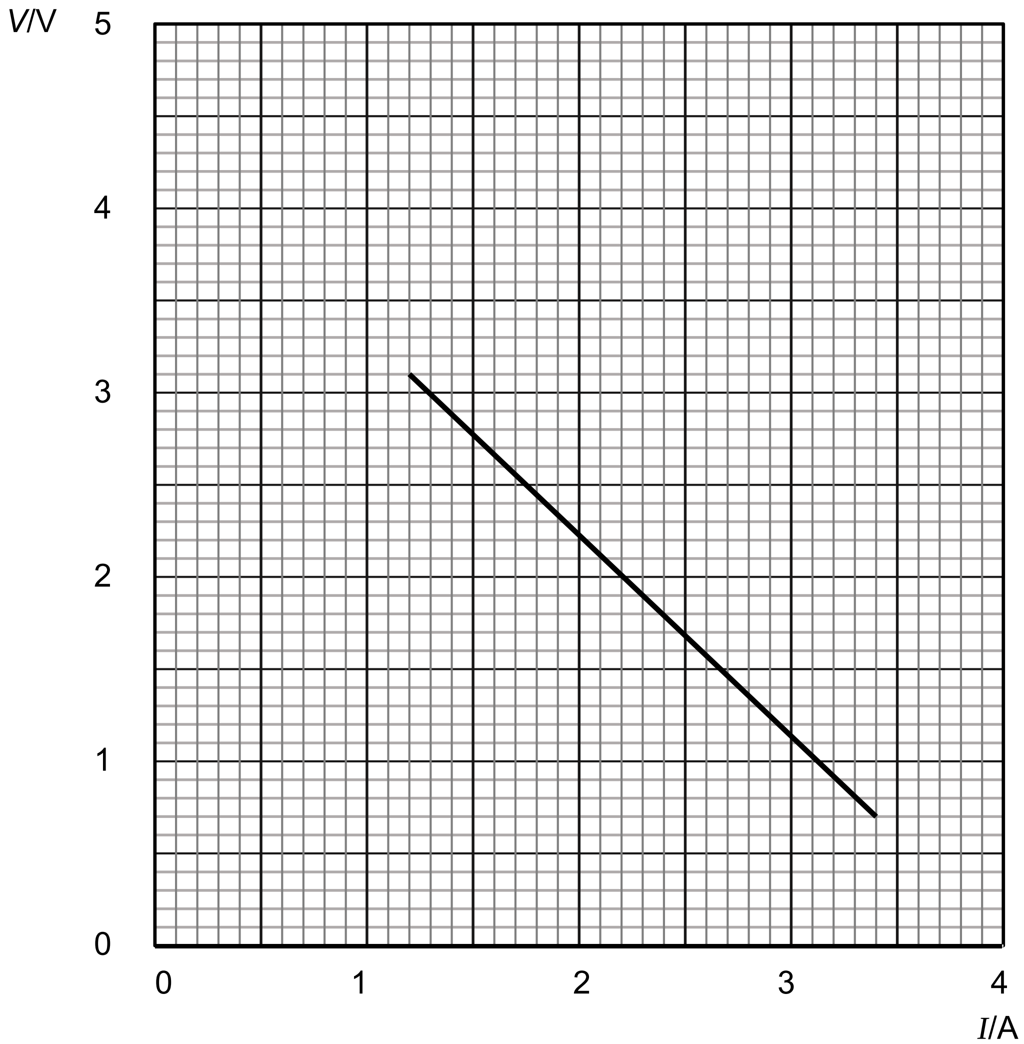


Fig. 4.2

For Examiner's Use

(a) **(i)** With reference to the graph, explain why the internal resistance of the battery is not negligible.

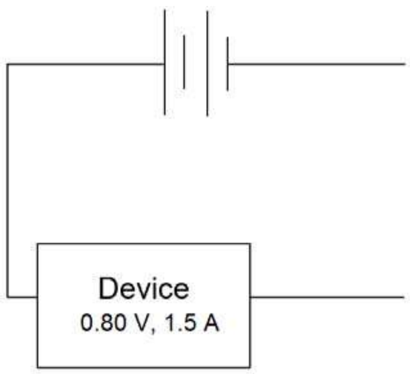
……………………………………………………………………………………………

……………………………………………………………………………………………... [1]

(ii) Show that the e.m.f of the battery and its internal resistance is 4.4 V and 1.1 Ω respectively.

[2]

(b) The battery in **(a)** is to be used as the power source for an electrical device. The device is rated as 0.80 V, 1.5 A.
Complete the circuit below to show how the battery may be connected so that the device operates normally. Calculate the value of any other component you may use.



[3]

For Examiner's Use

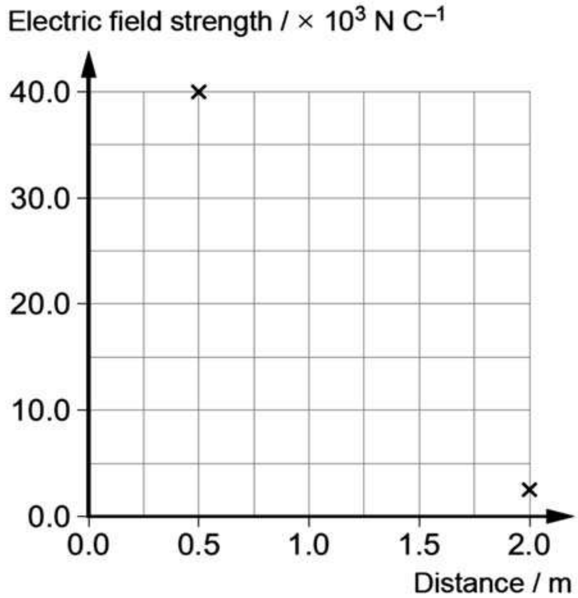
5 A small sphere has a charge $q = +1.11 \times 10^{-6}$ C.

(a) Determine the number of electrons that have been removed from the sphere.

number = ... [2]

(b) On the grids below, sketch curves between 0.5 m and 2.0 m from the centre of the sphere for the electric field strength.

The points at 0.5 m and 2.0 m are already shown.



[2]

For Examiner's Use

(c) A second identical sphere also has a charge of $+1.11 \times 10^{-6}$ C. It is brought from a distant point to a distance 1.2 m from the first sphere as shown in Fig. 5.1.

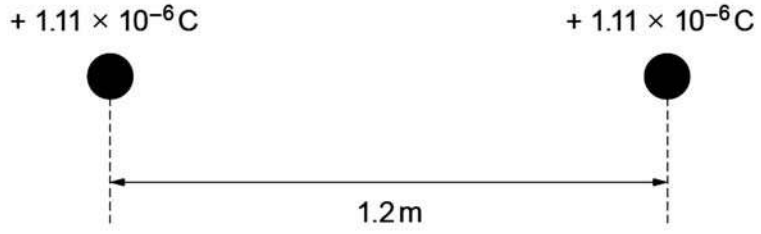


Fig. 5.1
(not to scale)

(i) Determine the work done required to do this.

work done = …………………… J [2]

(ii) Determine the magnitude and direction of the electric field strength at the point between the two spheres that is 0.70 m from the left-hand side sphere.

electric field strength = ...………………. $N\ C^{-1}$

direction = ……………………... [3]

For Examiner's Use

6 **(a)** Electromagnetic radiation is incident on a negatively charged zinc plate. Electrons are emitted from the surface of the plate when a weak intensity ultraviolet source is used. Electrons are not emitted at all when an intense visible light from a lamp is used.

Explain these observations.

....

....

....

....

....

....

....

....

.... [4]

(b) The **maximum** wavelength of the electromagnetic radiation incident on the surface of a metal which causes electrons to be emitted is 2.9×10^{-7} m. Calculate the maximum kinetic energy of electrons emitted from the surface of the metal when each incident photon has energy of 5.1 eV.

maximum kinetic energy = ... J [3]

For Examiner's Use

(c) Electromagnetic radiation of constant wavelength is incident on a metal plate. Photoelectrons are emitted from the metal plate. Fig. 6.1 shows an arrangement used to determine the maximum kinetic energy of electrons emitted from a metal plate.

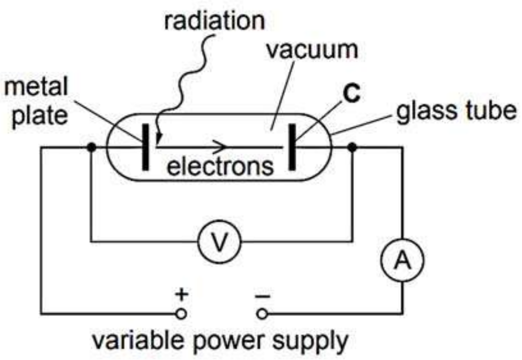


Fig. 6.1

The metal plate and the electrode **C** are both in a vacuum. The electrode **C** is connected to the negative terminal of the variable power supply. Fig. 6.2 shows the variation of current I in the circuit as the potential difference V between the metal plate and **C** is increased from 0 V to 3.0 V.

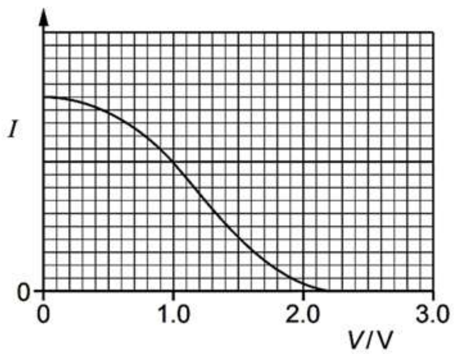


Fig. 6.2

(i) Explain why the current decreases as V increases.

....

....

....

.... [2]

(ii) Using Fig 6.2, determine the maximum kinetic energy of the emitted electrons. Explain your working.

....

....

....

.... [2]

7 Read the following article and then answer the questions that follow.

Powering the world's energy needs through nuclear fission

Nuclear power plants are a type of power plant that use the process of nuclear fission in order to generate electricity. They do this by using nuclear reactors in combination with the Rankine cycle, where the heat generated by the reactor converts water into steam, which spins a turbine and a generator.

The large amount of energy released in a nuclear fission reaction, together with the emission of more than one neutron, has made it possible for neutron-induced fission to be used as a source of useful energy. For most nuclear reactor, the uranium fuel is assembled in such a way that a controlled fission chain reaction can be achieved. When a neutron is captured by a Uranium-235 nucleus, it causes the nucleus to fission. On average, 2.5 neutrons are emitted in these fission reactions. When the conditions are suitable, a chain reaction can occur as shown in Fig. 7.1. If the chain reaction is controlled in the reactor, a source of continuous power may be created.

The induced fission reaction of Uranium-235 may be represented by a nuclear equation of the form

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{a}_{b}\text{P} + {}^{c}_{d}\text{Q} + (2 \text{ or } 3)\,{}^{1}_{0}\text{n} + \text{energy}$$

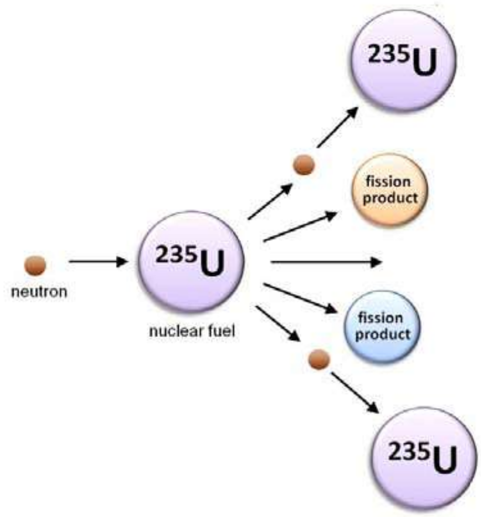


Fig. 7.1

Usually when any two nuclei are fissioned, the fission products may not be the same. If a large sample of Uranium-235 is fissioned, many different fission products will be produced. The percentage amount of each fission product in the fissioned material is referred to as percentage yield.

In 2016, nuclear plants have managed to supply 2477 TWh of electricity worldwide. That was the fourth consecutive year that the global nuclear generation has risen. Nuclear energy generated via nuclear reactions generate heat to produce steam, which is used to generate electricity. The efficiency of a nuclear power plant is determined similarly to other heat engines, since technically the plant is a large heat engine. The amount of electric power produced for each unit of thermal power gives the plant its thermal efficiency. Typical nuclear power plants achieve efficiency of 35%. In addition, nuclear power plants had an average capacity factor of 92.3 percent which is relatively much higher than other electrical systems, meaning they operated at full power on 336 out of 365 days per year.

(a) Suggest why there is a need for the fission process in the nuclear reactor to be controlled.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(b) Fig. 7.2 shows the variation of the energy release *E* during each stage of the chain reaction with its stage number *n*.

(Stage *n* = 1 represents the stage where the energy is released when the first neutron interacts with first Uranium nucleus and releases 2 or 3 neutrons.
Stages *n* = 2,3… represent the stages where the energy is released when the neutrons from previous stage interacts with other Uranium nuclei and releases 2 or 3 more neutrons for each reaction)

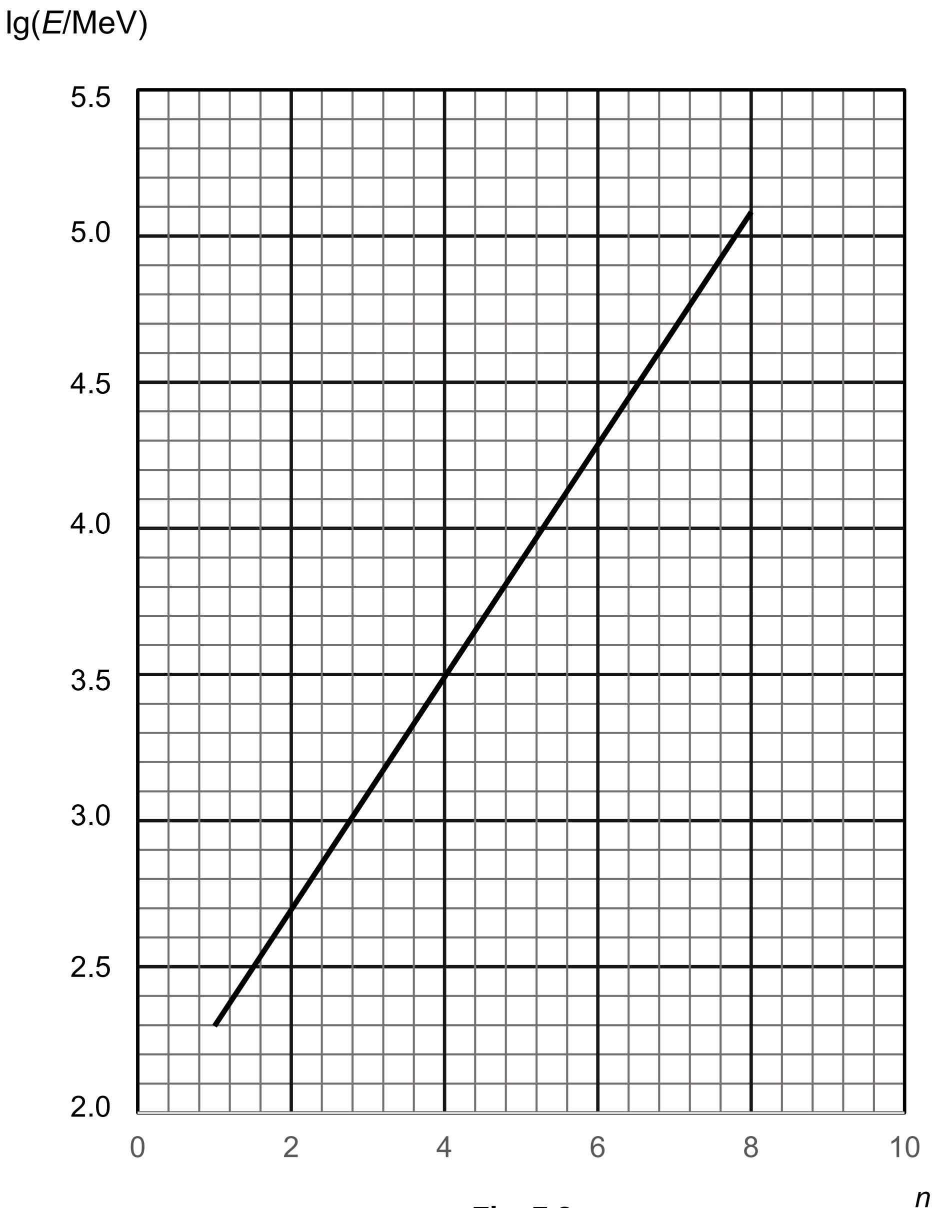


Fig. 7.2

For Examiner's Use

(i) The total energy released per chain E would thus increase with the number n of stage that the fission has proceed till and is given by

$$E = a^{n-1}b$$

where a is the average number of neutrons emitted per fission reaction and b is a constant.

Use Fig. 7.2 to determine the value of b.
Show your working clearly.

b = ……………………… MeV [3]

(ii) Suggest what is represented by the value of b.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(c) The variation with nucleon number of the percentage yield of different products is illustrated in Fig. 7.3.

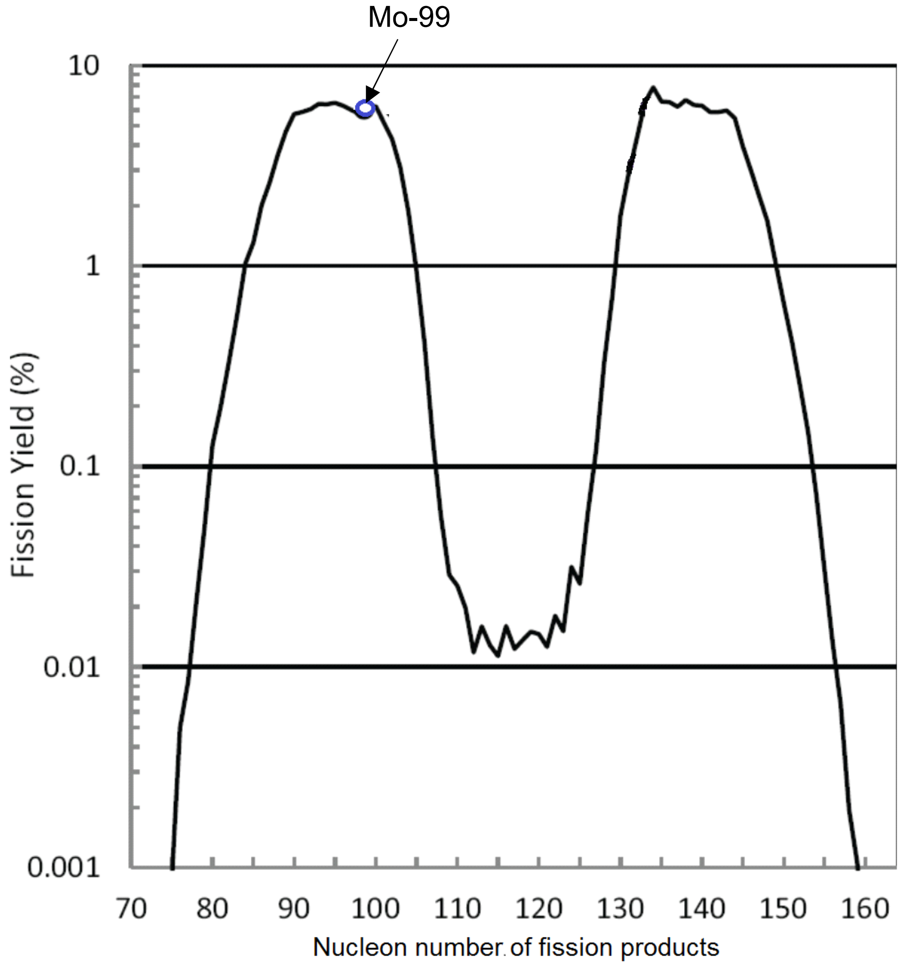


Fig. 7.3

(i) State the proton number of the other fission product for the fission of one uranium if one of the products is $^{89}_{36}Kr$.

proton number = ……………………………… [1]

(ii) Suggest why the percentage yield is shown on a logarithmic scale.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

For Examiner's Use

(iii) Show that the percentage yield of Mo-99 is about 400 times more than those having masses equal to each other.

[2]

(d) (i) The energy released during one fission reaction of a uranium nuclei occurs partly as kinetic energy of the fission products (167 MeV) and of the neutrons.

Suggest one other mechanism by which energy is released in the fission reaction.

……………………………………………………………………………..……….. [1]

(ii) Determine the amount of heat required to generate the electrical energy worldwide in 2016.

energy = …………………….. J [2]

(iii) Determine the rate at which uranium is consumed to generate the amount of heat required in 2016.

amount required = ……………………….. kg s^{-1} [3]

For Examiner's Use

(e) The fission products are usually radioactive and give rise to a series of radioactive decay products. Each decay product has its own half-life. Two such fission products with their decay products and half-lives are shown below.

$$ {}^{90}_{42}\text{Mo} \xrightarrow{\text{67 hours}} {}^{99}_{43}\text{Tc} \xrightarrow{2 \times 10^{5}\text{ years}} {}^{90}_{44}\text{Ru} \text{ (stable solid)} $$

$$ {}^{140}_{54}\text{Xe} \xrightarrow{\text{16 seconds}} {}^{140}_{55}\text{Cs} \xrightarrow{\text{1.1 minutes}} {}^{140}_{56}\text{Ba} \xrightarrow{\text{13 days}} {}^{140}_{57}\text{La} \xrightarrow{\text{40 hours}} {}^{140}_{58}\text{Ce} \text{ (stable solid)} $$

Consider equal amounts of these two products.
Suggest why there are very different problems for the storage of this nuclear waste.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(f) Despite the advantages of nuclear power, it is unlikely that our world will be purely powered by nuclear energy.
Suggest two reasons, aside from the danger from nuclear waste and cost, for this.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

End of Paper 2

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INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS 9749/03

Paper 3 Longer Structured Questions **12 September 2018**

Candidates answer on the Question Paper.
No Additional Materials are required. **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer only **one** question.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	11
2	10
3	7
4	8
5	7
6	10
7	7
Section B	
8	20
9	20
Significant Figures	
P3 Total	**80**

This document consists of **25** printed pages and **1** blank page.

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	$= 1.60 \times 10^{-19}$ C
the Planck constant,	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}$ kg
molar gas constant,	R	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	G	$= 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	g	$= 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas,	W	$= p\Delta V$
hydrostatic pressure,	p	$= \rho gh$
gravitational potential,	Φ	$= -\frac{GM}{r}$
temperature,	T/K	$= T/°C + 273.15$
pressure of an ideal gas	p	$= \frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of an ideal gas molecule	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_0 \sin \omega t$
velocity of particle in s.h.m.	v	$= v_0 \cos \omega t$
		$= \pm\omega\sqrt{(x_o^2 - x^2)}$
electric current	I	$= Anvq$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	$= x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 nI$
radioactive decay,	x	$= x_0 \exp(-\lambda t)$
decay constant,	λ	$= \frac{\ln 2}{t_{½}}$

For Examiner's Use

Section A

Answer **all** the questions in this section.

1 A man travels on a toboggan down a slope covered with snow from point A to point B. The path is illustrated in Fig. 1.1.

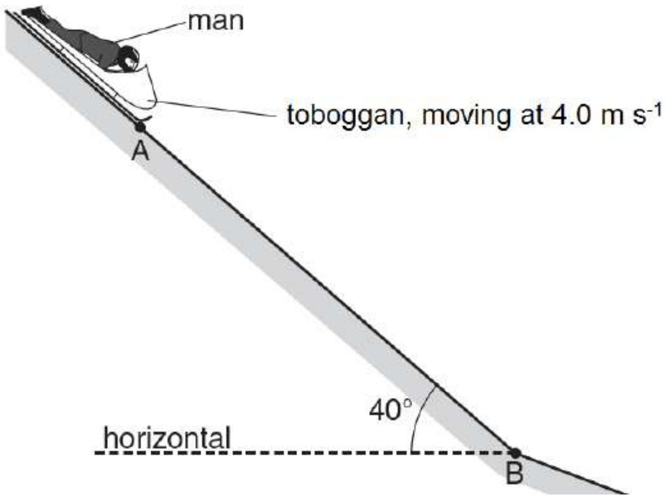

Fig. 1.1 (not to scale)

The slope AB makes an angle of 40˚ with the horizontal. Friction is **not negligible**.

The man and toboggan have a combined mass of 95 kg.

The mass starts with a speed of 4.0 m s^{-1} down the slope at A and has constant acceleration between A and B. The mass takes 17.0 s to reach B. His speed is 37.0 m s^{-1} at B.

(a) **(i)** Calculate the distance moved from A to B.

distance = …………………… m [2]

For Examiner's Use

(ii) The actual uncertainty in each measurement of the speed of the mass is ± 0.1 m s^{-1}. The percentage uncertainty in the time taken to move from A to B is ± 0.6%.

Calculate the percentage uncertainty in the distance moved from A to B.

percentage uncertainty = …………………… % [2]

(iii) Use your answers in **(a)(i)** and **(a)(ii)** to determine the value of distance moved from A to B, with its actual uncertainty, to an appropriate number of significant figures.

distance = ……………. ± ……………. m [1]

(b) For the man and toboggan moving from A to B,

(i) calculate the change in kinetic energy

change in kinetic energy = …………………… J [2]

(ii) calculate the change in potential energy

change in potential energy = …………………… J [2]

(iii) hence determine the average frictional force that acts on the toboggan between A and B.

frictional force = …………………… N [2]

For Examiner's Use

2 **(a)** State Newton's law of gravitation.

....

....

....

.... [2]

(b) Some of the planets in the Solar System have several moons (satellites) that have circular orbits about the planet.
The planet and each of its moons may be considered to be point masses.

Show that the radius x of the moon's orbit is related to the period T of the orbit by the expression

$$GM = \frac{4\pi^2 x^3}{T^2}$$

where G is the gravitational constant and M is the mass of the planet. Explain your working.

[3]

For Examiner's Use

(c) The planet Neptune has eight moons, each in a circular orbit of radius x and period T. The variation with T^2 of x^3 for some of the moons is shown in Fig. 2.1.

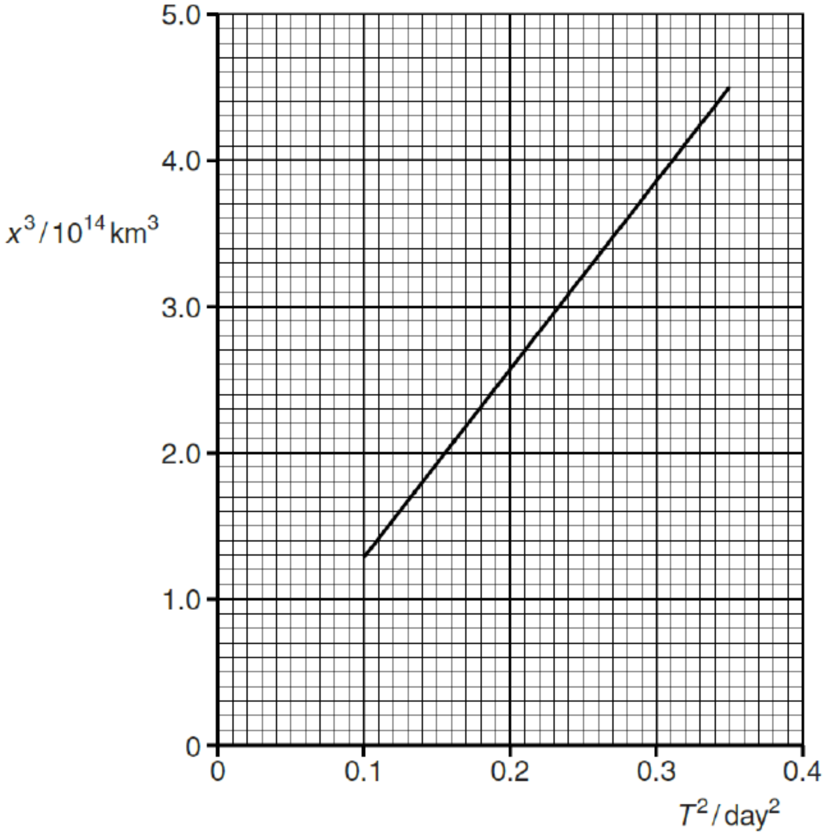

Fig. 2.1

(i) Show that the gradient of the line in Fig. 2.1 is 1.7×10^{14} m^3 s^{-2}.

[1]

(ii) Hence determine the mass of Neptune.

mass = ………………………………….. kg [2]

(d) The mass of the planet Uranus is smaller than that of the planet Neptune.
On Fig. 2.1, sketch the variation with T^2 of x^3 for the moons of Uranus.

[2]

3 **(a)** An ideal gas is assumed to consist of atoms or molecules that behaves as hard, identical spheres that are in continuous motion and undergo elastic collisions.

State two further assumptions of the kinetic theory of gases.

....

....

....

....

.... [2]

(b) Helium-4 ($^{4}_{2}He$) may be assumed to be an ideal gas.

(i) Show that the mass of one atom of helium-4 is 6.6×10^{-27} kg.

[1]

(ii) Determine the internal energy of 1.2 mole of helium-4 gas at a temperature of 27 °C.

internal energy = ... J [1]

For Examiner's Use

(iii) Determine the root-mean-square (r.m.s.) speed of a helium-4 atom at a temperature of 27 °C.

root-mean-square speed = ………………………………… m s^{-1} [2]

(iv) The above r.m.s. speed for helium is less than the escape speed for particles on the Earth's surface and yet there are still some helium atoms that escape the Earth's atmosphere. Explain.

..………………………………………………………………………………………..

..………………………………………………………………………………………..

..……………………………………………………………………………………… [1]

For Examiner's Use

4 **(a)** Distinguish between free oscillations and forced oscillations.

free oscillations: ....

....

forced oscillations: ....

.... [2]

(b) A trolley is held on a horizontal surface by means of two stretched springs, as shown in Fig. 4.1.

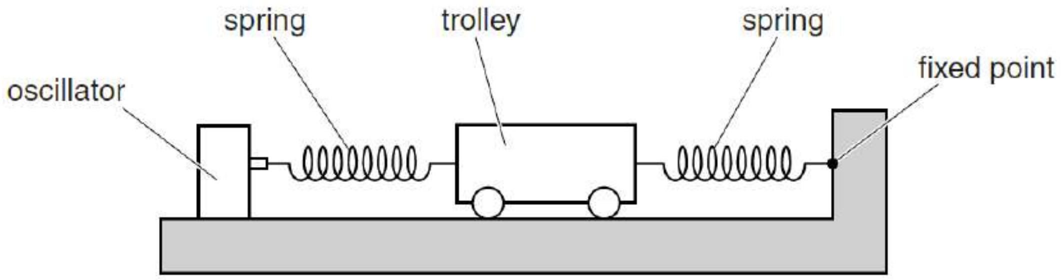

Fig. 4.1

One spring is attached to a fixed point. The other spring is attached to an oscillator that causes horizontal oscillations of the trolley.

The oscillator vibrates with a constant amplitude of vibration. The frequency of vibration of the oscillator is gradually increased from a very low value.

The variation with frequency f of the amplitude x_0 of vibration of the trolley is shown in Fig. 4.2.

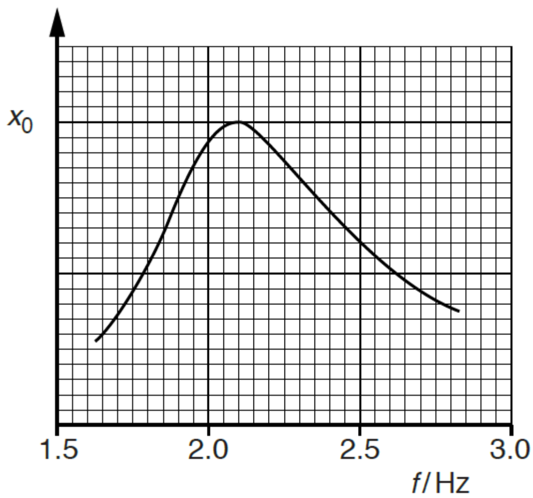

Fig. 4.2

Use Fig. 4.2 to state and explain

(i) the value of the natural frequency of vibration of the trolley,

....

....

....

....

....

.... [3]

(ii) whether there are any frictional forces acting on the trolley.

....

.... [1]

(c) The oscillator in **(b)** is now stopped.

The trolley is given a horizontal displacement of 4.7 cm along the line of the springs. The trolley is then released.

Use information from Fig. 4.2 to estimate the maximum speed of the trolley.

speed = ……………………………….. m s^{-1} [2]

5 Fig. 5.1 shows a demonstration of a *stationary wave* on a string.

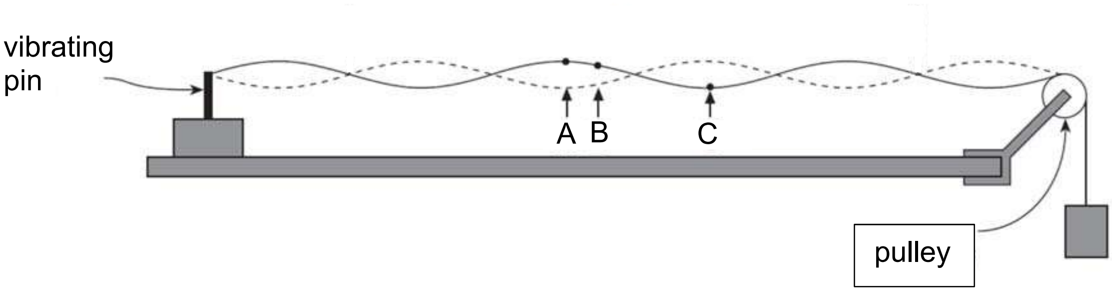

Fig. 5.1

(a) (i) State whether the following pairs of points on the string are vibrating *in phase*, *in antiphase*, or neither in phase nor in antiphase.

A and B ………………………………………………………………………………

A and C …………………………………………………………………………….. [2]

(ii) Describe briefly how you could check this experimentally.

..……………………………………………………………………………………….

..……………………………………………………………………………………….

..……………………………………………………………………………………… [1]

(b) (i) Progressive waves transfer energy through the medium; stationary waves do not do this. Describe the difference in term of the amplitude of the wave between progressive and stationary waves.

..……………………………………………………………………………………….

..……………………………………………………………………………………….

..……………………………………………………………………………………….

..……………………………………………………………………………………….

..……………………………………………………………………………………… [2]

For Examiner's Use

(ii) Explain how, in the set-up as shown in Fig. 5.1, the stationary wave can be thought of as arising from progressive waves.

....

....

....

....

.... [2]

6 **(a)** The resistivity of copper is 1.7×10^{-8} Ω m. Show that the resistance of a copper wire of length 1.5 m and cross-sectional area of 3.2×10^{-9} m^2 is about 8.0 Ω.

For Examiner's Use

[1]

(b) The copper wire in **(a)** is used to connect a circuit as shown in Fig. 6.1. Cell A has an e.m.f of 12.0 V and internal resistance 1.0 Ω. A 2.0 Ω resistance is used and connected in series with cell A.

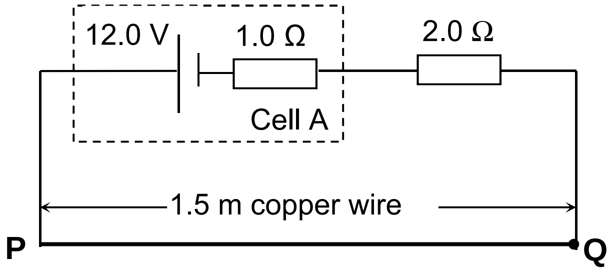

Fig. 6.1

Determine the drift velocity of the electrons flowing in the copper if the number of electrons per unit volume is 8.5×10^{28} m^{-3}.

drift velocity = ... m s^{-1} [2]

(c) Cell B, a galvanometer and resistor of 4.0 Ω is now placed in parallel together with the circuit and is shown in Fig. 6.2.

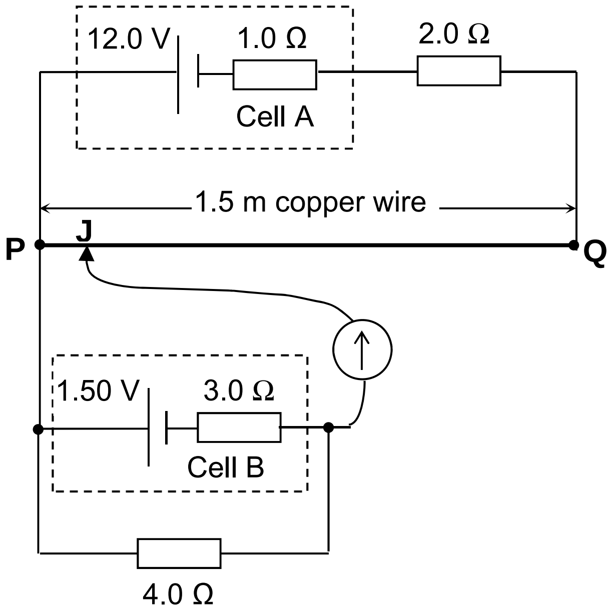

Fig. 6.2

For Examiner's Use

(i) Show that the potential difference across the copper wire is 8.7 V.

[1]

(ii) Calculate the balance length PJ, in which the galvanometer will show zero reading.

PJ = ……………………. m [3]

(iii) The balance point is found to be too near P resulting in high fractional error in the determination of balance length.

Suggest and explain how the circuit can be modified, without changing Cell B, to improve the accuracy.

..……………………………………………………………………………………..

..……………………………………………………………………………………..

..……………………………………………………………………………………..

..…………………………………………………………………………………… [2]

(d) PJ is now increased.

Indicate the direction in Fig. 6.2 how the current will flow, if any, through the galvanometer. [1]

7 **(a)** A radiation detector is placed close to a radioactive source. The detector does not surround the source.
Radiation is emitted in all directions and, as a result, the activity of the source and the measured count rate are different.

Suggest **two** other reasons why the activity and the measured count rate may be different.

....

....

....

....

.... [2]

(b) The variation with time *t* of the measured count rate in **(a)** is shown in Fig. 7.1.

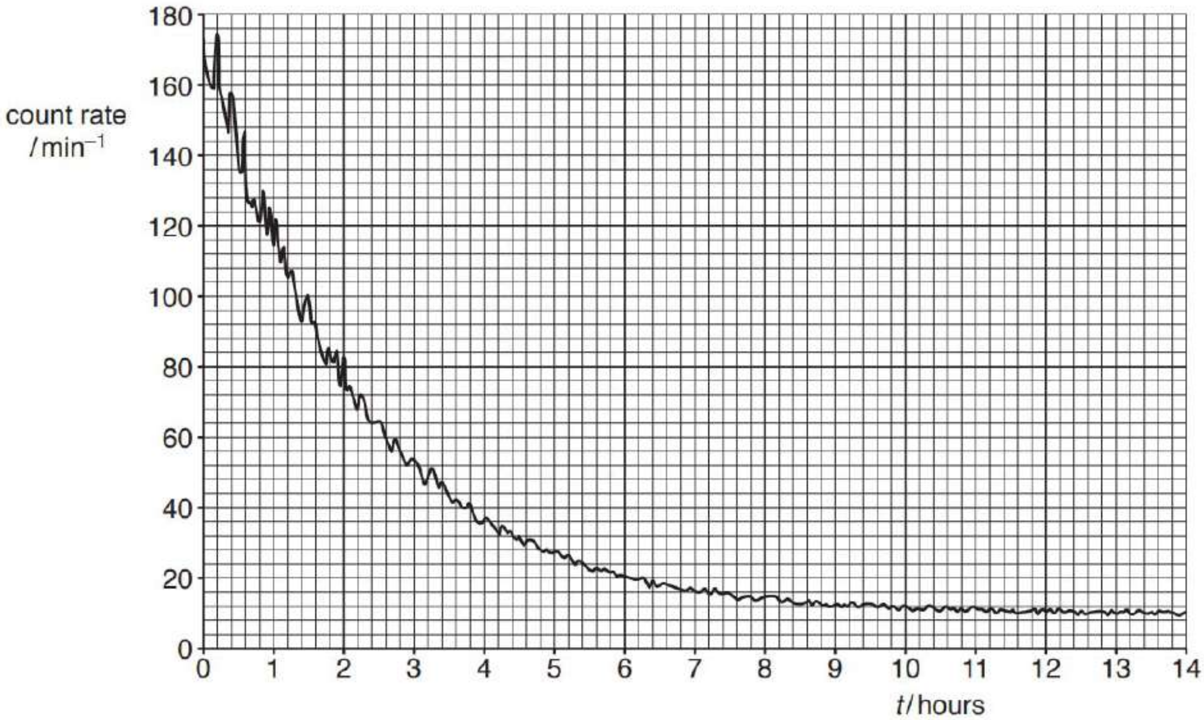

Fig. 7.1

(i) State the feature of Fig. 7.1 that indicates the random nature of radioactive decay.

....

.... [1]

For Examiner's Use

(ii) Use Fig. 7.1 to determine the half-life of the radioactive isotope in the source.

half life = …………………. s [3]

(c) The readings in (b) were obtained at room temperature.

A second sample of this isotope is heated to a temperature of 500°C.

The initial count rate at time *t* = 0 is the same as that in **(b)**.

The variation with time *t* of the measured count rate from the heated source is determined.

State, with a reason, the difference, if any, in the half-life.

....

.... [1]

Section B

For Examiner's Use

Answer **one** question in this section in the spaces provided.

8 **(a)** Define the *tesla*.

....

....

....

.... [2]

(b) Fig. 8.1 shows an arrangement used to accelerate an initially stationary alpha particle and make it travel in a uniform magnetic field.

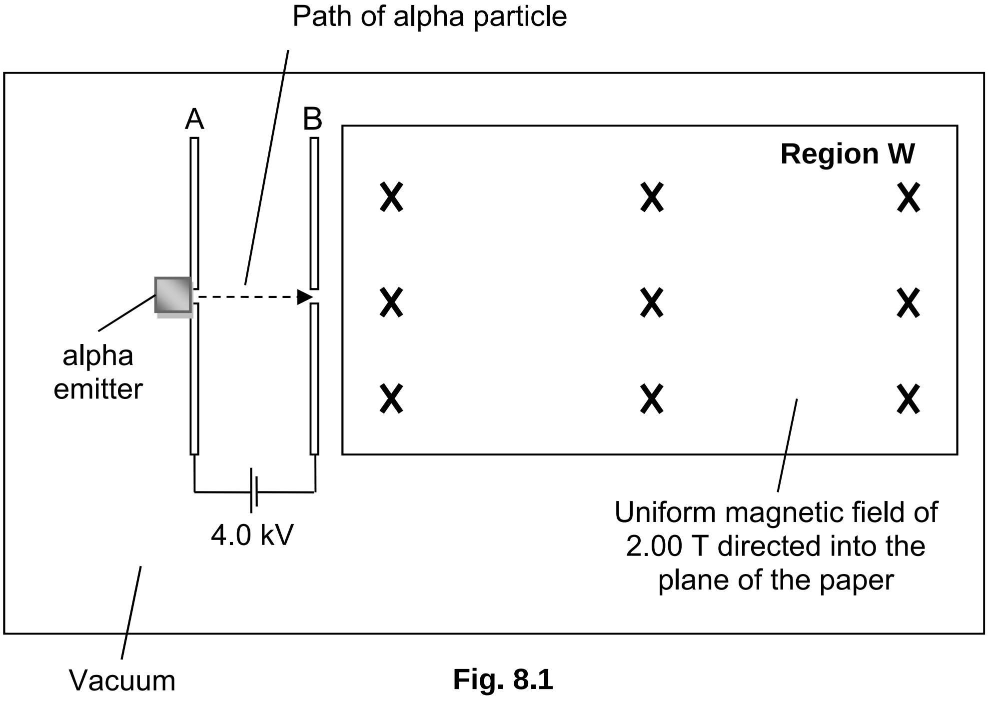

Fig. 8.1

(i) On Fig. 8.1, draw a possible trajectory of the alpha particle in the uniform magnetic field.

.... [1]

(ii) Explain whether the force experienced by the alpha particle due to the magnetic field changes its kinetic energy.

....

....

....

....

....

.... [3]

For Examiner's Use

(iii) Show that the alpha particle will attain a speed of 6.21 x 10^5 m s^{-1} when it reaches the slit opening of plate B.

[1]

(iv) Determine the electric field that needs to be applied in **Region W** for the alpha particle to pass through the uniform magnetic field undeflected.

magnitude = ………………….. V m^{-1} [2]

direction = ………………….. [1]

(c) Suppose that the arrangement in Fig. 8.1 is now modified so that the alpha particle enters the uniform magnetic field at an angle of 30° to the horizontal as shown in Fig. 8.2 below.

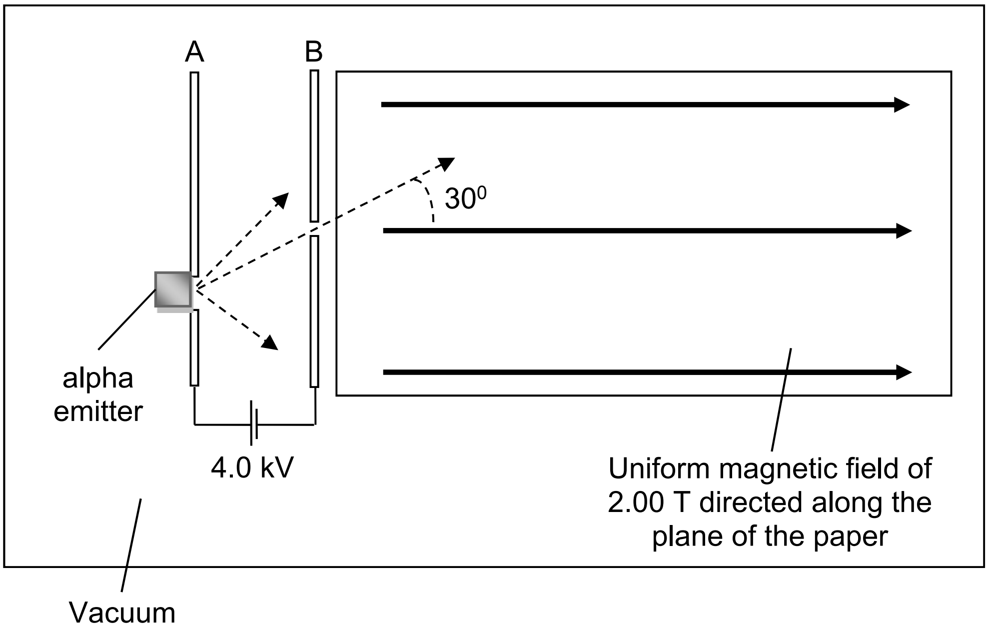

Fig 8.2

For Examiner's Use

The path of the alpha particle can be described as a helix as shown in Fig. 8.3.

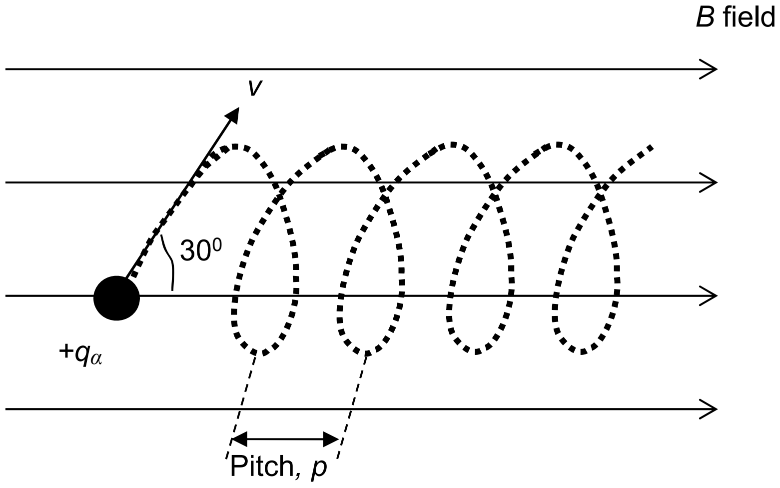

Fig. 8.3 (not to scale)

(i) Calculate the radius r of the helical path.

radius = ………………………… m [2]

(ii) Show that the period, T of the helical path can be expressed as:

$$T = \frac{2\pi m_\alpha}{q_\alpha B}$$

where m_α and q_α is the mass and charge of the alpha particle respectively.

[1]

For Examiner's Use

(iii) Calculate the pitch, p

pitch = ………………………… m [3]

(iv) Describe and explain how the helical path will change if a positron, $_{+1}^{0}e^{+}$ (i.e. a particle with the mass of an electron and charge $+1.6\times10^{-19}$ C) with the same initial velocity was to be used in the experiment instead. You may quote relevant equations to substantiate your answer.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [4]

9 **(a)** **(i)** Define the *magnetic flux.*

....

.... [1]

(ii) State the *laws of electromagnetic induction*.

....

....

....

....

.... [2]

(b) The variation of the magnetic flux density B beyond one end of a large bar magnet with distance is shown in Fig. 9.1.

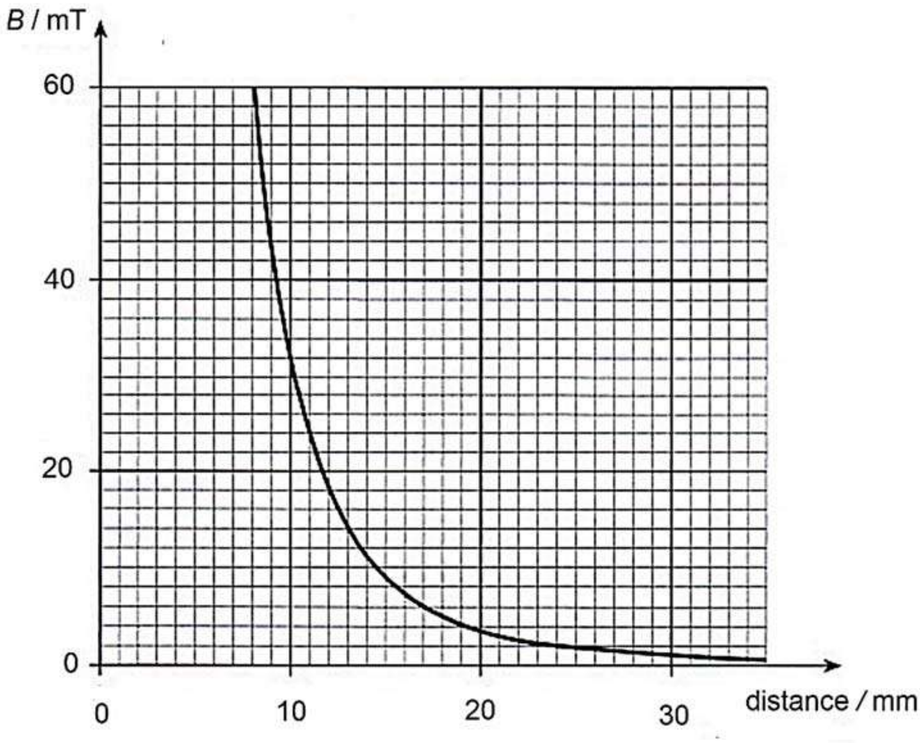

Fig. 9.1

A circular coil of wire with 50 turns and cross-sectional area 16 cm^2 is placed a few centimetres beyond the end of the above stated bar magnet. The axis of the coil is aligned with the axis of the magnet.

For Examiner's Use

(i) Calculate the magnetic flux linkage through the coil when it is 30.0 mm and when it is 10.0 mm from the end of the magnet respectively.

magnetic flux linkage at 30.0 mm = ………………………… Wb

magnetic flux linkage at 10.0 mm = ………………………… Wb [3]

(ii) The coil of wire is moved towards the magnet from the 30.0 mm position to the 10.0 mm position so that a steady e.m.f. of 0.80 mV is induced in it. Calculate the average speed of the movement of the coil.

average speed = ………………………… mm s^{-1} [2]

(iii) Describe how the speed of the coil would need to change when moving from the 30.0 mm position to the 10.0 mm position so as to maintain a steady e.m.f..

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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…………………………………………………………………………………………… [2]

(c) An a.c. generator consists of a rectangular coil of 800 turns with the dimensions 5.0 cm × 8.0 cm in a uniform magnetic field of magnitude 0.50 T. The coil has a resistance of 0.60 Ω and it is connected to an external load of resistance 11.4 Ω in a complete circuit. The coil is rotating at a constant speed of 240 revolutions per minute.

(i) Calculate the maximum voltage produced by this generator.

maximum voltage = ………………..… V [2]

(ii) State the relationship between the induced voltage *V* and the magnetic flux linkage Φ.

[1]

(iii) Fig. 9.2 shows the variation of the induced voltage *V* in the coil with time.

Draw on Fig. 9.2, the corresponding variation of the magnetic flux linkage Φ with time.

[2]

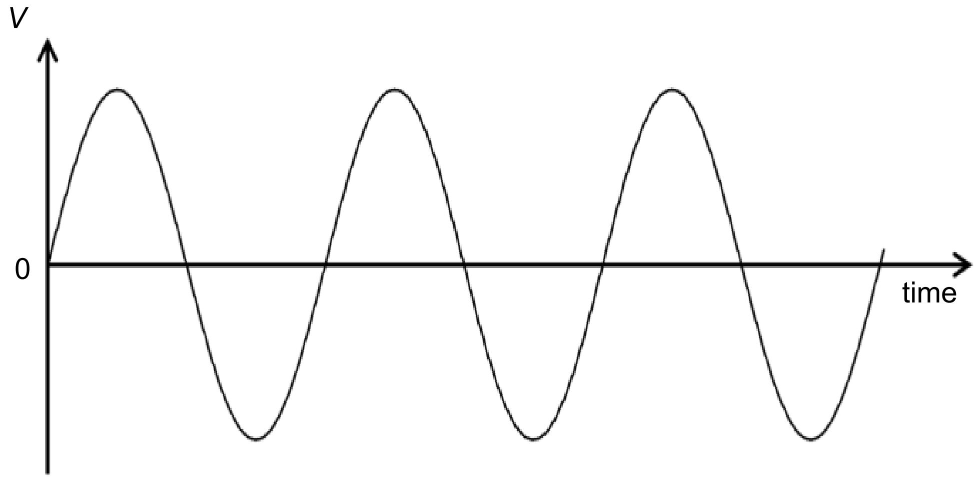

Fig. 9.2

(iv) Calculate the maximum current through the external load.

For Examiner's Use

current = ... A [1]

(v) Explain the terms

(1) *root-mean-square* (r.m.s.) value

....

....

(2) r.m.s. *current*.

....

.... [2]

(vi) Calculate the r.m.s. current through the external load.

r.m.s current = ……………………. A [1]

(vii) Calculate the average power through the external load.

average power = ……………………. W [1]

END OF PAPER

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INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS | INDEX NUMBER

PHYSICS 9749/04

Paper 4 Practical

16 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Shift
Laboratory

IMPORTANT

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

The number of marks is given in the brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	16
2	6
3	22
4	11
Penalty	
Total	**55**
Percentage	

1 In this experiment you will measure the current I through a resistor R_3 as its resistance is changed.

(a) **(i)** Use the multimeter to measure the e.m.f. E of the power supply.

E = ………………………….. [1]

(ii) Connect the circuit shown in Fig. 1.1. R_1 and R_2 are labelled, and R_3 is 100 Ω as indicated by its label. Each resistor carries a label indicating its resistance.

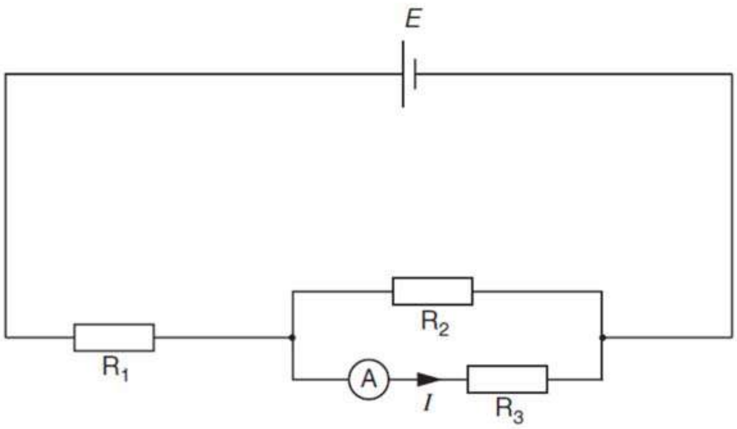

Fig. 1.1

(iii) Record the value of the current I for resistance R_3 of 100 Ω.

I = ………………………….. [1]

(b) Change the resistance of resistor R_3 and repeat **(a)(iii)** until you have six sets of readings for I and R_3. Include values of $\frac{1}{I}$ in your table of results.

[5]

(c) **(i)** Plot a graph of $\frac{1}{I}$ against R_3. [3]

(ii) Draw the line of best fit. [1]

(iii) Determine the gradient and the y-intercept of the graph.

gradient = …………………………….. [1]

y-intercept = …………………………….. [1]

(d) The relationship between I and R_3 is

$$\frac{1}{I} = \left(\frac{R_1 + R_2}{E R_2}\right) R_3 + \frac{R_1}{E}$$

where R_1 is the resistance of the resistor R_1, R_2 is the resistance of the resistor R_2, and E is the e.m.f. of the power supply.
Using your answers from **(a)(i)** and **(c)(iii)**, determine values of R_1 and R_2.

R_1 = ……………………………. [1]

R_2 = ……………………………. [1]

(e) Comment on any anomalous data or results that you may have obtained. Explain your answer.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………..[1]

[**Total: 16 marks**]

You may not need to use all of the materials provided.

2 In this experiment, you will investigate the motion of oscillating table tennis balls.

(a) **(i)** Tape each ball to a length of string. Ensure the total length of the string and ball is 35.0 cm, as shown in Fig. 2.1.

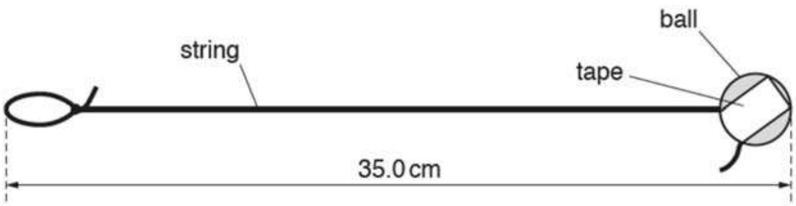

Fig. 2.1

(ii) Tape the shorter wooden block to one of the balls as shown in Fig. 2.2. Tape should be used on opposite sides of the block and the ball.
The distance between the end of the string loop and the mark around the wooden block is *x*. Measure and record *x*.

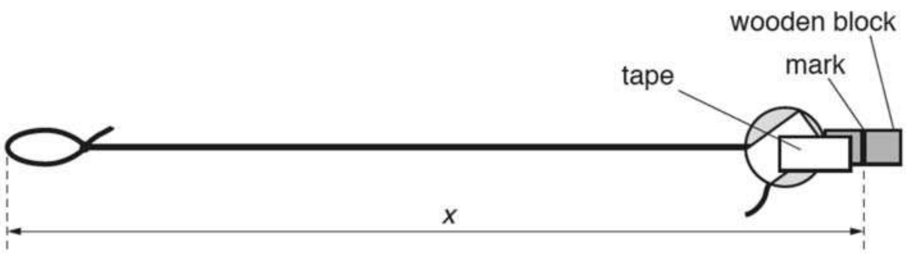

Fig. 2.2

x = ... [1]

(iii) Set up the apparatus as shown in Fig. 2.3

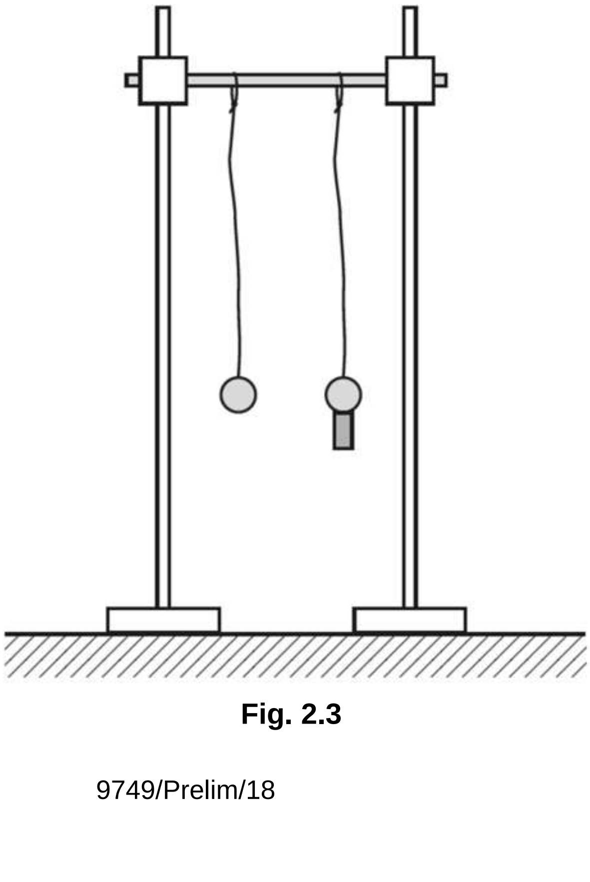

Fig. 2.3

(iv) Pull **both** balls towards you.

Release the balls at the same time and watch the movement.
The two balls will move backwards and forwards becoming out of phase.
After a time they will be back in phase so that they move towards you together.
The ball with the block attached completes n oscillations in this time.

(b) **(i)** Repeat **(a)(iv)** and record n.

n = ... [1]

(ii) Calculate $\frac{(n+1)^2}{n^2}$.

$\frac{(n+1)^2}{n^2}$ = ... [1]

(c) Using the longer wooden block, repeat **(a)** and **(b)**.

x = ...

n = ...

$\frac{(n+1)^2}{n^2}$ = ... [1]

(d) It is suggested that the relationship between *n* and *x* is

$$\frac{(n+1)^2}{n^2} = k\,x$$

where *k* is a constant.

(i) Using your data, calculate two values of *k*.

first value of *k* = ...

second value of *k* = ... [1]

(ii) Explain whether your results in **(d)(i)** support the suggested relationship.

………………………………………………………………………………………

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………………………………………………………………………………………

……………………………………………………………………………………… [1]

[Total: 6 marks]

3 In this experiment you will determine the density of water.

(a) **(i)** Set up the apparatus as shown in Fig. 3.1. The pointers A and B should be attached to each end of the spring. The pointer A should also be attached to the paper clip.
The pointer B should be attached to the mass holder. The total mass of the holder and the masses should be 200 g.

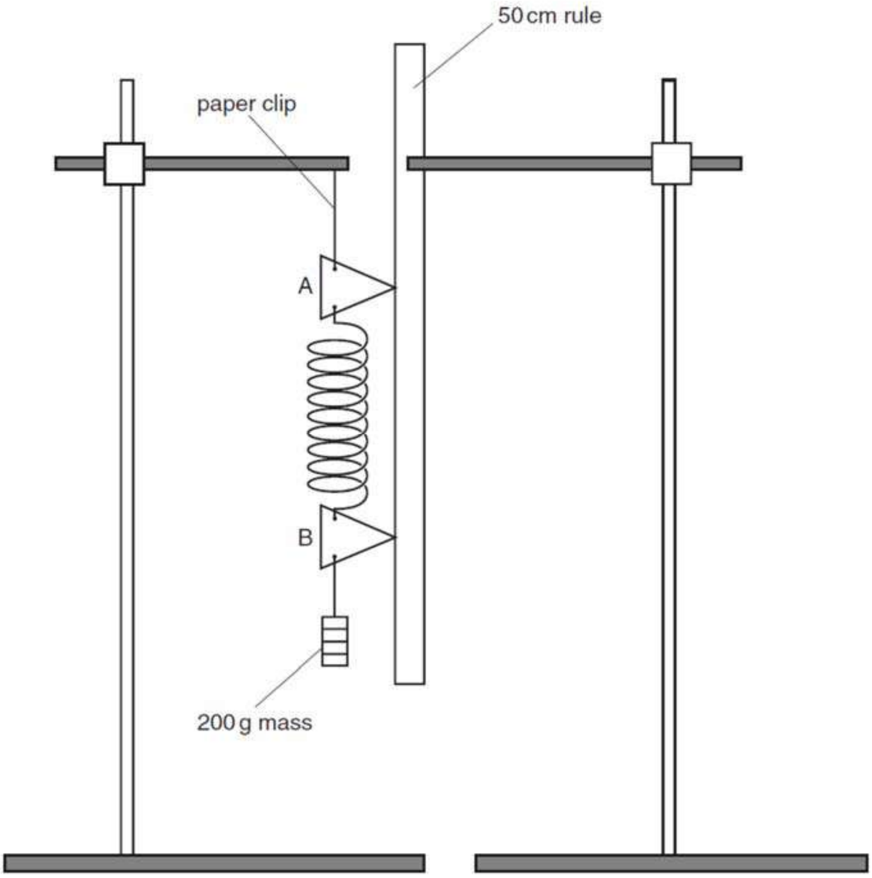

Fig. 3.1

(ii) Record the reading from point B.

reading from pointer B = ...

(iii) Add a further mass of 100 g (0.98 N) to the mass holder and record the new reading from pointer B.

new reading from pointer B = ...

(iv) Hence, determine the extension of the spring when an additional force of 0.98 N is applied to the spring.

extension = ... [1]

(b) Hooke's law can be expressed in the form

$$F = k\,x\ ,$$

where F is the force required to produce an extension x, and k is the spring constant.
Use your answers from **(a)** to determine a value for k. You may assume that the spring obeys Hooke's law.

k = ... [1]

(c) **(i)** Use the vernier callipers to measure the diameter of one of the slotted masses.

diameter = ... [1]

(ii) Determine the percentage uncertainty in the measurement of the diameter of the mass.

percentage uncertainty = ... [1]

(iii) Calculate the cross-sectional area A, in m^2, of the mass. Ignore the slot that is cut into the mass.

A = ... m^2 [1]

(d) **(i)** Put all of the masses onto the mass holder so that the spring supports a total mass of 300 g. This mass should remain constant for the rest of the experiment.
Determine a value for the length *l* between the pointers.

l = ...

(ii) Place a beaker under the suspended mass. Adjust the height of the boss such that the mass can be fully submerged if the beaker is filled with water. Pour water into the beaker so that part of the mass is immersed in the water as shown in Fig. 3.2.

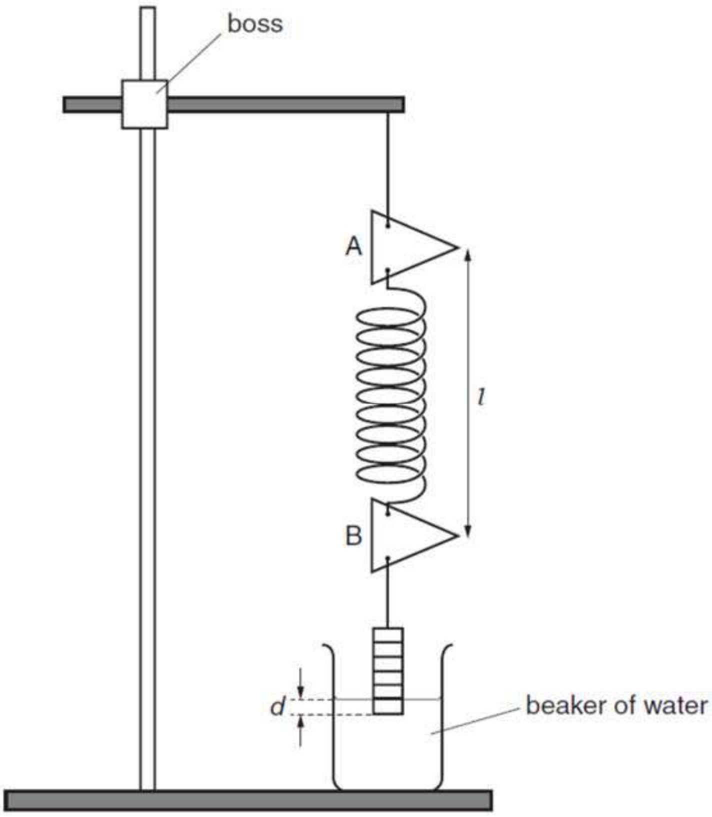

Fig. 3.2

(iii) Make and record the measurements to determine the depth *d* of the submerged part of the mass and the length *l* between the pointers.

d = ...

l = ...

(iv) Pour more water into the beaker and repeat **(iii)** until you have six sets of readings for *d* and *l*. Record all your readings in a table in the space below. [5]

(e) **(i)** Plot a graph of *l* against *d*. [3]

(ii) Draw the line of best fit. [1]

(iii) Determine the gradient of this line.

gradient = ... [1]

(f) Theory suggests that l and d are related by the equation

$$l = \frac{-\rho A g d}{k} + c$$

where ρ is the density of water, g is the acceleration of free fall and c is a constant. You may assume that g = 9.81 m s^{-2}.

Use your values from **(e)(iii)** together with the values of A, g and k to determine a value for the density of water.

ρ = ... [2]

[Total: 17 marks]

(g) A toy manufacturer wants to investigate the *minimum* volume of wood needed to make the bottom part of the toy ship. The top part of the toy ship is made of a fixed mass of metal. You may assume the shape of the ship as seen in Fig 3.3.

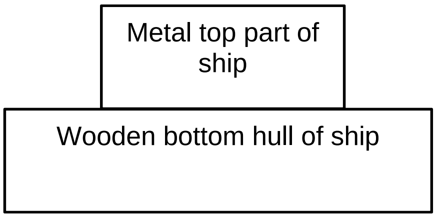

Fig. 3.3

The manufacturer wants the wooden hull to be completely submerged while keeping the metal top part of the ship dry. You may assume the hull of the toy ship to be of a rectangular shape.

Design an experiment to determine the *minimum* volume of the wooden hull needed.

Your account should include:

- your experimental procedure
- how you would determine the *minimum* volume of the wooden hull.

[5]

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[Total: 22 marks]

4 A hot wire in air loses energy. Some of the energy is lost to the air particles that hit the wire. This energy lost depends on the number of particles hitting the wire per second, and hence on the surrounding air pressure.

If the temperature of the wire is constant then the total energy lost per second E is equal to the electrical energy supplied per second.

A student suggests that E, pressure P and temperature of the heated wire T may be written in the form

$$E = k P^{m} T^{n}$$

where k, m and n are constants.

Design an experiment to determine the values of m and n.

You should draw a detailed labelled diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the control of variables,
(b) the equipment you would use,
(c) the procedure to be followed,
(d) how the constants m and n are determined,
(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

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[Total: 11 marks]

END OF PAPER

2018 JC2 H2 Physics Prelims Exam Solution (**9749** Paper 1)

Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans
1	**A**	6	**B**	11	**D**	16	**A**	21	**A**	26	**C**
2	**A**	7	**C**	12	**A**	17	**B**	22	**D**	27	**B**
3	**C**	8	**B**	13	**B**	18	**C**	23	**C**	28	**B**
4	**C**	9	**C**	14	**C**	19	**B**	24	**C**	29	**A**
5	**D**	10	**D**	15	**C**	20	**B**	25	**C**	30	**D**

1 *Ans: A*

Since it is precise, the spread of the values must be small.
Since it is not accurate, it must deviate from the true value.

2 *Ans: A*

Units of Q is C = A s
Units of V is J C^{-1} = kg m^2 s^{-2} / A s

Hence units of C = A^2 s^4 m^{-2} kg^{-1}

3 *Ans:* ***C***

$s_y = u_y t + ½ a_y t^2$
$- 8.0 = 0 + ½ (- 9.81)t^2$
$t = 1.3$ s

4 *Ans:* ***C***

$F_n = ma$
$U – W = ma$
With the fuel burning, the mass and the weight of the rocket reduces. Hence, with increase in resultant force and decrease in mass of the rocket, acceleration of the rocket increases.

After 5 s, the mass remains constant. With the resultant force which is only comprised of weight, the acceleration remains constant.

5 *Ans:* ***D***

collision:
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ where $m_1 = m_2$
$u_1 + u_2 = v_1 + v_2$
$(+ 50) + (- 30) = v_1 + v_2$
$v_1 + v_2 = 20$

elastic
$u_1 – u_2 = v_2 – v_1$
$(+ 50) – (- 30) = v_2 – v_1$
$v_2 – v_1 = 80$

	$v_1 + v_2$	$v_2 – v_1$
A	0 + 20 = 20	20 – 0 = 20
B	10 + 10 = 20	10 – 10 = 0
C	(-20) + 0 = - 20	0 – (-20) = 20
D	(-30) + (50) = 20	50 – (-30) = 80

6 *Ans:* ***B***

Rotational equilibrium: ΣM = 0

Since 4.0 N force is passing through the pivot, it does not create any moment.
Clockwise moment about O = Anticlockwise moment about O
$F × 5.0 = 2.0 \sin 30^\circ × 4.0 + 3.0 × 2.0$
$F = 2.0$ N

7 *Ans:* ***C***

ΔGPE = mgΔh where Δh = difference in height of CG
= 500 × (1.1 – 0.2)

= 450 J

8 Ans: **B**

$P = Fv$

$= 12.0 \cos 30^\circ \times 2.00$

$= 20.8$ W

9 Ans: **C**

Since the drive wheel and the turntable are in contact, they should be moving with the same speed, i.e. $V = v$

Therefore, $R\Omega = r\omega$

$\Omega = (r/R)\omega$

10 Ans: **D**

By conservation of energy,

$KE_i + GPE_i = Ke_f + GPE_f$

$$0 + \left(-\frac{GMm}{6R}\right) = \tfrac{1}{2}mv^2 + \left(-\frac{GMm}{R}\right)$$

$$v = \sqrt{\frac{5GM}{3R}}$$

11 Ans: **D**

$F_c = ma_c$

$mg = mr\omega^2$

When satellite is orbiting near the Moon's surface,

$$m\frac{g}{6} = m\left(\frac{R}{4}\right)\left(\frac{2\pi}{T_M}\right)^2 \qquad \text{--- (1)}$$

When satellite is orbiting near the Earth's surface

$$mg = mR\left(\frac{2\pi}{T}\right)^2 \qquad \text{--- (2)}$$

$$\frac{(1)}{(2)} : \frac{m\frac{g}{6}}{mg} = \frac{m\left(\frac{R}{4}\right)\left(\frac{2\pi}{T_M}\right)^2}{mR\left(\frac{2\pi}{T}\right)^2}$$

$$\left(\frac{T_M}{T}\right)^2 = \frac{6}{4}$$

$$T_M = \sqrt{\frac{3}{2}}T$$

12 Ans: **A**

Since there is no net transfer of heat energy from one to the other, bodies X and Y are in thermal equilibrium, i.e. same temperature. Their mean KE, given by 3/2 kT must be the same.

The internal energies and the total kinetic energies of bodies X and Y depends on both their temperature and the number of molecules.

Thermal equilibrium does not depends on thermal conductivity of the material of bodies X and Y.

13 Ans: **B**

Work done on gas is positive during compression, hence work done by gas is negative during compression (Y to Z).

For ideal gas, $U = 3/2\ pV$. Hence the internal energy of the ideal gas decreases with constant pressure but decreasing volume.

With work done on gas being positive, the heat is transferred out of the gas, i.e. heat is removed.

14 *Ans:* ***C***

A *It **increases** as the potential energy increases.*
B *It is always in the opposite direction to its **displacement**.*
C *True*
D *It is proportional to the **square** of the frequency.*

15 *Ans:* ***C***

$$\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda}$$

$$\frac{\pi/3}{2\pi} = \frac{0.050}{\lambda}$$

$\lambda = 0.30$ m
$v = f\lambda = 500 \times 0.30$
$= 150$ m s^{-1}

16 *Ans:* ***A***

According to Malu's law
$I = I_0\cos^2\theta$
With the axes initially 90° from each other,
$I = I_0\cos^2(90-\theta) = I_0\sin^2(\theta)$
The graph follows a sine square function.

17 *Ans:* ***B***

Since a << D, this scenario can be approximated to a Young's double slit experiment.

$$x = \frac{\lambda D}{a}$$

$$90 = \frac{\lambda \times 3000}{200}$$

$\lambda = 6.0$ m

18 *Ans:* ***C***

$d\sin\theta = n\lambda$
Violet light has a shorter wavelength than red light, thus it will be diffracted less from the normal than red light

Second order of violet light: $d\sin\theta_v = 2 \times 350\times10^{-9} = 700\times10^{-9}$
First order of red light: $d\sin\theta_r = 1\times700\times10^{-9} = 700\times10^{-9}$
For the same d, second order of violet light has the same angle of diffraction as that of red light of 700×10^{-9} *m*

19 *Ans:* ***B***

A: Since Y and Z is the same distance from charge Q, the potential at both point is the same. Having no potential difference, no work is done to taking a charge from Y to Z.
B: Electric field radiate outwards from the positive charge, hence the field strength acts in a direction from X to Z.
C: Since Y and Z is the same distance from charge Q, the magnitude of the electric field strength at both points is the same.
D: Since Y and Z is the same distance from charge Q, the potential at both point is the same.

20 *Ans:* ***B***

A: $R = V/I = 12/3.0 = 4.0\ \Omega$
B: $E = VIt = 12 \times 3.0 \times 5.0 = 180$ J
C: $Q = It = 3.0 \times 5.0 = 15$ C
D: Since potential is also defined as work done per unit charge, $[V] = V = J\ C^{-1}$.

21 *Ans:* ***A***

As V increases, I increases more than proportional. Thus resistance decreases.

22 *Ans:* ***D***
For the voltmeter to record zero voltage, the ratio of the resistance P/Q = R/S

23 *Ans:* ***C***
Current along PR is parallel to the magnetic field and so there is no magnetic force on PR.
The current along QP has a component flowing vertically downwards and perpendicular to the magnetic field. Using Fleming's LHR, the force acts on wire QP out of the page.
The current along RQ has a component flowing vertically upwards and perpendicular to the magnetic field. Using Fleming's LHR, the force acts on wire RQ into the page.
Considering the two forces on the triangular wire QPR, the triangle rotates about the axis WX with R pointing into the page.

24 *Ans:* ***C***
For the current to flow from P to Q, the motion of the copper wire must be ***vertically downwards*** *accordingly to Fleming's Right Hand Rule. [The first finger (Earth's magnetic field) is pointing into the page while the middle finger points from P to Q, the thumb, i.e. the motion of wire, points down.*
For maximum current, the rate of cutting of the Earth's magnetic flux lines must be maximum. This occurs at the instant when the wire is moving perpendicular to the field lines.

25 *Ans:* ***C***

Fig A, Mean Power, W = $\frac{V_{rms}{}^2}{R} = \frac{\left(\frac{V_0}{\sqrt{2}}\right)^2}{R} = \frac{V_0{}^2}{2R}$

Fig B, V_{rms} = $\sqrt{\frac{\text{area under the } V^2 - t \text{ curve over a period}}{T}}$

$= \sqrt{\frac{(2V_0)^2 \frac{1}{2}T + 0}{T}} = \sqrt{2}V_0$

Mean power, P_B = $\frac{V_{rms}{}^2}{R} = \frac{\left(\sqrt{2}V_0\right)^2}{R} = \frac{2V_0{}^2}{R} = 4W$

26 *Ans:* ***C***
$\langle P \rangle = V_{rms} I_{rms}$
$(I_{rms})_{min}$ = 2000 / 240 = 8.33 A
$(I_0)_{min}$ = 8.33 × √2 = 11.8 A

$(I_{rms})_{max}$ = 2400 / 220 = 10.9 A
$(I_0)_{max}$ = 10.9 × √2 = 15.4 A

$\omega = 2\pi f$
$\omega_{min} = 2\pi \times 50 = 314$
$\omega_{max} = 2\pi \times 60 = 377$

Probable current, $I = 14.1 \sin(375t)$

27 *Ans:* ***B***
$E_p = \Delta E$

$\frac{hc}{\lambda} = X - Y$

De Broglie's momentum

$p = \frac{h}{\lambda} = \frac{X - Y}{c}$

28 *Ans:* ***B***

$KE = \frac{p^2}{2m}$

$1.00 \times 10^6 \times 1.6 \times 10^{-19} = \frac{p^2}{2 \times 1.67 \times 10^{-27}}$

$p = 2.312 \times 10^{-20}$ *kg m s*$^{-1}$

$\Delta p = 0.01 \times 2.312 \times 10^{-20} = 2.312 \times 10^{-22}$

$\Delta p\, \Delta x = h$

$\Delta x = 2.87 \times 10^{-12}$ *m*

29 *Ans:* ***A***

$^{238}_{92}U \xrightarrow{\alpha} {}^{234}_{90}Q \xrightarrow{\beta} {}^{234}_{91}R \xrightarrow{\beta} {}^{234}_{92}S \xrightarrow{\alpha} {}^{230}_{90}T \xrightarrow{\alpha} {}^{226}_{88}Pb$

$^{228}_{88}Ra$ *is not produced during this series of transformations.*

30 *Ans:* ***D***

Energy releases = BE of products – BE of reactants
= 121(8.26) + 112(8.52) – 235(7.59)
= 179 MeV

1 (a)(i)

p = ρgh

= 1000 × 9.81 × 7.0 × 10^{-2} or 1000 × 9.81 × 1.9 × 10^{-2} *[C1]*

Δp = ρgΔh

= 1000 × 9.81 × (7.0 × 10^{-2} - 1.9 × 10^{-2})

500 Pa *[A1]*

1 (a)(ii)

Upthrust is the upward force by the water due to the difference in the pressure between the top and the bottom surface of the object. [B1]

U = Δp × A

U = 500 × (5.1 × 10^{-2})^2 *[M1]*

= 1.3 N *[A0]*

1 (a)(iii)

F_n = 0

T + U = W

T + 1.3 = 4.0 *[C1]*

T = 2.7 N *[A1]*

1 (a)(iv)

T = kx

2.7 = 30 × x

x = 0.090 m *[C1]*

height above surface = 0.090 – 0.070

= 0.020 m = 2.0 cm *[A1]*

1 (b)(i)

Newton's second law of motion state that the rate of change of momentum of an object is directly proportional to the resultant force acting on it [B1] and the change in momentum occurs in the direction of the resultant force [B1].

1 (b)(ii)

F_n = ma

$$4.0 - 1.3 = \frac{4.0}{9.81} \times a$$ *[C1]*

a = 6.6 m s^{-2} *[A1]*

1 (b)(iii)

As the cube accelerates, its velocity increases and hence the viscous force acting on the cube (by water) increases (and then becomes constant when reach terminal velocity) [M1]. With weight and upthrust being constant, net force and acceleration decreases (to zero) [A1].

2 (a)

When the gas is heated, the molecules ***gain kinetic energy****. As the molecules move faster, they also* ***collide with the piston more frequently****. [B1]*

The ***change of momentum*** *experienced by the molecules upon collision with the wall, causes an impact* ***force on the piston wall pushing it*** *to the right thereby doing work in causing the gas to* ***expand****. [B1]*

Credit was given for those who gave W= PΔV but they need to explain how the pressure originate from the collision of the gas particles on the wall and that the volume increases.

2 (b)(i)

Any two possible answers [B1x2]

1. *There can be work done against friction due to the piston rubbing against the wall which dissipates the supplied energy.*
2. *The heat generated does not totally transfer into mechanical work done as some is given to raise the internal energy of the gas.*
3. *The wall of the vessel is not a perfect insulator and it might conduct some of the heat away from the vessel resulting in smaller work done.*
4. *The gas is not ideal. So the collision is not elastics.*
5. *The wire conducts some of the heat energy from the heater.*

2 (b)(ii)1.

*In the first experiment, **the piston is fixed and so no work is done.** All the 150 J goes into increasing the internal energy of the gas. [B1]*

*In the second experiment, the piston is free to move and so work is done by the gas. Because there is **work done by the gas, there is less thermal energy** available to increase the internal energy and so **the temperature rise for the second experiment is less**. [B1]*

Using 1st law of thermodynamics
Expt 1 : $\Delta U = Q + 0$
Expt 2 : $\Delta U' = Q - W$ (Q is 150 J for both)

Thus, the rise in internal energy (and temperature) for Expt 2 is less.

2 (b)(ii)2.

$\Delta U = Q + W$
$= 150 + 0$
$= 150$ J [A1]

2 (b)(ii)3.

efficiency = Work / heat energy supplied
$40/100 = W / 150$ [C1]
$W = 60$ J [A1]

Deduct one mark for negative answer

2 (b)(ii)4.

$\Delta U = Q + W$
$= 150 + (-60)$
$= 90$ J [A1]
Allow ECF

3 (a)

The principle of superposition states that when two or more waves meet at a point [B1], the resultant displacement at that point is equal to the vector sum of the displacements of the individual waves at that point. [B1]

3 (b)(i)

It means that the signals from P and Q reaching the point are in antiphase. [A1] (accept completely or 180° or π out of phase.)

3 (b)(ii)

Along the line joining X and Y, any point Z along XY will be such that the distance PZ equals the distance QZ. Thus the path difference PZ – QZ will be zero. [B1]

The phase difference of the two signals reaching point Z will be due to the phase difference between the transmitter P and Q which is π out of phase.

*Thus the waves from P and Q meet point Z in antiphase and the resultant displacement is **always zero** [B1] and the signal detected by the ship is zero.*

3 (b)(iii)

λ wavelength of wave = v / f = (3.0 x 10^8 m s^{-1}) / (1.0 x 10^6 Hz) = 300 m

[M1]

When the ship detects an amplitude that is twice, it reaches a point of constructive interference. [M1]

Distance between destructive interference to constructive interference = $\lambda/4$

= 75 m [A1]

3 (b)(iv)

Distance from mid point to Q = 30 km.

Distance between two nodes = $\lambda/2$ = 150 m

Number of dips = 30000/ 150 = 200

4 (a)(i)

As the graph shows a significant drop in the p.d across the variable resistance as current changes, it shows that the variation of p.d in internal resistance is significant

4 (a)(ii)

Using V = E - Ir

Thus, when I = 0, V = E [B1]

When extending the graph, the line cut 4.4 V, E = 4.4 V

Gradient of graph = -r

Thus -r= (3.1-0.7)/(1.2-3.4) = -1.1 [B1]

r = 1.1

4 (b)

When device is operating in normal condition,

Resistance of device = 0.53Ω [B1]

Effective resistance of circuit needed = 4.4/1.5 = 2.93 [B1]

Additional resistance required = 2.93 – 0.53 – 1.1 = 1.3 Ω

[Draw an additional 1.3 Ω of resistor in series with the emf and device] [A1]

5 (a)

Number of electrons removed = total charge/ charge of 1 electron

$= \dfrac{1.11\times10^{-6}}{1.6\times10^{-19}}$ *[C1]*

$= 6.94 \times 10^{12}$ *[A1]*

5 (b)

(a) *Values for graph*

Distance/ m	$E/\times10^3$ V
0.50	40.0
1.00	10.0
1.50	4.44
2.00	2.50

Correct points [B1]
Shape for curve with decreasing magnitude with increasing distance. [B1]

5 (c)(i)

Work done = q∆V = $\frac{q^2}{4\pi\varepsilon_0}\left(\frac{1}{1.2}-0\right)$

$=(1.11\times10^{-6})^2(9.0\times10^9)(0.833)$ *[M1]*
$= 9.24\times10^{-3}$ J *[A1]*

5 (c)(ii)

Field strength due to charge of right = $\frac{q}{4\pi\varepsilon_0(0.5)^2}$ *points to the left.*

Field strength due to charge of left = $\frac{q}{4\pi\varepsilon_0(0.7)^2}$ *points to the right.*

Resultant field strength = $\frac{q}{4\pi\varepsilon_0(0.5)^2}-\frac{q}{4\pi\varepsilon_0(0.7)^2}$ *[C1]*
$= 1.96\times10^4$ V m^{-1} *[A1]*
Direction towards the left [A1] (accept negative sign if student states rightward as convention.

6 (a)

The photoemission of electrons from the zinc plate is due to the fact that the electromagnetic radiation incident on the plate exhibit a ***particle nature*** *as opposed to wave nature. They propogate as* ***photons****.*

Electrons are emitted from the zinc plate only when the photons each has energy that ***exceed the work function*** *(minimum energy for photoelectron emission) of the metal through a* ***one-to-one interaction*** *between the photons and electrons.*

Electrons are emitted from the metal surface because the energy of the uv photon ***exceed the work function*** *of the metal*
or
the frequency of the uv radiation (ultraviolet rays) ***exceed the threshold frequency*** *(minimum frequency for photoelectron emission),*

The emission of electrons is ***independent of the intensity*** *as changing the intensity merely changes the rate of the incident photons and it does not alter their energy. Thus, a weak intensity uv radiation can cause photoelectrom emission but an intense visible light may not cause photoelectron emission.*

6 (b)

Work function $\phi=\frac{hc}{\lambda_o}=\frac{(6.63\times10^{-34})(3.0\times10^8)}{2{,}9\times10^{-7}}$

$= 6.86\times10^{-19}$ J *[C1]*

Energy of photon E = 5.1 eV
$= (5.1)(1.60\times10^{-19})$
$= 8.16\times10^{-19}$ J *[C1]*

E = ϕ *+ Max KE*

Max KE = E - ϕ
$= (8.16-6.86)\times10^{-19}$
$= \mathbf{1.3\times10^{-19}}$ **J** ***[A1]***

6 (c)(i)

*Because the electrode C is connected to the negative terminal, the electrons are **repelled** by it [B1] (ie the electric force acts opposite to the initial electron flow).*
As V increases, fewer electrons per unit time reach C and hence the current I decreases. [B1]

6 (c)(ii)
*The electrons are emitted with a **range of KE.***
*When the **opposing potential** is raised to the point (**stopping potential**) where the **current is just zero**, it is an indication that the most energetic electron is stopped on its track just short of touching C. [B1]*

By COE,
Loss in Max KE = Gain in EPE
= (Stopping potential)(charge)
= V e
*= **2.2 eV***
*= **3.36×10^{-19} J** (max KE of e) [B1]*

7 (a)
As nuclear fission takes place very quickly and the number of neutrons emitted will be very large as the stages proceed on [1] (resulting in a chain reaction) and hence leading to a very large amount of energy in a short time, which may cause an explosion if not controlled [1]

7 (b)(i)
$E = a^{n-1}b$ *-> lgE=(n-1)lg(a) + lg(b)*
Thus the intercept of the graph is lg(b) – lg(a) [M1]
Gradient of graph , lg (a)= (4.6-2.7)/(6.8-2.0) = 0.3958
4.6 = (0.3958)(6.8)+c
c = 1.908 [M1]

therefore lg(b) – lg(a) = 1.908
lg (b) = 2.30
b=200 MeV [A1]

7 (b)(ii)
Energy release due to one nuclear fission reaction of uranium

7 (c)(i)
92 – 36 = 56

7 (c)(ii)
The range of percentage yield is very large and hence in order to show the variation of the values in a single graph, a logarithmic scale is used.

7 (c)(iii)
Percentage yield of having 135 and 99 = 6

If the Uranium produces two nuclei with the same masses, mass of each nuclide = 236/2 = 118
Percentage yield of masses equal = 0.015
Therefore, the ratio = 6/0.015
= 400

7 (d)(i)
Gamma (photon) radiation.

7 (d)(ii)
2477 TWh = $2477 \times 10^{12} \times 3600$
= 8.92×10^{18} J [C1]

Since the efficiency is 35%,
The amount of heat required
= 100/35 x 8.92 x 10^{18} = 2.55 x 10^{19} J [A1]

7 (d)(iii)
Power required = (2.55 x 10^{19})/(336x24x60x60)
= 8.78 x 10^{11} W [B1]

Number of reactions needed in one second
= (8.78 x 10^{11})/(167x10^{6} x 1.6x10^{-19})
= 3.28 x 10^{22} [B1]

Amount required (mass per s)
= 3.28 x 10^{22} x 235u
= 3.28 x 10^{22} x 235(1.66x10^{-27})
= 1.28 x 10^{-2} kg s^{-1} [A1]

7 (e)
The decay chain of Mo has a relatively longer half life and poses a health hazard if it is not stored properly over an extended period of time. And so it has to be securely shielded (or encapsulated) and stored in a safe and isolated place for a longer period of time.

The decay chain of Xe has much shorter half life and so the time it spends in isolated storage is much less and it can be 'disposed off'safely after a few days. However, due to its high activity at the initial stage, the shielding provided must be sufficiently 'thick' to contain its radiation.

7 (f)
- *Like fossil fuel, there is finite amount of uranium available for nuclear reactor plants to meet the increasing needs for energy supply. They are not renewable and so when the supply drops, alternative energy sources will be required. Its usage is not sustainable in the long run.*

- *Despite raising the safety standards of nuclear reactor plants, it is still subjected to potential natural disaster (eg earthquake and tsunami). In the event of such disruption, nuclear meltdown can occur.*

- *Nuclear plants generate lots of heat due to the poor efficiency of heat engines. Its contribution to global warming is substantial and it can lead to climate changes.*

- *For certain countries where land is scarce (eg Singapore)), setting up a nuclear reactor plant would not be feasible as there needs to be a minimum safe distance between populated areas and the nuclear site in case of a nuclear meltdown.*

1 (a)(i)

$s = \frac{1}{2}(u + v)t$

$= \frac{1}{2}(4.0 + 37.0)(17.0)$ [C1]

$= 348.51$

≈ 349 m [A1]

1 (a)(ii)

$\Delta t = 0.6/100 \times 17 = 0.1$ s

$s_{max} = \frac{1}{2}(4.1 + 37.1)(17.1) = 352.26$

$s_{min} = \frac{1}{2}(3.9 + 36.9)(16.9) = 344.76$

$2\Delta s = s_{max} - s_{min} = 352.26 - 344.76 = 7.4$ [C1]

$\Delta s = 3.7 \approx 4$

$$\frac{\Delta s}{s} \times 100\% = \frac{4}{348.51} \times 100\% = 1.1\%$$ [A1]

Alternatively

$$s = \frac{1}{2}(u + v)t$$

$$\frac{\Delta s}{s} = \frac{\Delta(u+v)}{(u+v)} + \frac{\Delta t}{t}$$ [C1]

$$\frac{\Delta s}{s} \times 100\% = \left(\frac{0.1+0.1}{4.0+36.0}\right) \times 100\% + 0.6\%$$

$$\frac{\Delta s}{s} \times 100\% = 1.1\%$$ [A1]

1 (a)(iii)

$$\frac{\Delta s}{s} \times 100\% = 1.1\%$$

$\Delta s = 0.011 \times 349$

$\Delta s = 3.84 \approx 4$ m

$s = (349 \pm 4)$ m [B1]

1 (b)(i)

$\Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$= \frac{1}{2} \times 95 \times [(37.0)^2 - (4.0)^2]$ [C1]

$= 64300$ J [A1]

1 (b)(ii)

$\Delta GPE = \Delta mgh$

$= 95 \times 9.81 \times -349 \sin 40^\circ$ [C1]

$= -209000$ J [A1]

1 (b)(iii)

$GPE_i + KE_i + W_{friction} = GPE_f + KE_f$

Work done by friction $= \Delta GPE - \Delta KE$

$= -209100 + 64300$ J

$= -144800$ [C1]

$f \times 349 \cos 180^\circ = -144800$

$f = 415$ N [A1]

2 (a)

Newton's law of gravitation states that the attractive gravitational force between two point masses [A1] is directly proportional to the product of the masses and inversely proportional to the square of their separation [M1].

2 (b)

The gravitational force acting on the moon provides the centripetal force. [B1]

$F_c = ma_c$

$\frac{GMm}{x^2} = mx\omega^2$ [M1]

Since $\omega = \frac{2\pi}{T}$

$\frac{GMm}{x^2} = mx\left(\frac{2\pi}{T}\right)^2$ [M1]

$GM = \frac{4\pi^2 x^3}{T^2}$ [A0]

2 (c)(i)

gradient = $\frac{(4.5\times10^{14} - 1.3\times10^{14})\times(1000)^3}{(0.35-0.10)\times(24\times60\times60)^2}$ [M1]

$= 1.71 \times 10^{14}$ m^3 s^{-2} [A0]

2 (c)(ii)

$GM = \frac{4\pi^2 x^3}{T^2}$

$6.67\times10^{-11}\times M = 4\pi^2 \times 1.71\times10^{14}$ [C1]

$M = 1.02 \times 10^{26}$ kg [A1]

2 (d)

The gradient of the graph is equal to $\frac{GM}{4\pi^2}$. Since the mass of planet Uranus is smaller than that of planet Neptune,

the graph for Uranus is one with smaller gradient [B1] with the same zero-y-intercept [B1].

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3 (a)

Any 2 assumptions [B1x2]

- Large number of particles.
- The time of collisions is negligible compared to the time between the collisions.
- Negligible intermolecular forces (except during collisions)
- Total volume of the gas particles are negligible compared to volume of the containing vessel.
- Average separation of gas particles is very large compared to the size of particle. Negligible microscopic PE.
- The gas particles moves randomly in all directions.

3 (b)(i)

Mass of 1 mole of helium-4 gas = 4.0×10^{-3} kg

Mass of 1 atom = $4.0\times10^{-3} / 6.02\times10^{23}$

$= 6.6\times10^{-27}$ kg [A1]

Alternatively

Mass of one atom = 4u = 4 x (1.66×10^{-27})

$= 6.6 \times10^{-27}$ kg

Mass the 2 electrons is negligible and so can be ignored.

No marks if 4xmass of proton. He-4 has 2 protons and 2 neutrons

3 (b)(ii)

Internal Energy U = $\frac{3}{2}nRT = \frac{3}{2}(1.2)(8.31)(273+27)$

= 4.5×10³ J [A1]

Alternatively, can use $\frac{3}{2}NkT = \frac{3}{2}(nN_a)kT$

3 (b)(iii)

$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ [C1]

$\frac{1}{2}(6.6\times10^{-27})\langle c^2\rangle = \frac{3}{2}(1.38\times10^{-23})(300)$ [C1]

r.m.s. speed = 1.4×10^3 *m s*$^{-1}$ [A0]

Alternatively,

Mean KE = Internal E / (no. of atoms)

$\frac{1}{2}m\langle c^2\rangle = \frac{4.49\times10^3}{6.023\times10^{23}} = 7.45\times10^{-21}$ [C1]

$\frac{1}{2}(6.64\times10^{-27})\langle c^2\rangle = \frac{4.49\times10^3}{6.023\times10^{23}} = 7.45\times10^{-21}$ [C1]

r.m.s. speed = 1.5×10^3 *m s*$^{-1}$ [A0]

3 (b)(iv)

The r.m.s. speed is a ***singular representation of the effective speed*** *that determines the internal energy of the gas. It is a sort of an 'average' speed.*

(MUST put inverted comma for the term 'average' as it denotes a proxy value and not the actual average speed. FYI, the average velocity is zero as the motion is random, Average speed is not the same as rms speed as the distribution of the speed does not follow a normal distribution).

Statistically, that means there are some particles that have speeds greater (or less) than the r.m.s. speed. Thus, some helium particles that have ***with speed greater than the escape speed will escape*** *the Earth's atmosphere. [B1]*

---

4 (a)

free oscillation: oscillation in which a body oscillates without any loss of energy or without resistive forces or without external forces applied. [B1]

forced oscillation: oscillation in which a body is made to vibrate by an external periodic force or continuous energy is transferred to the vibrating body. [B1]

4 (b)(i)

Resonance can be used as the driving frequency of the oscillator matches the natural frequency of the vibration of the trolley. [B1]

It can be observed where the amplitude of the vibration is the maximum. [B1]

From Fig. 4.2, frequency is 2.1 Hz (allow 2.08 to 2.12 Hz).

[B1]

4 (b)(ii)

The peak of the graph is not very sharp or the amplitude of the vibration is finite, so frictional forces are present. [B1]

4 (c)

$v_0 = \omega x_0$

$= 2\pi\times2.1\times4.7\times10^{-2}$ [C1]

$= 0.62$ m s^{-1} [A1]

5 (a)
A and B: in phase [A1]
A and C: in antiphase (accept completely or 180° or π out of phase.) [A1]

5 (b)
Use stroboscope (B1) and adjust flash frequency for slow motion/ expect to see A moving up as C moves down etc.
Or use a video camera and replay in slow motion/ expect to see A moving up as C moves down etc.

5 (c)(i)
The amplitude of the wave is constant for progressive wave [B1] but varies from 0 at the the node to 2A at the antinode for stationary wave. {B1}

5 (c)(ii)
Reflection give rise to waves propagating in both directions [B1].
Interference between these progressive waves of the same amplitude, frequency and speed moving in opposite direction gives rise to stationary wave. {B1}

6 (a)
$$R = \frac{\rho l}{A} = \frac{1.7 \times 10^{-8} \times 1.5}{3.2 \times 10^{-9}}$$ [M1]
$= 8.0\ \Omega$ [A0]

6 (b)
$E = IR$
$12 = I \times (1.0 + 2.0 + 8.0)$
$I = 1.091$ A [C1]

$I = nAqv$
$1.091 = (8.5 \times 10^{28})(3.2 \times 10^{-9})(1.6 \times 10^{-19})\, v$
$v = 0.025$ m s^{-1} [A1]

6 (c)(i)
Using potential divider equation,
$$V_{PQ} = \frac{R_{RQ}}{R_{total}} = \frac{8.0}{8.0 + 1.0 + 2.0} \times 12.0$$ [M1]
$= 8.7$ V [A0]

6 (c)(ii)
$$\text{terminal pd of B} = \frac{R}{R + r} \times E = \frac{4.0}{4.0 + 3.0} \times 1.5$$
$= 0.857$ V [C1]

$$\frac{V_{PJ}}{V_{PQ}} = \frac{l_{PJ}}{l_{PQ}}$$
Since terminal pd of B = V_{PJ}
$$\frac{0.857}{8.7} = \frac{l_{PJ}}{1.5}$$ [C1]
$l_{PJ} = 0.148$ m [A1]

6 (c)(iii)
To improve accuracy, the modification is either to
1. make the potential difference of PJ larger by increasing the resistance of the 4.0 Ω larger [B1].
However this amendment has minimal effect due to the small value of e.m.f. of cell B
Only award 1 mark.

2. make the potential difference per unit length of PQ smaller [M1] to increase the length of PQ needed at balance length by decreasing the e.m.f. of cell A or reducing the resistance of the wire through increasing its cross-sectional area, decreasing length or resistivity or increasing the resistance of the 2.0 Ω resistor [A1]

6 (d)
From galvanometer towards J

7 (a)
- Emission from radioactive daughter products
- Self absorption in source
- Absorption in air before reaching detector
- Detector not sensitive to all radiations
- Window/detector may absorb some radiations
- Dead-time of the counter
- Background radiation

Any two

7 (b)(i)
Curve is not smooth
Or
Curve fluctuates/is jagged

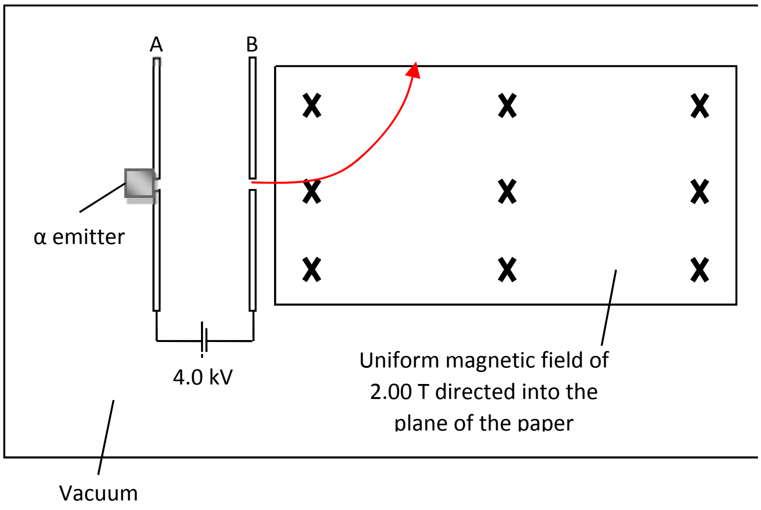
7 (b)(i)
Evidence of background radiation taken account [B1]
Half life determine twice [B1]
Half life = 1.5h (accepting a range of 1.4-1.6 [A1]

7 (c)
Half life has no change as radioactive is spontaneous/is not affected by external factor

8 (a)
One tesla is defined as the amount of magnetic flux density of a uniform magnetic field when a magnetic force per unit current per unit length of 1 newton per ampere per metre acts on a straight wire placed perpendicular to the magnetic field.

8 (b)(i)

Award [B1] if student's answer shows evidence of a circular path and particle is deflected upwards.



8 (b)(ii)

The magnetic force acting on the α-particle is always directed at right angles to the velocity of the particle. [B1]

The resulting acceleration is directed at right angles to the velocity of the particle and thus will not alter the speed but merely changes its direction. [B1] **OR** The magnetic force hence does not do work on the particle. [B1]

The kinetic energy of the particle thus does not change. [B1]

8 (b)(iii)

$$\frac{1}{2}mv^2 = qV$$

$$v = \sqrt{\frac{2(2\times1.6\times10^{-19})(4000)}{6.644\times10^{-27}}} \quad \text{[M1]}$$

$$= 6.207\times10^5 \text{ m s}^{-1} \quad \text{[A0]}$$

8 (b)(iv)

$$F_B = F_E$$

$$qvB = qE$$

$$E = vB$$

$$= (6.207\times10^5)(2.00) \quad \text{[M1]}$$

$$= 1.24\times10^6 \text{ V m}^{-1} \quad \text{[A1]}$$

E Field is directed downwards [B1]

8 (c)(i)

$F_B = F_c$

$qvB = \frac{mv^2}{r}$

$r = \frac{mv}{qB}$

$= \frac{6.644\times10^{-27}\left(6.207\times10^{5}\right)\sin 30^\circ}{\left(2\times1.6\times10^{-19}\right)(2.00)}$ [M1]

$= 3.22\times10^{-3}$ m [A1]

8 (c)(ii)

Magnetic force on charged particle provides the centripetal force.

$q_\alpha v_y B = m_\alpha v_y \omega$

$q_\alpha B = m_\alpha\left(\frac{2\pi}{T}\right)$ [M1]

$T = \frac{2\pi m_\alpha}{q_\alpha B}$ (shown)

8 (c)(iii)

$T = \frac{2\pi m_\alpha}{q_\alpha B}$

$= \frac{2\pi\left(6.644\times10^{-27}\right)}{\left(2\times1.6\times10^{-19}\right)(2.00)}$

$= 6.522\times10^{-8}$ s [M1]

Pitch, $p = v_x T$

$= \left(6.207\times10^{5}\right)\cos 30^\circ \times 6.522\times10^{-8}$ [M1]

$= 0.0351$ m [A1]

8 (c)(iv)

Since $q_{\text{positron}} = \frac{1}{2}q_\alpha$, $m_{\text{positron}} << m_\alpha$

$\frac{m_{\text{positron}}}{q_{\text{positron}}} = \frac{9.11\times10^{-31}}{1.6\times10^{-19}} = 5.69\times10^{-12}$

$\frac{m_{\text{alpha}}}{q_{\text{alpha}}} = \frac{6.644\times10^{-27}}{2\times1.6\times10^{-19}} = 2.07\times10^{-8}$

Thus, $(m/q)_{\text{positron}} < (m/q)_{\text{alpha}}$ [M1]

For a positron, the period, $T = \frac{2\pi m}{qB}$ will decrease for the same magnetic field [A1]

Since radius is also proportional to the ratio (m/q) for the same B and speed, the radius $r = \frac{mv}{qB}$ for positron will also decrease. [A1]

Pitch is proportional to the period for the same horizontal speed $p = v_x T$, thus the pitch will decrease. [A1]

---

9 (a)(i)

Magnetic flux through the surface is defined as the product of the magnetic flux density B **perpendicular** to the surface and the area A of the surface. [B1]

Or

Magnetic flux is the product of the magnetic flux density and the area **normal** to the lines of flux. [B1]

9 (a)(ii)

Faraday's law of electromagnetic induction states that the magnitude of the induced e.m.f. across a conductor is directly proportional to the rate of change of magnetic flux linkage (or the rate of cutting of magnetic flux). [B1]

Lenz's Law states that the induced e.m.f in a closed circuit will produce effects that oppose the magnetic flux change that causes it.
OR
Lenz's Law states that the induced current in a closed circuit will flow in such a way as to oppose the change that causes it.

[B1]

9 (b)(i).

Magnetic flux linkage Φ = *NBA* [C1]

At 30.0 mm position,
Φ_i =(50)(1.0×10^{-3})(16.0×10^{-4})
= 8.0 × 10^{-5} Wb [A1]

At 10.0 mm position,
Φ_f = (50)(32.0×10^{-3})(16.0×10^{-4}) [A1]
= 2.56 ×10^{-3} Wb

9 (b)(ii)
From Faraday's law,

$$E = \left|\frac{\Delta\Phi}{\Delta t}\right|$$

[M1]

$$0.80\times10^{-3} = \frac{2.56\times10^{-3} - 8.0\times10^{-5}}{\Delta t}$$

time take Δt = 3.10 s
average speed = (30.0 – 10.0) / 3.10
= 6.45 mm s^{-1}
= 6.5 mm s^{-1} (2s.f.) [A1]

9 (b)(iii)

$$E = \frac{dN\phi}{dt} = \frac{dNBA}{dt} = NA\left(\frac{dB}{dt}\right)$$

$$E = NA\left(\frac{dB}{dt}\right) = NA\left(\frac{dB}{dx/v}\right) = NA\left(\frac{dB}{dx}\right)v$$

Consider the coil moving at constant speed towards the end of the bar magnet. The induced emf in the coil will increase as the B-x gradient increases.
From the above, it can be seen that to maintain the same induced e.m.f., the rate of change (or rise) of magnetic flux linkage in the coil must be steady. The instantaneous velocity of the coil should therefore be inversely proportional to the B-x gradient. So, when approaching the magnet and the B-x gradient rises sharply, to mitigate the rise, the speed of the coil must decrease gradually. The combined effect is to make the magnetic flux linkage to rise at a steady rate resulting in a steady emf. See graphs on right.

At the 30.0 mm position, since the B-x slope is gradual, the speed of the coil must be large initially [B1]

When the coil approaches the magnet, the B-x gradient increases at an increasing rate wrt x. Thus, to maintain the same emf, the **speed of the coil must decrease at a decreasing rate** when moving from 30.0 mm position to the 10.0 mm position. [B1]

9 (c)(i)

For a rotating coil, $E = NBA\omega\sin(\omega t)$

For e.m.f. to be maximum, $\sin(\omega t) = 1$.

Hence, max e.m.f. $E_o = NBA(2\pi f)$

$= (800)(0.50)(5.0\times10^{-2}\times8.0\times10^{-2})(2\pi)(240/60)$ [M1]

$= 40.2$ V

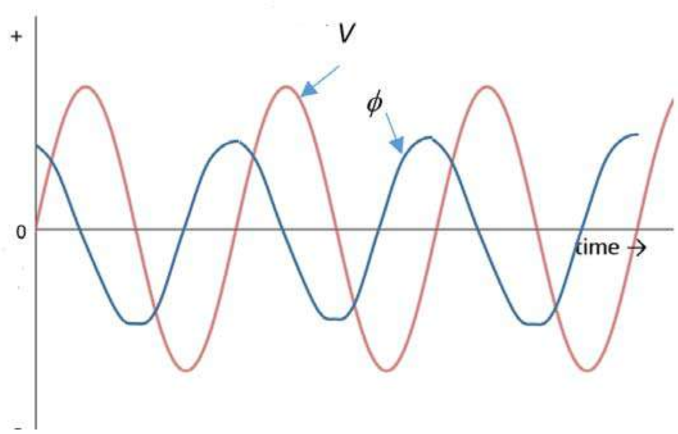
$= 40$ V [A1]

9 (c)(ii)

$V = -\frac{d\Phi}{dt}$ [B1]

Do not award mark if the negative sign is omitted.

9 (c)(iii)



Both graphs have same frequency (period) [B1]
A phase difference of 90° with V lagging ϕ. [B1]

9(c)(iv)

$I_o = \frac{V_o}{R} = \frac{40}{12} = 3.3\ A$ [A1]

9 (c)(v)
The term r.m.s. value refers to the square root of the mean squared values. [B1]

The r.m.s. current is equivalent to that of a steady direct current which would dissipate energy in a given resistance at the same rate as the alternating current (same heating effect) [B1]

9 (c)(vi)

$I_{rms} = \frac{I_o}{\sqrt{2}} = \frac{3.35}{\sqrt{2}} =$ 2.37 A
= 2.4 A [2 s.f.] [A1]

9 (c)(vii)

Average power = $I_{rms}^2 R = (2.37)^2(11.4)$ = 64.0 W
= 64 W (2 s.f.) [A1]

INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS | INDEX NUMBER

PHYSICS — 9749/04

Paper 4 Practical

16 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Shift
Laboratory

IMPORTANT

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

The number of marks is given in the brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 16
2	/ 6
3	/ 22
4	/ 11
Penalty	
Total	/ **55**
Percentage	

1 In this experiment you will measure the current I through a resistor R_3 as its resistance is changed.

(a) **(i)** Use the multimeter to measure the e.m.f. E of the power supply.

E = 1.54 V

- Accept answers between 1.40 V to 1.70 V
- Accept answers in mV eg 1534mV (4s.f.)

Answer to the correct precision of the digital multimeter (to be consistent with instrument) and with unit

E = ... [1]

(ii) Connect the circuit shown in Fig. 1.1. R_1 and R_2 are labelled, and R_3 is 100 Ω as indicated by its label. Each resistor carries a label indicating its resistance.

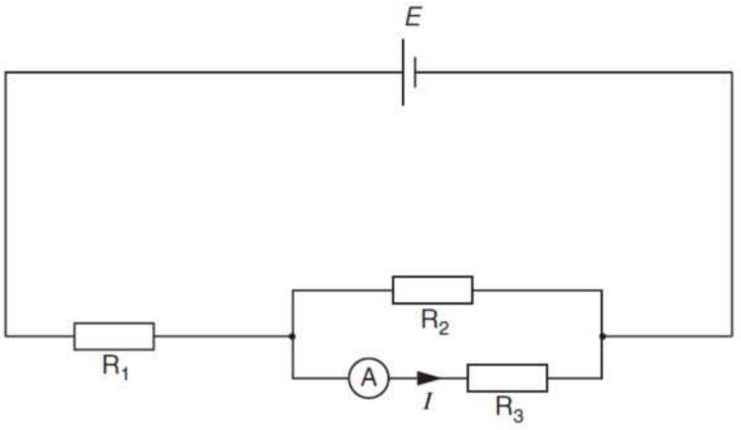


Fig. 1.1

(iii) Record the value of the current I for resistance R_3 of 100 Ω.

I = 8.22 mA

- Award 1 mark for answers between 7.40 mA to 9.40 mA with correct precision and unit.

Reject if they wrote 7.90 A instead of 7.90 mA

I = ... [1]

(b) Change the resistance of resistor R_3 and repeat **(a)(iii)** until you have six sets of readings for I and R_3. Include values of $\frac{1}{I}$ in your table of results.

[5]

R_3/Ω	I / mA	I^{-1} / A^{-1}
33	14.40	69.44
47	12.40	80.65
82	9.24	108
100	8.22	122
180	5.33	188
220	4.58	218

- Award 2 marks for 6 sets of readings (tick)
- Award 1 mark for 5 sets of readings (tick, annotate "5 sets -1")
- Award zero mark for 4 sets or less readings

- Award 1 mark for proper labelling of column headers with units (accept separating marks as a solidus, brackets around the units but not commas (UCLES))
- Award 1 mark for correct precision of (I / mA)
- Award 1 mark for correct s.f. of (I^{-1} / A^{-1}). The number of s.f. for 1/ I must follow that for I.

(c) **(i)** Plot a graph of $\frac{1}{I}$ against R_3. [3]

- Award 1 mark for
  - sensible scale must be used such as 1:10, 2:10, 4:10, 5:10. Awkward scales (e.g. 3:10, 6:10, 7:10, 9:10) are not allowed. Allow 2.5:10 scale.
  - scale must be chosen so that the plotted points occupy at least half the grid in y and x directions (6 squares on the long axis and 4 squares on the short axis)
  - Scale must be plotted with the quantity which is being plotted (i.e. I^{-1} vs resistance R_3). (allow inverted axes i.e. R_3 vs I^{-1} but do not allow wrong graph. Ignore units) (UCLES)
  - Scale markings should be no more than 3 large squares apart. (allow inverted axes i.e. R_3 vs I^{-1} but do not allow wrong graph)
- Award 1 mark for all observations to be plotted. (6 or 5 points must be plotted if student collected 6 or 5 data sets to be awarded this mark).
  - Zero mark if 4 or fewer points in the table.
  - Check 3 points for R_3 = 1, 3 and 5.
  - Diameter of plotted point must be ≤ half a small square (no blobs)
- Award 1 mark for line of best fit must start from the first point and end at the last point. (curve must pass through 6 or 5 points if student plotted 6 or 5 data sets to be awarded this mark)

(ii) Draw the line of best fit. [1]

Draw a straight line with points equally distributed above and below the line.
Line must not be kinked or thicker than half a square. No hairy lines. (UCLES)

(iii) Determine the gradient and the y-intercept of the graph.

Using 2 points from the straight line, (284, 270) & (52, 84)
Gradient G = (270 – 84) / (284 – 52)
= 0.802 $A^{-1}\ \Omega^{-1}$(or V^{-1})

Using y = mx + c,
270 = (0.802)(284) + c
c = 42.3 A^{-1}

- Award 1 mark for **each correct calculation** of gradient and y-intercept to 3 s.f. (if 2 s.f., marker to check the scale of graph). (unit is not required)
- sign of gradient must match graph.
- gradient triangle must be more than half of the line drawn. Allow hypotenuse to be exactly equal to half the drawn line.
- Zero mark for Δx/Δy
- If axis is shown with a multiplier (such as $(mA)^{-1}$), allow multiplier to be omitted from the read-off.
- Allow ECF mark if student calculate the gradient correctly if the axes plotted are wrong.
- gradient coordinates must be read correct to half a small square precision.

If y-intercept is read from graph, appropriate s.f. applies.

gradient = ... [1]

y-intercept = ... [1]

(d) The relationship between I and R_3 is

$$\frac{1}{I} = \left(\frac{R_1 + R_2}{E R_2}\right) R_3 + \frac{R_1}{E}$$

where R_1 is the resistance of the resistor R_1, R_2 is the resistance of the resistor R_2, and E is the e.m.f. of the power supply.
Using your answers from **(a)(i)** and **(c)(iii)**, determine values of R_1 and R_2.

To find R_1, using the y-intercept,
$42.3 = R_1 / E$
$R_1 = (42.3)(1.54) = 65.1\ \Omega$

To find R_2, using the gradient,
$\left(\frac{R_1 + R_2}{E R_2}\right) = \text{gradient}$

$\left(\frac{65.1 + R_2}{1.54 R_2}\right) = 0.802$

$R_2 = 277\ \Omega$

- Award 1 mark for **each** correct calculation with units of R_1 & R_2 to 3 s.f. Do not allow fractions
- Award 1 mark only if there is no unit for R_1 & R_2.
- Zero marks for negative values for R_1 & R_2.
- No marks awarded if R_1 & R_2 has values inconsistent with units e.g. 0.056 Ω when it should be 56 Ω. This is because students forget to convert per mA to per A. (need to $\times 10^3$)
- No marks awarded if they use substitution method instead of the gradient and y-intercept.

R_1 = ... [1]

R_2 = ... [1]

(e) Comment on any anomalous data or results that you may have obtained. Explain your answer.

....

....

....[1]

[**Total: 16 marks**]

Either
All points fall close to the best fit line.
They are randomly and equally distributed about the best fit line drawn.
There is no anomalous data.
Or
Point (x, y) is relatively further away from the best-fit line than the rest.
The point (x, y) is anomalous.
Or
All points lie on the best fit line. There is no anomalous data.
Or
All points are scattered about the best fit line. There is no anomalous data.

Award 1 mark for correct interpretation of data.

You may not need to use all of the materials provided.

2 In this experiment, you will investigate the motion of oscillating table tennis balls.

(a) **(i)** Tape each ball to a length of string. Ensure the total length of the string and ball is 35.0 cm, as shown in Fig. 2.1.

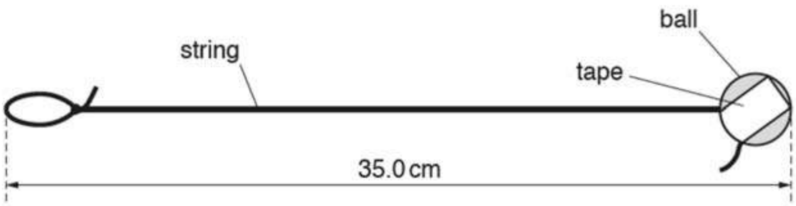


Fig. 2.1

(ii) Tape the shorter wooden block to one of the balls as shown in Fig. 2.2. Tape should be used on opposite sides of the block and the ball. The distance between the end of the string loop and the mark around the wooden block is *x*. Measure and record *x*.

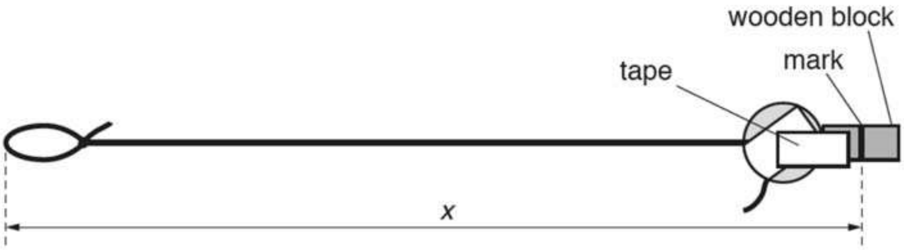


Fig. 2.2

x = 405 mm or 40.5 cm or 0.405 m (35.0 -50.0 cm)
Award 1 mark for correct calculation of answer to correct precision of instrument of ruler up to 1 mm

x = ... [1]

(iii) Set up the apparatus as shown in Fig. 2.3

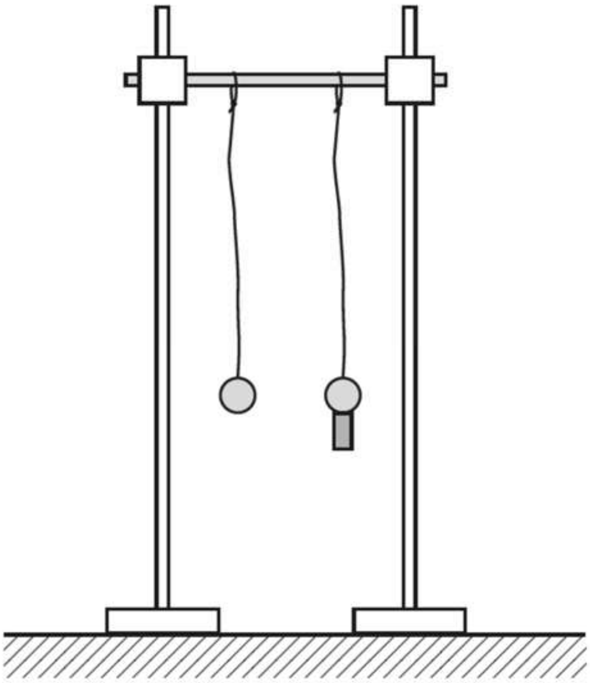


Fig. 2.3

(iv) Pull **both** balls towards you.

Release the balls at the same time and watch the movement.
The two balls will move backwards and forwards becoming out of phase.
After a time they will be back in phase so that they move towards you together.
The ball with the block attached completes *n* oscillations in this time.

(b) **(i)** Repeat **(a)(iv)** and record *n*.

n = (15 + 16) / 2 = 16
Award 1 mark for integer value of n and with repeated readings.

n = ... [1]

(ii) Calculate $\frac{(n+1)^2}{n^2}$.

To calculate $(n+1)^2 / n^2 = (16+1)^2 / 16^2$
= 1.128
= 1.1 (2 s.f.)
Award 1 mark for correct calculation and to 2 s.f (1 s.f if students follow the usual multiplication rule and is consistent later on).

$\frac{(n+1)^2}{n^2}$ = ... [1]

(c) Using the longer wooden block, repeat **(a)** and **(b)**.

x = 0.440 m
n = 7

To calculate $(n+1)^2 / n^2 = (7+1)^2 / 7^2$
= 1.306
= 1.3 (2 s.f.)
Award 1 mark for correct calculation and to 2 s.f./consistent s.f

x = ...

n = ...

$\frac{(n+1)^2}{n^2}$ = ... [1]

(d) It is suggested that the relationship between *n* and *x* is

$$\frac{(n+1)^2}{n^2} = k\,x$$

where *k* is a constant.

(i) Using your data, calculate two values of *k*.

First set
1.128 = k (0.405)
k = 2.785 or 2.8 m^{-1} (2 s.f.)

Second set
1.306 = k (0.440)
k = 2.968 or 3.0 m^{-1} (2 s.f.)

Award 1 mark for correct substitution and calculation of both k values

first value of *k* = ...

second value of *k* = ... [1]

(ii) Explain whether your results in **(d)(i)** support the suggested relationship.

% uncertainty of k = [(2.968 - 2.785) / 2.785] x 100%
= 6.57 %

% uncertainty of x = (0.002 m/ 0.405 m) x 100% = 0.49 %

Since the % uncertainty of k is greater than % uncertainty of x, the relationship is not valid.
(Marks were awarded if students follow a threshold value to argue)

....

.... [1]

[Total: 6 marks]

3 In this experiment you will determine the density of water.

(a) **(i)** Set up the apparatus as shown in Fig. 3.1. The pointers A and B should be attached to each end of the spring. The pointer A should also be attached to the paper clip.
The pointer B should be attached to the mass holder. The total mass of the holder and the masses should be 200 g.

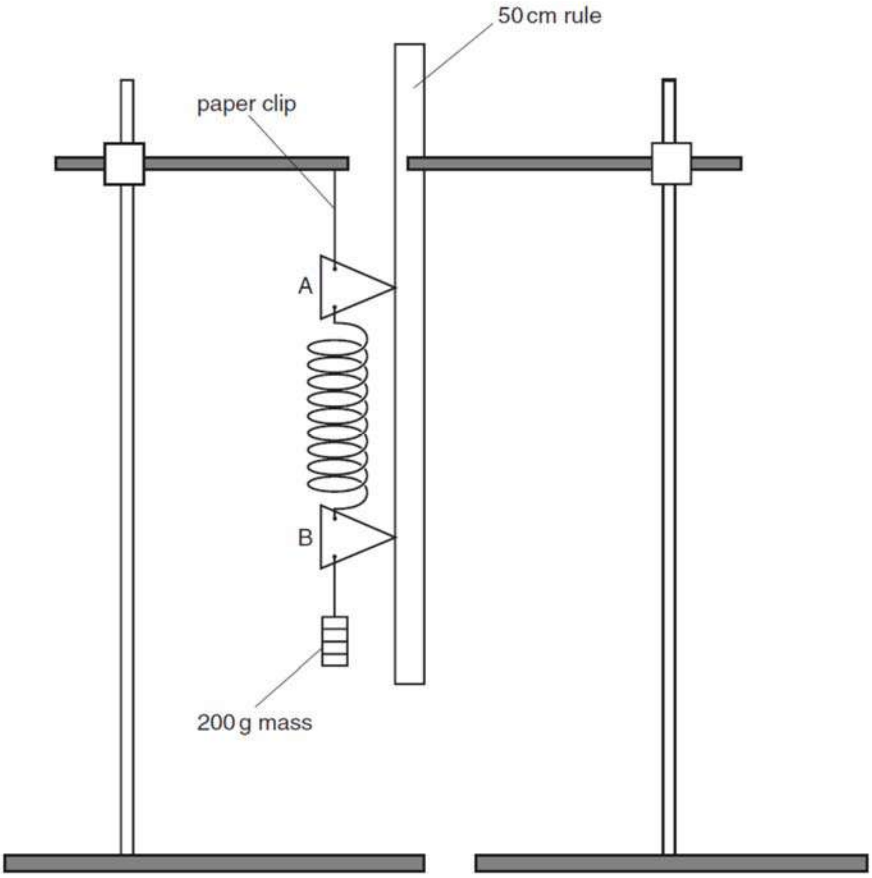


Fig. 3.1

(ii) Record the reading from point B.

Reading = 0.2300 m (up to 0.5 mm or half smallest interval)
No mark allocated

reading from pointer B = ...

(iii) Add a further mass of 100 g (0.98 N) to the mass holder and record the new reading from pointer B.

Reading = 0.2700 m (up to 0.5 mm or half smallest interval)
No mark allocated

new reading from pointer B = ...

(iv) Hence, determine the extension of the spring when an additional force of 0.98 N is applied to the spring.

Extension = 0.270 – 0.230 = 0.040 m

- Range of extension between 0.034 m to 0.046 m.

Award 1 mark for the value of extension within range and correct precision of up to 1 mm for half-metre rule.

extension = ... [1]

(b) Hooke's law can be expressed in the form

$$F = k\,x\,,$$

where F is the force required to produce an extension x, and k is the spring constant.
Use your answers from **(a)** to determine a value for k. You may assume that the spring obeys Hooke's law.

k = F / x
= 0.98 / 0.040
= 24.5
= 25 N m^{-1} (or 0.25 N cm^{-1})

Award 1 mark for correct calculation for k correct to 2 s.f and with correct units. Accept units of N m^{-1} or N cm^{-1}.

k = ... [1]

(c) **(i)** Use the vernier callipers to measure the diameter of one of the slotted masses.

Diameter = ½ (x_1 + x_2)
= ½ (3.20 + 3.18) cm
x = 3.19 cm or 3.19 x 10^{-2} m

Award 1 mark for correct calculation, precision of vernier calipers (of up to 0.1 mm) and with repeated readings.

Accepted range (0.0287-0.0290 m, 0.0298-0.0302 m, 0.0316-0.0320 m)

diameter = ... [1]

(ii) Determine the percentage uncertainty in the measurement of the diameter of the mass.

% uncertainty of diameter = (0.02 cm/ 3.19 cm) x 100% = 0.63 %
Accept uncertainty of diameter to be between 0.02 cm to 0.05 cm

Award 1 mark for correct calculation of uncertainty to 1 or 2 s.f.

percentage uncertainty = ... [1]

(iii) Calculate the cross-sectional area A, in m^2, of the mass. Ignore the slot that is cut into the mass.

Cross sectional area = $\pi/4 \times d^2$
$= \pi/4 \times (3.19 \times 10^{-2})^2$
$= 7.99 \times 10^{-4}$ m^2
Or 7.99 cm^2

- Award 1 mark for correct calculation of area, 3 s.f. <u>and</u> units

A = ... m^2 [1]

(d) **(i)** Put all of the masses onto the mass holder so that the spring supports a total mass of 300 g. This mass should remain constant for the rest of the experiment.
Determine a value for the length *l* between the pointers.

Reading from pointer A = 0.090 m
Reading from pointer B = 0.350 m
Length *l* = 0.350 - 0.090 = 0.260 m
No marks awarded

l = ...

(ii) Place a beaker under the suspended mass. Adjust the height of the boss such that the mass can be fully submerged if the beaker is filled with water. Pour water into the beaker so that part of the mass is immersed in the water as shown in Fig. 3.2.

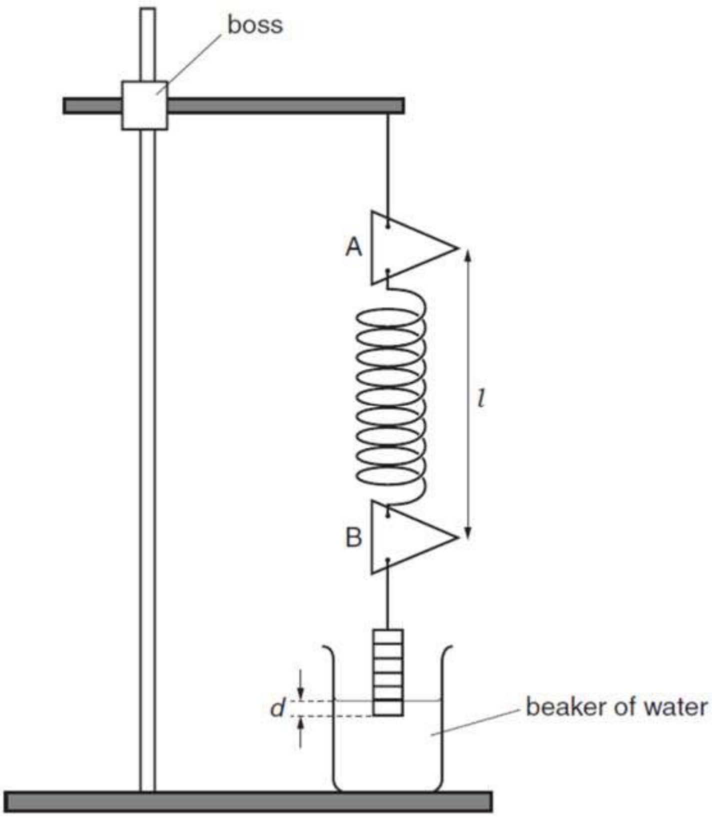


Fig. 3.2

(iii) Make and record the measurements to determine the depth *d* of the submerged part of the mass and the length *l* between the pointers.

d = 0.38 cm (measured using vernier calipers) *l* = 0.259 m No marks awarded

d = ...

l = ...

(iv) Pour more water into the beaker and repeat **(iii)** until you have six sets of readings for *d* and *l*. Record all your readings in a table in the space below. [5]

d/m	*l* / m
0.0460	0.247
0.0378	0.249
0.0290	0.252
0.0206	0.255
0.0122	0.257
0.0038	0.259

- Award 2 marks for 6 sets of readings (tick)
- Award 1 mark for 5 sets of readings (tick, annotate "5 sets - 1")
- Award zero mark for 4 sets or less readings

- Award 1 mark for proper labelling of column headers with units (accept separating marks as a solidus, brackets around the units but not commas (UCLES))
- Award 1 mark for correct precision of (*d* / m) of up to 0.1 mm by vernier callipers or 1 mm by metre rule/ correct precision of (*l* / m) of 1 mm by metre rule
- Award 1 mark for range of d of at least 0.035 m. d should be less than 0.055 m, which is the height of the mass on the mass hanger.

(e) **(i)** Plot a graph of *l* against *d*.

- Award 1 mark for
  - sensible scale must be used such as 1:10, 2:10, 4:10, 5:10. Awkward scales (e.g. 3:10, 6:10, 7:10, 9:10) are not allowed. Allow 2.5:10 scale.
  - scale must be chosen so that the plotted points occupy at least half the grid in y and x directions (6 squares on the long axis and 4 squares on the short axis)
  - Scale must be plotted with the quantity which is being plotted (i.e. I^{-1} vs resistance R_3). (allow inverted axes i.e. R_3 vs I^{-1} but do not allow wrong graph. Ignore units) (UCLES)
  - Scale markings should be no more than 3 large squares apart. (allow inverted axes i.e. R_3 vs I^{-1} but do not allow wrong graph)

- Award 1 mark for all observations to be plotted. (6 or 5 points must be plotted if student collected 6 or 5 data sets to be awarded this mark).
  - Zero mark if 4 or fewer points in the table.
  - Check 3 points for R_3 = 1, 3 and 5.
  - Diameter of plotted point must be ≤ half a small square (no blobs)

- Award 1 mark for line of best fit must start from the first point and end at the last point. (curve must pass through 6 or 5 points if student plotted 6 or 5 data sets to be awarded this mark)

Line must not be kinked or thicker than half a square. No hairy lines.

[3]

(ii) Draw the line of best fit.

[1]

Draw a straight line with points equally distributed above and below the line.
Line must not be kinked or thicker than half a square. No hairy lines.
(UCLES)

(iii) Determine the gradient of this line.

Using 2 points on the graph,
Gradient, m
= – 0.294 (from excel file)

Award 1 mark for calculating gradient correctly (without using any plotted points from the table). No unit for gradient

gradient = ... [1]

(f) Theory suggests that l and d are related by the equation

$$l = \frac{-\rho A g d}{k} + c$$

where ρ is the density of water, g is the acceleration of free fall and c is a constant. You may assume that g = 9.81 m s^{-2}.

Use your values from **(e)(iii)** together with the values of A, g and k to determine a value for the density of water.

gradient = – p A g / k
p = – (gradient) k / (A g)
= – (– 0.294) (24.5) / [(7.99 x 10^{-4})(9.81)]
= 919 kg m^{-3} or 0.919 g cm^{-3}.

- Award 1 mark for calculating density correctly (without using any plotted points from the table).
- Award 1 mark for correct unit.

ρ = ... [2]

[Total: 17 marks]

(g) A toy manufacturer wants to investigate the *minimum* volume of wood needed to make the bottom part of the toy ship. The top part of the toy ship is made of a fixed mass of metal. You may assume the shape of the ship as seen in Fig 3.3.

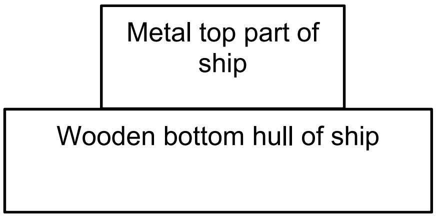


Fig. 3.3

The manufacturer wants the wooden hull to be completely submerged while keeping the metal top part of the ship dry. You may assume the hull of the toy ship to be of a rectangular shape.

Design an experiment to determine the *minimum* volume of the wooden hull needed.

Your account should include:

- your experimental procedure
- how you would determine the *minimum* volume of the wooden hull.

[5]

1. Set up the apparatus as shown in the diagram above.
2. Measure the length, breath and height of the rectangular wooden block using a metre rule.
3. Calculate the volume of the wooden block as the product of its length, breath and height.
[**M1** for indicating instrument to measure length and how to calculate volume]
4. Add masses to the top of the wooden block until it is fully submerged. [**C1**]
5. Measure the added mass of metal top part of the ship with a weighing scale. [**M1**]
6. Record the value of the total masses.
7. Repeat steps 2 to 5 with five different volumes of rectangular wooden block.
8. Plot a graph of volume of wooden block against masses and draw a line of best fit. [**A1**]
9. From the graph in Step 8, find the volume of the block which corresponds to the mass of the metal top part of the ship. [**A1**]

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[Total: 22 marks]

4 A hot wire in air loses energy. Some of the energy is lost to the air particles that hit the wire. This energy lost depends on the number of particles hitting the wire per second, and hence on the surrounding air pressure.

If the temperature of the wire is constant then the total energy lost per second E is equal to the electrical energy supplied per second.

A student suggests that E, pressure P and temperature of the heated wire T may be written in the form

$$E = k P^{m} T^{n}$$

where k, m and n are constants.

Design an experiment to determine the values of m and n.

You should draw a detailed labelled diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the control of variables,
(b) the equipment you would use,
(c) the procedure to be followed,
(d) how the constants m and n are determined,
(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

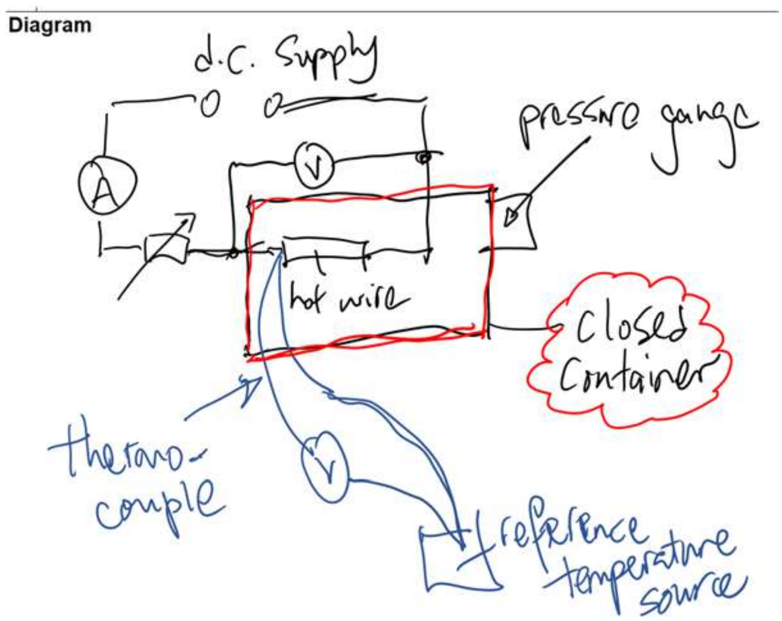

Diagram of workable arrangement

D1 Electrical arrangement where the wire is connected to a power supply with means of measuring the energy lost per second using voltmeter and ammeter or joulemeter and stopwatch.
D2 Mechanical arrangement where the wire is shown in a closed container with means of changing and measuring the pressure and changing and measuring temperature.

To find constant *n*
P1 Independent variable:temperature *T* of the wire
Dependent variable: energy lost *E* per unit time of the wire
Control variable: pressure *P* of the closed container
1. Set up the apparatus as shown above
2. Close the switch.
M1 3. Measure the temperature of the wire using a thermocouple.
M2 4. Measure the potential difference V and current I of the wire using a voltmeter and ammeter respectively.
R1 5. Fix the pressure of the closed container by using a (needle) value and air pump to release or pump in air.
P2 6. Repeat the experiment for another 7 set of *T* by varying the potential difference V of the wire through changing the resistance of the variable resistor
A1 7. Power lost of the wire $E = V \times I$
A2 8. Plot a graph of log *E* vs log *T*. The gradient of the graph is *n*.

To find constant *m*
(P1) Independent variable: pressure *P* of the closed container
Dependent variable: energy lost *E* per unit time of the wire
Control variable: temperature *T* of the wire
9. Set up the apparatus as shown above
10. Close the switch.
M3 11. Measure the pressure of the closed container using the pressure gauge or manometer.
(M2) 12. Measure the potential difference V and current I of the wire using a voltmeter and ammeter respectively.
R2 13. Fix the temperature of the wire by adjusting the voltage and current through the wire and monitoring using a thermocouple.
P3 14. Repeat the experiment for another 7 set of *P* by releasing air from closed container using the (needle) valve.
(A1) 15. Power lost of the wire $E = V \times I$
A3 16. Plot a graph of log *E* vs log *P*. The gradient of the graph is *m*.

Any one safety precaution related to and high temperature
S1 Low/high pressure of closed container
Safety screens / goggles / wire mesh surrounding vacuum chamber / appropriate pressure used in pressure chamber in case of explosion of the closed container
Do not allow the wire to become too hot in case of melting of the thermocouple

Reliability measure
R3 Use vacuum grease to seal the holes of the connecting wires to the heater wire

Mark Scheme

Diagram	[1]	D1, D2
Measurement	[2]	All 3 Measurement [2], 2 Measurement [1]
Procedure	[3]	P1, P2, P3
Analysis	[2]	All 3 Analysis [2], 2 Analysis [1]
Reliability	[2]	One of Reliability measure
Safety	[1]	Safety

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[Total: 11 marks]

END OF PAPER

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS 9749/1

Higher 2

Multiple Choice

14 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

(This question paper consists of 17 printed pages)

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1} = $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	$= 1.60 \times 10^{-19}$ C
the Planck constant,	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}$ kg
molar gas constant,	R	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	G	$= 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	g	$= 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2, \quad v^2 = u^2 + 2as$
work done on/by a gas,	W	$= p\,\Delta V$
hydrostatic pressure,	p	$= \rho g h$
gravitational potential,	ϕ	$= -\dfrac{Gm}{r}$
temperature,	T/K	$= T/°C + 273.15$
pressure of an ideal gas,	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.,	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.,	v	$= v_o \cos \omega t$
	v	$= \pm \omega \sqrt{(x_o^2 - x^2)}$
electric current	I	$= Anvq$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential,	V	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

1 The speedometer in a car consists of a pointer which rotates. The pointer is situated several millimetres from a calibrated scale.

What could cause a random error in the driver's reading of the car's speed?

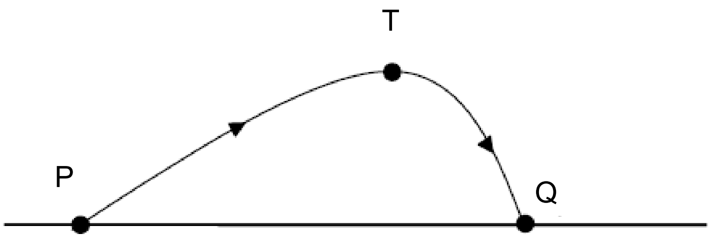
A The car's speed is affected by the wind direction.

B The speedometer does not read zero when the car is at rest.

C The speedometer reads 5% higher than the car's actual speed.

D The driver's eye is not always in the same position in relation to the pointer.

2 In the presence of air resistance, a stone is thrown from P and follows a path in which the highest point reached is T as shown in the diagram below.



Given that the drag force acting on the stone is directly proportional to the magnitude of its instantaneous velocity, the vertical component of the acceleration of the stone is

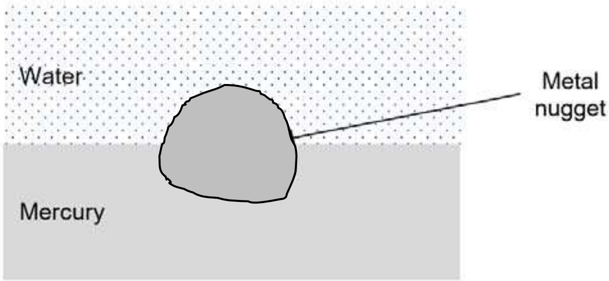
A highest at point P.

B highest at point T.

C highest at point Q.

D constant through the travelled path.

3 A metal nugget floats in between some water and mercury. The densities of the metal nugget, mercury and water are 7900 kg m^{-3}, 13600 kg m^{-3} and 1000 kg m^{-3} respectively.



What is the ratio of the volume of the nugget submerged in water to that in mercury?

A 0.541

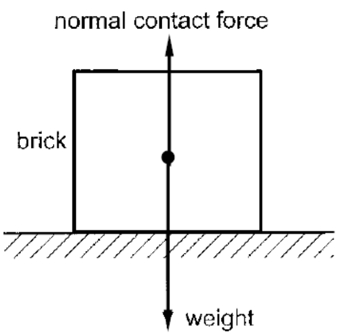
B 0.826

C 0.924

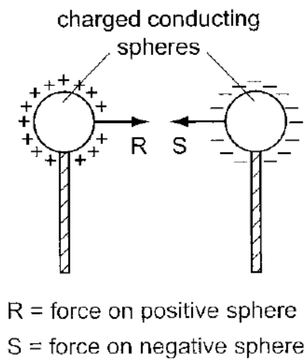
D 1.21

4 Which diagram shows a pair of forces that are **not** related to one another by Newton's third law?

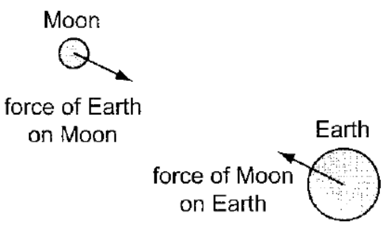
A



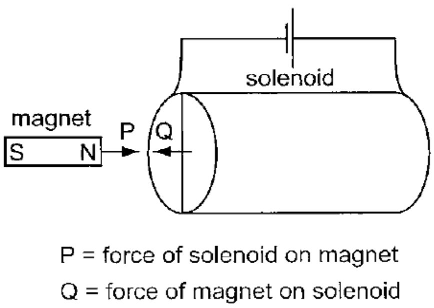
B



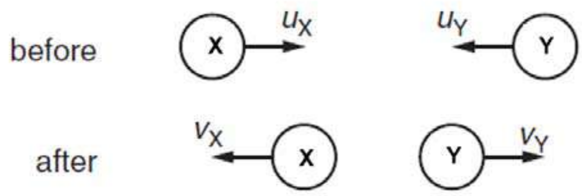
C



D



5 Two balls **X** and **Y** approach each other along the same straight line and collide elastically. Their speeds are u_X and u_Y respectively. After the collision they move apart with speeds v_X and v_Y respectively. Their directions are shown below.



Which of the following equations is correct?

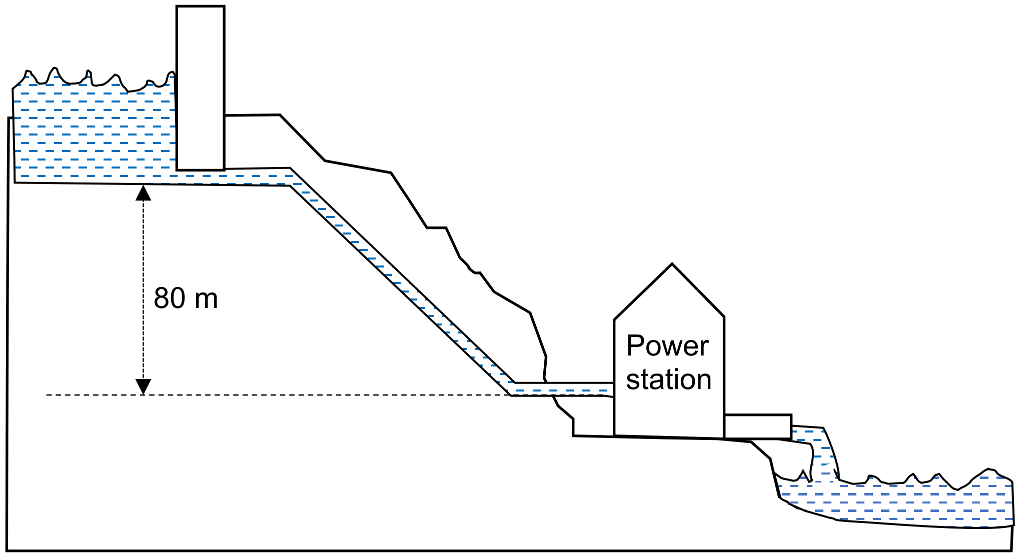
A $u_X - u_Y = v_Y - v_X$

B $u_X + u_Y = v_X - v_Y$

C $u_X + u_Y = v_X + v_Y$

D $u_X - u_Y = v_X - v_Y$

6 A hydroelectric power station is shown.



Water is supplied from a reservoir which is 80 m above the power station. The water passes through its turbines at a rate of 6.0 $m^3 s^{-1}$.

Assume that the density of water is 1000 kg m^{-3}. If the efficiency of the power station is 60%, what is the electrical power output?

A 0.29 MW

B 1.9 MW

C 2.8 MW

D 4.7 MW

7 A particle travels at a constant speed around a circle of radius *r* with centripetal acceleration *a*. What is the time taken for ten complete revolutions?

A $\frac{\pi}{5}\sqrt{\frac{a}{r}}$

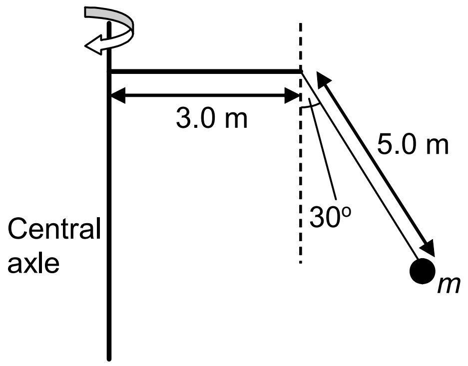
B $\frac{\pi}{5}\sqrt{\frac{r}{a}}$

C $20\pi\sqrt{\frac{a}{r}}$

D $20\pi\sqrt{\frac{r}{a}}$

8 A mass *m*, attached to one end of an inextensible string of length 5.0 m, is made to move in a horizontal circle as the vertical central axle is rotated. In a particular circular motion, the string makes an angle of 30° with the vertical as shown below.

Calculate the period of the mass about the central axle.



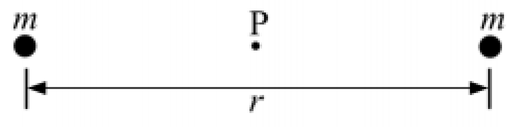
A 1.0 s

B 3.5 s

C 4.8 s

D 6.2 s

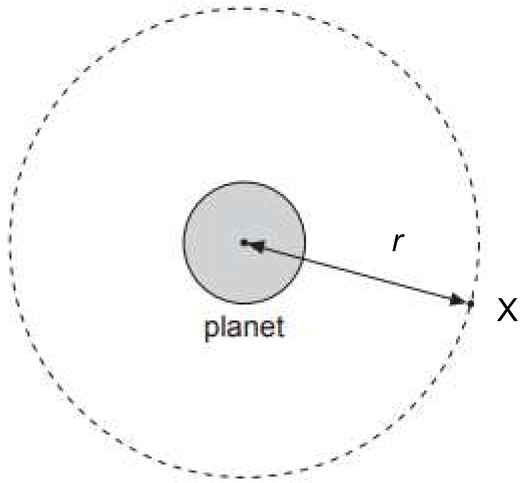
9 The figure below shows two objects of equal mass *m* separated by a distance *r*.



Which of the following gives the correct values of the gravitational field strength and gravitational potential at the mid-point P between the two objects?

	gravitational field strength	gravitational potential
A	$-\frac{8Gm}{r^2}$	$-\frac{4Gm}{r}$
B	$-\frac{8Gm}{r^2}$	0
C	0	$-\frac{4Gm}{r}$
D	0	0

10 A satellite X is in a circular orbit of radius *r* about the centre of a spherical planet of mass M.



Which of the following gives the correct expressions for the centripetal acceleration *a* and the speed *v* of the satellite?

	centripetal acceleration *a*	speed *v*
A	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{2r}}$
B	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{r}}$
C	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{2r}}$
D	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{r}}$

11 The r.m.s. speed of the molecules of a gas at 295 K is decreased by 20 %.

What is the new temperature of the gas?

A – 84.4 ˚C

B – 37.2 ˚C

C 189 ˚C

D 236 ˚C

12 A piston is pushed into a cylinder containing an ideal gas such that the pressure of the gas increases to 1.5 times its initial value while the volume decreases to half its original value.

Which one of the following statements is correct?

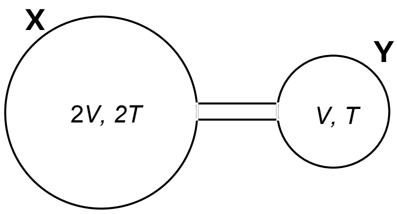
A The average random kinetic energy of the gas molecules increases.

B Work is done by the gas on its surroundings.

C Heat is extracted from the gas.

D There is no change in the internal energy of the gas.

13 An ideal gas is contained in two spherical containers X and Y of volume 2*V* and *V* respectively, connected by a hollow tube of negligible volume. The containers X and Y are maintained at temperatures 2*T* and *T* respectively. The setup is shown in the figure below.



Determine the ratio $\frac{\text{number of moles of gas in container X}}{\text{number of moles of gas in container Y}}$.

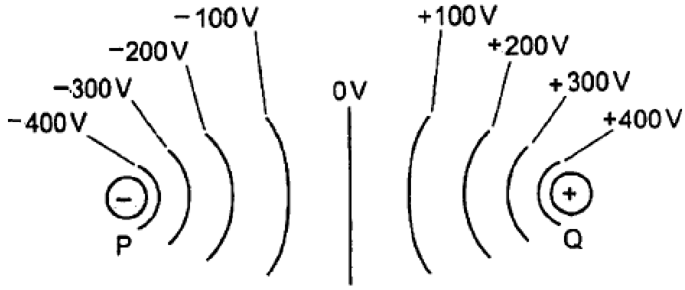
A 0.25

B 1.00

C 2.00

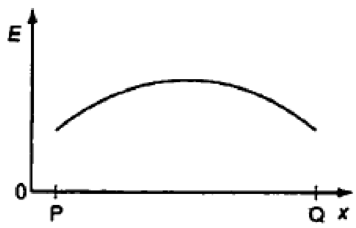
D 4.00

14 An object with a negative charge is placed at P and a similar object with a positive charge is placed at Q. The diagram shows the equipotential lines between these two objects.



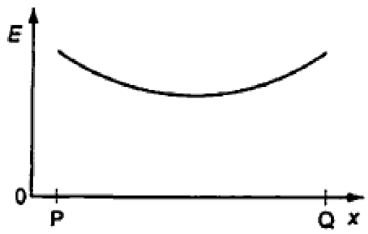
Which graph shows the variation with distance *x* along line PQ of the electric field strength *E*?

A



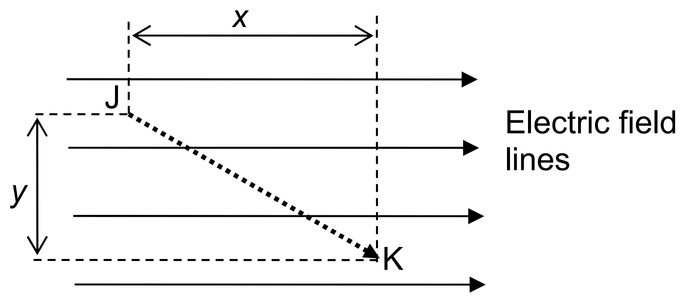
B

C



D

15 A small negative charge (- q) is placed at point J inside a uniform electric field of field strength E. It is then moved from point J to point K.



What is the change in electric potential energy of the charge?

A gain of qEx

B loss of qEx

C gain of $qE\sqrt{x^2 + y^2}$

D loss of $\dfrac{q}{4\pi\varepsilon_o\sqrt{x^2 + y^2}}$

16 A p-n junction diode has the forward current-p.d. characteristic as shown in Fig 16.1. It is connected in series with a variable, low voltage d.c. power supply, a meter of negligible internal resistance and a 50 Ω resistor as shown in Fig 16.2.

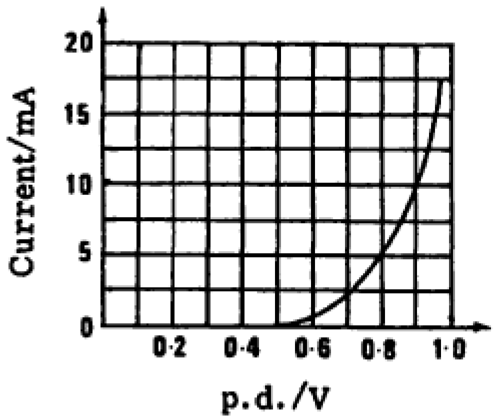


Fig 16.1

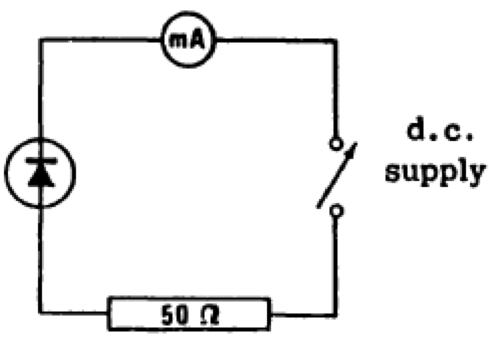


Fig 16.2

When the meter reads 5 mA, the potential difference across the supply is about

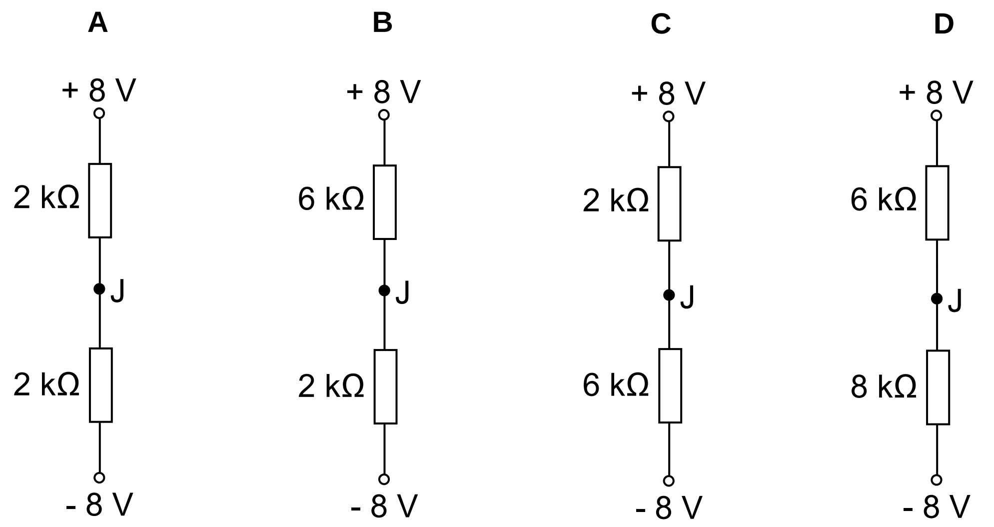
A 0.25 V

B 0.80 V

C 1.05 V

D 1.25 V

17 In which of the circuits below is the potential at J equal to - 4 V?



18 The current in a component is reduced uniformly from 100 mA to 20 mA over a period of 8.0 s.

What is the charge that flows during this time?

A 160 mC

B 320 mC

C 480 mC

D 640 mC

19 Fig. 19.1 shows the variation with displacement *x* of the velocity *v* of a simple harmonic oscillator. Fig. 19.2 shows the variation with *t* of the net force *F* acting on the oscillator.

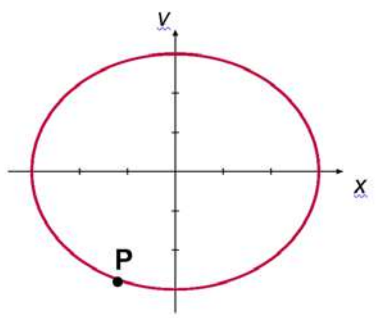


Fig. 19.1

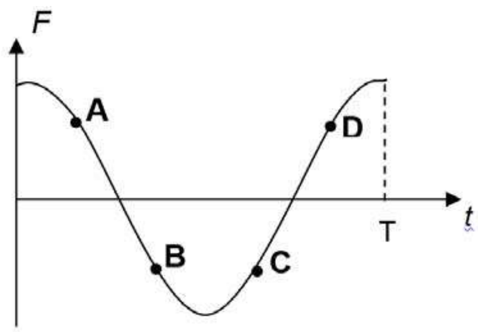
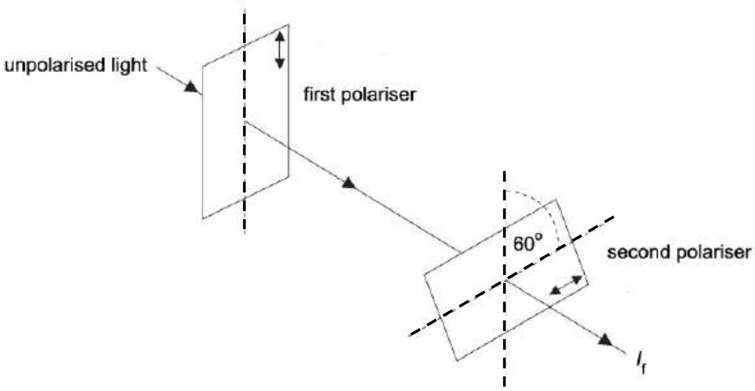


Fig. 19.2

Which of the points in Fig. 19.2 corresponds to the state of motion represented by point P in Fig. 19.1?

20 Unpolarised light is incident on a polariser. The light transmitted by the first polariser is then incident on a second polariser. The polarising axis of the second polariser is at 60° to that of the first polariser.



The intensity emerging from the second polariser is I_f .
Which of the following correctly gives the intensity incident on the first polariser?

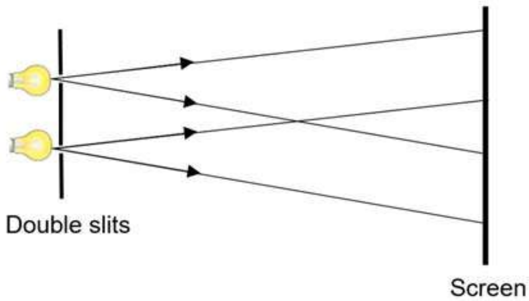
A $\frac{I_f}{8}$

B $\frac{I_f}{4}$

C $4I_f$

D $8I_f$

21 A student set up an interference effect experiment using two lamps emitting white light and a pair of slits as shown in the diagram below. However, no interference pattern was observed on a screen placed a distance away from the pair of slits.



Which of the following is the reason for the observation?

A The lamps are not point sources.

B The lamps emit light of different amplitudes.

C The light from the lamps is not coherent.

D The light from the lamps is white.

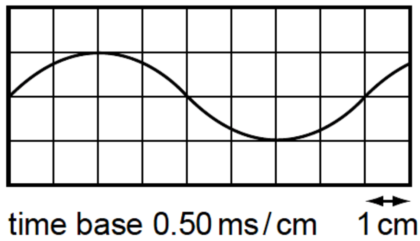
22 A stationary sound wave is set up between a loudspeaker and a wall.

A microphone is connected to a cathode-ray oscilloscope (c.r.o.) and is moved along a line directly between the loudspeaker and the wall. The amplitude of the trace on the c.r.o. rises to a maximum at a position X, falls to a minimum and then rises once again to a maximum at a position Y.

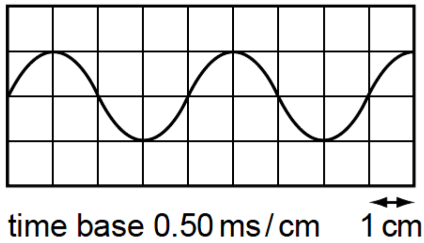
The distance between X and Y is 33 cm. The speed of sound in air is 330 m s^{-1}.

Which diagram represents the c.r.o. trace of the sound received at X?

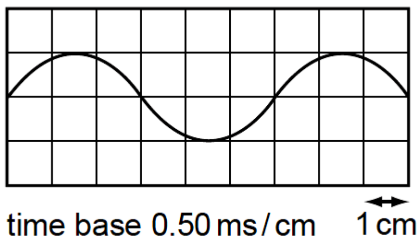
A



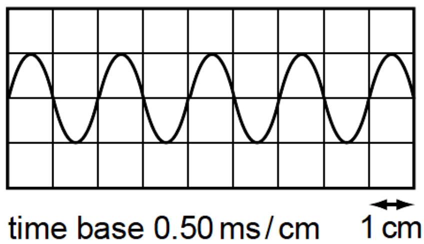
B



C



D



23 An electron moves in a circular orbit in a uniform magnetic field.

Which of the following statements is correct?

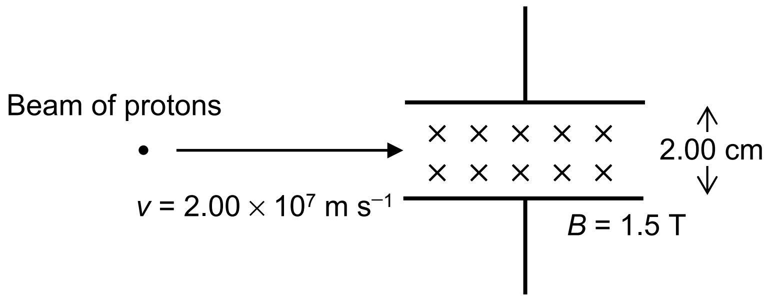
A The period of the orbit is independent of the speed of the electron.

B The momentum of the electron is dependent on its charge.

C The radius of the orbit is directly proportional to its charge.

D The magnetic force on the electron is dependent on the mass of the electron.

24 A beam of protons passes through a velocity selector with a plate separation of 2.00 cm as shown in the diagram below. The magnetic flux density, *B* is 1.5 T and directed into the plane of the paper.

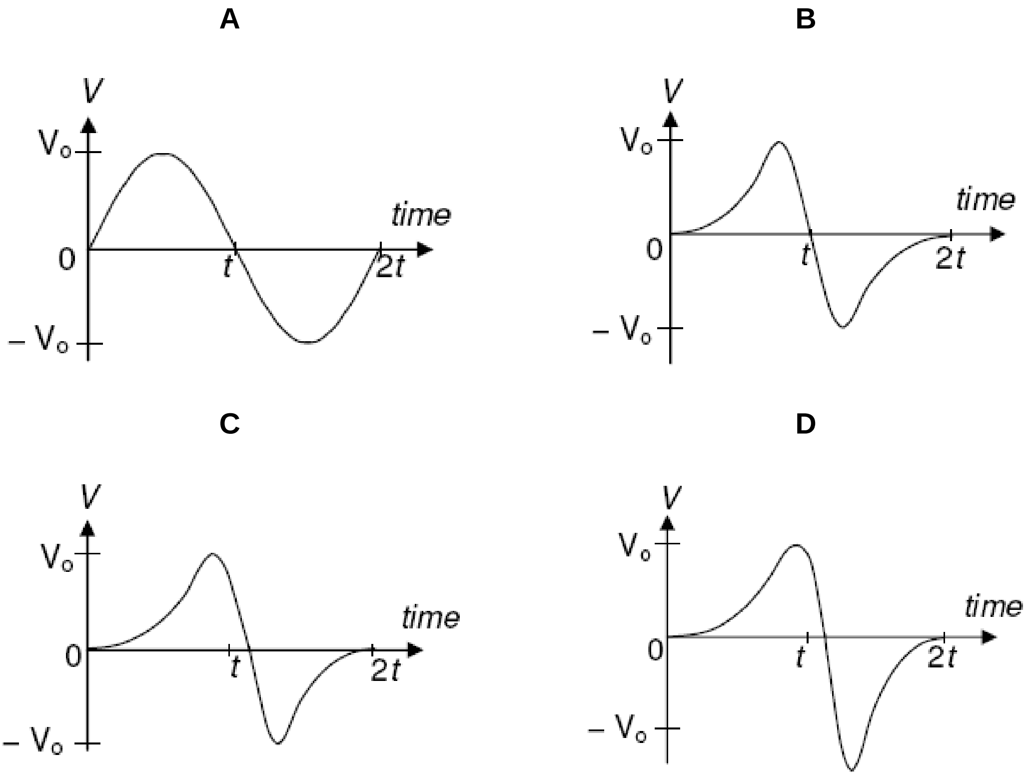


If protons travelling at 2.00×10^7 m s^{-1} pass through undeflected, what would be the direction and magnitude of the electric field?

	Direction	Magnitude
A	Downwards	6.00×10^5 N C^{-1}
B	Upwards	6.00×10^5 N C^{-1}
C	Downwards	3.00×10^7 N C^{-1}
D	Upwards	3.00×10^7 N C^{-1}

25 A bar magnet is dropped from rest vertically into a solenoid connected to a sensitive voltage sensor. The entire body of the magnet spent a time of 2*t* inside the solenoid.

Which of the following graphs best represents the time variation of the voltage, *V* recorded by the sensor?



26 A direct current I passing a resistor produces a certain heating effect. If an alternating current is used, the resistance has to be reduced to one quarter of its value to obtain the same heating effect.

What is the peak value of the alternating current?

A I

B $\sqrt{2}\,I$

C $2\,I$

D $2\sqrt{2}\,I$

27 Which type of electromagnetic radiation is emitted when an electron in an atom makes a transition from an energy level at –1.5 eV to an energy level at –3.5 eV?

A Microwaves

B Infra-red

C Visible light

D Ultra violet

28 Which of the following is NOT a characteristic of the X-ray spectrum produced when electrons are accelerated and incident onto a target material?

A The range of wavelengths is continuous.

B The minimum wavelength is dependent on the target metal

C The minimum wavelength is dependent on the accelerating potential

D The intensity is dependent on the number of electrons incident on the target metal per unit time.

29 The activity of a sample of carbon taken from an archaeological specimen was 190 counts per minute. The activity of an equal mass of carbon taken from a living plant was 360 counts per minute. The background count was 20 counts per minute.

Taking the half-life of carbon-14 to be 5700 years, what was the approximate age of the archaeological specimen?

A 2850 year

B 5700 years

C 10800 years

D 11400 years

30 Radon $^{222}_{86}\text{Rn}$ decays by α– and β–emission to bismuth $^{214}_{83}\text{Bi}$.

For the decay of each nucleus of radon, how many α– and β–particles are emitted?

	α– particles	β–particles
A	1	1
B	2	1
C	1	2
D	2	2

End of Paper

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS **9749/02**

Higher 2

Structured Questions **23 August 2018**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use highlighters, glue or correction fluid.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
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Total	

Data

speed of light in free space	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1} = $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	$= 1.60 \times 10^{-19}$ C
the Planck constant	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton	m_p	$= 1.67 \times 10^{-27}$ kg
molar gas constant	R	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	k	$= 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	G	$= 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	g	$= 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas	W	$= p\,\Delta V$
hydrostatic pressure	p	$= \rho gh$
gravitational potential	ϕ	$= -\dfrac{Gm}{r}$
temperature	T/K	$= T/^{o}\mathrm{C} + 273.15$
pressure of an ideal gas	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
mean kinetic energy of a molecule of an ideal gas	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t = \pm\, \omega\sqrt{(x_o^2 - x^2)}$
electric current	I	$= Anvq$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o nI$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

1. A tennis ball is thrown vertically downwards from a height of 0.65 m above the ground. It leaves the hand with an initial speed of 1.5 m s^{-1}. The ball rebounds and is caught when it is travelling upwards with a speed of 1.0 m s^{-1}.

Assume that air resistance is negligible.

(a) Calculate the speed of the ball just before it strikes the ground.

speed = ____________ m s^{-1} [2]

(b) The tennis ball is thrown downwards at t = 0. It hits the ground at time t_1 and is caught at time t_2.

On Fig. 1, sketch the velocity-time graph for the motion of the ball from the time it leaves the hand to when it returns.

Assume that the contact time between the ball and the ground is negligible. The initial velocity **X** and final velocity **Y** are marked on Fig. 1.

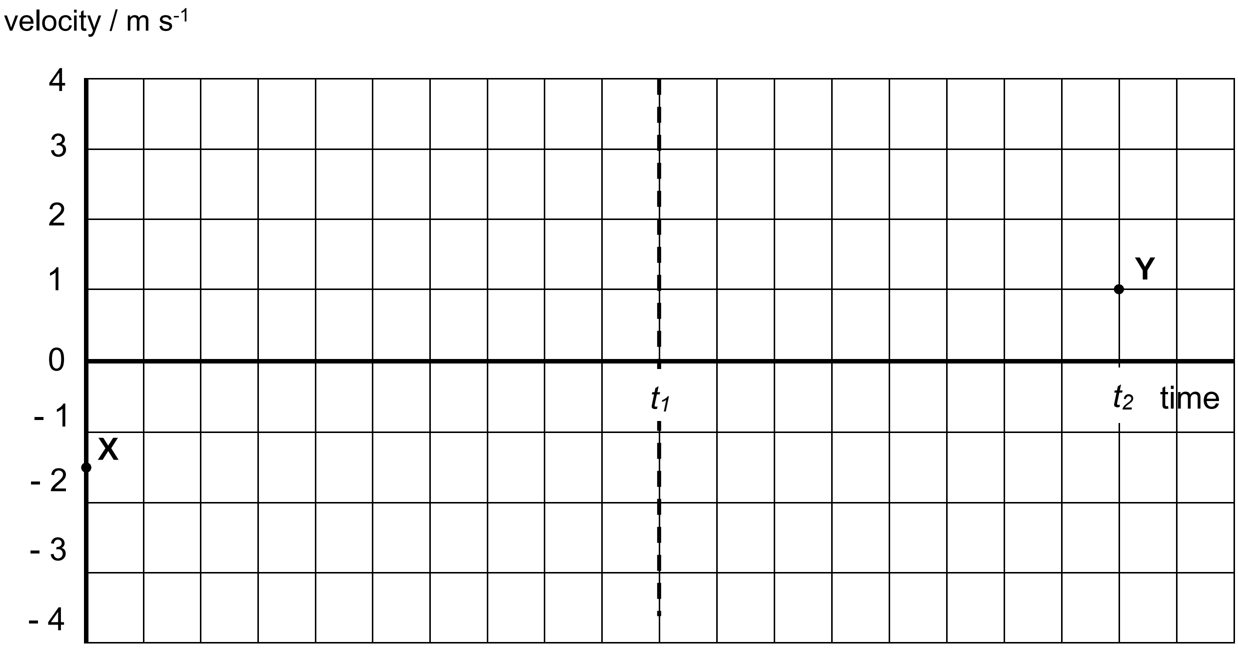


Fig. 1

[2]

(c) State and explain whether the bounce is elastic.

....

....

.... [2]

(d) On Fig. 1, sketch the velocity-time graph of the tennis ball if air resistance is not negligible. Label this graph **P**. [2]

2. **(a)** State the conditions for a body to be in equilibirum.

1. ____

____

2. ____

____ [2]

(b) Fig. 2.1 shows a 70 kg climber hanging by only the crimp hold of one hand on the edge of a shallow horizontal ledge in a rock wall. The fingers are pressed down.

Her feet touch the rough rock wall at distance *H* = 2.0 m directly below her crimped fingers. The frictional force between her feet and the wall is 32 N. Her centre of mass is at distance *a* = 0.20 m from the wall.

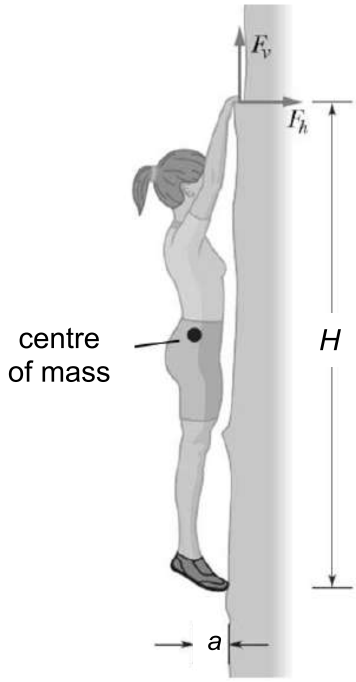


Fig. 2.1

(i) Determine the horizontal frictional force F_h acting on the fingers.

F_h = ____________________ N [2]

(ii) Determine the vertical force F_v acting on the fingers.

F_v = ... N [2]

(iii) The weight W of the climber and the resultant force F exerted by the ledge on her fingers are indicated in Fig. 2.2. Draw and label the force S exerted by the rock wall on her feet.

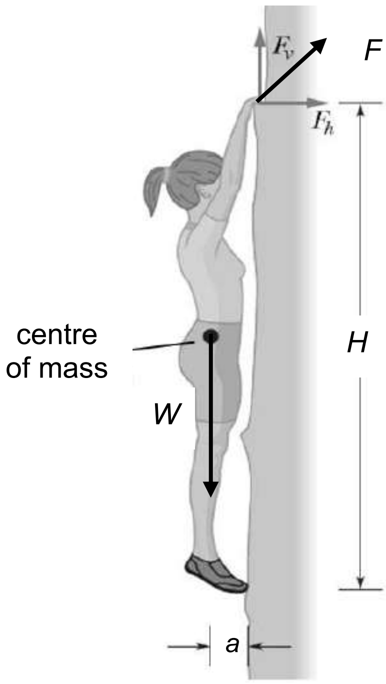
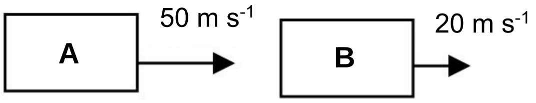


Fig. 2.2

[2]

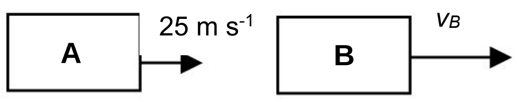
3. A 900 kg car A travelling at 50 m s^{-1} collides inelastically with a 1500 kg car B travelling at 20 m s^{-1} in the same direction as shown in Fig. 3.1. Immediately after the collision, the velocity of car A is 25 m s^{-1} and the velocity of car B is v_B as shown in Fig. 3.2.

The collision begins at time t. During the collision, both cars are in contact for 120 ms.



Before

Fig. 3.1



After

Fig. 3.2

(a) **(i)** Determine the magnitude of the velocity v_B.

magnitude of velocity v_B = ... m s^{-1} [1]

(ii) On Fig. 3.3, sketch and label the momentum-time graphs for car A and car B, before, during and after the collision. Include numerical values.

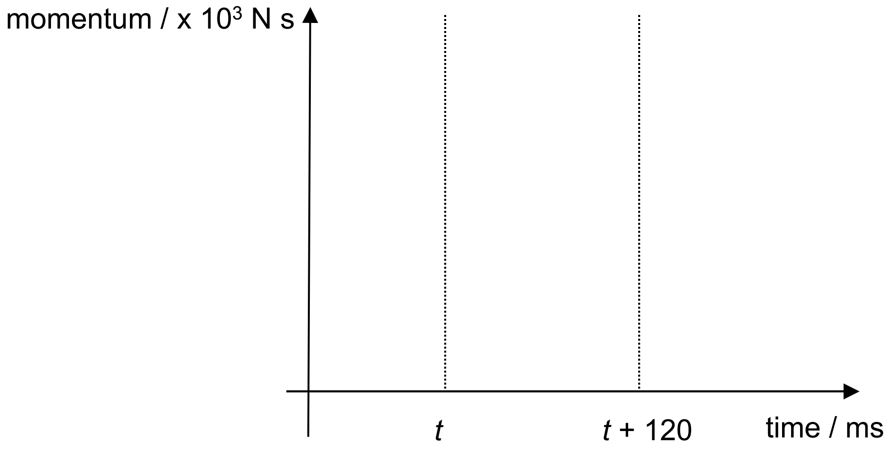


Fig. 3.3

[4]

(b) Determine the average force that car B exerts on car A during the collision.

average force = ... N [1]

(c) State and explain one design or feature of the car that reduces the force experienced by the driver.

....

....

....

.... [2]

4. The needle of a sewing machine is made to oscillate vertically through a total distance of 22 mm, as shown in Fig. 4.

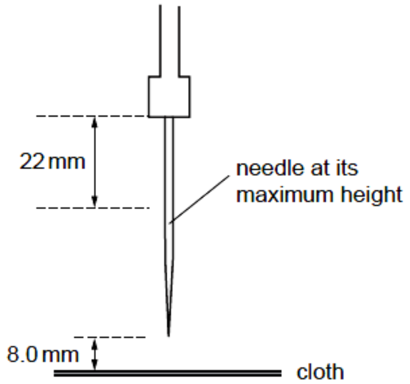


Fig. 4

The oscillations of the needle are simple harmonic with a frequency of 4.5 Hz. The cloth that is being sewn is positioned 8.0 mm below the point of the needle when the needle is at its maximum height.

(a) Explain what is meant by *simple harmonic motion*.

....

....

.... [2]

(b) Determine the values of the

(i) amplitude of oscillation,

amplitude = ... mm [1]

(ii) angular frequency,

angular frequency = ... rad s^{-1} [1]

(iii) maximum acceleration,

acceleration = ... $m\ s^{-2}$ [1]

(iv) displacement of the needle from its equilibrium position as it just passes downwards through the cloth (taking upward direction as positive),

displacement = ... mm [1]

(v) speed of the needle as it just passes downwards through the cloth.

speed = ... $m\ s^{-1}$ [2]

5. **(a)** Fig. 5.1 shows the variation of the height of a water wave against its horizontal distance at 12 noon.

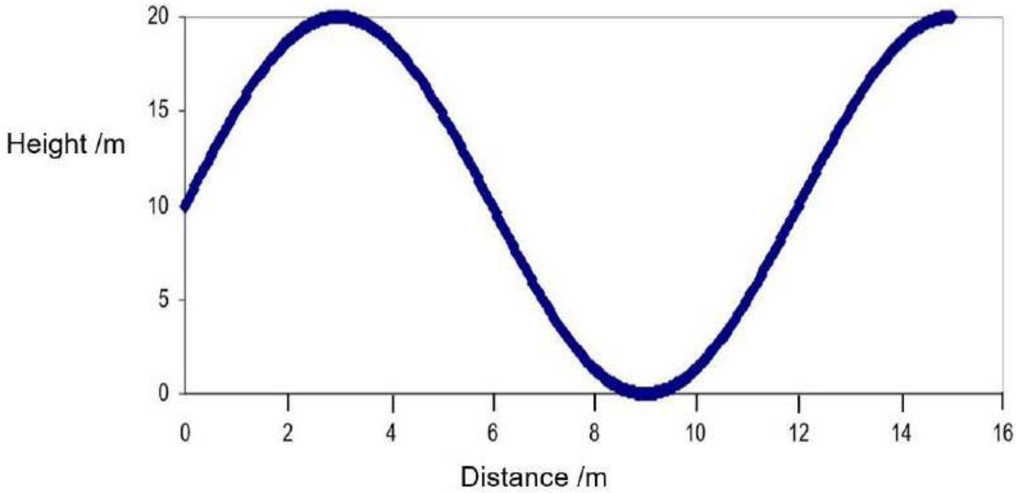


Fig. 5.1

(i) The waves are traveling at the speed of 1.25 m s^{-1}. Show that the frequency of the waves is 0.104 Hz.

[1]

(ii) Two buoys, fixed in position, are floating on the open sea.

The waves take 2.00 minutes to travel directly from one buoy to the other buoy. Determine the phase difference of the two buoys.

phase difference = ... rad [2]

(b) In Fig. 5.2, a narrow beam of monochromatic light of wavelength 590 nm passes through two different diffraction gratings A and B positioned perpendicular to each other. Assume that the distance between the two gratings is negligible.

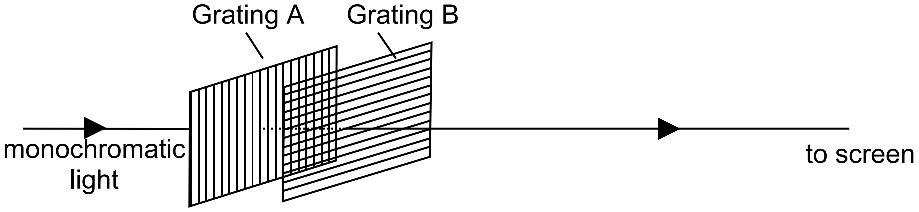


Fig. 5.2

As a result of this arrangement, a diffraction pattern is formed on a screen placed 2.5 m away from the gratings. The pattern is shown in Fig. 5.3.

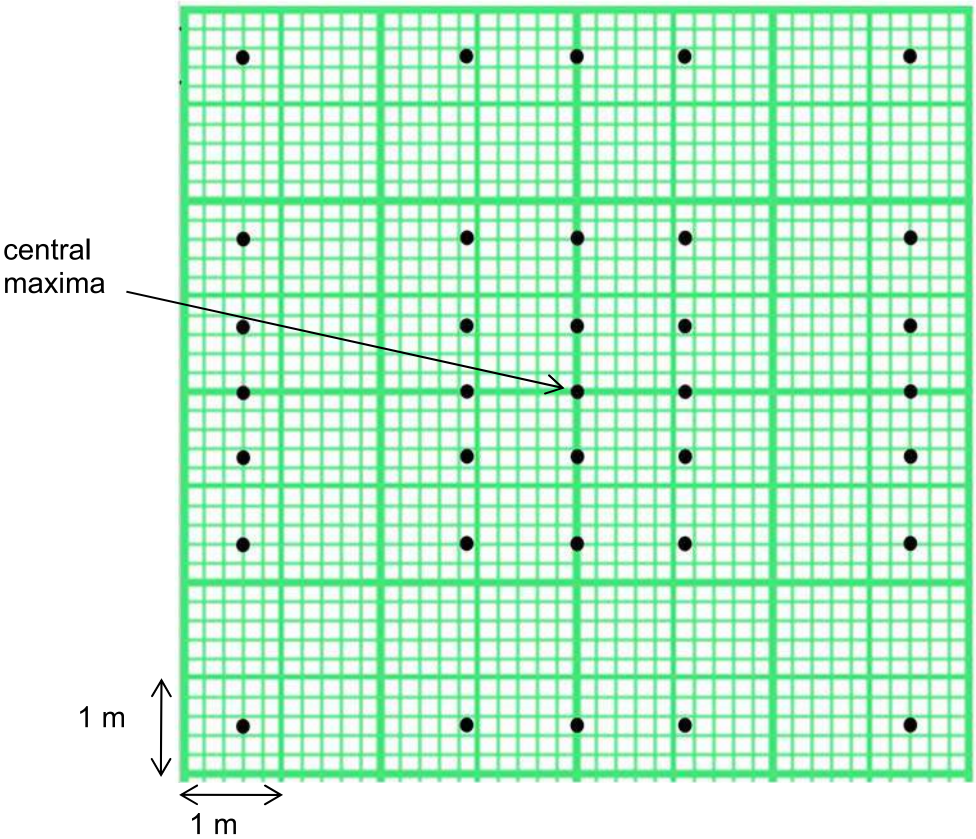


Fig. 5.3

(i) Explain the meaning of the term *diffraction*.

....

.... [1]

(ii) By taking appropriate measurements from Fig. 5.3, determine the number of lines per unit length on diffraction grating B.

number = ... lines m^{-1} [3]

(iii) Based on the diffraction pattern shown in Fig. 5.3, explain qualitatively what can be deduced about the slit separation of both diffraction gratings.

....

....

.... [2]

(iv) The two diffraction gratings are now replaced with a fine nylon mesh with 24000 nylon threads per metre of the mesh. Suggest one way in which the diffraction pattern observed would be different.

....

.... [1]

6. **(a)** Explain what is meant by photoelectric effect.

[1]

(b) In a photoelectric experiment, a parallel beam of monochromatic radiation is incident normally upon a metal surface of area 1.0×10^{-4} m^2 in a vacuum tube. The metal has a work function of 2.06 eV. The photocurrent I against p.d. V graph is shown in Fig. 6.1 below.

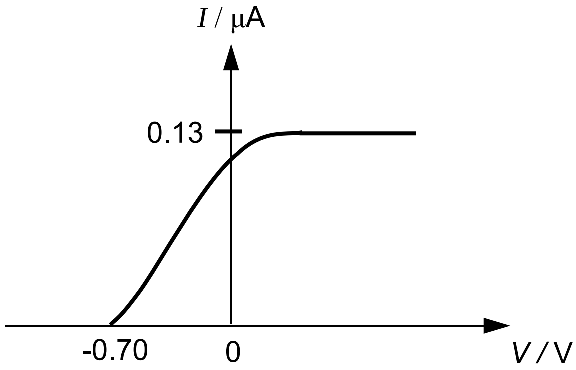


Fig. 6.1

(i) Calculate the maximum kinetic energy of the photoelectrons emitted.

maximum kinetic energy = ... J [1]

(ii) Hence, determine the frequency of radiation incident on the metal surface.

frequency = ... Hz [2]

(iii) If one photoelectron is emitted for every 8000 photons incident on the metal, calculate the intensity of the radiation incident on the metal surface.

intensity = ... W m^{-2} [3]

(iv) Sketch on Fig. 6.1 the graph you expect to obtain if the intensity of the radiation is halved. [1]

(v) Suggest a reason for the part of the graph in Fig. 6.1 for negative values of *V*.

....

....

.... [2]

7. **(a)** In a nuclear reaction, a uranium-235 $\left({}^{235}_{92}\text{U}\right)$ nuclide is transformed into an unstable uranium-236 nuclide $\left({}^{236}_{92}\text{U}\right)$ through bombardment by a slow-moving neutron. The unstable uranium-236 nuclide undergoes nuclear fission to form stable products of a lathium-139 nuclide $\left({}^{139}_{57}\text{La}\right)$ and a nuclide of bromine $\left({}^{A}_{Z}\text{Br}\right)$.

$${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{236}_{92}\text{U} \rightarrow {}^{139}_{57}\text{La} + {}^{A}_{Z}\text{Br} + 3\,{}^{1}_{0}\text{n} + \gamma$$

Use the following masses in answering this question:

rest mass of ${}^{235}_{92}\text{U}$ nuclide	= 235.044u
rest mass of ${}^{139}_{57}\text{La}$ nuclide	= 138.906u
rest mass of proton	= 1.00728u
rest mass of neutron	= 1.00866u

(i) Determine the nucleon number A and proton number Z of the bromine nuclide.

A = ...

Z = ... [1]

(ii) Calculate the binding energy of the uranium-235 nuclide to 4 significant figures.

binding energy = ... MeV [3]

(iii) State the feature of this equation that indicates that a chain reaction may be possible.

....

.... [1]

(b) In a laboratory source of strontium-90, the number of atoms present in the year 2013 was 2.36×10^{13}. Strontium-90 decays by emission of a β-particle and this nuclide has a half-life of 28 years.

(i) State what is a β-particle.

....

.... [1]

(ii) Calculate the activity of the source in the year 2113.

activity = ... Bq [2]

8. Hywind, the world's first floating wind turbine that combines technologies from both the wind farming industry and the oil and gas sectors was recently commissioned off the coast of Norway in 2009. The Hywind are towed out to the open sea of density 1025 kg m^{-3} and is anchored to the seabed by three long cables as shown in Fig. 8.1. The high-speed wind turbine is used to generate electricity of output frequency of 50 Hz. One of the reasons for operating the Hywind offshore is the continuous presence of high speed wind from 8.0 m s^{-1} to 30 m s^{-1}.

Fig. 8.2 shows the different parts inside the generator housing.

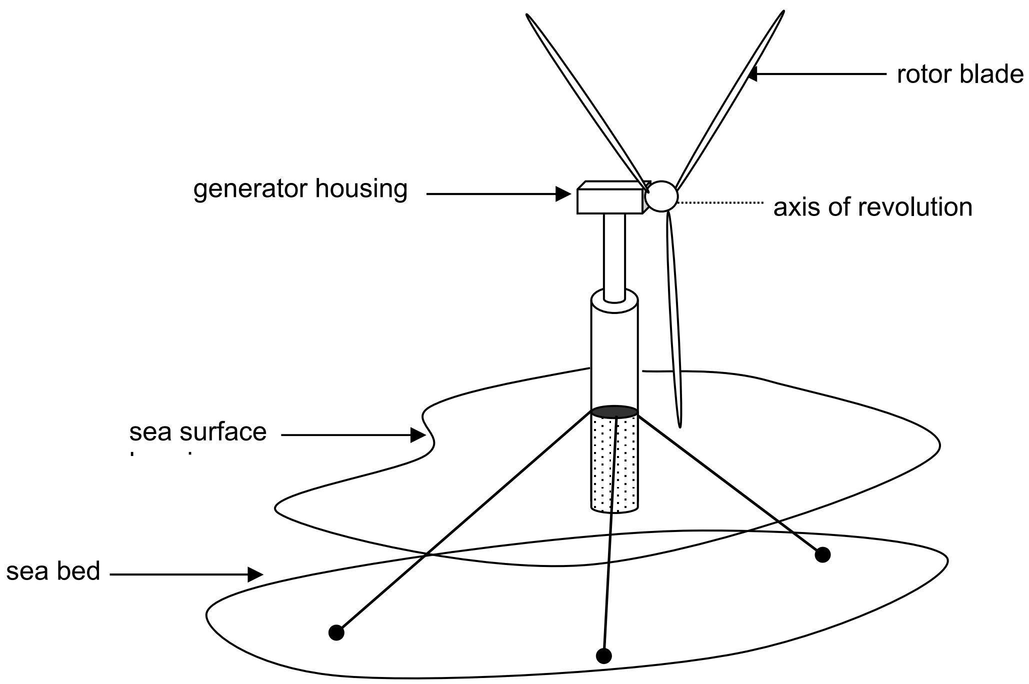


Fig. 8.1

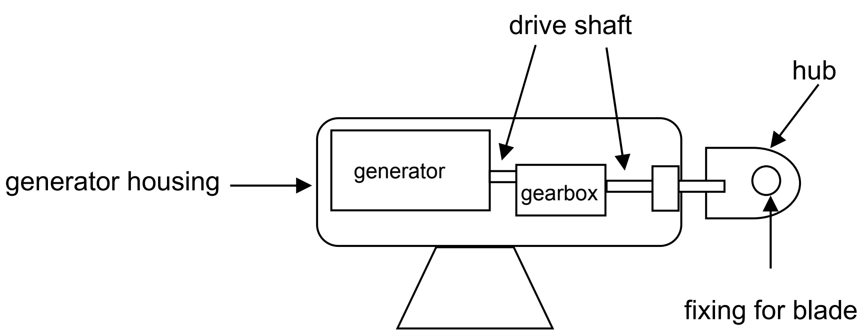


Fig. 8.2

Some information provided by the manufacturer of Hywind is given in Fig. 8.3.

Turbine mass	138 000 kg
Turbine height above the sea surface	65.0 m
Rotor blade diameter	82.4 m
Displacement of water by Hywind	5300 m^3
Diameter of submerged body	8.3 m
Range of water depth	120 - 700 m
Frequency	50 Hz

Fig. 8.3

(a) State and explain whether the generator produces direct current or alternating current.

[1]

(b) Determine the upthrust on the Hywind structure.

upthrust = ... N [1]

(c) **(i)** The turbine is located so that it faces the wind. The rotor blades are set at an angle to the plane in which they revolve so that the wind is deflected.

Explain why the rotor blades are able to revolve about the axis when subjected to the wind.

[3]

(ii) Describe briefly how electrical energy is generated using the energy from the wind.

....

....

....

.... [2]

Question 8 continues on next page

(d) Fig. 8.4 shows how the output power, *P*, from a wind turbine varies with the speed, *v*, of the wind.

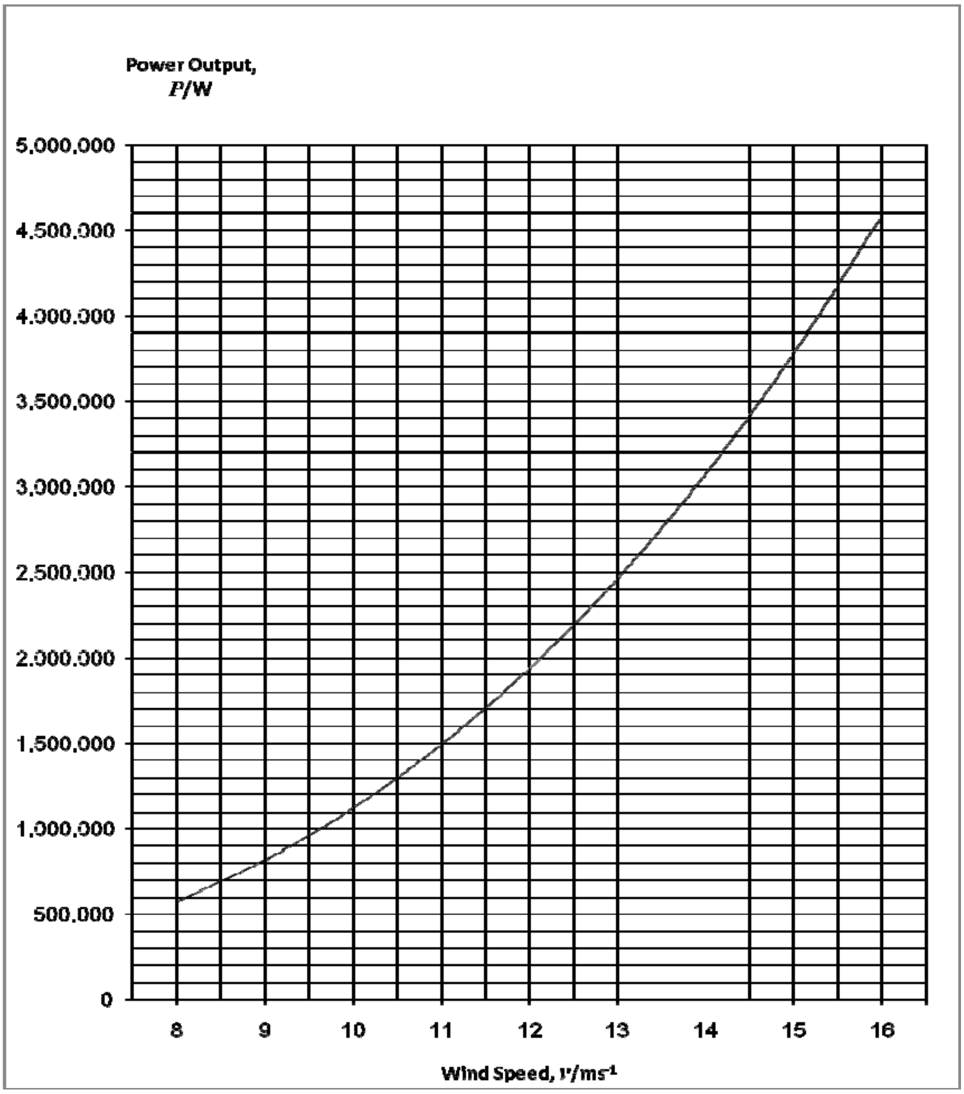


Fig. 8.4

It is thought that, for a given fixed size of the rotor blade, the electrical power output, *P*, varies with the wind speed *v* according to the expression

$$P = kv^3$$

Using the graph of Fig. 8.4, show that *k* is a constant.

[2]

(e) Some corresponding values of lg P and lg v for the data in Fig. 8.4 are plotted on the graph of Fig. 8.5.

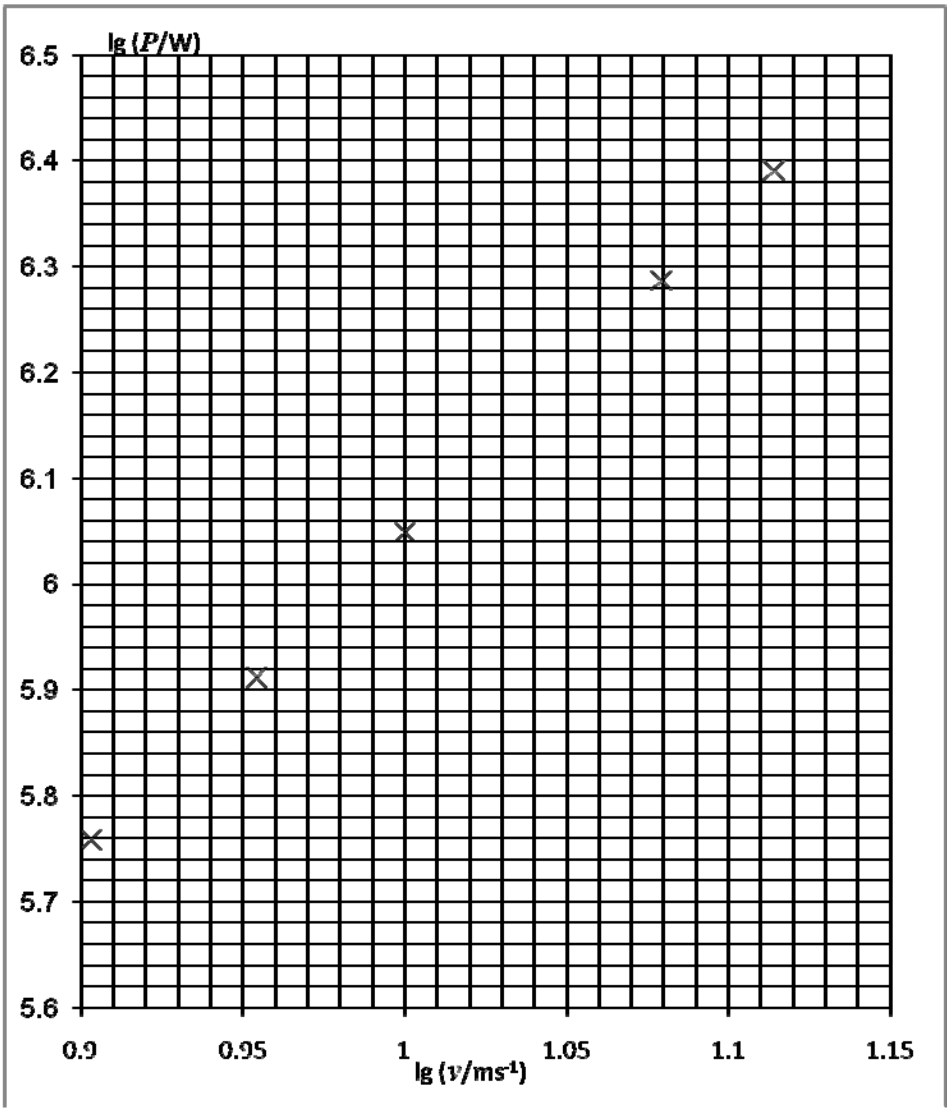


Fig. 8.5

(i) On Fig. 8.5,

1. plot the point corresponding to v = 11.0 m s^{-1}, [1]

2. draw the best fit line for all the plotted points. [1]

(ii) Determine the gradient of the line drawn in **(i) part 2**.

gradient = ... [2]

(iii) Hence comment on the validity of the relation given in **part (d)**.

Explain your answer.

...

...

...

... [2]

(f) The initial kinetic energy per second of the air that passes through the wind turbine is given by ½ $\rho A v^3$, where ρ is the density of air and A is the area swept out by the rotor blades in each rotation.

Given: density of air = 1.2 kg m^{-3}

Calculate, for the wind turbine operating at wind speed of 11.0 m s^{-1},

(i) kinetic energy of air incident per second on the rotor blades,

incident wind power = ... MW [2]

(ii) the overall efficiency of generation of electric power.

efficiency = ... [1]

(g) Suggest two possible problems encountered when operating the Hywind in the open sea.

1. ....

....

2. ....

.... [2]

End of Paper

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS **9749/03**

Higher 2

Longer Structured Questions

10 September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

The use of an approved scientific graphic calculator is expected where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
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Total	

(This question paper consists of 26 printed pages)

Data

speed of light in free space	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1} = $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	$= 1.60 \times 10^{-19}$ C
the Planck constant	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton	m_p	$= 1.67 \times 10^{-27}$ kg
molar gas constant	R	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	k	$= 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	G	$= 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	g	$= 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas	W	$= p\,\Delta V$
hydrostatic pressure	p	$= \rho g h$
gravitational potential	ϕ	$= -\dfrac{Gm}{r}$
temperature	T/K	$= T/^{o}\text{C} + 273.15$
pressure of an ideal gas	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean kinetic energy of a molecule of an ideal gas	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t = \pm\, \omega\sqrt{(x_o^2 - x^2)}$
electric current	I	$= Anvq$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

Section A

Answer **all** the questions in this Section.

1. In a simple pendulum experiment to determine the acceleration of free fall g, the following equation is used

$$T = 2\pi\sqrt{\frac{l}{g}}.$$

The following measurements were obtained using a metre rule and stopwatch respectively.

Length of the pendulum: $l =$ (98.0 ± 0.1) cm

Average time of 10 oscillations: $t =$ (19.8 ± 0.2) s

(a) **(i)** The calculated acceleration of free fall g is 9.869 m s^{-2}.

Determine the acceleration of free fall with its associated uncertainty.

acceleration of free fall g = ... ± .... m s^{-2} [3]

(ii) Using a different set of apparatus, another student obtained g to be (11.15 ± 0.02) m s^{-2}.

Compare the accuracy and precision of the two sets of readings.

....

....

.... [1]

(b) Tempered glass screen protector is made of many atoms.

Estimate the number of atoms in a 0.5 mm thickness tempered glass screen protector for a mobile phone. Show your working and reasoning clearly.

number of atoms = ... [4]

2. In a bungee jump, a light elastic rope is used to attach a man to a bridge. The man has a mass of 80.0 kg while the rope has a natural length of 25.0 m and an elastic constant of 120 N m^{-1}. The man steps off the bridge and falls vertically downwards from rest. Assume that air resistance acting on the man is negligible.

(a) **(i)** Show that the extension of the rope is 6.54 m when the man is falling at maximum speed.

[1]

(ii) Determine the maximum speed of the man after he steps off the bridge.

maximum speed = ... m s^{-1} [2]

(iii) Calculate the maximum kinetic energy of the man.

maximum kinetic energy = ... J [1]

(b) **(i)** Calculate the maximum extension of the elastic rope when the man is at the lowest point of his motion.

maximum extension = ... m [2]

(ii) Hence, or otherwise, determine the gravitational potential energy of the man on the bridge. Assume that gravitational potential energy of the man is zero at the lowest point of the man's motion.

gravitational potential energy = ... J [1]

(c) On Fig. 2, sketch three clearly-labelled graphs for the variation with downward displacement s of

(i) the gravitational potential energy of the man, (Label as **G**)

(ii) the elastic potential energy stored in the rope, and (Label as **E**)

(iii) the kinetic energy of the man. (Label as **K**)

Assume that gravitational potential energy of the man is zero at the lowest point of the man's motion. Take s = 0 m as the start point of motion.

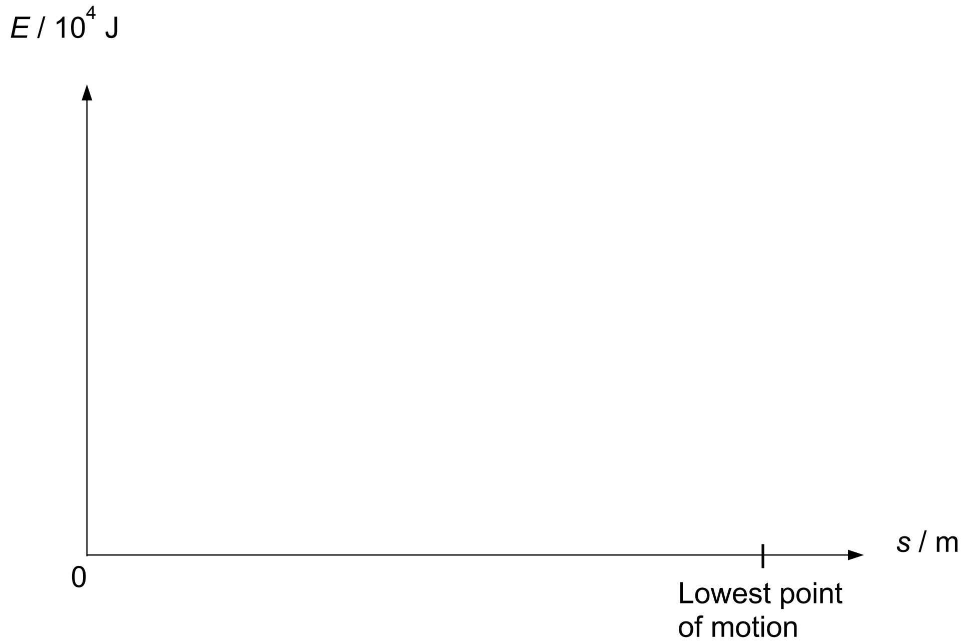


Fig. 2

[3]

3. **(a)** An elastic light cord has an unextended length of 13.0 cm. One end of the cord is attached to a fixed point C. A small mass of 0.50 kg is hung from the free end of the cord. The cord extends to a length of 14.8 cm as shown in Fig. 3.1.

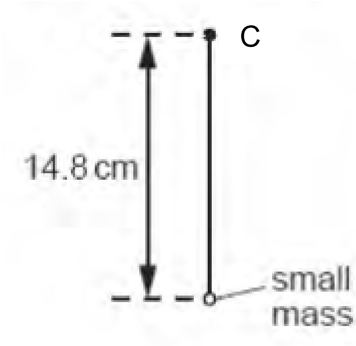


Fig. 3.1

(i) Determine the force constant *k* of the light cord.

k = ... N m^{-1} [1]

(ii) The mass is now made to move at constant angular speed ω in a vertical plane about point C. When the cord is vertical and above C, its length is the unextended length of 13.0 cm, as shown in Fig. 3.2.

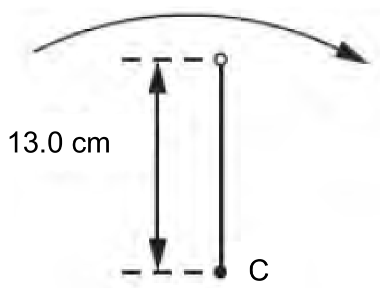


Fig. 3.2

Show that the angular speed ω of the mass is 8.7 rad s^{-1}.

[2]

(iii) The mass moves so that the cord is vertically below C, as shown in Fig. 3.3.

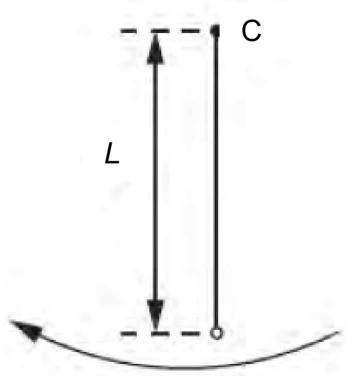


Fig. 3.3

Calculate the length *L* of the cord, assuming it obeys Hooke's law.

L = ______________ m [2]

(b) A mass m of 5.00 kg rests on the equator of the Earth as shown in Fig. 3.4. The Earth, assumed to be a perfect sphere, rotates about its axis with a period of 1.00 day. The surface of the Earth exerts a normal contact force N on the mass. The radius R of the Earth is 6.40×10^3 km.

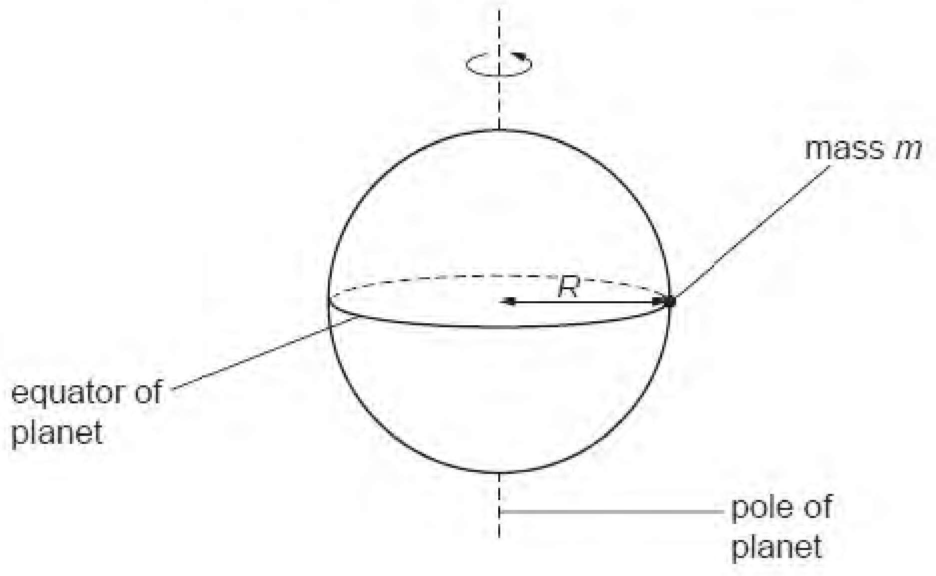


Fig. 3.4

(i) Calculate, for mass m,

1. the centripetal force F_C,

F_C = ... N [2]

2. the normal contact force N.

N = ... N [2]

(ii) Explain why the normal contact force *N* acting on the mass at the poles is different from the answer in **(b)(i)2.**

[2]

4. The variation of the gravitational potential ϕ with distance x from the centre of the Earth is shown in Fig. 4.1. The radius R of the Earth is 6.40×10^3 km.

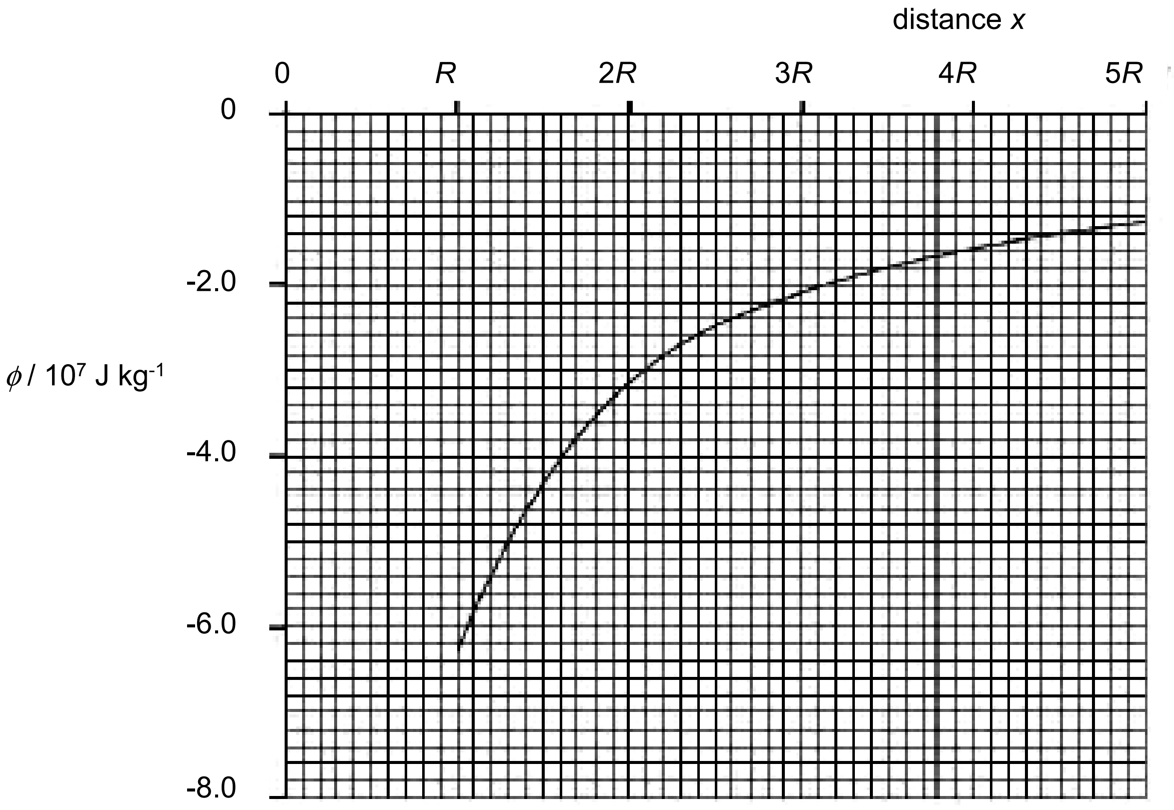


Fig. 4.1

(a) By considering the gravitational potential at the Earth's surface, determine a value for the mass of the Earth.

mass = ... kg [2]

(b) A meteorite is at rest at infinity. It travels from infinity towards the Earth.

(i) Calculate the speed of the meteorite when it is at a distance of *R* above the Earth's surface.

speed = ______________ m s^{-1} [3]

(ii) In practice, the Earth is not an isolated sphere because it is orbited by the Moon, as illustrated in Fig. 4.2.

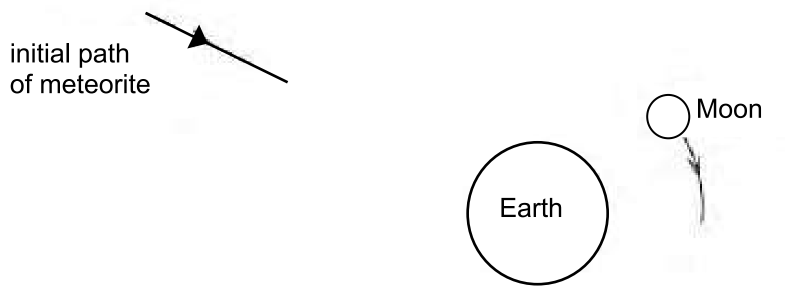


Fig. 4.2

The initial path of the meteorite is also shown.

Suggest two changes to the motion of the meteorite caused by the Moon.

____

____

____

____ [2]

5. **(a)** Define *electric field strength*.

[1]

(b) Electrons from a filament source enter a region between the parallel plates after being accelerated by an electric field. Fig. 5 below shows the electrons travelling horizontally at a speed of 2.50 x 10^7 m s^{-1} entering the pair of parallel plates.

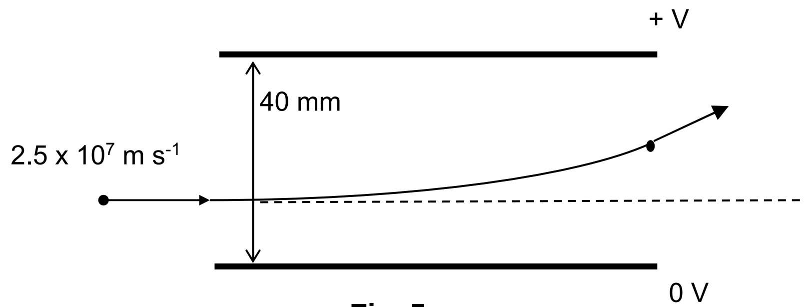


Fig. 5

(i) The electrons deviate by 30° on leaving the parallel plate of 80.0 mm long. The separation between the plates is 40.0 mm.

Calculate the time taken for the electrons to travel through the plates.

time = ………………… s [1]

(ii) Calculate the vertical component of the velocity when the electrons exit the parallel plates.

vertical component of velocity = ... m s^{-1} [2]

(iii) Hence calculate the acceleration of the electrons.

acceleration = ... m s^{-2} [1]

(iv) Calculate the potential difference *V* between the two plates.

V = ... V [2]

(v) If the plate separation is reduced, suggest how the answer to **(b)(ii)** is affected.

....

....

.... [1]

6. A small electric torch is powered by a single cell which supplies 1.6 J of energy per coulomb of charge passing through the cell. When the torch is switched on, the cell supplies a constant current of 0.50 A to bulb X. The potential difference across the bulb is 1.2 V.

(a) Show that the internal resistance, *r*, of the cell is 0.80 Ω.

[2]

(b) The bulb X is replaced by another bulb Y, which draws a current of 0.30 A. Calculate the potential difference across bulb Y.

potential difference = ... V [2]

(c) Calculate the power lost in the cell when connected to bulb Y.

power lost = ... W [2]

(d) When bulb Y is replaced by bulb Z, the power drawn from the cell is maximum. Determine the maximum current that can be drawn from the cell.

maximum current = ... A [2]

7. **(a)** A copper pipe has an internal diameter of 4.00 cm and an external diameter of 7.00 cm. The resistivity of copper is $1.68 \times 10^{-8}\ \Omega$ m.

Determine the resistance of 15.0 m of this pipe.

resistance = ... Ω [3]

(b) A number of resistors are connected to a 6.0 V cell in an electrical circuit as shown in Fig. 7.

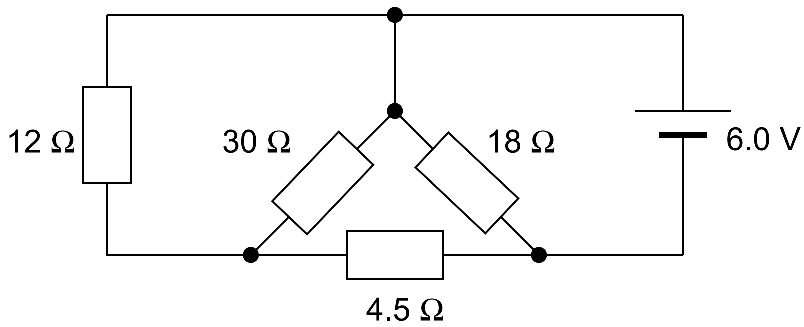


Fig. 7

With reference to Fig. 7,

(i) show that the equivalent resistance of the circuit is 7.6 Ω.

[1]

(ii) determine the current in the 18 Ω resistor.

current = ... A [1]

(iii) determine the power dissipated in the 4.5 Ω resistor.

power = ... W [3]

Section B

Answer **any one** question in this Section.

8. **(a)** **(i)** State two assumptions of the kinetic theory of gases.

1. ______________________________

____

2. ______________________________

______________________________ [2]

(ii) A sealed container holds a mixture of nitrogen-14 and helium-4 gas molecules at at temperature of 290 K.

1. Determine the average kinetic energy of a helium molecule.

average kinetic energy = ______________ J [2]

2. Explain whether it is possible for the mean square speed of the nitrogen molecules to be different from the helium molecules at the same temperature.

____

______________________________ [1]

(b) **(i)** State what is meant by the internal energy of a system.

____

____

______________________________ [1]

(ii) In Fig. 8.1 below, place a tick (√) against those changes where the internal energy of a system is increasing.

Water freezing at constant temperature	
A stone falling under gravity in a vacuum	
Water evaporating at constant temperature	
Stretching a wire at constant temperature.	

Fig. 8.1

[2]

(iii) A cylinder of gas at constant volume is placed under the sun so that its temperature rises.

Explain the changes to the internal energy of the gas.

[2]

(iv) The volume occupied by 1.00 mol of water at 100 °C is 1.87×10^{-5} m^3. When the water is vaporised at an atmospheric pressure of 1.03×10^5 Pa, the water vapour has a volume of 2.96×10^{-2} m^3.

The latent heat required to vaporise 1.00 mol of water at 100 °C and 1.03×10^5 Pa is 4.05×10^4 J.

Determine, for this change of state,

1. the work done on the system,

work done = ... J [2]

2. the increase in internal energy of the system.

increase in internal energy = ______________ J [2]

(c) **(i)** A student states wrongly that temperature measures the amount of thermal energy in a body.

State and explain two observations that show why the statement is incorrect.

____

____

____

____ [2]

(ii) Some crushed ice at 0 ^{o}C is placed in a funnel together with an electric heater, as shown in Fig. 8.2 below.

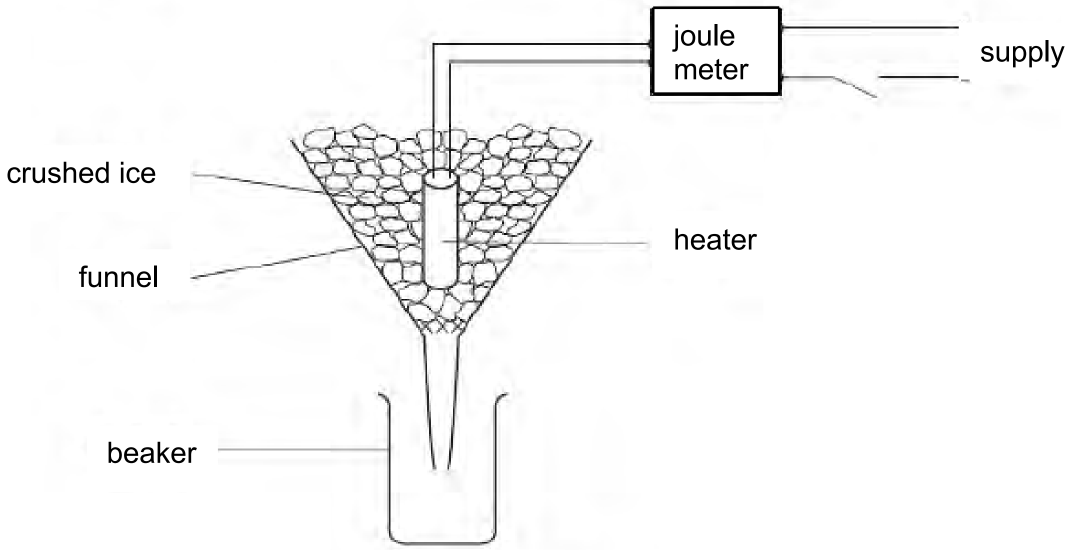


Fig. 8.2

The mass of water collected in the beaker in a measured interval of time is determined with the heater switched off. The mass is then found with the heater switched on. The energy supplied to the heater is also measured.

For both measurements of the mass, water is not collected until melting occurs at a constant rate.

The data shown in Fig. 8.3 are obtained.

	mass of water / g	energy supplied to heater / kJ	time interval / min
heater switched off	8.3	0	5.0
heater switched on	64.7	18	5.0

Fig. 8.3

1. State why it is necessary to determine the mass of water with the heater switched off.

[1]

2. Suggest how it can be determined that the ice is melting at a constant rate.

[1]

3. Calculate a value for the specific latent heat of fusion of ice.

specific latent heat = ... $kJ\ kg^{-1}$ [2]

9. **(a)** Define *magnetic flux density*.

[2]

(b) Fig. 9 below shows a current carried by a square coil GHJK of 500 turns and side 5.0 cm. The coil is suspended vertically in a uniform horizontal magnetic field of flux density $B = 2.0 \times 10^{-4}$ T. The plane of the coil is at angle $\theta = 35°$ to B.

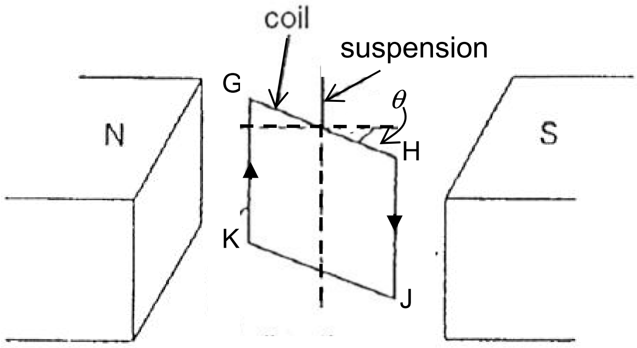


Fig. 9

(i) Indicate, in Fig. 9, the direction of the magnetic force acting on the side JK of the coil. [1]

(ii) The current in coil GHJK is 0.40 A. Calculate the magnetic force acting on side JK of the coil.

magnetic force = ... N [2]

(iii) Calculate the torque acting on the coil GHJK.

torque = ______________ N m [3]

(c) State the *laws of electromagnetic induction*.

____

____

____

____

____ [2]

(d) The coil GHJK in Fig. 9 is disconnected from its e.m.f. source. The plane of the coil is at angle $\theta = 35°$ to B.

(i) Calculate the magnetic flux linkage through the coil.

magnetic flux linkage = ______________ Wb [2]

(ii) The coil is then rotated at 100 Hz about the vertical suspension.

1. Calculate the magnitude of the maximum induced e.m.f. in the coil.

maximum induced e.m.f. = ... V [3]

2. The coil is now acting as an AC generator. It is connected to a heater of resistance 5.0 Ω. Assuming the coil has negligible resistance, calculate the power generated in the heater.

power = ... W [3]

3. If the heater in **(d)(ii)2** is also connected in series with an ideal diode, determine the power generated in the heater.

power = ... W [2]

End of Paper

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME			
CLASS		**INDEX NUMBER**	

PHYSICS **9749/04**
Higher 2

Paper 4 Practical

14 Aug 2018

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST
Do not open this booklet until you are told to do so.

Write your name, index number and class in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift	
Laboratory	
For Examiner's Use	
Q1	/15
Q2	/08
Q3	/20
Q4	/12
Total:	/55

This document consists of **20** printed pages

1 In this experiment, you will investigate the time for the voltage across an electrical component to decrease after a switch is opened.

(a) You are provided with a power supply, a component C, an unknown resistor Y, five resistors labelled with their resistance values in kΩ, a voltmeter and a switch.

Assemble the circuit of Fig. 1.

Ensure that the positive terminal of the power supply is connected to the positive terminal of component C.

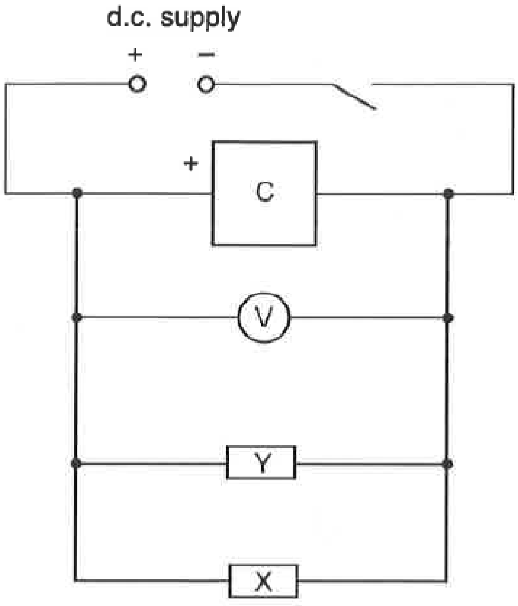


Fig. 1

X has a value of resistance *S*. Connect the resistors provided such that *S* has a value of 16 kΩ.

(b) **(i)** Close the switch and check that the voltmeter reading is about 6 V.

(ii) When the switch is opened the voltmeter reading will gradually decrease.

Take measurements to determine the time *t* for the voltmeter reading to fall from 5.0 V to 2.0 V after the switch is opened.

Record *t*.

t = ... [1]

(c) Estimate the percentage uncertainty in your value of *t*.

percentage uncertainty = ... [1]

(d) Repeat **(b)** for another four different values of *S*.

[5]

(e) It is suggested that *t* and *S* are related by the expression

$$\frac{1}{t} = \frac{a}{S} + b$$

where *a* and *b* are constants.

Plot a suitable graph to determine the values of *a* and *b*.

a = ...

b = ... [3]

[3]

(f) Calculate the value of *S* for which *t* is equal to 6.5 s.

S = ... kΩ [1]

(g) State **one** significant source of error.

....

....

.... [1]

[Total: 15 marks]

2 In this experiment, you will investigate the deflection of a loaded metre rule.

(a) **(i)** Set up the apparatus as shown in Fig.2.1.

Diagram not drawn to scale

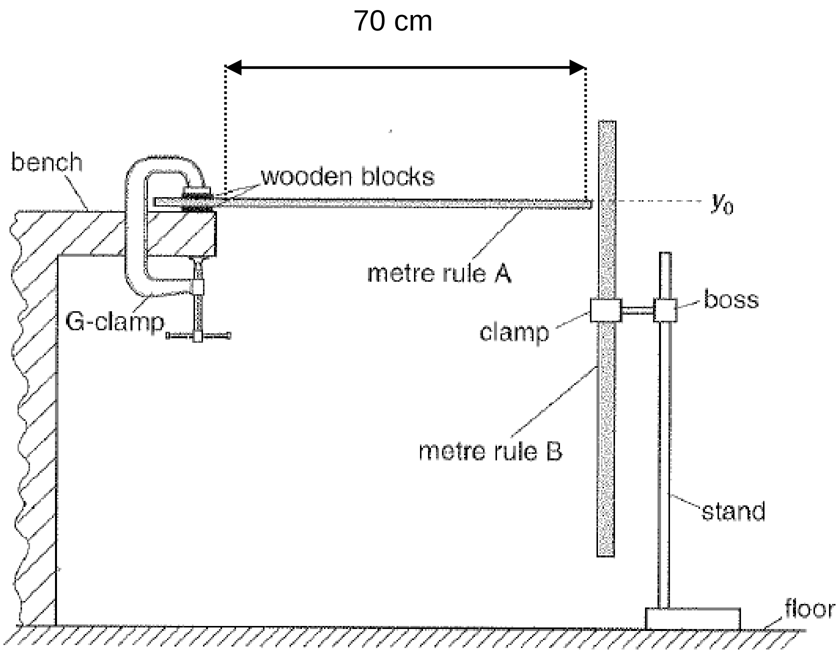


Fig. 2.1

y_0 is the point on rule B level with the top of rule A.

(ii) Record the reading y_0.

y_0 = ____________ [1]

(iii) Place a 200 g mass on the end of rule A as shown in Fig. 2.2

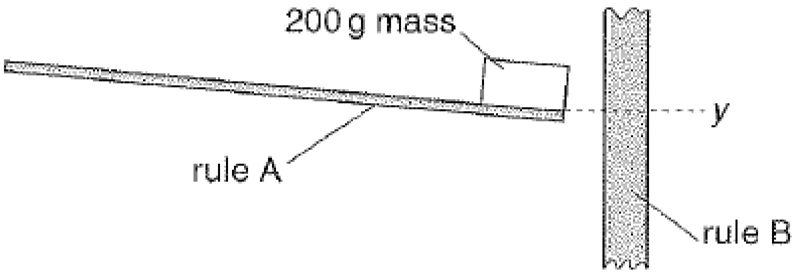


Fig. 2.2

y is the point on rule B level with the top of rule A.

(iv) Record the reading y.

y = ______________________.

(v) Remove the 200 g mass from rule A.

(vi) Calculate the deflection $(y - y_0)$.

$(y - y_0)$ = ______________ [1]

(vii) Determine the percentage uncertainty in $(y - y_0)$.

percentage uncertainty in $(y - y_0)$ = ______________ [1]

(b) **(i)** Repeat **(a)(ii)**.

y_0 = ______________

(ii) Place the 200 g mass at a position approximately half way along rule A.

(iii) Repeat **(a)(iv)**, **(a)(v)** and **(a)(vi)** with the 200 g mass placed at a position approximately half way along rule A.

y = ______________

$(y - y_0)$ = ______________ [1]

(c) **(i)** It is suggested that:

> "If both masses are placed on rule A in different positions at the same time, the deflection will equal the sum of the deflections for each mass on its own."

Take another reading to investigate this suggestion.

[1]

(ii) State whether or not the results of your experiment support this suggestion.

Justify your answer by referring to your calculated percentage uncertainty in **(a)(vii)**.

[1]

(d) **(i)** State a significant source of error in this experiment.

[1]

(ii) Suggest one improvement that could be made to the experiment to address the source of error identified in **(d)(i)**. You may suggest the use of other apparatus or a different procedure.

[1]

[Total: 8 marks]

3 In this experiment, you will investigate the equilibrium position of a half-metre rule supported by a spring.

(a) Attach the spring tied to the string and the 20 cm length of string to the half-metre rule as shown in Fig. 3.1

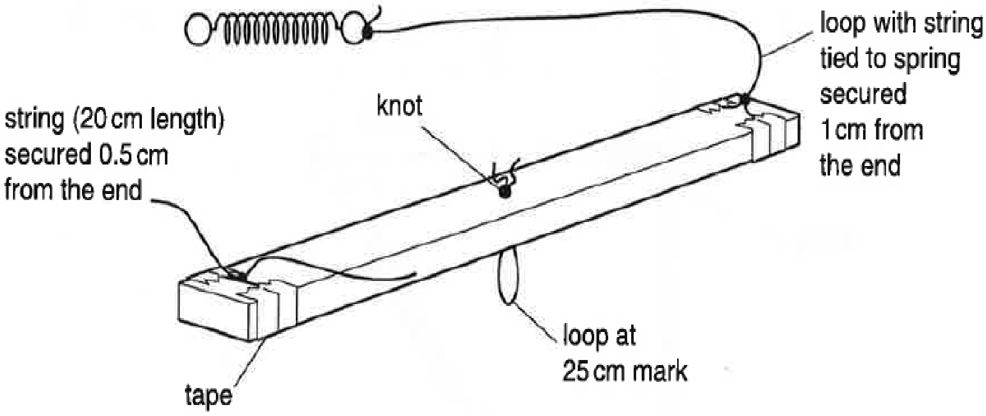


Fig. 3.1

Assemble the apparatus as shown in Fig. 3.2 using a mass of 300 g.

Ensure that the mass hanger and masses are not touching the bench.

The upper string must be parallel to the bench.

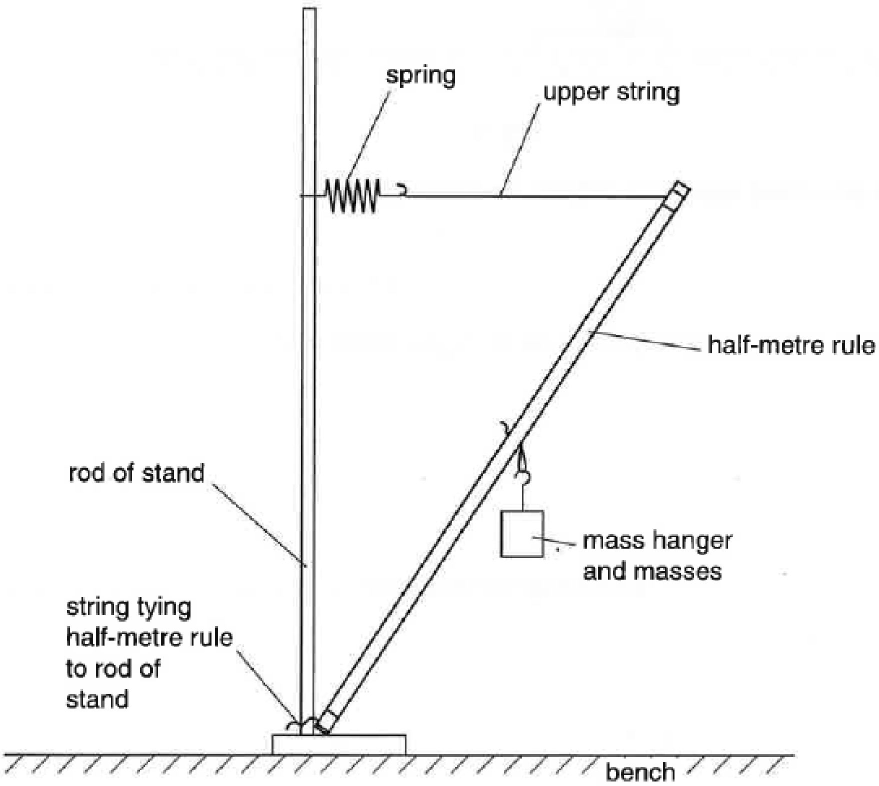


Fig. 3.2

(b) Fig. 3.3 shows the measurements you will take.

Point A is where the line of the upper string meets the half-metre rule.

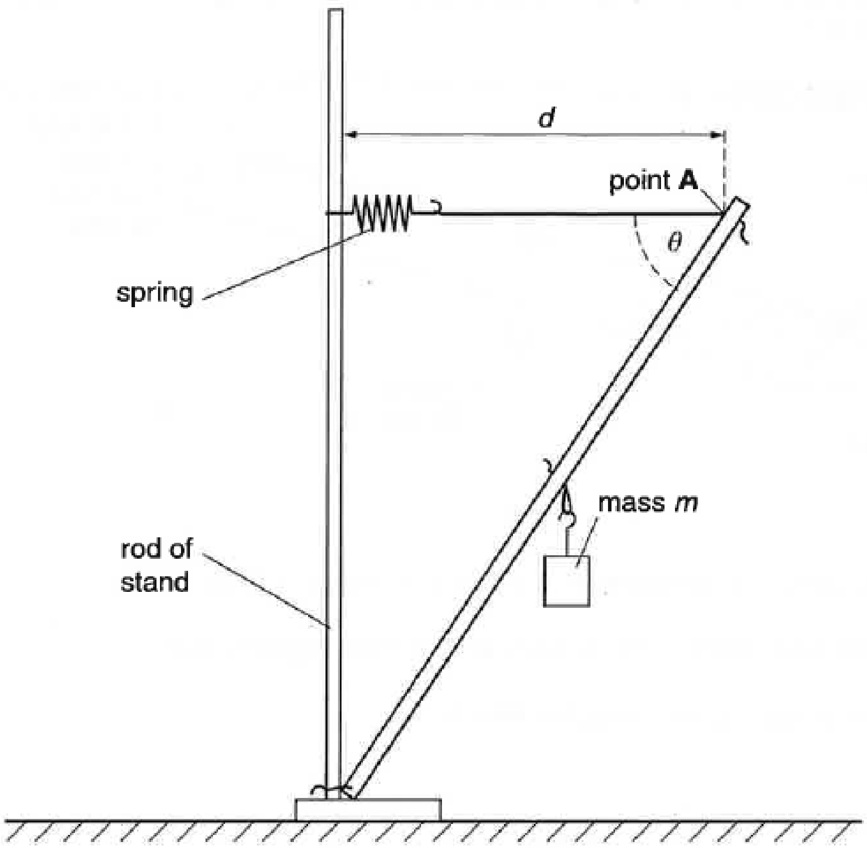


Fig. 3.3

(i) Measure and record the angle θ as shown in Fig. 3.3.

θ = ... [1]

(ii) Estimate the percentage uncertainty in your value of θ.

percentage uncertainty = ... [1]

(iii) Record the total mass m of the mass hanger and masses.

m = ...

(iv) Measure and record the distance *d* between the rod of the stand and **A**, as shown in Fig. 3.3

d = ……………………… [1]

(c) Record the mass of the half-metre rule, *M* as written on the ruler.

M = ………………………

(d) Change the value of m and repeat **(b)(i),(b)(iii)** and **(b)(iv)** to obtain further sets of values of m, d and θ.

[5]

(e) Theory suggests that m, d and θ are related by the expression

$$\frac{(m+M)}{\tan\theta} = Pd - Q$$

where P and Q are constants, and M is the mass of the half-metre rule as written on the ruler.

Plot a suitable graph to determine the values of P and Q.

P = ...

Q = ... [4]

[4]

(f) Comment on any anomalous data or results you may have obtained.

[1]

(g) **(i)** State one significant source of error in the experiment. Give a reason.

[1]

(ii) Suggest one improvement that could be made to the experiment and explain how this addresses the error identified in **(g)(i)**. You may suggest the use of other apparatus or a different procedure.

[1]

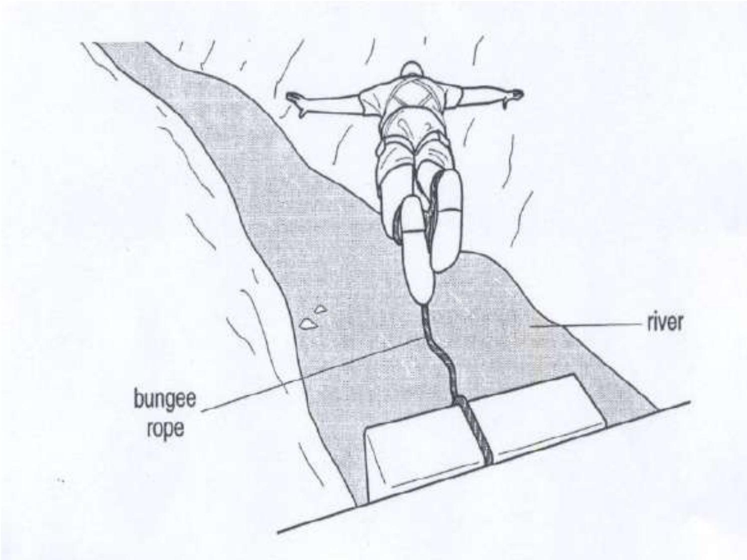
(h) The constant P is proportional to the spring constant.

On the graph grid on page 15, sketch a second graph to represent the results if a spring with a larger spring constant is used. Label this graph Z.

[1]

[Total: 20 marks]

4 The origin of bungee-jumping is quite recent but the activity is related to the centuries-old ritualistic practices of “land divers” of the Pentecost Island in the Pacific Archipelago of Vanuatu. The men would demonstrate their courage and offer their injuries to the gods for a plentiful harvest of yams. Nowadays, the sport uses cranes, towers, bridges or hot-air balloons to serve as jump platforms.



A group of bungee jumping enthusiasts proposed to set up a Bungee Jumping Extreme Club in the college. There are many safety considerations to consider. One of the most important safety considerations would be the minimum safety height from which the jumper jumps. If this safety consideration is not enforced, the jumper might hit the ground and suffer serious injury before the rubber cord that is tied to his ankles is fully extended. It is suggested that the minimum safety height depends on the mass of the jumper and the original length of the rubber cord.

For the safety of the bungee jumping enthusiasts, design a scaled down experiment in the laboratory to investigate how the minimum safety height depends on the mass of the object and the length of the rubber cord.

The apparatus available includes the following:

- Rubber cords
- Measuring tape
- Brick
- Spherical bobs
- Retort stand with clamp and boss head

You should draw diagram(s) to show the arrangement of your apparatus. In your account, you should pay attention to

(a) the apparatus you would use for the investigation,

(b) the procedure to be followed,

(c) the control of variables,

(d) any safety precautions,

(e) any precautions that you would take to improve the accuracy of the experiment.

Diagram

[12]

End of paper

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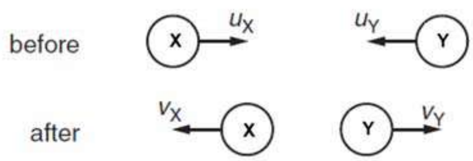
Qn	Ans	Suggested solution
1	**D**	Option A does not affect the driver's reading of the car's speed. Option B causes a systematic error. Option C causes a systematic error. Option D causes a parallax error, which is a random error.
2	**A**	Vertical acceleration is directly proportional to vertical resultant force. Considering only vertical direction, At P, it experiences weight and drag force in the same direction. At T, it experiences only weight and no drag force because vertical velocity is zero. At Q, it experiences weight and drag force but in opposite direction.
3	**B**	$U_w + U_m = W$ $\rho_w V_w g + \rho_m V_m g = \rho_n V_n g = \rho_n (V_w + V_m) g$ $1000 V_w + 13600 V_m = 7900 (V_w + V_m)$ $5700 V_m = 6900 Vw$ $V_w / V_m = 57/69 =$ **0.826**
4	**A**	The pair of action and reaction forces (Newton's third law) must act on ***separate*** bodies.
5	**C**	 For elastic collision, relative speed of approach = relative speed of separation $v_2 - v_1 = u_1 - u_2$ (where the sign conventions of u_1, u_2, v_1, v_2 are to the right) Hence $u_X - (-u_Y) = v_Y - (-v_X)$ → $u_X + u_Y = v_X + v_Y$
6	**C**	Raw Power input = Rate of GPE converted to Electrical Energy $= \frac{mgh}{t} = \frac{\rho Vgh}{t}$ $= \frac{1000(6.0)(9.81)(80)}{1}$ = 4.78088 MW Since Efficiency $= \frac{P_{out}}{P_{in}} = 0.60$ Then $P_{out} = 0.60(4.7088) =$ **2.8 MW**

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Qn	Ans	Suggested solution
7	**D**	$a = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 r}{T^2}$ $T = 2\pi\sqrt{\frac{r}{a}}$ $10T = 20\pi\sqrt{\frac{r}{a}}$
8	**D**	$F \sin 30° = m(3 + 5 \sin 30°)\,\omega^2$ - - - (1) $F \cos 30° = mg$ - - - (2) $\frac{(1)}{(2)}$: $\tan 30° = \frac{(3+5\sin 30°)4\pi^2}{(9.81)T^2}$ → $T =$ **6.2 s**
9	**C**	The gravitational field strength at P due to both masses are equal and in opposite directions → resultant field strength = 0 $\phi = \phi_m + \phi_m = -\frac{Gm}{r/2} - \left(-\frac{Gm}{r/2}\right) = -\frac{4Gm}{r}$
10	**D**	Gravitational force provides the centripetal force for the satellite to orbit the Earth → $\frac{GMm}{r^2} = ma$ → $a = \frac{GM}{r^2}$ $\frac{GMm}{r^2} = ma = \frac{mv^2}{r}$ $v = \sqrt{\frac{GM}{r}}$
11	**A**	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ → $c_{rms} = \sqrt{\frac{3kT}{m}}$ $\frac{c'_{rms}}{c_{rms}} = \sqrt{\frac{T'}{T}}$ → $\frac{0.8c_{rms}}{c_{rms}} = \sqrt{\frac{T'}{295}}$ T' = 188.8 K = **–84.4 °C**
12	**C**	pV → $(1.5p)(0.5V) = 0.75pV$ The temperature of the gas decreases → average KE of the molecules decreases → internal energy decreases. Work is done on the gas since the volume decreases.
13	**B**	$n_Y = \frac{pV}{RT}$, $n_X = \frac{p(2V)}{R(2T)}$ → $\frac{n_X}{n_Y}$ = **1.00**
14	**C**	Direction of *E* doesn't change, only magnitude changes. *E* is greatest close to the charge and minimum at midpoint.

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<table>
<tr><th>Qn</th><th>Ans</th><th>Suggested solution</th></tr>
<tr><td>15</td><td>A</td><td>Force on electron, $F = qE$ (to the left)

Work done by electric force on electron = $-Fx$

When the electron moves to the right, it gains EPE. The amount of EPE gained is equal to the work done by the electric force (Fx), where x is the distance moved in the direction of the field lines.</td></tr>
<tr><td>16</td><td>C</td><td>From Fig. 16.1,

when current = 5 mA, p.d. = 0.8 V (across diode)

p.d. across 50 Ω resistor = (5 mA)(50 Ω) = 0.25 V

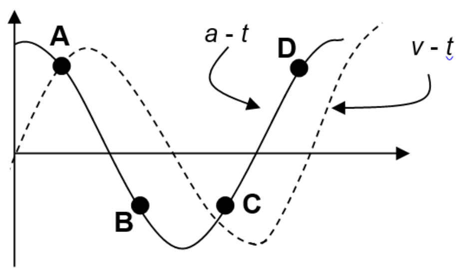
Total p.d. across supply = 0.8 + 0.25 = **1.05 V**</td></tr>
<tr><td>17</td><td>B</td><td>Consider circuit B:
By potential divider,
p.d across 6 kΩ is $\frac{6}{6+2}[8-(-8)] = 12$ V

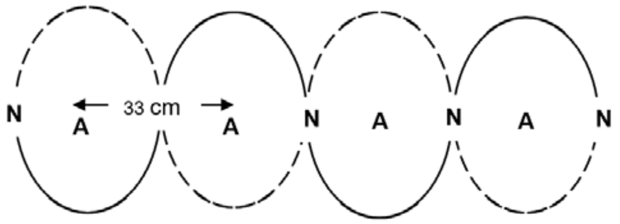
Potential at J = 8 – 12 = –4 V</td></tr>
<tr><td>18</td><td>C</td><td>Charge flows = area under the graph

= ½ (100 mA + 20 mA) (8) = **480 mC**</td></tr>
<tr><td>19</td><td>D</td><td>At point P, the displacement, x is negative and velocity, v is negative.

Since $a = -\omega^2 x \Rightarrow F = ma = -m\omega^2 x$, x negative will mean F is positive (B and C no longer plausible).

Since a-t graph is a cosine graph, v-t graph will be a sine graph and hence A is not possible since its velocity is positive.


</td></tr>
<tr><td>20</td><td>D</td><td><table>
<tr><th></th><th>Unpolarised light</th><th>After 1st polariser</th><th>After 2nd polariser</th></tr>
<tr><td>Amplitude</td><td></td><td>A</td><td>$A \cos 60 = 0.5 A$</td></tr>
<tr><td>Intensity</td><td></td><td>A^2</td><td>$0.25 A^2$</td></tr>
<tr><td></td><td>$8I_f$</td><td>$4I_f$</td><td>I_f</td></tr>
</table></td></tr>
<tr><td>21</td><td>C</td><td>To be able to ***observe*** interference fringes, the waves that superpose must be coherent i.e. have a constant phase difference.</td></tr>
</table>

Qn	Ans	Suggested solution
22	B	 $\lambda = 2 \times 0.33 = 0.66$ m $f = v/\lambda = 330 / 0.66 = 500$ Hz $T = 1/f = 1/500 = 0.002$ s = 2 ms Period of waveform in option B = 4 cm $\times$ 0.5 ms cm^{-1} = 2 ms
23	A	Magnetic force provides centripetal force → $Bqv = \frac{mv^2}{r}$ → $Bq = \frac{mv}{r}$ → $r = \frac{mv}{Bq}$ $Bq = \frac{mv}{r} = m\omega = \frac{2\pi m}{T}$ → $T = \frac{2\pi m}{Bq}$
24	C	The magnetic force acting on the proton is **upwards**. To balance this force, so that the proton would pass undeflected, the electric force on the proton acts downwards, so the electric field is directed downwards. $v = \frac{E}{B}$ → $E = Bv = (1.5)(2.00 \times 10^7) = \mathbf{3.00 \times 10^7}$ **N C^{-1}**
25	D	When the bar magnet begin to fall through the solenoid, the flux linkage through the solenoid increases, inducing an e.m.f. in it. When the bar magnet falls out of the solenoid, the flux linkage through the solenoid decreases, inducing an e.m.f. in the opposite direction. As the magnet accelerates under gravity, the rate of change increases. Hence the magnitude of the induced e.m.f. is larger when the magnet falls out of the solenoid.
26	D	Same heating effect implies same power dissipated in the resistor, i.e. $P = I^2R$ For the new resistance $R_1 = R/4$, the new r.m.s. current I_1 is given by $P = I_1^2 R_1 = I_1^2 R/4 = I^2R$ → $I_1^2 = 4I^2$ → $I_1 = 2I$ The peak current $I_o = \sqrt{2}\, I_1 = \sqrt{2}\,(2I)$
27	C	$E = [-1.5 - (-3.5)] \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ $E = hf = hc/\lambda$ → $\lambda = hc/E = 6.63 \times 10^{-34} \times 3 \times 10^8 / 3.2 \times 10^{-19}$ $= 6 \times 10^{-7}$ m → visible light
28	B	The two peaks are the ones that are dependent. The wavelengths depend on the energy of the electron and how much energy it loses in each interaction with an atom.
29	B	$A_o = 360 - 20 = 340$ min^{-1} $A = 190 - 20 = 170$ min^{-1} t = 1 half life = **5700 years**
30	B	${}^{222}_{86}\text{Rn} \rightarrow {}^{214}_{83}\text{Bi} + 2\,{}^{4}_{2}\text{He} + {}^{0}_{-1}\text{e}$

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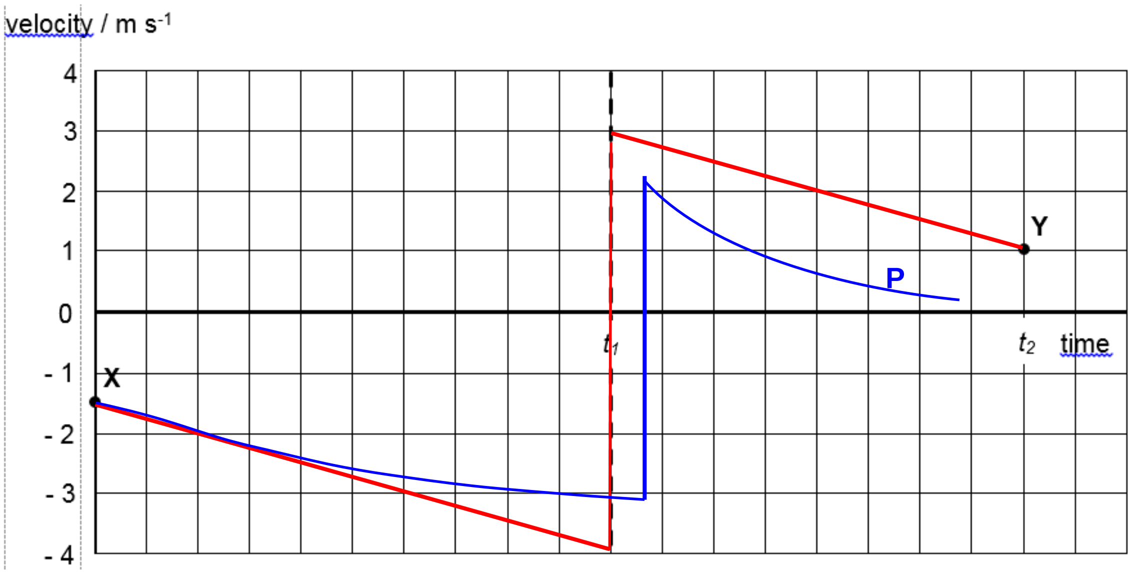
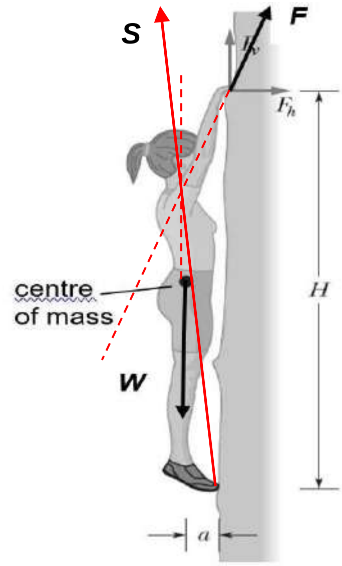
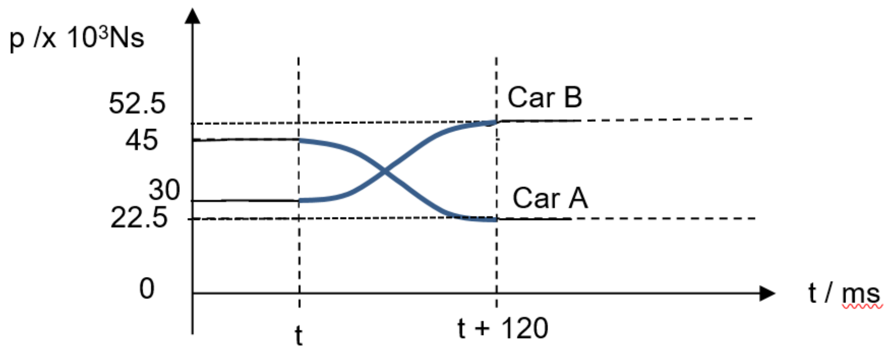
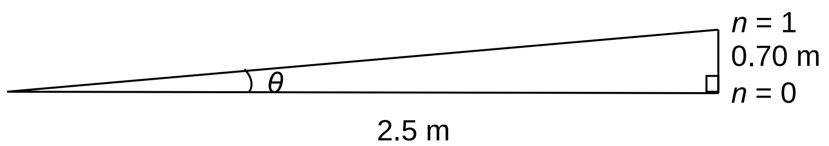
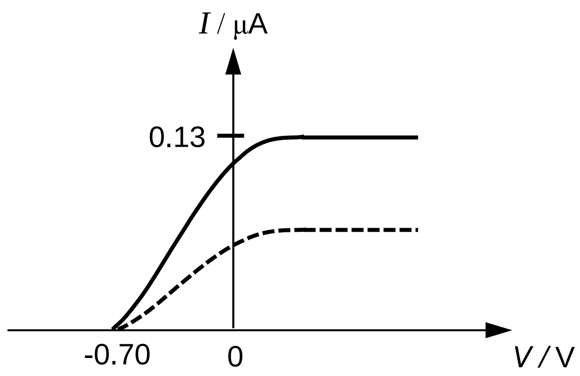
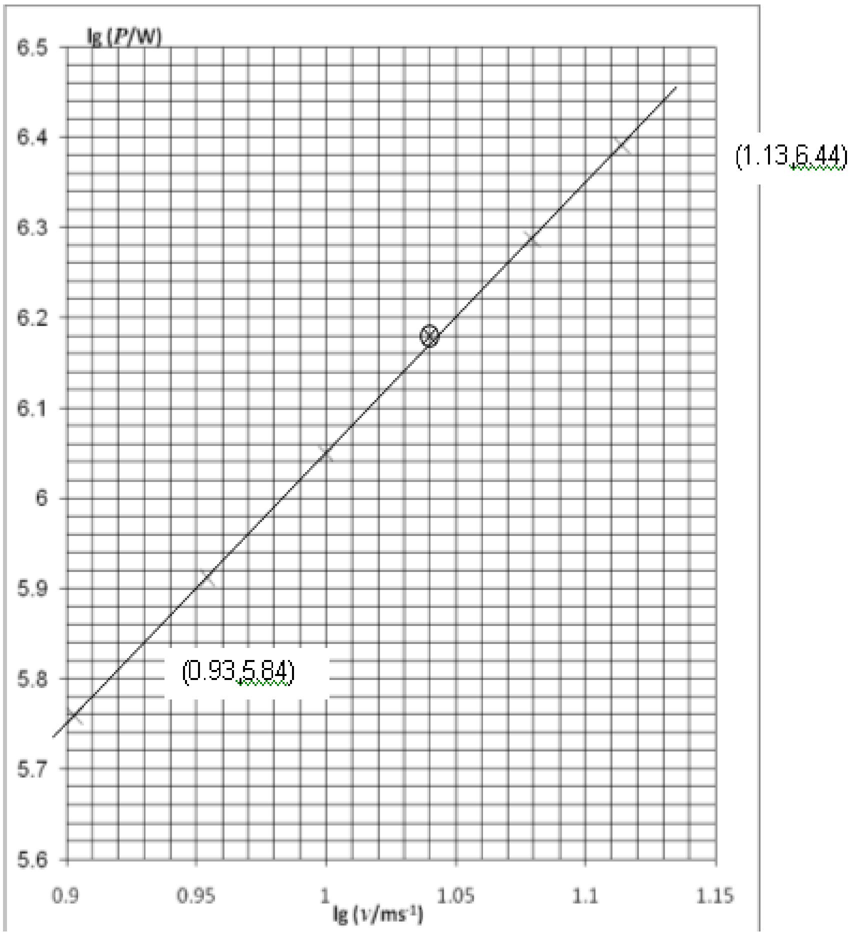
Qn	Suggested solution	Remarks
1(a)	Method 1: Using equations of motion Taking downwards to be positive: $v^2 = u^2 + 2as = 1.5^2 + 2(9.81)(0.65)$ $v = \pm 3.9 \text{ m s}^{-1}$ Final speed = **3.9 m s^{-1}** OR Method 2: Using conservation of energy Loss in GPE = Gain in KE $mgh = \frac{1}{2}m(v^2 - u^2)$ $v^2 = 2gh + u^2$ $v = 3.9 \text{ m s}^{-1}$ Final speed = 3.9 m s^{-1}	**[1] sub** **[1] ans**
MC		
(b)	 • **[1] Straight lines** from X to t_1 and t_1 to Y; and both with **negative gradients**. • **[1]** The two straight lines must be **parallel** and with **correct values (ecf)**.	
(c)	The **speed of the ball just after rebound is less than the speed just before impact**. Hence there is a loss/change in the kinetic energy of the system during the bounce. The bounce is **inelastic**.	**[1]** **[1]**
MC	State without reason, **[0]**. State with loss/change in kinetic energy **[1]**.	
(d)	Graph for downward motion - smaller gradient and duration is longer than t_1 Graph for upward motion - larger gradient and duration is shorter than $(t_2 - t_1)$	**[1]** **[1]**
2(a)	1. The **vector sum of** all external **forces** acting on a body must be **zero**. 2. The **vector sum of** all external **torques** acting on a body must be **zero**.	**[1]** **[1]**

2(b)(i)	Taking moments about contact point between feet and wall, Weight $\times$ a = $F_h \times H$ (70)(9.81)(0.20) = F_h(2.0) F_h = 68.67 N = **69 N**	**[1] sub** **[1] ans**
(ii)	Consider the vertical forces, Weight = F_v + 32 (70)(9.81) – 32 = F_v F_v = 654.7 N = **650 N**	**[1] sub** **[1] ans**
(iii)		**[1] correct general direction of *S*** **[1] passing through the point of inter-section between lines of action of *F* and *W***
3(a)(i)	Using Principle of Consevation of Linear Momentum 900 $\times$ 50 + 1500 $\times$ 20 = 900 $\times$ 25 + 1500 $\times$ v_B v_B = **35 m s^{-1}**	**[1] ans**
(ii)	 **[1]** Position and values of intial (A&B) and final (A only) momentum shown correctly. **[1]** Change of momentum takes place over same time interval. **[1]** Final momentum of B deduced correctly. (credit given if ans is given in (a)(ii))	**[1] correct shape** **i.e. graphs between *t* and (*t*+120) are curved correctly**
(b)	Apply $F = \frac{\Delta p}{\Delta t} = \frac{(22.5-45)\times 10^3}{120\times 10^{-3}}$ = **–1.9 $\times$ 10^5 N**	**[1] ans**
(c)	By undergoing deformation, **seat belts / air bags / crumple zones increase the time** for the body to be **brought to rest / change momentum**. According to Newton's second law of motion, as **change of momentum is the same**, increase in time will reduce the resultant force acting on the body.	**[2]**
MC	accept: same impulse, some energy converted to elastic PE of seat belt. Feature + longer time **[1]**; feature + same change in momentum **[1]**	

4(a)	**Simple harmonic motion** is defined as a periodic motion of a particle whose **acceleration is directly proportional to its displacement from the equilibrium position** and **this acceleration is always directed towards that position**.	**[1]** **[1]**
(b)(i)	x_o = 22/2 = **11 mm**	**[1]-ans**
(ii)	$\omega = 2\pi f = 2\pi(4.5)$ = **28.3 rad s^{-1}**	**[1]-ans**
(iii)	$a = \omega^2 x_o = (28.32)^2\ (0.011)$ = **8.8 m s^{-2}**	**[1]-ans**
(iv)	x = 11.0 – 8.0 = **3.0 mm**	**[1]-ans**
MC	accept no d.p., not accept 2.d.p.	
(v)	$v = \omega\sqrt{(x_o^2 - x^2)} = 28.3\sqrt{0.011^2 - 0.0030^2}$ = **0.30 m s^{-1}**	**[1]-sub** **[1]-ans**
5(a)(i)	Wavelength = 12 m $f = \frac{v}{\lambda} = \frac{1.25}{12}$ = 0.104 Hz	**[1] sub**
(ii)	Distance between the two buoys = (1.25)(2 × 60) = 150 m Phase difference = (150 / 12) × 2π = 25π rad which is equivalent to **π rad** OR Path difference = (1.25)(2 × 60) = 150 m = 12.5 λ Phase difference = π rad	**[1] distance** **[1] ans**
(b)(i)	Diffraction is the **spreading of waves through an aperture** or **around an obstacle.**	**[1]**
(ii)	From Fig. 5.3, separation of first order from central maximum for grating B = 0.70 m  $\tan\theta = \frac{0.70}{2.5} \Rightarrow \theta = 15.64°$ Using $\sin\theta = n\lambda p$ $\sin 15.64° = (1)(590 \times 10^{-9})p$ ∴ p = **4.57 x 10^5 m^{-1}** Note: can also use the 2nd and 3rd order separations: separation of 2nd order from central maximum = 1.6 m separation of 3rd order from central maximum = 3.5 m	**[1] working to find θ** **[1] sub** **[1] ans**
MC	Ecf within part	

5(b)(iii)	The **separation of the orders is observed to be smaller in the vertical spread**. This shows that the **angle of diffraction due to grating B is smaller**. Since $d \propto \frac{1}{\sin\theta}$ (from $d \sin\theta = n\lambda$), **slit spacing for diffraction grating B is larger** than that of diffraction grating A. OR The highest order that can be observed for any diffraction grating depends on the relationship $n \le \frac{d}{\lambda}$. Since there are **more orders observed in the vertical spread**, this implies that diffraction **grating B has a larger slit separation** than diffraction grating A,	**[1] reason** **[1] deductn**
(iv)	Any one of the following: - Approximately equal spacing of the diffraction fringes (or Equal spacing of fringes in the horizontal spread and the vertical spread) - More number of spots seen on the screen. (or Spacing between fringes decreases) - The intensity of higher order (2nd or 3rd order) fringes of the nylon mesh is approximately the same as that of the 1st order. - It would not be a sharp and distinct fringe pattern as the nylon does not have a sharp edge as that of a diffraction grating.	**[1]**
6(a)	It is the phenomenon whereby **electrons from a metal are emitted** when **electromagnetic radiation of sufficiently high frequency** is incident on the metal.	**[1]**
(b)(i)	From the graph, stopping potential is 0.70 V (not –0.70V). Hence, maximum kinetic energy of the photoelectrons = eV_s = $\mathbf{1.12 \times 10^{-19}}$ **J**	**[1]**
(ii)	$hf = \Phi + E_{k\,max}$ → $f = \frac{(2.06)(1.60\times10^{-19}) + 1.12\times10^{-19}}{6.63\times10^{-34}}$ $= \mathbf{6.66 \times 10^{14}}$ **Hz**	**[1] Sub** **[1] ans**
(iii)	For the photoelectrons, the saturated current $I = \frac{Q}{t} = \frac{Ne}{t}$ → No. of electrons emitted per second: $\frac{N}{t} = \frac{I}{e} = \frac{0.13\times10^{-6}}{1.60\times10^{-19}} = 8.13 \times 10^{11}\ s^{-1}$ Number of photons incident per second: $\frac{N_{photon}}{t} = (8.13 \times 10^{11})(8000) = 6.50 \times 10^{15}\ s^{-1}$ Intensity $= \frac{E}{tA} = \frac{N_{photon}(hf)}{tA} = \left(\frac{N_{photon}}{t}\right)\left(\frac{hf}{A}\right)$ $= (6.50 \times 10^{15})\frac{(6.63\times10^{-34})(6.66\times10^{14})}{1.0\times10^{-4}} = \mathbf{28.7\ W\ m^{-2}}$	**[1] No of electrons s^{-1}** **[1] No of photons s^{-1}** **[1] ans**
MC	Ecf within part	

6(b)(iv)	 **Fig. 1.1**	**[1]**
(v)	The negative p.d. creates a repulsion to the emitted photoelectrons causing less electrons to reach the collector. (effect) It denotes the fact that the electrons are emitted with a range of KE. (cause)	**[1]** **[1]**
7(a)(i)	A = 94, Z = 35	**[1]**
(ii)	Mass defect of U-235, $m = (143)(1.00866) + (92)(1.00728) - (235.044)$ $= 1.864\ u$ Binding energy of U-235 = $mc^2 = (1.864)(1.66 \times 10^{-27})(3.00 \times 10^{8})^2$ $= 2.785 \times 10^{-10}$ J = **1741 MeV** OR 1.864 (934) = 1741 MeV	**[1] sub for *m*** **[1] working** **[1] ans**
MC	Ecf within part	
(iii)	**Neutron(s) is/are produced**	**[1]**
(b)(i)	High energy **electron**	**[1]**
(ii)	$\lambda = \dfrac{\ln 2}{28(365)(24)(3600)} = 7.85 \times 10^{-10}\ \text{s}^{-1}$ $A = \lambda N = \lambda N_o e^{-\lambda t} = (7.85 \times 10^{-10})(2.36 \times 10^{13})\ e^{-\frac{\ln 2}{28}(100)}$ $= \mathbf{1.56 \times 10^{3}\ s^{-1}}$	**[1] sub for λ in s^{-1}** **[1] ans**
8(a)	The generator produces **alternating current**. The information provided in Fig. 8.3 indicates **frequency** of 50 Hz which is irrelevant for direct current.	**[1]**
(b)	Upthrust on Hywind structure, *W* = weight of the sea water displaced = 1025 × 5300 × 9.81 = **5.33 × 10^{7} N**	**[1] ans**
(c)(i)	The rotor blades exert a force on the wind to **change its momentum.** By Newton's 3rd law, there is an **equal and opposite force acting on the rotor blades.** The force on each blade causes a **moment** which results in a revolution of the rotor blade about the axis. OR There is force on blades by wind. The angled blades cause/provide a component of force in plane of rotation. The force on each blade causes a **moment** about the axis.	**[1]** **[1] N3L** **[1]**

8(c)(ii)	The **kinetic energy** of the **wind** is used to **do work in turning the coil** in the generator. The gear box coupled to the generator cause the coils in the generator to rotate and cut the magnetic flux inside the generator. The **cutting of the magnetic flux by the rotating coil** in the generator **produces electrical energy** through the effect of electromagnetic induction.	**[1]** **[1]**
(d)	Using points: (10.5, 1300000): $k = \frac{1300000}{10.5^3}$ = 1123 = 1120 (11.5, 1700000): $k = \frac{1700000}{11.5^3}$ = 1118 = 1120 (14.5, 3400000): $k = \frac{3400000}{14.5^3}$ = 1115 = 1120 ***k* is approximately 1120 for all the 2 points tested.** Hence we can conclude that *k* is a constant.	**[1] working** **Any 2** **[1] reason**
(e)(i)1.	When v = 11 m s^{-1}, P = 1500000 W lg (11/m s^{-1}) = **1.04** , lg (1500000/W) = = **6.18**	**[1] correct plot**
2.		**[1] best fit line drawn**
(ii)	Using points from the graph: (0.93,5.84), (1.13,6.44) Gradient = $\frac{6.44-5.84}{1.13-0.93}$ = **3.0**	**[1] sub** **[1] ans**

8(e)(iii)	Given $P = kv^3$ **lg *P* = 3 lg *v* + lg *k*** where gradient of the line is 3. Since the experiment data shows a **straight line graph with gradient equals 3.0**, the relationship $P = kv^3$ is **valid.**	**[1] exp** **[1] comment with reason**
MC	ecf for comment	
(f)(i)	Kinetic energy of air incident per second, $P = \frac{1}{2}\rho A v^3$ $= \frac{1}{2}(1.2)\pi\left(\frac{82.4}{2}\right)^2(11.0)^3$ $= 4.26 \times 10^6$ W = **4.26 MW**	**[1] sub** **[1] ans**
(ii)	Overall efficiency $= \frac{\text{Power output}}{\text{Power input}} = \frac{1500000}{4.26 \times 10^6}$ = **0.352**	**[1] ans**
(g)	Wind speed which is excessively high leading to over current produced which will damage the generator. Rotor blades struck by lightning since they are the tallest point of the wind turbine and they have relatively pointed ends. Corrosion of the structure due to the salty environment. Power loss due to long distance transmission. Difficulty in maintenance as it is out in the open sea.	**[2] any 2**

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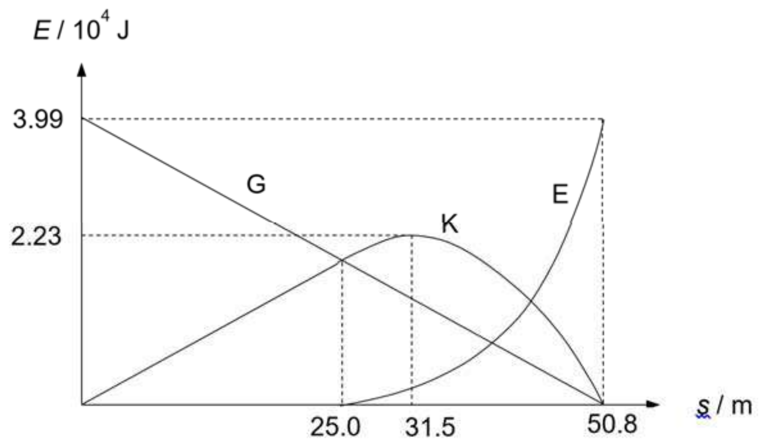
Suggested Solutions with Markers' Comments

Qn	Suggested solution	Remarks
1(a)(i)	$\frac{\Delta g}{g} = \frac{0.1}{98.0} + \frac{2(0.2)}{19.8} = 0.0212$ $\Delta g = 0.0212 \times 9.869 = 0.2$ (1 s.f.) $g = (9.9 \pm 0.2)$ m s^{-2}	**[1] sub** **[1]** Δg to 1 s.f. **[1] ans**
(a)(ii)	$g = (9.9 \pm 0.2)$ m s^{-2} is more accurate but less precise. $g = (11.15 \pm 0.02)$ m s^{-2} is less accurate but more precise.	**[1]**
(b)	An estimated area of a mobile phone screen is about 6 cm by 11 cm. (Accept 5 to 12 cm by 10 to 19 cm. ±1 cm at both ends) Volume of tempered glass screen protector, $V = 0.06 \times 0.11 \times 0.0005 = 3.30 \times 10^{-6}$ m^3 (smallest = 2.5×10^{-6} m^3, largest = 1.14×10^{-5} m^3) The diameter of 1 atom is approximately 0.1 nm. Therefore, the estimated volume of a spherical atom, $V_{atom} = \frac{4}{3}\pi(\frac{d}{2})^3$ $V_{atom} = \frac{4}{3}\pi(\frac{0.1\times10^{-9}}{2})^3 = 5.23\times10^{-31}\text{ m}^3$ Therefore, the total number of atoms in the screen protector, $n = \frac{V}{V_{atom}} = \frac{3.30\times10^{-6}}{5.23\times10^{-31}} = 6.31\times10^{24}$ (smallest = 5.97×10^{23}, largest = 2.18×10^{25})	**[1] Vol of screen protector** **[1] Vol of an atom, accept d^3** **[1] sub** **[1] No. of atoms**
2(a)(i)	Man is moving at maximum speed when resultant force acting on him is zero, hence $mg = kx$ where x is the extension of the rope at that point. $x = \frac{mg}{k} = \frac{(80.0)(9.81)}{120}$ = 6.54 m	**[1] sub**
(a)(ii)	Applying Principle of Conservation of Energy to when the man is at maximum speed, Loss of GPE = Gain in KE + Gain in Elastic PE $mg(l+x) = \frac{1}{2}mv_{max}^2 + \frac{1}{2}kx^2$ $(80.0)(9.81)(25.0+6.54) = \frac{1}{2}(80.0)v_{max}^2 + \frac{1}{2}(120)(6.54)^2$ $v_{max} = 23.6$ m s^{-1}	**[1] sub** **[1] ans**
(a)(iii)	Maximum KE = $\frac{1}{2}(80.0)v_{max}^2 = \frac{1}{2}(80.0)(23.6)^2 = 2.23 \times 10^4$ J	**[1]**

Qn	Suggested solution	Remarks
(b)(i)	Applying Principle of Conservation of Energy at the lowest point, Loss of GPE = Gain in Elastic PE $mg(l+x_{max})=\frac{1}{2}kx_{max}^2$ $(80.0)(9.81)(25.0+x_{max})=\frac{1}{2}(120)x_{max}^2$ x_{max} = 25.8 m	**[1] sub** **[1] ans**
(b)(ii)	GPE = $mg(l+x_{max})$ = (80.0)((9.81)(25.0 + 25.8) = 3.99 x 10^4 J	**[1]**
MC		
(c) **(i)** **(ii)** **(iii)**		**[1] G with values** **[1] E with values** **[1] K with values**
3(a)(i)	$mg=kx$ $(0.5)(9.81)=k(0.148-0.13)$ $k=$ 272.5 ≈ 273 N m^{-1}	**[1] ans**
(ii)	Above C, the weight of mass provides the centripetal force. $mg=mr\omega^2$ $9.81=0.13\omega^2$ $\omega=\sqrt{\frac{9.81}{0.13}}=8.687\approx 8.7$ rad s^{-1}	**[1] state** **[1] sub**
(iii)	$T-mg=mr\omega^2$ $(272.5)(x)-(0.50)9.81=(0.50)(0.13+x)(8.7)^2$ $234.655x=9.82485$ $x=$ 0.0418 m $L=0.13+0.0418=0.172$ m	**[1] sub** **[1] ans**
(b)(i)1.	$F_c=mr\omega^2$ $=(5)(6.4\times10^6)\left(\frac{2\pi}{(24)(3600)}\right)^2$ $=0.169$ N	**[1] sub** **[1] ans**

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Qn	Suggested solution	Remarks
2.	$N = W - F_c$ $N = (5)(9.81) - 0.169$ $= 48.9$ N	**[1] sub** **[1] ans**
(ii)	At the **poles,** the mass is **not moving in a circle**. Hence **normal contact force equals gravitational force**. ($N = F_G$) *[At the equator, some of the gravitational force is used to provide the centripetal force to move the mass in a circle. ($N = F_G - F_c$)]*	**[1]** **[1]**
4(a)	On the surface of the Earth, $\phi = -6.2\times10^{7}$ J kg^{-1} $\phi = -\frac{(6.67\times10^{-11})M}{6.4\times10^{6}} = -6.2\times10^{7}$ $M = 5.95\times10^{24}$ kg	**[1] Φ** **[1] ans**
(b)(i)	At distance R above the Earth's surface, $x = 2R$ $\phi = -3.2\times10^{7}$ J kg^{-1} By conservation of energy, U loss $= KE$ gain $m\left[0-(-3.2\times10^{7})\right] = \frac{1}{2}mv^2$ $v = 8000$ m s^{-1}	**[1] Φ** **[1] sub** **[1] ans**
(ii)	speed / velocity / acceleration would be greater. Deviates / bends from straight path	**[1]** **[1]**
5(a)	Electric field strength at a point is defined as the **electric force per unit positive charge** exerted on a **small charge** placed at that point.	**[1]**
(b) (i)	Time = $\frac{80 \times 10^{-3}}{2.50 \times 10^{7}} = 3.2 \times 10^{-9}$ s	**[1] ans**
(ii)	$\tan 30° = \frac{V_y}{2.50 \times 10^{7}}$ $V_y = \tan 30° \times 2.5 \times 10^{7}$ $= 1.44 \times 10^{7}$ ms^{-1}	**[1] sub** **[1] ans**
(iii)	Acceleration = $\frac{V_y}{t} = \frac{(1.44\times10^{7})}{3.2\times10^{-9}} = 4.5 \times 10^{15}$ ms^{-2}	**[1] ans**
(iv)	$a = \frac{eE}{m} = \frac{e(V/d)}{m}$ $V = \frac{adm}{e} = \frac{(4.41\times10^{15})(40\times10^{-3})(9.11\times10^{-31})}{1.6\times10^{-19}} = 1.02 \times 10^{3}$ V	**[1] sub** **[1] ans**

Qn	Suggested solution	Remarks
(v)	With the plate separation reduced, the electric force experienced by the charge is greater and hence the **acceleration due to the force would increase**. Therefore the vertical component of the velocity calculated **would be greater**.	
6(a)	1.6 J of energy per coulomb means the cell's emf is 1.6 V. This means that the p.d. across the internal resistor is **1.6 – 1.2 = 0.4 V.** Hence the resistance across the internal resistor is **0.4 / 0.5** = 0.8 Ω (shown)	**[1] working** **[1] working**
(b)	p.d across the bulb Y = $E - Ir$ = 1.6 – (0.3)(0.8) = 1.36 V	**[1] sub** **[1] ans**
(c)	When connected to bulb Y, Total input power = EI = 1.6 x 0.3 = 0.48 W Output power = VI = 1.36 x 0.3 = 0.408W Power lost = 0.072 W Or Power dissipated in internal resistance = I^2r= $(0.3^2)(0.8)$ = 0.072 W	**[1] working** **[1] ans**
(d)	Maximum power drawn occurs when $R_Z = r$ (maximum power theorem) Using $E = I\ (R+r)$ 1.6 = I (0.8+0.8) I = 1 A	**[1] working** **[1] ans**
7(a)	$R = \frac{\rho L}{A}$ $= \frac{1.68\times10^{-8}\times15.0}{\pi(0.07^2-0.04^2)/4}$ = 2.52×10^{-7} Ω m^2 ÷ 2.59×10^{-3} m^2 = 9.73×10^{-5} Ω	**[1] exp for area** **[1] sub** **[1] ans**
(b)(i)	$R = \left\{\left[\left(\frac{1}{30}+\frac{1}{12}\right)^{-1}+4.5\right]^{-1}+\frac{1}{18}\right\}^{-1}$ = 7.6 Ω	**[1] working**
(ii)	Current in 18 Ω, = Emf ÷ 18 Ω = 6.0 ÷ 18 = 0.33 A	**[1] ans**

Qn	Suggested solution	Remarks
(iii)	Total current = Emf ÷ Total resistance, R = 6 V ÷ 7.6 Ω = 0.79 A Current through 4.5 Ω = 0.79 A– 0.33 A = 0.46 A Power dissipated in 4.5 Ω = $I^2 R$ {or V^2/R} = $0.46^2 \times 4.5$ = 0.95 W	**[1], total current** **[1], current through** 4.5 Ω **[1], ans**
8(a)(i)	1. Any gas is made up of very **large number** of molecules. 2. The gas molecules are in **continuous random motion.** 3. The **volume** of the **gas molecules** is **negligible** compared to the volume of the container. 4. There are **no intermolecular forces** between molecules except during collisions between molecules. 5. The collision between gas molecules and between gas molecules and the wall of the container is **elastic.** 6. The **duration of collisions** is **negligible** compared with the time interval between collisions.	**[1]** **[1]** **Any 2**
(ii)1.	$E = \frac{3}{2}kT = \frac{3}{2}(1.38\times10^{-23})(290)$ $= 6.00\times10^{-21}$ J	[1] sub [1] ans
2.	**It is possible** because **their molecular masses are different**	**[1]**
(b)(i)	**Internal energy** of a system is the **sum** of a **random distribution of kinetic and potential energies** associated with the **molecules** of the system.	
(ii)	Water freezing at constant temperature: (blank) A stone falling under gravity in a vacuum: (blank) Water evaporating at constant temperature: √ Stretching a wire at constant temperature.: √	**[-1] for each error**
(iii)	The **random kinetic energy of the gas molecules increases** as the temperature increases. **The potential energy of the molecules remains unchanged** since the volume is constant. → **Internal energy increases**	**[1]** **[1]**
(iv)1.	W = 1.03 x 10^5(1.87 x 10^{-5} – 2.96 x 10^{-2}) = – 3050 J	**[1] sub** **[1] ans**
2.	$U = Q + W$ $= 4.05\times10^4 - 3050$ $= 3.75\times10^4$ J	[1] sub [1] ans

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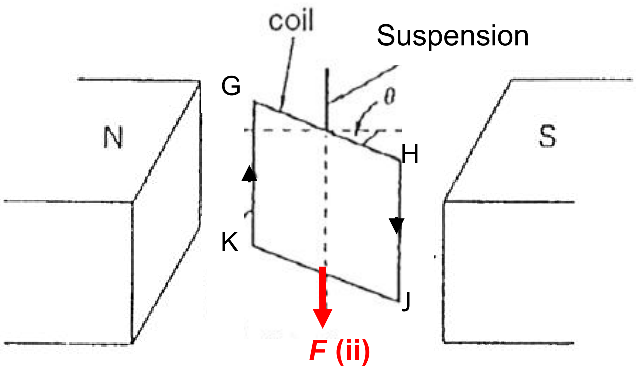
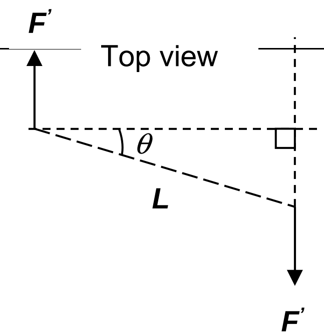
Qn	Suggested solution	Remarks
(c)(i)	• Two bodies of different masses at same temperature → same material would have different amount of internal energy • When a substance undergoes a change of state → the temperature remains unchanged although thermal energy is supplied. Temperature shows the direction of heat transfer → always from high to low temperature	[1] [1] Any 2
(ii)1.	To make allowance for heat gain from the atmosphere	[1]
2.	**Constant mass of water collected per minute in the beaker**	[1]
3.	mass melted by heater in 5 minutes = 64.7 – 8.3 = 56.4 g 56.4×10^{-3} (L) = 18 L = **319 kJ kg** $^{-1}$	 [1] sub [1] ans
MC	Use of m = 64.7, giving L = 278 kJ kg^{-1} no marks; Use of m = 48.1, giving L = 374 kJ kg^{-1} 1 mark	
9(a)	**Magnetic flux density** is defined as the **magnetic force per unit length per unit current** acting on **a straight conductor** placed **perpendicular** to the magnetic field.	[2]
(b)(i)		[1] – ans
(ii)	$F = NBIL \sin\theta = (500)(2.0 \times 10^{-4})(0.40)(5.0 \times 10^{-2}) \sin 35°$ = **1.15×10^{-3} N**	[1] - sub [1] - ans
(iii)	Torque = $NBIA \cos\theta$ $= (500)(2.0 \times 10^{-4})(0.40)(5.0 \times 10^{-2})^2 \cos 35°$ = **8.19×10^{-5} N m** OR Torque = $F'd$ = ($NBIL$) ($L \cos\theta$) 	[1] – eqn [1] - sub [1] – ans
(c)	**Faraday's law** states that the **magnitude** of the **induced e.m.f.** in a coil is **proportional** to the **rate of change of magnetic flux linkage through that coil**. **Lenz's law** states that the **polarity** of the **induced e.m.f. is such that it tends to produce a current with effects that oppose the change** causing it.	[1] [1]

Qn	Suggested solution	Remarks
(d)(i)	$\Phi = NBA \sin\theta = (500)(2.0 \times 10^{-4})(5.0 \times 10^{-2})^2 \sin 35°$ $= \mathbf{1.43 \times 10^{-4}\ Wb}$	**[1] - sub** **[1] - ans**
(ii)1.	$\varepsilon_{max} = \omega NBA = 2\pi f\, NBA$ $= 2\pi(100)(500)(2.0 \times 10^{-4})(5.0 \times 10^{-2})^2$ $= \mathbf{0.157\ V}$ OR $\Phi = \Phi_o \sin \omega t \rightarrow \varepsilon = \frac{d\Phi}{dt} = \omega\Phi_o \cos \omega t$ $\rightarrow \varepsilon_{max} = \omega\Phi_o = \omega NBA$	**[1] – exp** **[1] - sub** **[1] - ans**
2.	$V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{0.157}{\sqrt{2}} = 0.111\ V$ $<P> = \frac{V_{rms}^2}{R} = \frac{0.111^2}{5.0}$ $= \mathbf{2.46 \times 10^{-3}\ W}$ OR $P_o = \frac{V_o^2}{R} = \frac{0.157^2}{5.0} = 4.93 \times 10^{-3}\ W$ $<P> = \frac{1}{2}P_o = \frac{1}{2}(4.93 \times 10^{-3}) = 2.46 \times 10^{-3}\ W$	**[1] - V_{rms} value** **[1] – sub** **[1] - ans**
3.	With diode, $<P> = \frac{1}{2}(2.46 \times 10^{-3}) = \mathbf{1.23 \times 10^{-3}\ W}$ OR $V_{rms} = \frac{V_o}{2} = \frac{0.157}{2} = 0.0785\ V$ $<P> = \frac{V_{rms}^2}{R} = \frac{0.0785^2}{5.0}$ $= \mathbf{1.23 \times 10^{-3}\ W}$	**[1] – working** **[1] – ans**

Mark Scheme for Practical Paper 9749/04

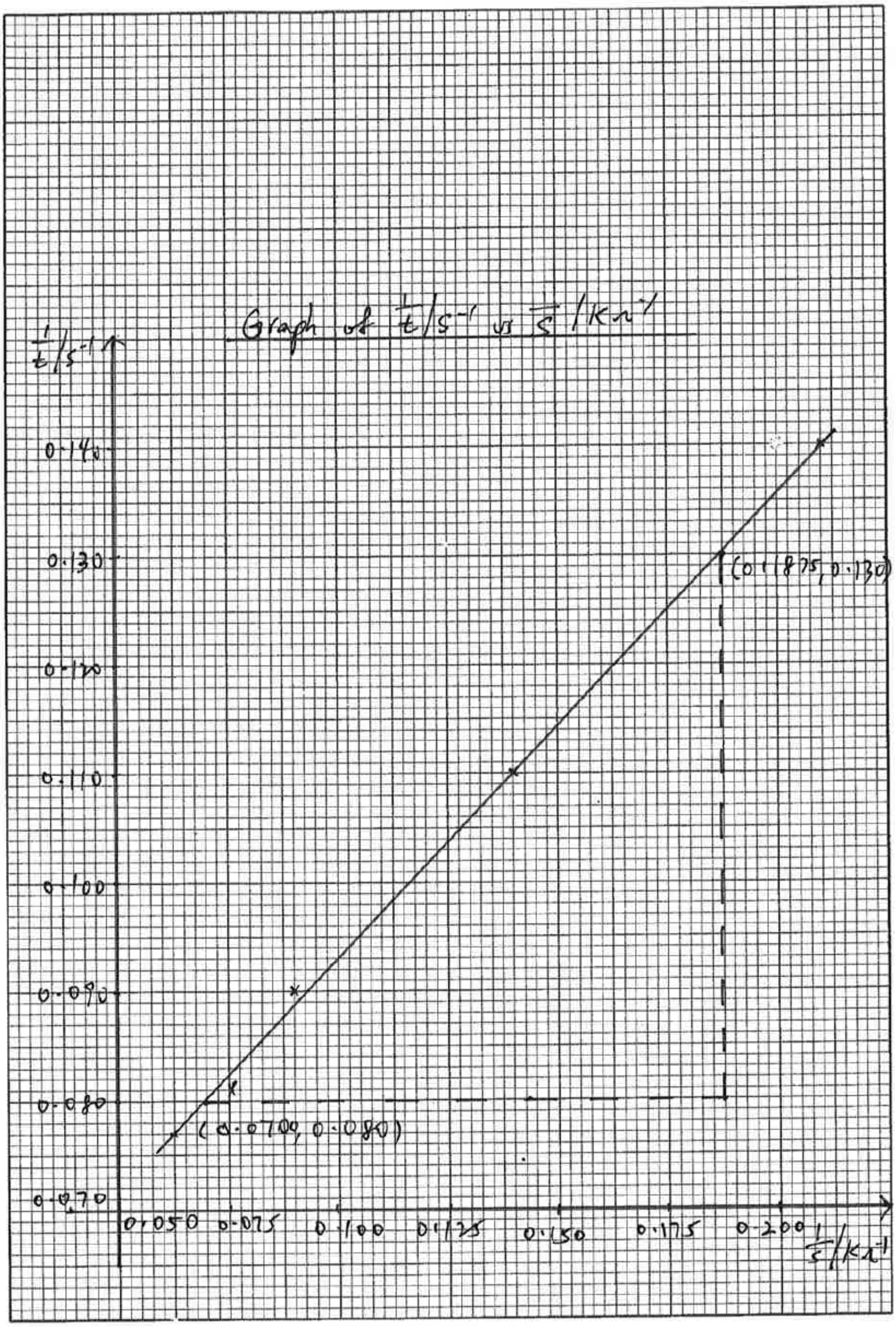
1(b)(ii)	t_1 = 12.9 s t_2 = 13.0 s $t = \frac{12.9+13.0}{2}$ = 13.0 s
	[1] Answer with unit. Repeated reading required. Accuracy – 11 s ≤ *t* ≤ 19 s
MC	A number of candidates did not do repeated readings to get the average value. Answer without unit was also another common mistakes. Some candidates recorded very fast timing e.g less than 3.0 s which was impossible for this resistance.
(c)	Percentage uncertainty $= \frac{\Delta t}{t} \times 100\% = \frac{0.2}{13.0} \times 100\% = 1.5\%$
	[1] percentage error correctly calculated. Δ*t* ≥ 0.2 s. Accept Δ*t* = 0.2 s to 0.4 s. Accept one or two sig. fig ONLY.
MC	Many candidates **still** presented their answer in 3 significant figure.
(d)	(table below)

S / kΩ	t_1 /s	t_2 /s	t/s	$\frac{1}{t}$ / s^{-1}	$\frac{1}{S}$ / kΩ^{-1}
16.0	12.9	13.0	13.0	0.0769	0.0625
13.3	12.3	12.2	12.3	0.0813	0.0752
11.0	11.1	11.0	11.1	0.0901	0.0909
7.0	8.8	8.9	8.9	0.11	0.14
4.8	7.1	6.9	7.0	0.14	0.21

Accept 3 sig, fig for 1/*t* and 1/*S* (last two rows)

	[1] Five sets of measurement and trend of data
	[1] Correct d.p for the raw data and repeated measurement of time t_1 and t_2 and repeated measurement.
	[1] Each column heading should contain a quantity and a unit where appropriate. There must be some distinguishing mark between the quantity and the unit.
	[1] Calculated values given to an appropriate number of sig. fig.
	[1] Correct calculated values of 1/*t* and 1/*S*. Allow one slip in computation.
MC	Most of the candidates performed commendably for this part. Some of the mistakes included heading without unit, no repeated measurement for timing and wrong presentation for the precision of the raw data.
(e)	Given that $\frac{1}{t} = \frac{a}{S} + b$ Graph of $\frac{1}{t}$/s^{-1} vs $\frac{1}{S}$ / kΩ^{-1} is plotted. Compare with straight line equation $y = mx + c$, the gradient = a, the y-intercept = b

	gradient of graph = $\dfrac{(0.130-0.080)}{(0.1875-0.0700)}$ = 0.426 Hence *a* **=** 0.426 kΩ s^{-1} Substitute $(0.0700,\ 0.080)$ and gradient $=0.426$ into $\dfrac{1}{t}=\dfrac{a}{S}+b$, 0.080 = (0.426)(0.0700) + *b* *b* = 0.0502 Hence *b* = 0.0502 s^{-1}
	[1] value of *a* with correct unit.
	[1] value of *b* with correct unit.
	[1] correct substitution of the coordinates chosen to calculate the gradient.
MC	Candidates had no problem linearizing the equation. They were able to determine the gradient and y-intercept correctly. However many candidates were penalized for the answer because **unit was excluded** in answer. A small percentage of candidates determined the y-intercept wrongly by reading directly from the graph which did not start from zero along the horizontal axis. Another **common mistake** made by candidates was to **choose a point that was not on the best fit line** to determine the y-intercept. Candidates were reminded to **use one of the points used to calculate the gradient** in determining the y-intercept.
	Graph plotting
	[1] Sensible scale must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* direction. **Axes must be labelled with the quantity with correct unit which is being plotted.** **The hypotenuse of the Δ must be larger than half the length of the drawn line.**
	[1] All observations must be plotted accurately.
	[1] Straight line of best fit. There must be a fair scatter of points either side of the line.
MC	Some candidates did not include the unit both the axes. Most candidates were able to plot the points accurately. Few candidates used inconvenient scales that made them more prone to plot the points wrongly. The best fit line was generally well drawn.
(f)	$\dfrac{1}{6.5}=\dfrac{0.426}{S}+0.0502$, *S* = 4.11 kΩ
	[1] Answer
MC	This part was well answered and e.c.f was practised.
(g)	Voltmeter reading decreases rapidly and it is difficult to determine the time for the voltmeter to decrease from 5.0 V to 2.0 V**.**
	[1] Source of error
MC	Some candidates suggested human reaction time which was not acceptable. Other wrong suggestions included resistance of wire, connection of the wire not reliable and simply stated that it was difficult to time without explaining why.


Graph of 1/t /s⁻¹ vs 1/S /kΩ⁻¹
1/t /s⁻¹
0.140
0.130
0.120
0.110
0.100
0.090
0.080
0.070
(0.1875, 0.130)
(0.0700, 0.080)
0.050
0.075
0.100
0.125
0.150
0.175
0.200
1/S /kΩ⁻¹

[3]

2(a)(ii)	y_0 = 11.6 cm
	[1] Answer with unit.
MC	Some candidates did not include unit in the answer.
(iv)	y = 17.6 cm
MC	Some candidates did not include unit in the answer.
(vi)	$(y - y_0)$ = 17.6 – 11.6 = 6.0 cm
	[1] Answer with unit.
MC	No problem in the calculation.
(vii)	Percentage uncertainty $= \dfrac{\Delta(y-y_0)}{(y-y_0)} \times 100\% = \dfrac{0.2}{6.0} \times 100\% = 3.3\%$
	[1] Percentage error correctly calculated. $\Delta(y-y_0)$ = 0.2 cm. **Accept one or two sig. fig ONLY.**
MC	Many candidates **still** presented their answer in 3 significant figure.
(b)(i)	y_0 = 11.6 cm
MC	Some candidates did not include unit in the answer.
(iii)	y = 13.1 cm
	$(y-y_0)$ = 13.7 – 11.6 = 2.1 cm
	[1] Answer with unit.
MC	Some candidates did not include unit in the answer.
(c)(i)	Sum of deflections for each mass placed on its own = 6.0 + 2.1 = 8.1 cm. {can be in **(ii)**} Reading when both masses are placed at the same time = 19.6 cm => deflection = 19.6 – 11.6 = 8.0 cm
	[1] Value of the deflection when both masses are placed at the same time.
MC	This part was well answered.
(ii)	Percentage uncertainty $= \dfrac{8.1-8.0}{8.0} \times 100\% = 1.3\%$ The percentage uncertainty is 1.3 % which is less than 3.3% obtained in **(a)(vii)**. Thus the results of the experiment support this suggestion.
	[1] Conclusion with reason.
MC	Some candidates just stated the difference between the two values was small and hence the results of the experiment supported the suggestion **without comparing** the answer in **(a)(vii).**
(d)(i)	Difficulty in judging the position of the bend ruler since there is a gap between rule A and rule B.
	[1] Source of error.
MC	Candidates simply stated parallax error without any elaboration.

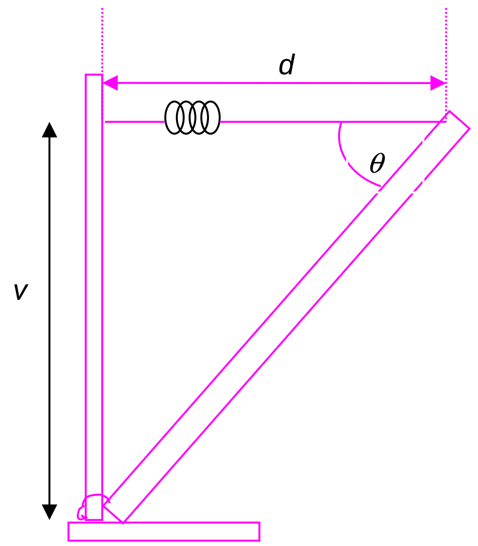
(ii)	Attach optical pin horizontally to end of rule A when taking the readings *y* and y_0.
	[1] Improvement
MC	Most candidates either leave it blank or answer this part wrongly. Common answers such as using spirit level to check that the ruler was horizontal, ruler was not parallel to the table initially were unacceptable

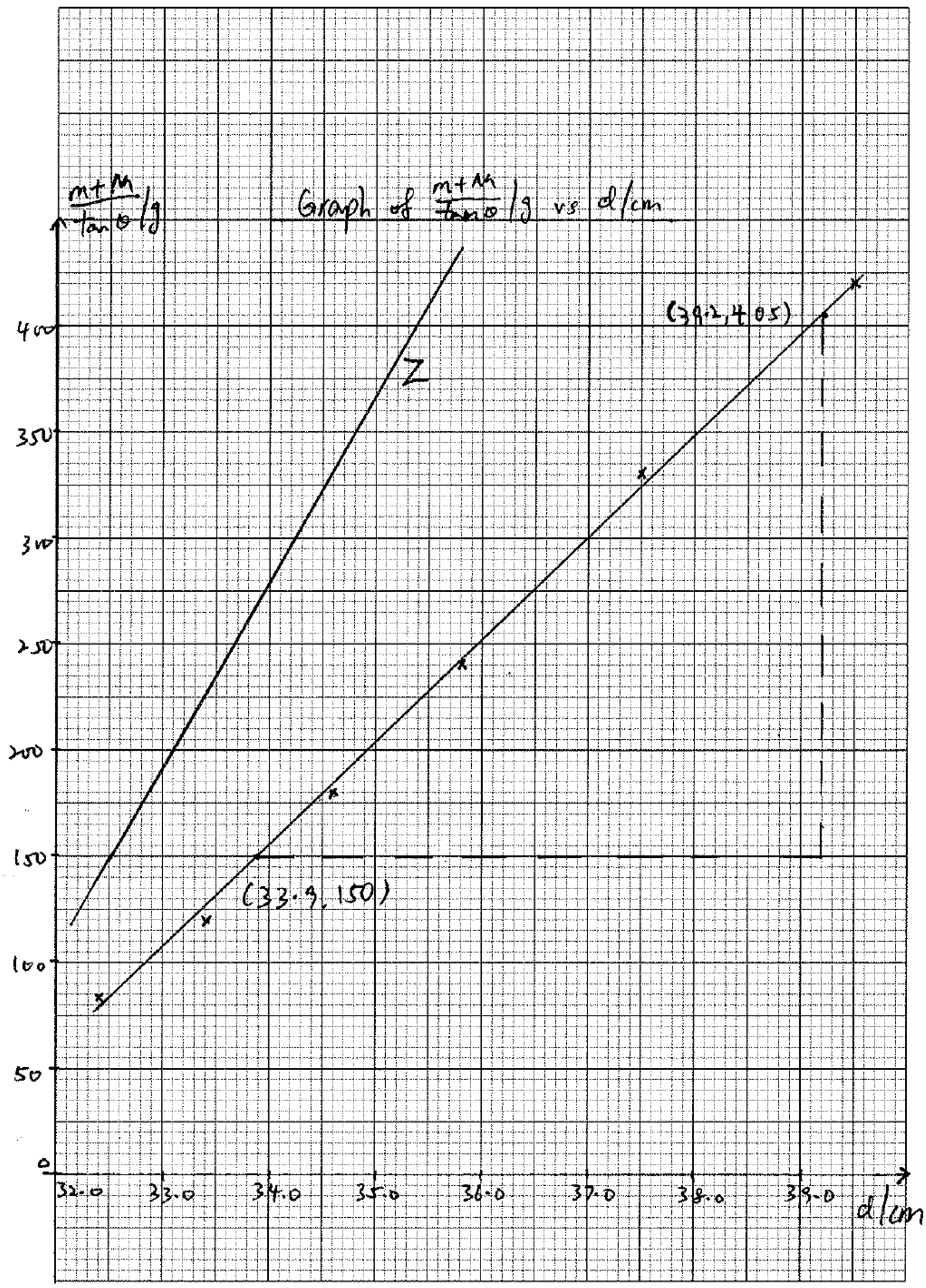
3(b)(i)	$\theta = 39^0$
	[1] θ measured to the correct precision with unit. No d.p.
MC	Many candidates included a decimal place in the answer. A small percentage of candidates did not include unit for the angle neasured.
(ii)	Percentage uncertainty $= \frac{\Delta\theta}{\theta} \times 100\% = \frac{2}{39} \times 100\% = 5.1\%$
	[1] percentage error correctly calculated. $\Delta\theta = 2^0$. Accept $\Delta\theta = 3^0$ **Accept one or two sig. fig ONLY.**
MC	Many candidates **still** presented their answer in 3 significant figure.
(iii)	m = 300 g
MC	No problem with this part.
(iv)	d = 39.5 cm
	[1] *d* measured to the correct precision with unit.
MC	Some candidates might have read the measurements wrongly and gave answer around 15.0 cm. The distance is around 40.0 cm. Accept $d \geq 35.0$ cm. Some candidates might have added the wrong weights when taking measurement for this part of the question.
(c)	M = 43 g
MC	No problem for this part.
(d)	(see table below)
	[1] –Take six sets of measurement and correct trend of data
	[1] – Correct d.p for the raw data.
	[1] – Each column heading should contain a quantity and a unit where appropriate. There must be some distinguishing mark between the quantity and the unit.
	[1] – Calculated values given to an appropriate number of sig. fig.
	[1] – Correct calculated values of $\frac{m+M}{\tan\theta}$. Allow one slip in computation.
MC	The most common mistake is the missing unit for $\frac{m+M}{\tan\theta}$. Not much problem in calculation and expressing the calculated values in appropriate significant figure.
(e)	Given that $\frac{m+M}{\tan\theta} = Pd - Q$

Table for (d):

mass, m/g	θ /^{0}	d/cm	$\frac{m+M}{\tan\theta}$ /g
300	39	39.5	420
250	42	37.5	330
200	45	35.8	240
150	47	34.6	180
100	50	33.4	120
50	48	32.4	84

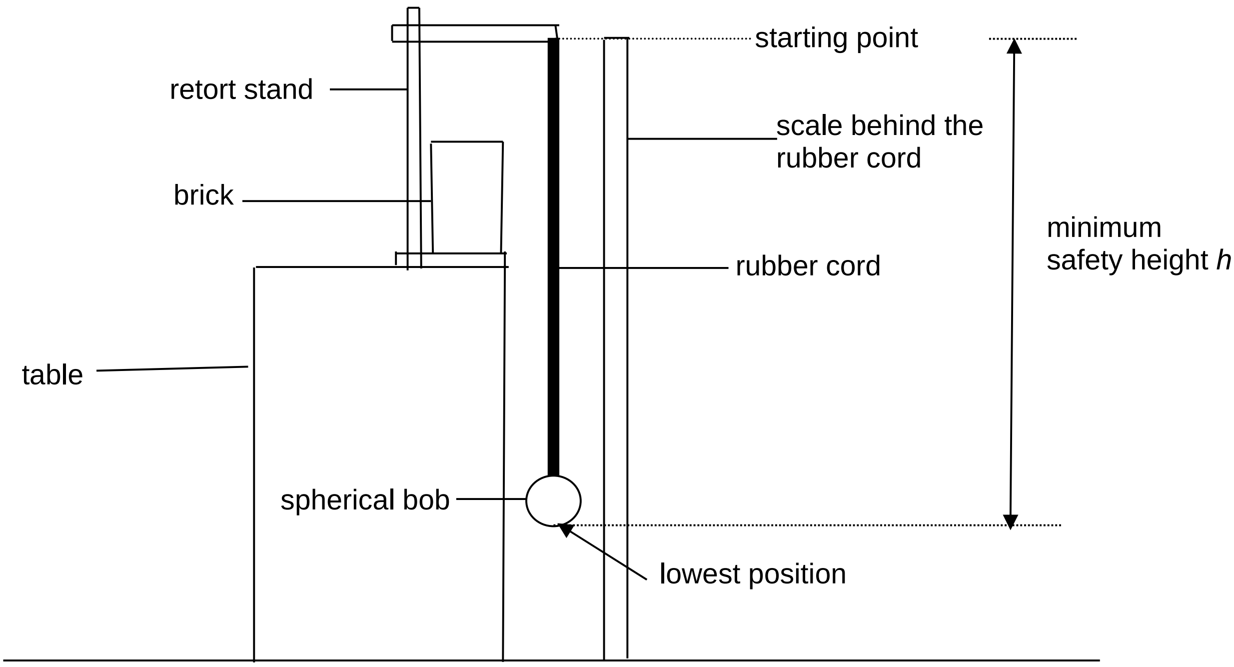
	Graph of $\dfrac{m+M}{\tan\theta}$ vs d is plotted. Compare with straight line equation $y = mx + c$, the gradient = P, the y-intercept = - Q gradient of graph = $\dfrac{(405-150)}{(39.2-33.9)}$ = 48.1 Hence P = 48.1 g cm^{-1} Substitute $(39.2,\ 405)$ and gradient $= 48.1$ into $\dfrac{m+M}{\tan\theta} = Pd - Q$, 405 = (48.1)(39.2) - Q Q = 1480 Hence Q = 1480 g
(e)	**[1] Linearization of equation.**
	[1] Correct substitution of the coordinates chosen to calculate the gradient.
	[1] Value of *P* with correct unit.
	[1] Value of *Q* with correct unit.
MC	Candidates had no problem linearizing the equation. They were able to determine the gradient and y-intercept correctly. However many candidates were penalized for the answer because **unit was excluded** in answer. A small percentage of candidates determined the y-intercept wrongly by reading directly from the graph which did not start from zero along the horizontal axis. Another **common mistake** made by candidates was to **choose a point that was not on the best fit line** to determine the y-intercept. Candidates were reminded to **use one of the points used to calculate the gradient** in determining the y-intercept.
	<u>Graph plotting</u>
	[1] Axes must be labelled with the quantity with correct unit which is being plotted. **The hypotenuse of the Δ must be larger than half the length of the drawn line.**
	[1] Sensible scale must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* direction.
	[1] All observations must be plotted accurately.
	[1] Straight line of best fit. There must be a fair scatter of points either side of the line.
MC	Some candidates did not include the unit both the axes. Most candidates were able to plot the points accurately. Few candidates used inconvenient scales that made them more prone to plot the points wrongly. The best fit line was generally well drawn.
(f)	There are no anomalous data points. All the data points are evenly distributed and reasonably close to the best-fit straight line.

	[1] Comment on anomaly.
MC	Most candidates were able to comment on the anomaly correctly.
(g)(i)	• Difficulty in measuring the angle θ due to the movement of the hands (difficult to stabilise the hands). • Difficulty in measuring the angle θ. There may be movement/oscillation of the spring and masses during measurements of the angle θ with the protractor.
	[1] Source of error.
MC	A number of candidates were able to discuss about the difficulty in measuring the angle. Other reasonable answer such as difficulty in measuring *d* and the string tied to the spring was not horizontal was accepted.
(ii)	• Measure the distance *y* and *d* and determine the θ using $\tan\theta = \frac{y}{d}$  **OR** Measure the distance *d* and determine the θ using $\cos\theta = \frac{d}{49.0}$. The distance from the pivot to the loop at 49 cm mark is 49.0 cm. • Clamp the protractor and minimise contact between protractor and set-up during measurements of the angle.
	[1] Improvement.
MC	Most candidates were able to give a reasonable improvement. Some candidates suggested using spirit level to check that the string was horizontal which was unacceptable. A better response would be to use the ruler to measure the height of the string above the table at both end.
(h)	Z is any steeper line (greater gradient) above the original graph.
	[1] Correct graph.
MC	A number of candidates had problem sketch the graph Z. They did not realise that the gradient should increase since constant *P* is proportional to spring constant.


Graph of (m+M)/tanθ /g vs d/cm
(m+M)/tanθ /g
d/cm
Z
(39.2, 405)
(33.9, 150)
0
50
100
150
200
250
300
350
400
32.0
33.0
34.0
35.0
36.0
37.0
38.0
39.0

4

Diagram



<u>Objective</u>

To investigate how the minimum safety height *h* depends on the mass *m* of the object and the length *l* of the rubber cord.

<u>Experiment 1</u>:

To investigate how the minimum safety height *h* depends on the mass *m* of the object

1. **Independent variable** : mass of the sphere, *m*
2. **Dependent variable** : minimum safety height, *h*
3. **Controlled variables** : **(a)** unstretched length of the rubber cord remains constant
   (b) release the sphere at rest from the starting point.

<u>Experiment 2</u>:

To investigate how the minimum safety height *h* depends on the length *l* of the rubber cord.

1. **Independent variable** : length of the rubber cord *l*.
2. **Dependent variable** : minimum safety height, *h*.
3. **Controlled variables** : **(a)** mass of the sphere remains constant.
   : **(b)** release the sphere at rest from the starting point.

Procedure

1. Set up the apparatus as shown in the diagram above.

2. The retort stand is placed at the edge of the table.

3. One end of the rubber cord is tied securely to the rod of clamp.

4. Measure the initial length of the rubber cord *l* using a measuring tape.

5. Weigh the mass of the spherical bob *m* by using the electronic balance.

6. Suspend the spherical bob from the starting point and release. Note the position of the lowest point reached and record the minimum safety height *h* by using the scale behind the rubber cord.

7. Repeat step **(6)** at least 2 times to get an average value of the minimum safety height *h*.

8. Use the same rubber cord so that the length of the rubber cord *l* is kept constant.

9. Repeat step **(5)** and **(6)** using another spherical bob of different mass until 6 sets of reading are obtained.

10. Repeat **(6)** and **(7)** using different length of the cord until 6 sets of reading are obtained, keeping the mass of the spherical bob constant.

Analysis

1 **For Experiment 1:**

Assume that the minimum safety height *h* is related to mass *m* by the equation

$$h = km^{n}.$$

where *k* and n are constants.

$\Rightarrow \lg h = n \lg m + \lg k$

Plot a graph of lg *h* vs lg *m*.

If the above relationship is true, a straight line graph will be obtained where the gradient is equal to n and the *y*-intercept is equal to lg *k*.

2 **For Experiment 2:**

Assume that the minimum safety height *h* is related to mass *l* by the equation

$$h = cl^{p}.$$

where *c* and p are constants.

$\Rightarrow \lg h = p \lg l + \lg c$

Plot a graph of lg *h* vs lg *l*.

If the above relationship is true, a straight line graph will be obtained where the gradient is equal to p and the *y*-intercept is equal to lg *c*.

Safety considerations

1. Place the brick on the base of the retort stand to stabilize it and prevents the retort stand from toppling.

2. Place the retort stand at a higher level e.g. on a table so that the spherical bob will not hit the ground (this may cause hazard to others) after the rubber cord has fully extended.

Additional details

1. Release the spherical bob with no downward velocity. Do not exert any force vertically or horizontally on the sphere upon release of the sphere.

2. The retort stand is placed at the edge of the table because the extension of the rubber cord can be longer than the height of the retort stand.

3. Measure the unstretched length of the rubber cord before releasing the spherical bob of different mass to ensure that the same length of the rubber cord is used for all spherical bobs.

4. In real situation, for safety consideration, there is a need for a minimum safety distance between the lowest point of the extension and the ground. Since the bungee cord is tied to the ankle of the person, the height of the person must be taken into consideration.

   ⇒ Safety height

   = Distance between starting point and lowest point +
   distance between the lowest point of the extension and the ground + height of the person

Suggested mark scheme to Planning Question

Diagram		**[2]**
Good choice of apparatus and a clearly labeled diagram. - good choice of apparatus and arrangement. - clear information on starting point / lowest position / minimum safety height.	**D1** **D2**	
Procedure		**[3]**
- The procedure is outlined in a clear and logical manner such that it can be followed by another person carrying out the experiment.	**P1** **P2**	
Mention of apparatus used for different measurement - **measuring tape** to measure **length of rubber cord**, - **electronic balance** to measure the **mass of spherical bob**. - **measuring scale** to determine the **minimum safety height.**	**Any one P3**	
Control of variables		**[2]**
- unstretched length of the rubber cord remains constant (for 1st experiment)	**C1**	
- mass of sphere bob kept constant (for 2nd experiment)		
- release the sphere at rest from the starting point.	**C2**	
Note: **minus [1]** if dependent or independent variable is stated wrongly		
Analysis		**[2]**
- details of derived quantities to be calculated. Plot lg *h* vs lg *m*, y-intercept = lg *k* , gradient = n must be included. Plot lg *h* vs lg *l*, y-intercept = lg *c* , gradient = p must be included.	**A1** **A2**	
Safety Precaution		**[1]**
Place the brick on the base of the retort stand to stabilize it and prevents the retort stand from toppling.	**S1**	
Place the retort stand at a higher level e.g. on a table so that the spherical bob will not hit the ground (this may cause hazard to others) after the rubber cord has fully extended.		
Any additional details		**[max 2]**
Release the spherical bob with no downward velocity. Do not exert any force vertically or horizontally on the sphere upon release of the sphere.	**AD1**	
The retort stand is placed at the edge of the table because the extension of the rubber cord can be longer than the height of the retort stand.		
Measure the unstretched length of the rubber cord before releasing the spherical bob of different mass to ensure that the same length of the rubber cord is used for all spherical bobs.	**AD2**	

In real situation, for safety consideration, there is a need for a minimum safety distance between the lowest point of the extension and the ground. Since the bungee cord is tied to the ankle of the person, the height of the person must be taken into consideration. $\Rightarrow$ Safety height = Distance between starting point and lowest point + distance between the lowest point of the extension and the ground + height of the person		

Common mistakes made by candidates	
1	The diagram was too simple and not well labelled. Some information was missing from the diagram such as the starting point and the minimum safety height. Many candidates simply mentioned measure the minimum safety height without stating clearly or indicating on the diagram. In this case the minimum safety height must be measured from the starting point to the **bottom** of the spherical bob and not the centre of the spherical bob.
2	Stated the dependent variable and independent variable wrongly.
3	Candidates did not state clearly two experiments would be conducted separately and they stated mass of the spherical bob and length of the cord as independent variable in the same experiment.
4	Many candidates did not mention which apparatus was needed to measure certain physical quantities. They simply stated measure the length of the rubber cord and measure the mass of the spherical bob.
5	Candidates did not state what graph need to be plotted and how was the y-intercept and gradient determined clearly.
6	Most candidates could score for the safety consideration.
7	Some additional details mentioned were incomplete and trivial which was not given any credit.

Class | Adm No

Candidate Name: ____________________

H

millennia institute

2018 Preliminary Exams

Pre-University 3

H2 PHYSICS **9749/01**

Paper 1 Multiple Choice **19 September 2018**

Additional Materials: OMR Answer Sheet **1 hour**

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, class, admission number and NRIC number on the OMR Answer Sheet in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate OMR Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

The use of approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/{}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\,\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 Which of the following pair of physical quantities includes a scalar quantity and a vector quantity?

A work, magnetic flux density

B voltage, frequency

C resistance, charge

D tension, electric field

2 The acceleration of free fall g was determined during an experiment by a student. The table below shows the recorded measurements.

Readings / m s^{-2}				
9.25	9.23	9.25	9.24	9.23

Which of the following gives a suitable description of the readings?

A The readings were accurate with large systematic error.

B The readings were accurate with large random error.

C The readings were precise with large systematic error.

D The readings were precise with large random error.

3 An e-scooter travels at a uniform velocity of 15 ms^{-1} along a level road and passes a motorised bicycle which is initially at rest at t = 0 s. The motorised bicycle immediately accelerates uniformly along the same direction to catch up with the e-scooter. At *t* = 6 s, both the e-scooter and the motorised bicycle are 54 m apart.

What additional time will it take for the motorised bicycle to catch up with the e-scooter?

A 4.6 s **B** 9.0 s **C** 10.0 s **D** 15.0 s

4 A squash ball approaches a squash player who gives it a hard hit with a swing of her racket. The ball then returns directly to her opponent.

Which of the following is true about the squash ball and the racket during the time of contact?

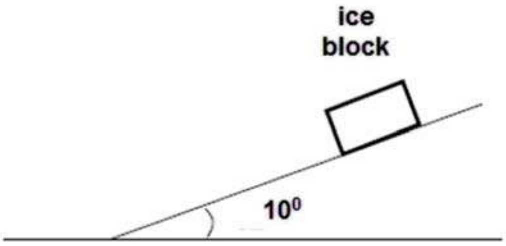
A The force on the racket due to the ball is smaller than the force on the ball due to the racket because the ball is much smaller and lighter than the racket.

B The force on the racket due to the ball is smaller than the force on the ball due to the racket because the ball moves off with high speed after the contact whereas the racket does not.

C The force on the racket due to the ball is larger than the force on the ball due to the racket because smaller mass means smaller force.

D The force on the racket due to the ball is equal to the force on the ball due to the racket.

5 A block of ice of mass 1.8 kg slides down a smooth slope from rest.



What is the momentum of the ice block after 3.0 s?

A 9.2 kg m s^{-1} **B** 18.4 kg m s^{-1} **C** 27.2 kg m s^{-1} **D** 53.0 kg m s^{-1}

6 A missile of mass 3M was projected with a velocity of 50.0 m s^{-1} at an angle of 80° above the horizontal. At the highest point, it explodes into three equal fragments X, Y and Z. Fragment X moves vertically upwards with velocity of 25.0 m s^{-1}. Fragment Y moves vertically downwards with velocity of 25.0 m s^{-1}.

What is the velocity of fragment Z?

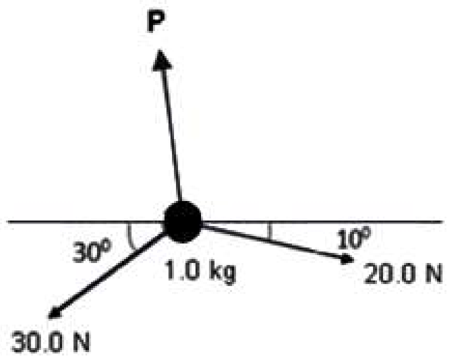
A 8.6 m s^{-1} horizontally.

B 26.0 m s^{-1} horizontally.

C 8.6 m s^{-1} at an angle of 80° above the horizontal.

D 26.0 m s^{-1} at an angle of 80° above the horizontal.

7 A 1.0 kg mass is at rest on a smooth horizontal surface. Three forces keep the 1.0 kg mass in equilibrium.



What is the magnitude of force **P**?

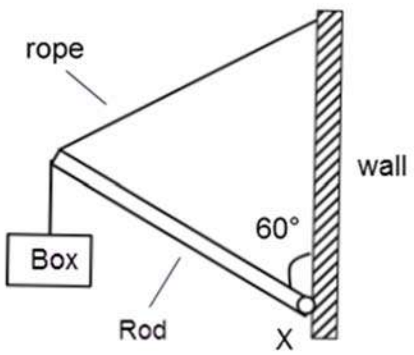
A 6.3 N **B** 12.2 N **C** 18.5 N **D** 19.5 N

8 A 0.15 kg plastic cube of volume 1.0×10^{-3} m^3 is held at rest at the bottom of a tank of liquid of density 3000 kg m^{-3}. The cube is then released and rises up until it reaches a constant speed.

What is the upthrust on the plastic cube?

A 0.0 N **B** 1.5 N **C** 28.0 N **D** 29.4 N

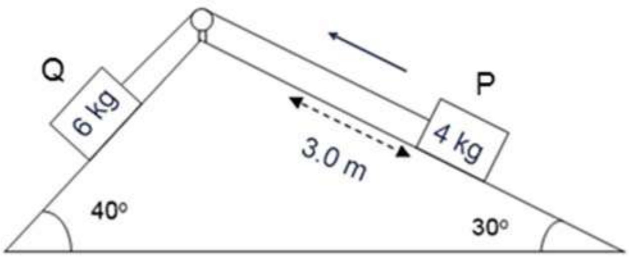
9 A uniform rod of weight 50 N and length L is hinged at X to a wall as shown. A rope of length L supports the rod and is also attached to the wall. A box of weight 24 N is suspended at the other end of the rod.



What is the tension in the rope?

A 28 N **B** 49 N **C** 74 N **D** 85 N

10 Two masses P and Q are connected by a light inextensible string which passes over a frictionless pulley. P and Q are initially at rest and their masses are 4.0 kg and 6.0 kg respectively. When Q is released, P moves up the plane inclined at 30^0 to the horizontal as shown.



What will be the speed of Q after P has moved 3.0 m up the plane?

A 2.3 m s^{-1} **B** 3.3 m s^{-1} **C** 4.3 m s^{-1} **D** 5.3 m s^{-1}

11 A motorised boat moving at constant speed S through still water experiences total drag X.

What is the power of the motorised boat?

A X^2 S **B** ½ XS^2 **C** XS **D** ½ XS

12 A ball is inside a pail that is moving in a vertical circle of radius 70.0 cm. The ball will just remain in contact with the pail at the top of the circular path if the pail is rotating with a minimum speed V.

What is the minimum speed V of the pail?

A 2.6 m s^{-1} **B** 3.7 m s^{-1} **C** 26.0 m s^{-1} **D** 37.0 m s^{-1}

13 A planet X has half the mass of the Earth and half its radius. The accelecration due to gravity on the Earth's surface is g.

What is the acceleration due to gravity on the surface of planet X?

A ¼ g **B** ½ g **C** g **D** 2 g

14 The mean kinetic energy of the gas molecules of an ideal gas at 573 K is 1.6×10^{-23} J.

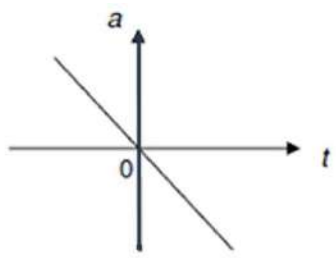
Which of the following correctly shows the values of temperature and mean kinetic energy of the gas molecules when the gas molecules are travelling twice as fast?

	temperature / K	kinetic energy / J
A	873	3.2×10^{-23}
B	1370	3.2×10^{-23}
C	2292	6.4×10^{-23}
D	2573	6.4×10^{-23}

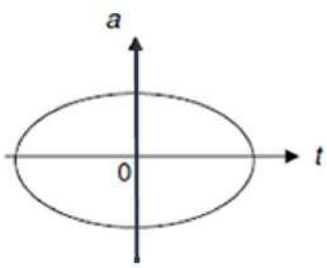
15 The bob of a pendulum is moving in simple harmonic motion. The bob has maximum potential energy at time t = 0 s.

Which of the following graphs best describes the variation of the acceleration *a* of the bob with time *t*?

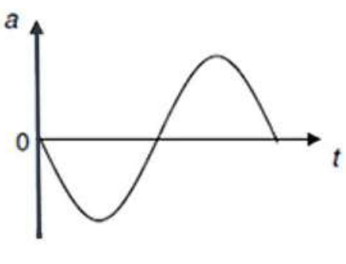
A



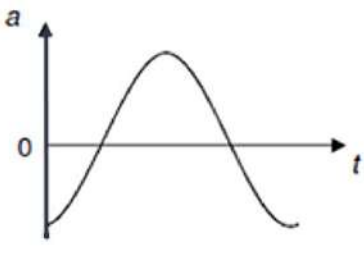
B



C



D



16 A mass of 20 g is oscillating vertically in simple harmonic motion. The displacement of the mass is given by the equation

$$x = 6.0 \times 10^{-3} \sin(3\pi t)$$

where x is in metres and t in seconds.

What is the magnitude of the maximum force acting on the mass?

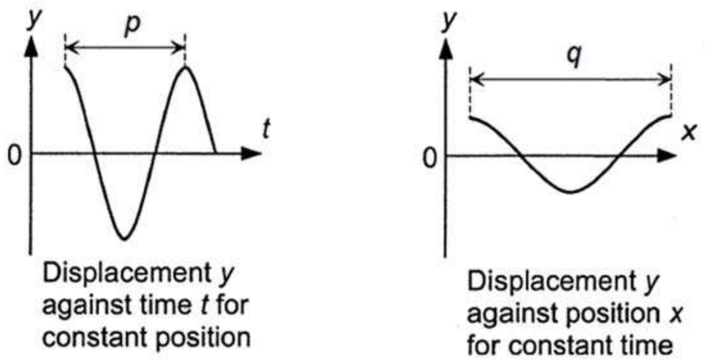
A 0.01 N **B** 0.50 N **C** 1.80 N **D** 10.7 N

17 A longitudinal wave of frequency 100 Hz is traveling in a gas at a speed of 200 m s^{-1}. The phase difference between 2 points P and Q along the path of the wave is $5\pi/4$ radian.

What is the distance between points P and Q?

A 0.525 m **B** 1.05 m **C** 1.15 m **D** 1.25 m

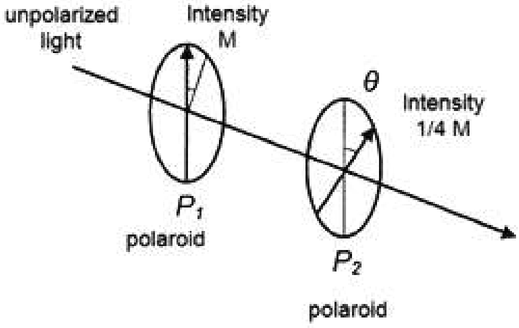
18 The same progressive wave is represented by the following graphs.



Which of the following gives the speed of propagation of the progressive wave?

A pq **B** $\frac{p}{q}$ **C** $\frac{q}{p}$ **D** $\frac{1}{q}$

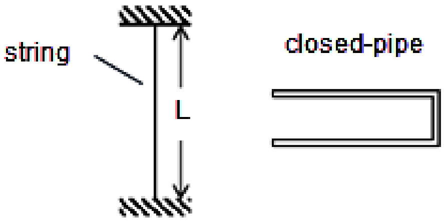
19 A beam of plane-polarised light of intensity *M* after passing through polaroid P_1 falls normally on to a thin sheet of Polaroid P_2 as shown below. When polaroid P_2 is rotated through an angle θ, the transmitted beam through polaroid P_2 has an intensity of ¼ *M*.



What is the angle θ between the plane of incident polarisation and the polarising direction of the polaroid P_2?

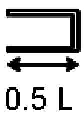
A 60^0 **B** 45^0 **C** 30^0 **D** 22.5^0

20 The figure shows a stretched string of length L placed near a closed-pipe. The fundamental mode of oscillation in the string occurs when the speed of waves in the string equals the speed of soundwaves in the air.

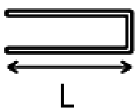


In which closed-pipe below will the sound produced by the string cause resonance in the pipe?

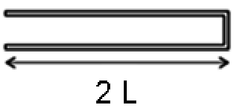
A



B



C



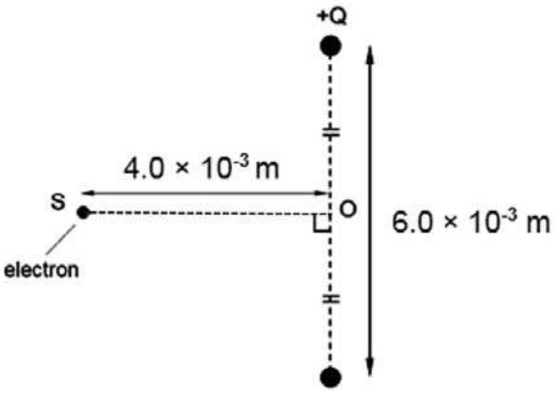
D

21 Red light of wavelength 700 nm passes through a Young's double-slit arrangement. Fringes of separation Z are observed in a plane 1.20 m away from the slits. The light source is then replaced with blue light of wavelength 420 nm.

At what distance from the slits would fringes of the same separation Z be observed?

A 0.60 m **B** 0.72 m **C** 1.67 m **D** 2.00 m

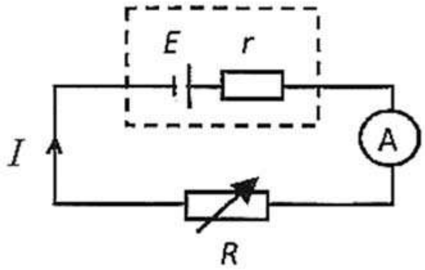
22 Two identical point charges +*Q* of $+1.45 \times 10^{-15}$ C each are fixed 6.0×10^{-3} m apart as shown below. An electron is then projected with a speed V into the plane of the paper at point S which is 4.0×10^{-3} m away from the perpendicular bisector between the two charges.



Which of the following gives the magnitude of net force on the electron and the speed V with which the electron must be projected into the plane of the paper at S to just perform circular motion with its centre at point O.

	net force / N	speed V / m s^{-1}
A	8.34×10^{-20}	1.2×10^{4}
B	1.33×10^{-19}	2.4×10^{4}
C	8.34×10^{-20}	2.4×10^{4}
D	1.33×10^{-19}	1.2×10^{4}

23 A battery of e.m.f. E and internal resistance r delivers a current I through a variable resistor R as shown below.



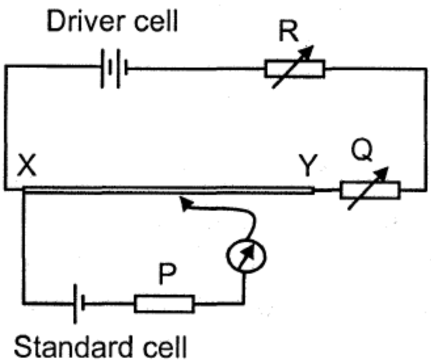
The table below shows two different values of R and corresponding currents I measured using an ammeter of negligible resistance.

R / Ω	I / A
1.0	3.0
2.0	2.0

What is the value of e.m.f E of the battery?

A 3.0 V **B** 3.5 V **C** 4.0 V **D** 6.0 V

24 The potentiometer is to be calibrated with a standard cell using the circuit shown. XY is a 1.000 m along uniform wire.



The balance point is found to be nearer X. The accuracy of the balance length can be improved by having the balance point nearer to Y.

What should be varied to ensure the balance point is near Y?

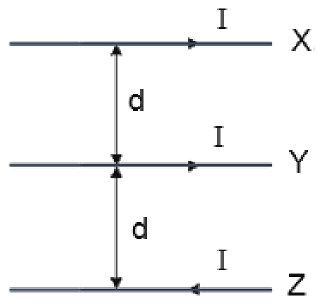
A increasing P

B increasing R

C replacing the wire with one of higher resistance per unit length

D reducing Q

25 The three parallel wires X, Y and Z carry currents of equal magnitude I in the direction shown.



Which one of the following gives the direction of the resultant force experienced by Y due to the currents in X and Z?

A along Y

B towards Z.

C towards X.

D Along Z

26 An e.m.f is induced in a coil of wire that is rotating inside a magnetic field.

Which one of the following does not affect the magnitude of e.m.f induced in the coil?

A the angular velocity of the coil

B the resistance of the coil

C the number of turns of the coil

D the magnetic flux density

27 When a sinusoidal e.m.f of peak value V is connected across a resistor R, a current of peak value I flows through it.

What is the mean power dissipated in the resistor?

A I^2R **B** $\frac{IV}{\sqrt{2}}$ **C** $\frac{IR^2}{\sqrt{2}}$ **D** $\frac{V^2}{2R}$

28 When electrons are accelerated and then stopped suddenly by a metal, X-rays are produced. The accelerating voltage across an X-ray tube is doubled.

Which of the following is true when the accelerating voltage across the X-ray tube is doubled?

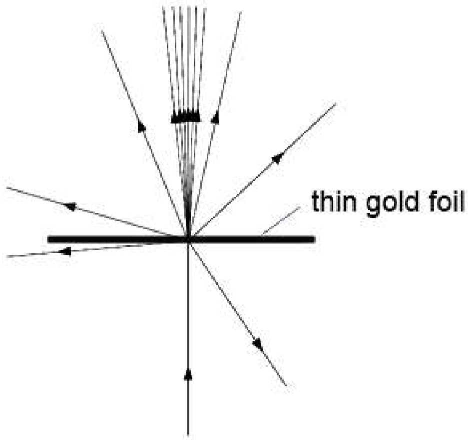
A The intensity of the X-ray beam is doubled.

B The wavelengths of the characteristics lines are halved.

C The minimum wavelength of the X-rays is halved.

D The X-rays are most probably less penetrating.

29 The diagram shows a thin gold foil bombarded with alpha-particles.



What does the results of this experiment provide?

A wave properties of a gold atom

B size of a gold nucleus

C mass number of a gold atom

D binding energy of a gold nucleus

30 A radioactive sample of half-life of 10 minutes is placed 40.0 cm away from a radioactivity detector. The detector gives an average count-rate of 39.0 s^{-1}. In the absence of the radioactive sample, the detector records an average count-rate of 5.0 s^{-1}.

After 20 minutes, the detector, which is still facing the radioactive sample, is moved 20.0 cm nearer the radioactive sample. The sample can be regarded as a point source of radiation.

What is the average count rate on the detector?

A 8.5 s^{-1} **B** 13.5 s^{-1} **C** 34.0 s^{-1} **D** 39.0 s^{-1}

Class	Adm No

Candidate Name: ______________________________

H

millennia institute

2018 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749/02**

Paper 2 Structured Questions **14 September 2018**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

Write your full name, class and Adm number in the spaces at the top of this page and on any separate answer paper used.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use		
1		/10
2		/9
3		/11
4		/12
5		/8
6		/10
7		/20
Presentation		
Total		/80

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 **(a)** A speed boat has an initial velocity of 12 m s^{-1} south. The speed boat then changes its course to a final velocity of 16 m s^{-1} east. Determine the magnitude of the change in velocity, Δv, of the speed boat, and the angle between vector Δv and the north direction.

magnitude of Δv = ………………… m s^{-1} [1]

angle between Δv and north = ……………………….° [1]

(b) A student uses a pair of vernier caliper to take several measurements of the diameter of a rubber ball. He applies different pressures when closing the gap of the vernier caliper. State and explain whether this introduces a systematic error or random error into the readings.

……………………………………………………………………………………………………...........

……………………………………………………………………………………………………...........

…………………………………………………………………………………………………….........[2]

(c) The energy per unit time, P radiated by an object with a surface area A at thermodynamic temperature T is given by

$$P = e\sigma AT^4$$

where e is the emissivity of the surface and σ is the Stefan-Boltzmann constant.

(i) Given that the SI unit for σ is W m^{-2} K^{-4}, determine the base units of emissivity, e.

base units of e = …………………. [2]

(ii) In an experiment to determine emissivity e of a circular surface area of diameter d of an object, the following measurements are taken:

P = (3.0 $\pm$ 0.2) W
d = (5.0 $\pm$ 0.1) cm
T = (500 $\pm$ 1) K
σ = 5.67 X 10^{-8} W m^{-2} K^{-4}

Determine the value of emissivity, e of the surface and express it with its associated uncertainty.

e = ………………… $\pm$ …………………. ………….. [4]

2 **(a)** Derive, from the equations for uniformly accelerated motion in a straight line, the equation

$$E_k = \frac{1}{2}mv^2.$$

[3]

(b) A 2.0 kg box on a frictionless incline of angle 40° is connected by a cord that runs over a massless and frictionless pulley to a light spring of spring constant k = 120 N m^{-1}, as shown in Fig. 2.1. The box is released from rest along the inclined plane when the spring is unstretched.

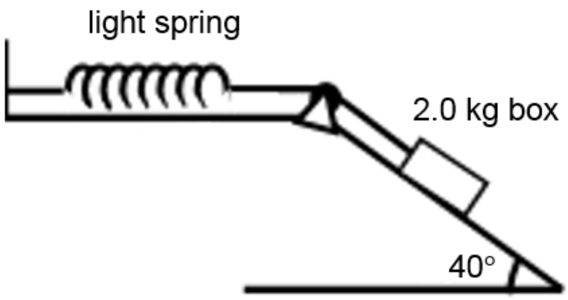


Fig 2.1

(i) Calculate the energy stored in the spring when the box reaches 10 cm down along the incline.

energy = …………………. J [1]

(ii) Determine, *D*, the distance along the incline moved through by the box before it comes to a stop.

D = …………………. m [2]

(iii) State what will happen to the answer calculated in **(b)(ii)** if the inclined angle is increased.

……………………………………………………..…………………..………………..…. [1]

(iv) The frictionless incline is now replaced by a rough incline. Assuming the friction between the rough incline and the box is 5.0 N, determine *D'*, the new distance moved through by the box before it comes to a stop.

D' = …………………. m [2]

3 **(a)** State what is meant by *simple harmonic motion*.

....

....

.... [2]

(b) A smooth ball of mass m is held between two fixed points A and B by two similar springs, each of spring constant k, as shown in Fig. 3.1.

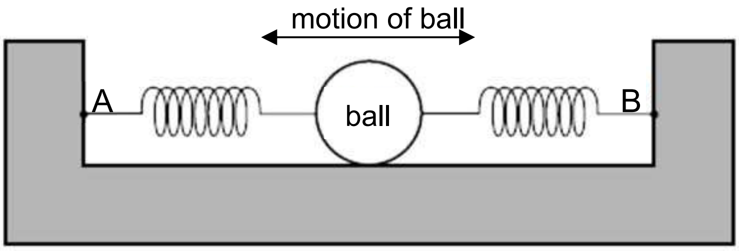


Fig. 3.1

When the ball is in equilibrium, the extension of each spring is e. The ball is then displaced a small distance x to the right along the axis of the springs. The ball is then released and oscillates on the smooth surface along the straight line joining points A and B.

(i) Show that the acceleration a of the ball is given by the equation

$$a = -\frac{2kx}{m}$$

[3]

(ii) The mass *m* of the ball is 900 g and the spring constant *k* is 120 N m^{-1}. The maximum acceleration of the ball is 5.2 m s^{-2}.

1. Determine the frequency of oscillation of the ball.

frequency = …………………. Hz [2]

2. Determine the amplitude of the oscillation.

amplitude = …………………. m [2]

3. Determine the maximum kinetic energy of the ball.

maximum kinetic energy = …………………. J [2]

[Turn over

4 **(a)** A contractor tries to measure the depth of a new well shaft to build a ladder to reach the bottom of the shaft. He uses an audio oscillator with adjustable frequency and applies it across the top of the well. Two successive resonances are heard at 70.6 Hz and 90.8 Hz. The speed of sound is 343 ms^{-1}. Determine the depth of the well.

depth of well = …………………. m [3]

(b) An engineering student designed an Automated Guided Vehicle (AGV) using interference of radio waves from two coherent emitters 2.0 m apart emitting radio waves of frequency *f* that are in phase as shown in Fig. 4.1. The computer on the AGV detects and searches for lines of constructive interference and adjusts the AGV so that it is always aligned along the centre-line, in the middle of the emitters.

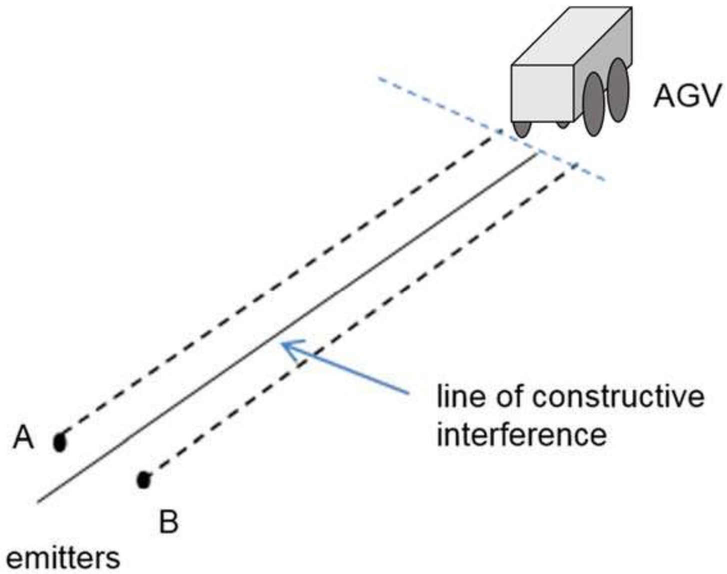


Fig 4.1

(i) State and explain one disadvantage in using this method for the AVG to align itself along the centre-line.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(ii) During one such operation, the AGV strays off the centre-line as shown in Fig. 4.2.

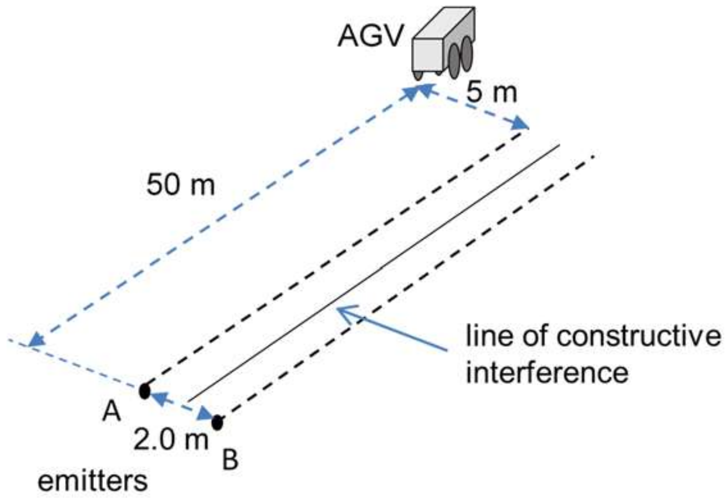


Fig 4.2

Fig. 4.3 shows the radio signals X and Y detected by the receiver on the AGV.

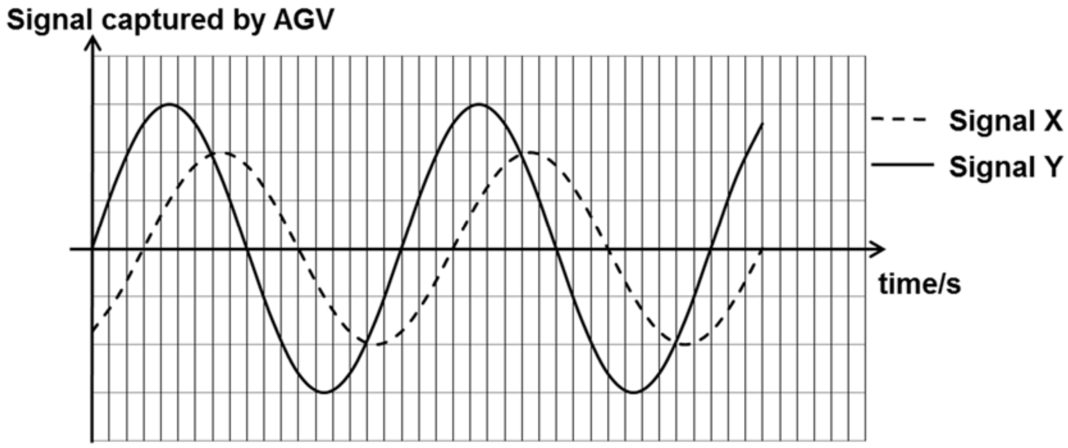


Fig 4.3

1. State and explain whether the source of signal X is from emitter A or B.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

2. State the phase difference between signals X and Y.

phase difference = …………………. rad [1]

3. Assuming the path difference is less than one wavelength, determine frequency *f* of the radio wave used.

frequency *f* = …………………. Hz [4]

5 **(a)** Define *electric potential* in an electric field.

....

.... [1]

(b) Two spherical charges P and Q, each of mass m = 0.20 g are separated by a horizontal distance of 30 mm as shown in Fig. 5.1. P has a charge of +20 μC and Q has a charge of –40 μC.

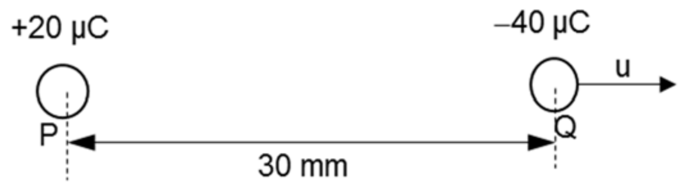


Fig 5.1

(i) In Fig 5.2, r represents the distance from centre of P towards centre of Q. On the axis provided, sketch the variation of the resultant electric potential V between boundaries A and B.

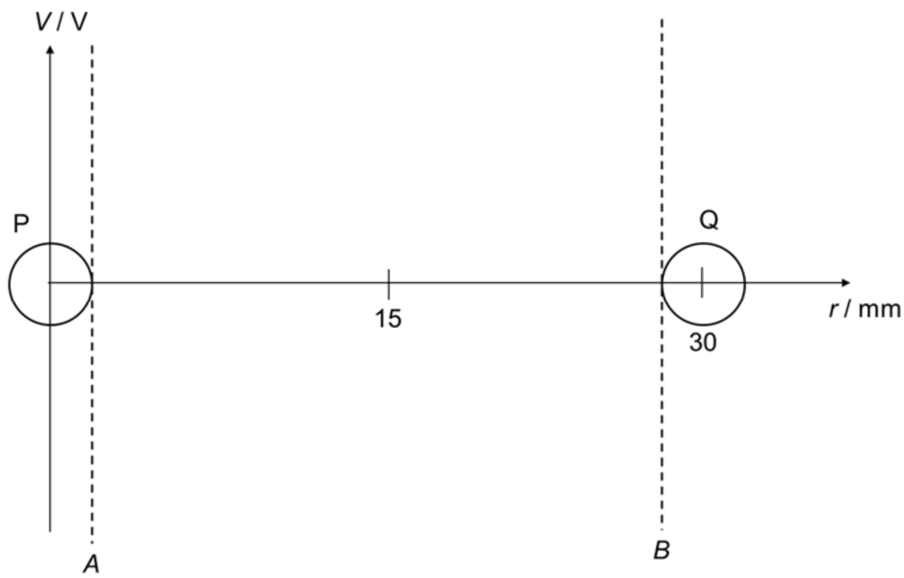


Fig 5.2

[3]

(ii) Q is then projected away from P with an initial speed *u* such that it reaches a position far enough beyond the influence of charge P.

1. Determine the electric potential energy of Q at its initial position.

electric potential energy = …………………. J [2]

2. Determine the minimum initial speed *u* required.

minimum speed *u* = …………………. m s^{-1} [2]

6 **(a)** Electrons are emitted from a metal surface when light of a particular wavelength is incident on the surface. Explain why the emitted electrons have a range of values of kinetic energy below a maximum value.

………

………

………

……… [2]

(b) An evacuated tube contains two parallel metal electrodes, one of which is an emitter of electrons and the other a collector. The emitter has a work function energy of 2.0 eV and is illuminated with electromagnetic radiation of wavelength 410 nm. The area illuminated on the emitter is 24 mm^2. The potential difference *V* between the collector and the emitter is adjusted, and the photocurrent *I* is measured. Fig. 6.1 shows the variation of *I* with *V*.

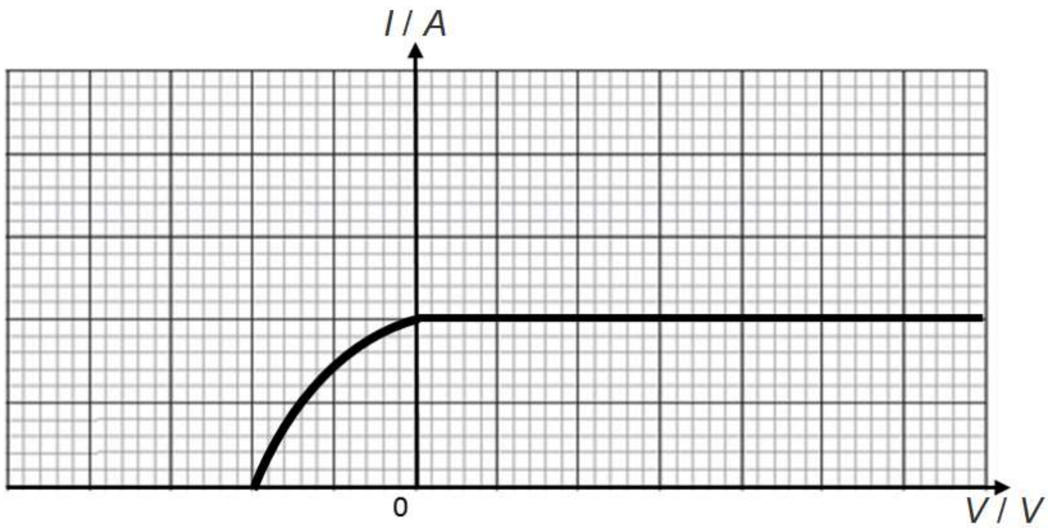


Fig 6.1

On Fig 6.1, sketch graphs to show the variation of *I* with *V* when the following changes are made to the original setup.

(i) The wavelength of the electromagnetic radiation is kept constant but its intensity is reduced by half. Label the graph **(i)**. [2]

(ii) The wavelength of the electromagnetic radiation is decreased but its intensity is kept constant. Label the graph **(ii)**. [2]

(iii) At a particular setting, a photocurrent of 4.8×10^{-10} A was observed.

1. Determine the rate of emission of photoelectrons.

rate of emission = …………………. s^{-1} [1]

2. Hence, determine the intensity of the light source, assuming that 1 in 2500 photons succeeds in ejecting an electron from the surface.

intensity = …………………. W m^{-2} [3]

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7 A German astronomer, Johannes Kepler, deduced that for a planet in a circular orbit around the Sun, its period of rotation T and the radius of its orbit r, is related by

$$T^2 \propto r^3 .$$

(a) Using Newton's law of gravitation and considering the mass of Saturn to be M, show that, for a circular orbit of a moon around Saturn,

$$T^2 = \frac{4\pi^2}{GM} r^3 .$$

[3]

(b) Table 7.1 contains some of the data for the major moons of Saturn.

Table 7.1

moon	period T / 10^6 s	mean distance from centre of Saturn r / 10^9 m	lg (T / s)	lg (r / m)
Enceladus	0.121	0.238	5.08	8.38
Tethys	0.164	0.295	5.21	8.47
Rhea	0.380	0.501		
Titan	1.38	1.26		
Lapetus	6.83	3.56	6.83	9.55

Complete Table 7.1 for the moons Rhea and Titan. [2]

(c) Fig. 7.1 shows a graph representing the variation of lg (T / s) with lg (r / m) for the moons of Saturn, with some of the data from Table 7.1 plotted.

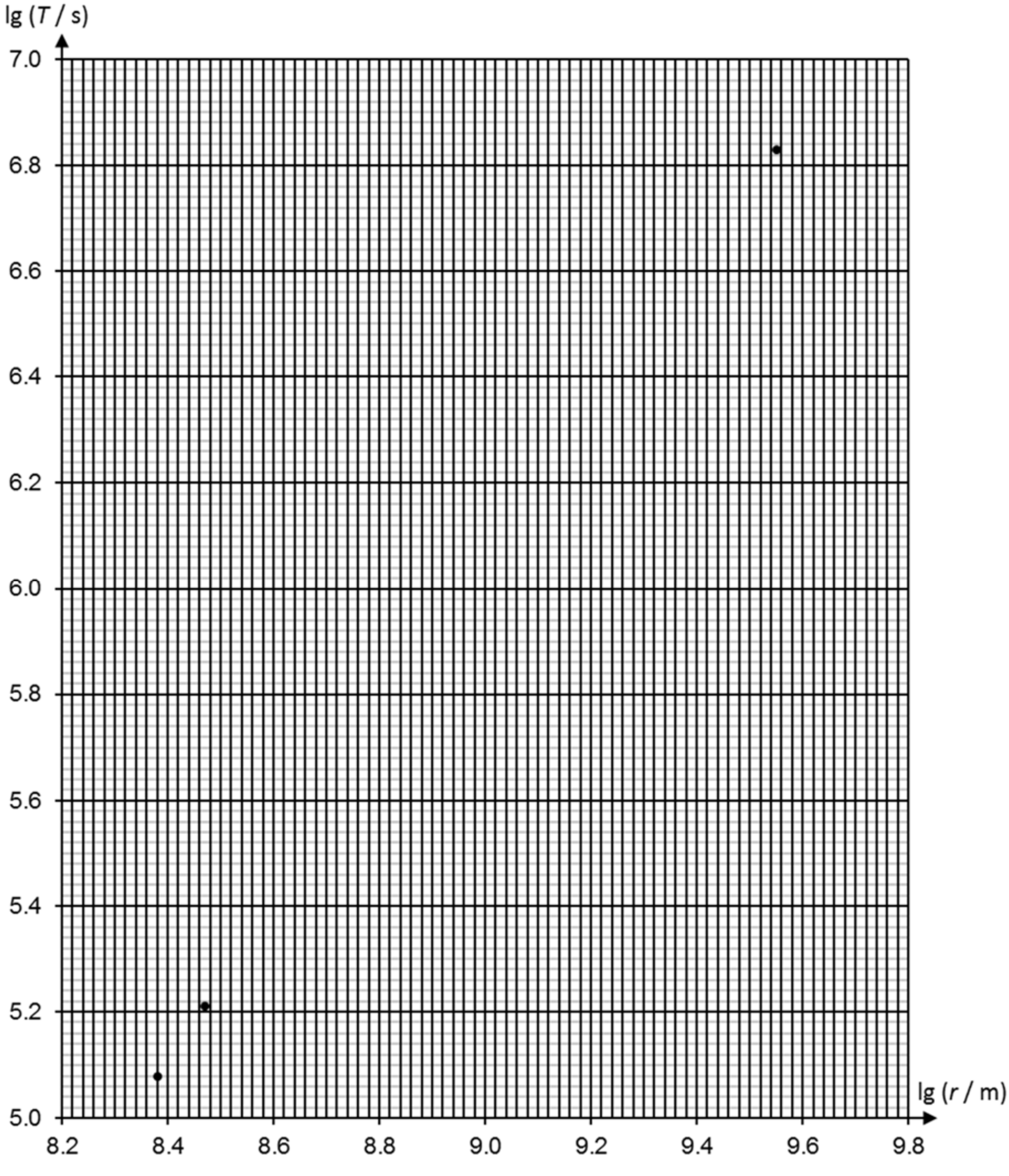

Fig 7.1

On Fig 7.1,

(i) plot the points corresponding to the moons Rhea and Titan. [1]

(ii) draw the line of best fit for all the data points. [1]

(d) **(i)** Determine the gradient of the graph in Fig 7.1.

gradient = …………………. [2]

(ii) Hence, discuss whether the data in Fig 7.1 supports the relation given in **(a)**.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(e) Dione, which is another moon of Saturn, has an orbital radius of 3.78×10^5 km.

Using the graph in Fig. 7.1, determine the period of Dione's orbit around Saturn.

period = …………………. s [2]

(f) Scientist were able to determine the mass of planets in the Solar System through studying the orbits of their moons.

(i) Using Fig 7.1, determine the mass of Saturn.

mass = …………………. kg [2]

(ii) A student studying the orbits of the moons of Saturn decides to determine the mass of Saturn with the orbital radius and period of Titan only.

Discuss one disadvantage of using this method as compared to **(f)(i)**.

....

....

.... [2]

(iii) It was reported that another moon of Saturn, Mimas, has a period of rotation 7.78×10^4 s and orbits at a height of 1.79×10^5 km above Saturn's surface. Comment on the accuracy of this report.

....

....

.... [3]

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Class	Adm No

Candidate Name: ______________________________

H

millennia institute

2018 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749/03**

Paper 3 Long Structured Questions **17 September 2018**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

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The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer all questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use		
Sect A		
1		**/10**
2		**/12**
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4		**/7**
5		**/7**
6		**/11**
Sect B		
7		**/20**
8		**/20**
Presentation		
Total		**/80**

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radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** Fig. 1.1 shows the variation of force F with the extension x of a spring.

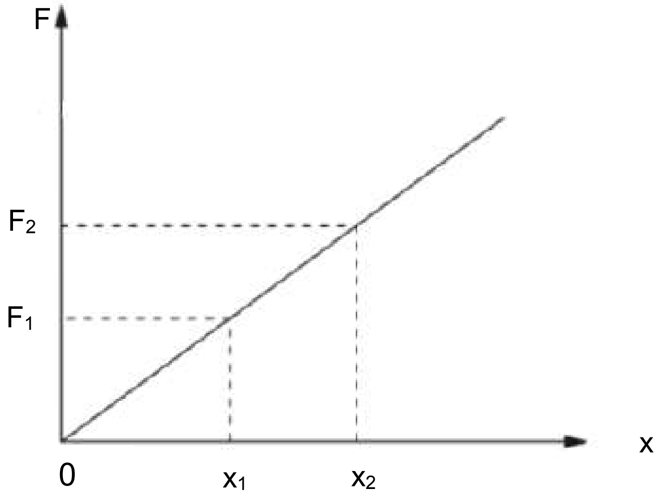

Fig. 1.1

The extension of the spring is increased from x_1 to x_2.
Show that the work done W in extending the spring is given by

$$W = \frac{1}{2} k (x_2^2 - x_1^2)$$

where k is the spring constant.

[2]

(b) Fig. 1.2 shows a signboard suspended by two elastic springs.

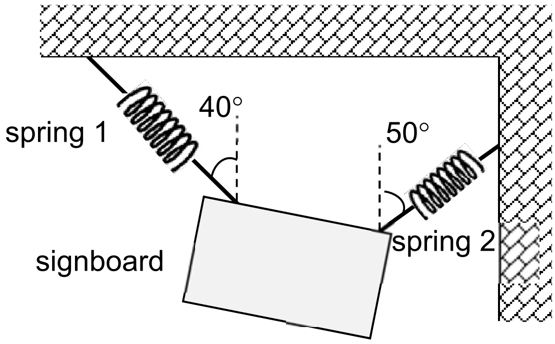

Fig. 1.2

(i) State the conditions for equilibrium.

…………………………………………………………………………………………………….....................

…………………………………………………………………………………………………............ [2]

(ii) On Fig. 1.2, draw and label clearly the forces acting on the signboard. Mark the centre of gravity of the signboard with a dot and label the point as G. [2]

(iii) Given that the tension in spring 1 is 300 N and the tension in spring 2 is 252 N, determine the weight of the signboard.

weight = ………………….. N [2]

(iv) The signboard is pulled vertically downwards with a force of 20 N so that the springs are stretched to a new position. Determine the acceleration of the signboard immediately after it is released.

acceleration = …………………………….m s^{-2} [2]

2 **(a)** Fig. 2.1 shows the variation of the gravitational potential ϕ with distance r along a line joining the centres of the moon and the Earth.

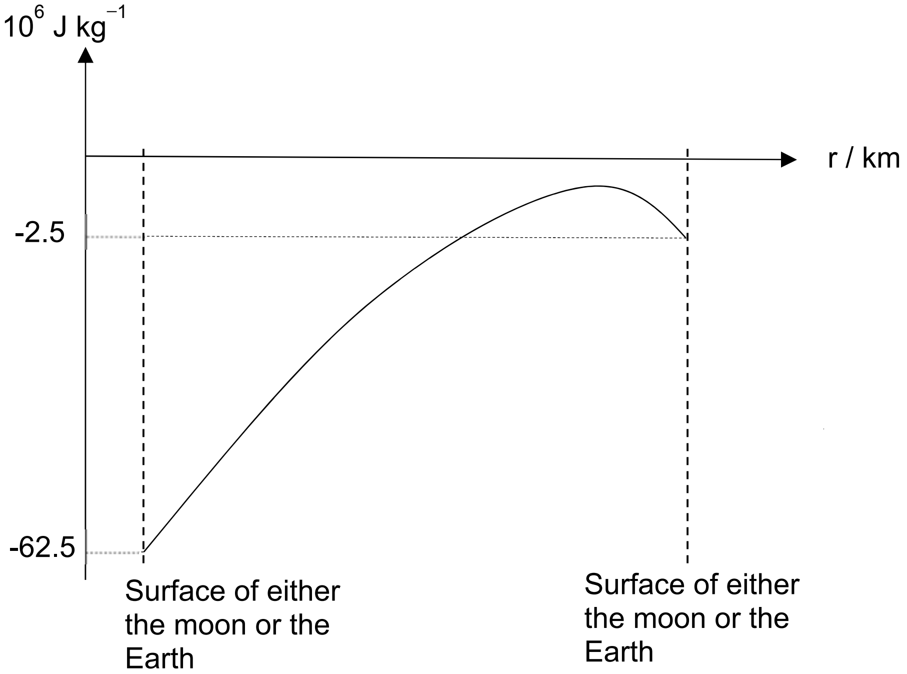

Fig. 2.1

(i) Explain whether r is measured from the moon or the Earth.

....

.... [1]

(ii) A 1500 kg meteorite needs a minimum energy of 2.25×10^9 J to reach the neutral point as it travels from the moon to the Earth.

1. Explain what is meant by *the neutral point between the moon and the Earth*.

....

.... [1]

2. Determine the gravitational potential at the neutral point.

gravitational potential = ……………… J kg^{-1} [2]

3. Determine the speed at which the meteorite would hit the Earth. You may neglect atmospheric resistance.

speed = ………………… m s^{-1} [2]

(b) The mass of the Earth is 5.98×10^{24} kg and the moon takes 27.4 days to orbit the Earth.

(i) Show that the distance between the centre of the Earth and the moon is about 384 000 km. [2]

(ii) Hence, determine the linear speed of the moon.

linear speed = …………………… m s^{-1} [2]

(c) An astronaut in a spacecraft orbits around the Earth in a circular path. The astronaut appears to float inside the spacecraft. Students A and B provide some explanations about this observation of weightlessness.

1. Student A claims that the astronaut floats because he has no weight.
2. Student B claims that the astronaut floats because both the astronaut and the spacecraft have the same centripetal force.

Comment on the validity of each of these explanations.

1. ....

....

2. ....

.... [2]

3 **(a)** **(i)** One of the assumptions of the kinetic theory of gases is that the motion of gas molecules is random. Therefore explain why the average momentum of the gas molecules in a container is zero.

[2]

(ii) According to the kinetic theory of gases, explain how a gas exerts a pressure on the walls of a container.

[3]

(b) A student designed an air-filled “load-lifting” system where the air could be uniformly heated by suitably located electrical heaters in the enclosure of the system. All sides of the enclosure have good thermal insulation and the top surface is movable vertically.

The volume of air inside the enclosure at tempature of 300 K and pressure of 101.0 kPa is 2.000 m^3.

When a load of mass 500 kg is placed on the top of the movable surface of the system, an average depression of 5.0 cm of the top surface is observed and the volume of air in the enclosure is reduced to 1.947 m^3.

(i) State the first law of thermodynamics.

[2]

(ii) The air may be considered as an ideal gas. Determine

1. the change in internal energy of the air in the system after the load is placed on top of the movable surface.

change in internal energy = ……………………. J [3]

2. the new pressure of air in the system.

new pressure = ………………….. kPa [3]

Question 4 begins on next page

4 Fig. 4.1 shows how the resistance of a light-dependent resistor (LDR) varies with the intensity of the light incident on it.

Fig. 4.1

Fig. 4.2 shows a light-sensing potential divider circuit used in a lamp where the potential difference across the LDR can be used to control the brightness of the lamp in a room.

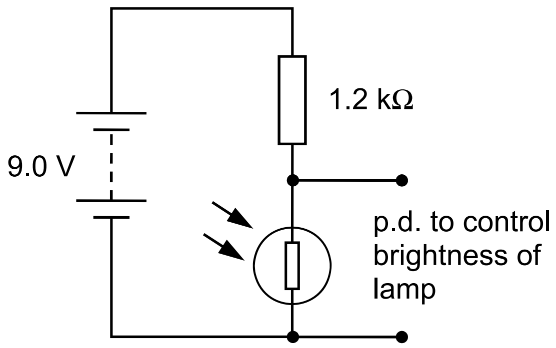

Fig. 4.2

The battery has an e.m.f. of 9.0 V and negligible internal resistance. A fixed resistor of 1.2 kΩ and the LDR is connected in series with the battery. When the room is in a low-light condition, the potential difference across the LDR reaches 7.0 V.

(a) State and explain *quantitatively*, if the resistance of the LDR is inversely proportional to the intensity of the light incident on it.

....

....

.... [1]

(b) Calculate the resistance R of the LDR.

R = ………………….. kΩ [3]

(c) Use Fig. 4.1 to determine the intensity of light incident on the LDR.

light intensity = ... $W\,m^{-2}$ [1]

(d) Fig. 4.3 shows a close-up of the LDR device used in the circuit in Fig. 4.2. The LDR consists of a uniform strip of semiconductor whose resistance is dependent on the intensity of the light incident on it. The cross-sectional area of the strip is 0.50 mm^2.

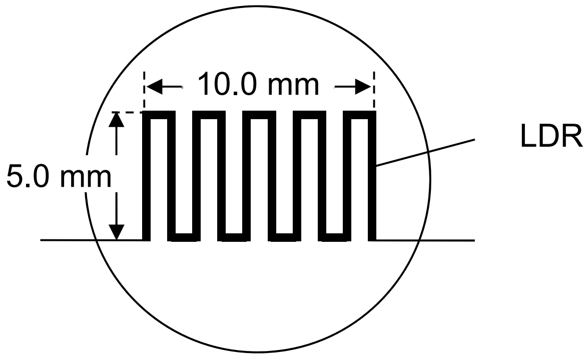

Fig. 4.3

Use your answer in **(b)** to estimate the resistivity of the LDR.

resistivity = ... Ω m [2]

5 **(a)** **(i)** Fig. 5.1 shows the cross section of a wire XY which carrying a constant current flowing out of the plane of the paper at right angles. Sketch the magnetic flux pattern due to the current. [2]

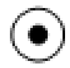

Fig. 5.1

(ii) The current-carrying wire XY in **(a)(i)** is placed in the region between the poles of a strong magnet. Sketch in Fig. 5.2 the resultant magnetic flux pattern in the region between the poles of a magnet. [2]

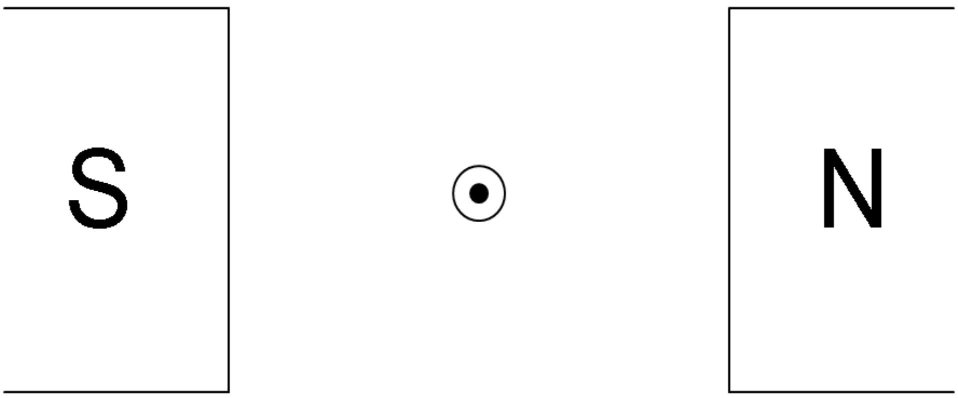

Fig. 5.2

(b) The setup in **(a)** is now placed on a top-pan balance as shown in Fig. 5.3 and Fig. 5.2 shows the front view. Outside the region between the poles of the strong magnet, the flux density can be considered as zero. When there is no current passing through XY, the top-pan balance is tared.

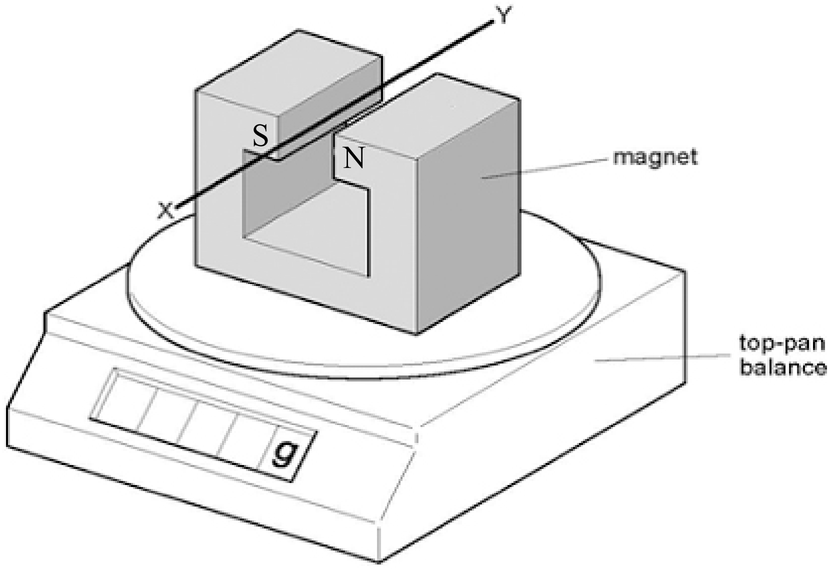

Fig. 5.3

A direct current is now passed through the wire in the direction from Y to X.

State and explain the observation in the reading on the top-pan balance.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

6 The radioactive isotope plutonium-238 ($^{238}_{94}Pu$) has a half-life of 86 years and decays by emitting an alpha particle with little or no gamma emission. The daughter nucleus is an isotope of uranium (U).

The mass of $^{238}_{94}Pu$ is 238.0496 u and the mass of an α-particle is 4.0026 u.

(a) Write down an equation representing the decay, indicating clearly the atomic number and mass number of each nucleus.

.... [1]

(b) The total kinetic energy of the products is 5.649 MeV.

(i) Calculate the mass of the uranium nucleus formed in the reaction, giving your answer in terms of atomic mass units to 4 decimal places.

mass of uranium nucleus = ... u [3]

(ii) By using the principle of conservation of momentum, show that the ratio of the kinetic energy of the alpha particle to that of the uranium nucleus is 58.5. [3]

(iii) Hence, calculate the kinetic energy of the alpha particle.

kinetic energy = ……………………… MeV [2]

(c) Satellites can be powered by the energy produced by the decay of plutonium. Plutonium is not placed in its pure form in the satellites, but installed as bricks of plutonium dioxide, PuO_2. PuO_2 is a ceramic and when it is shattered, it breaks into large pieces rather than smaller and more dangerous dust.

(i) Explain why there is no difference in the probability of decay of plutonium whether it exists as pure plutonium or in the form of PuO_2.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Suggest a reason why large pieces of PuO_2 pose less of a health risk than plutonium dust, which can be inhaled into the body.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

Section B

Answer **one** question in this section in the spaces provided.

7 **(a)** A ball of mass 320 g is projected at an angle by a ball launcher. Air resistance is not negligible. The ball is launched from a height of 0.50 m above the level ground.

The variation with time t of the vertical velocity component v_y of the ball is shown in Fig. 7.1.

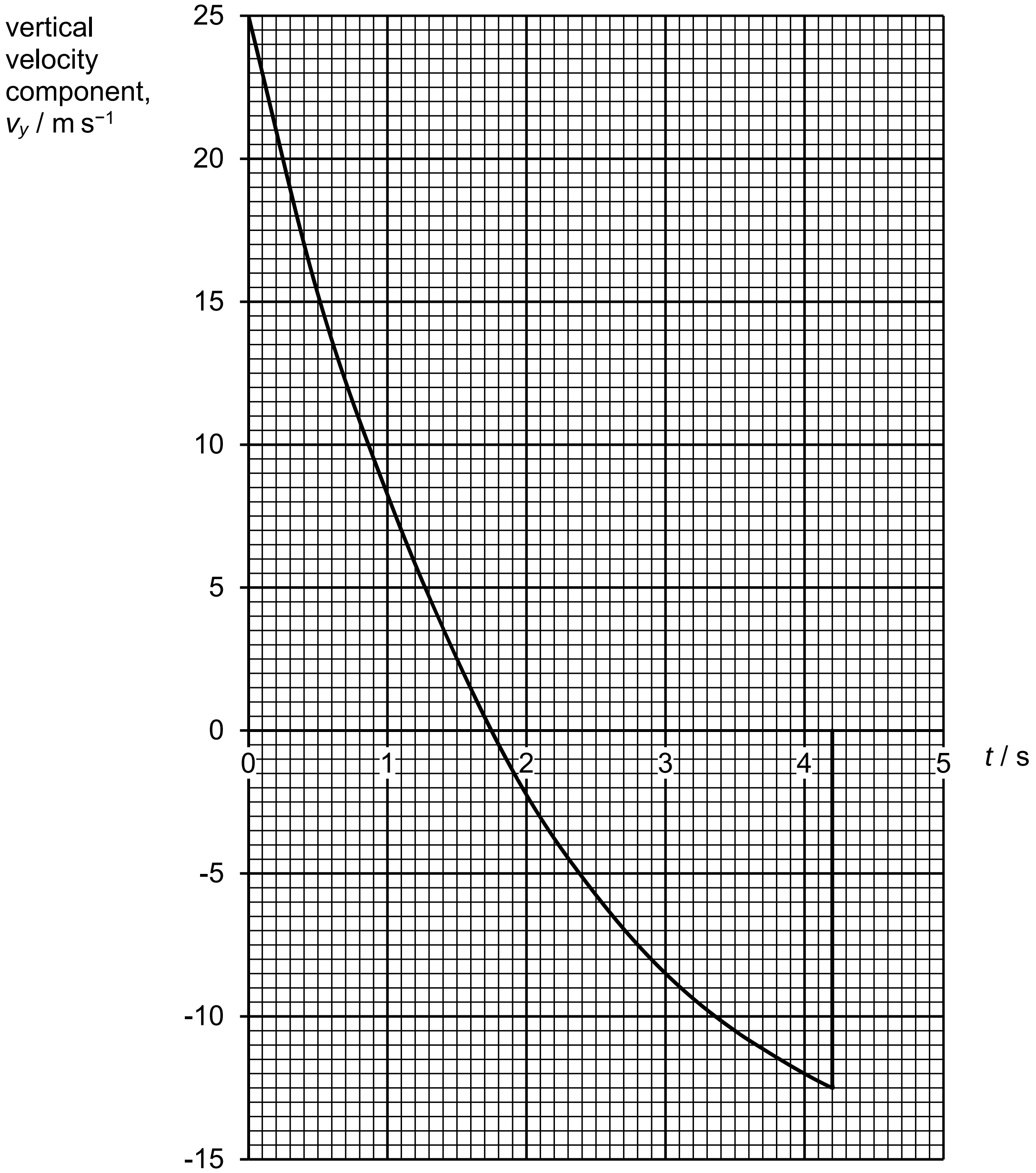

Fig. 7.1

(i) Estimate the vertical height from level ground reached by the ball at t = 1.0 s.

height = ………………………………. m [2]

(ii) Estimate the vertical component of the air resistance that is acting on the ball at t = 1.0 s.

air resistance = ……………………………….N [3]

(iii) In the case that air resistance is negligible, the ball has a horizontal velocity component of 12.0 m s^{-1}.

1. On Fig. 7.1, sketch a graph to show the variation with time *t* of the velocity vertical component of the ball. Label this line Z. [2]

2. Hence, determine the resultant velocity of the ball at t = 1.0 s.

velocity = ……………….. m s^{-1} [2]

(b) Another 2 balls, X and Y are travelling towards each other along a horizontal frictionless surface.

(i) Show how the principle of conservation of linear momentum can be derived using Newton's Laws.

....

....

....

....

....

....

.... [3]

(ii) **1.** The two balls collided and rebounded in opposite directions. Table 7.1 shows data for X and Y during the collision.

Table 7.1

ball	mass / g	velocity just before collision / m s^{-1}	velocity just after collision / m s^{-1}
X	50	+4.5	-1.8
Y	M	-2.8	+1.4

The positive direction is horizontal and to the right.

Use your answer in **(b)(i)** to determine the mass of Y.

mass of Y = ... kg [3]

2. State and explain quantitatively whether the collision is elastic.

....

.... [2]

(iii) The variation of the force that X exerts on Y with time is shown in Fig. 7.2.

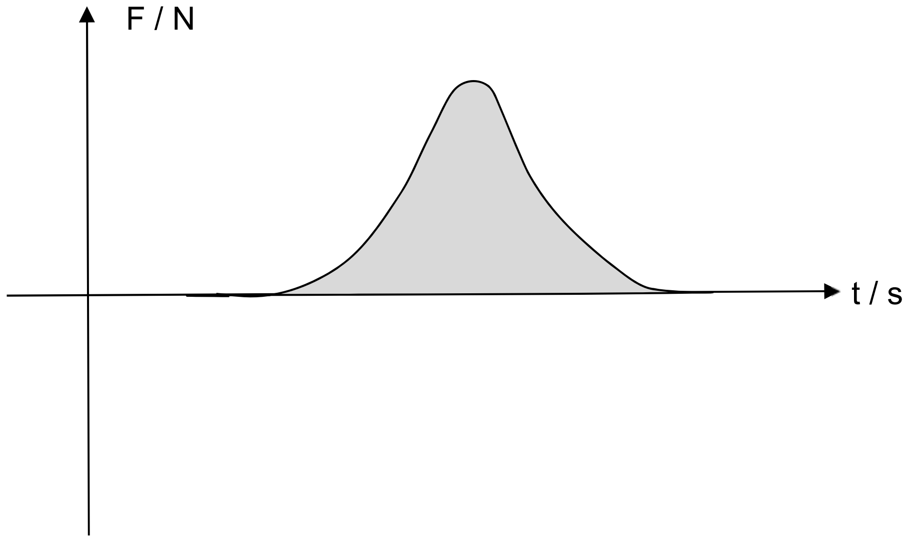

Fig. 7.2

1. Sketch a graph on Fig. 7.2 to show the variation of the force that Y exerts on X with time. Explain your answer.

....

.... [2]

2. Explain what the shaded area in Fig. 7.2 represents.

....

.... [1]

8 Fig. 8.1 shows a rectangular coil. The coil has 25 turns with dimensions of 15.0 cm by 6.0 cm.

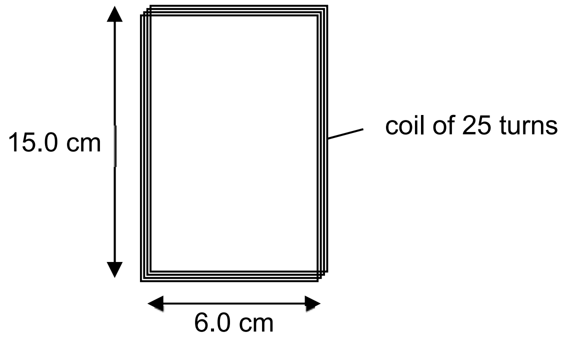

Fig. 8.1

(a) **(i)** Define magnetic flux.

………………………………………………………………………………………………...

……………………………………………………………………………………………….. [1]

(ii) A uniform magnetic field of flux density 25 mT is at right angles to the plane of the coil initially.

Calculate the magnetic flux through the coil at this instance.

magnetic flux =………………......Wb [1]

(b) **(i)** Fig. 8.2 shows the sinusoidal variation with time *t* of the magnetic flux density *B* that is passing through the rectangular coil in Fig. 8.1.

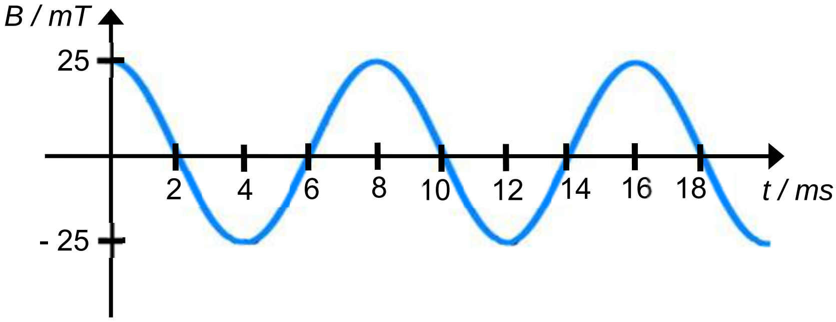

Fig. 8.2

Using Faraday's Law, explain why the variation in magnetic flux density passing through the coil as shown in Fig. 8.2 leads to a generation of sinusoidal alternating e.m.f.

……………………………………………………………………………………………………

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………………………………………………….. [3]

(ii) Show that the equation for the induced e.m.f. of the coil is

$$E = NAB_o \frac{2\pi}{T} \sin\left(\frac{2\pi}{T} t\right)$$

where *N* is the number of turns in the coil, *A* is the area of coil, B_0 is the maximum magnetic flux density and *T* is the period of the change in magnetic flux density.

[2]

(iii) Hence, determine the maximum magnitude of the induced e.m.f. of the coil.

maximum e.m.f. = ………………. V [2]

(iv) On Fig. 8.3, sketch a graph to show the variation with time of the e.m.f. induced in the coil from 0 ms to 16 ms. [2]

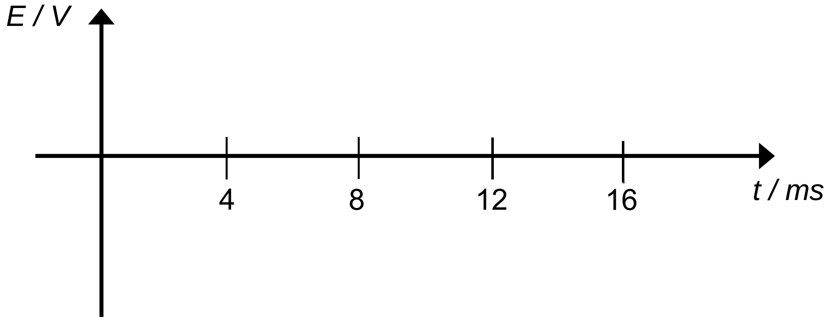

Fig. 8.3

(c) **(i)** The AC generated by the rectangular coil passes through a transformer. The primary coil of the ideal transformer has 15 turns.

Assuming that the transformer is ideal, calculate the number of turns in the secondary coil if the value of root-mean-square potential difference of the output at the secondary coil is 240 V.

number of turns =………………..... [3]

(ii) A non-ideal transformer has an input e.m.f. of 12 V while the secondary coil draws a current of 0.25 A with a potential difference of 240 V.

If the efficiency of the transformer is 81 %, determine the current in the primary coil.

current =………………..... A [2]

(d) In many distribution systems for electrical energy, the power is transmitted using alternating current at high voltages.

Suggest and explain an advantage, one in each case, for the use of

(i) alternating voltages,

....

....

.... [2]

(ii) high voltages.

....

....

.... [2]

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Class	Adm No

Candidate Name: ____________________

H

millennia institute

2018 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749 / 04**

Paper 4 Practical **20 September 2018**

Candidates answer on the Question Paper. **2 hours 30 minutes**

READ THESE INSTRUCTIONS FIRST

Write your name, class and admission number in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of the papers.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided in this question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
4	
TOTAL	

1 In this experiment, you will investigate the resistance of a wire coil.

(a) You have been provided with a coil as shown in Fig. 1.1.

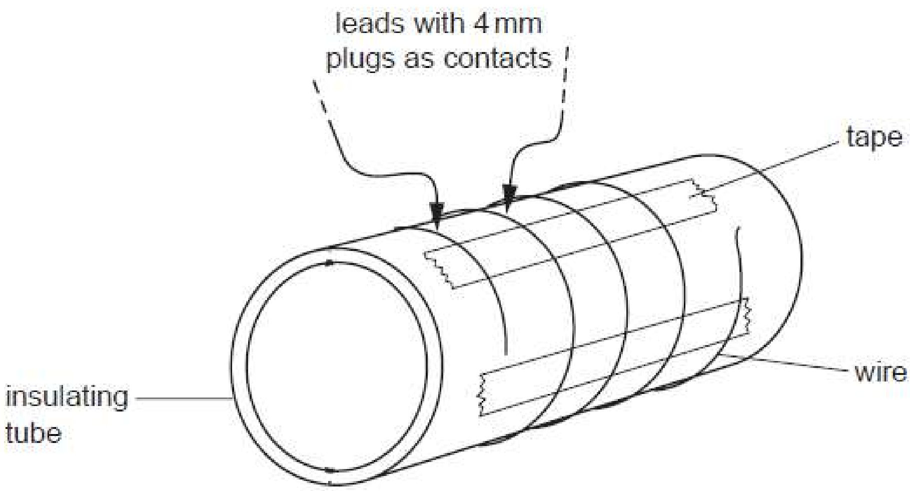


Fig. 1.1

(i) Measure and record the external diameter D of the insulating tube.

D = ………………….cm [1]

(ii) Use your value from **(a)(i)** to estimate the length x of wire in a single turn.

x = …………………………… [1]

(b) Set up the circuit as shown in Fig. 1.2 and hold the contacts against any two positions on the coil.

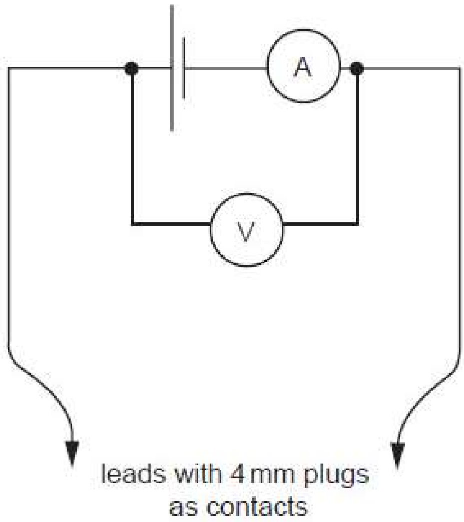


Fig. 1.2

(c) **(i)** Measure and record the number of turns *n* between the contacts, voltage *V* and current *I*.

n = ...

V = ...

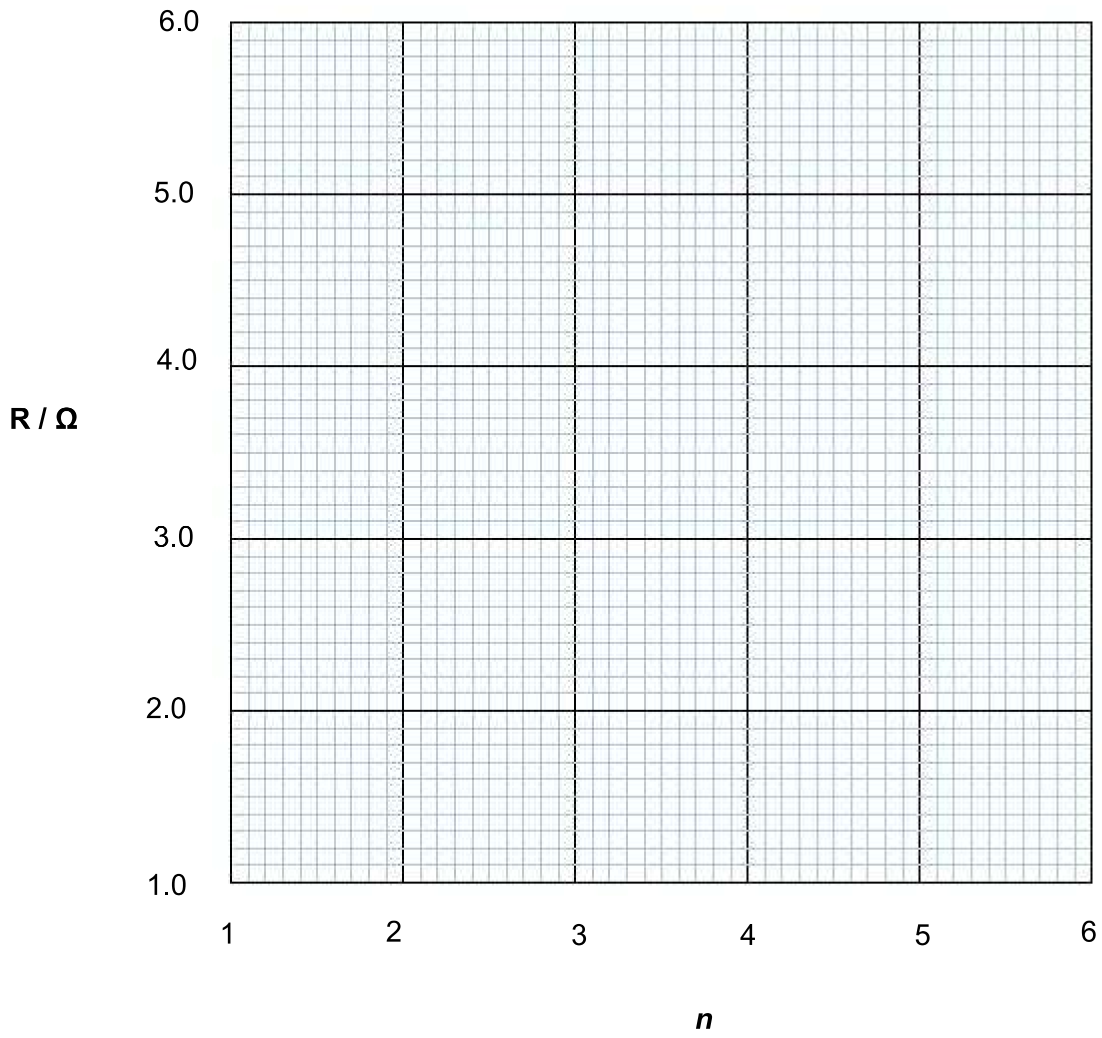
I = ... [2]

(ii) Determine the resistance R between the contacts.

R = ... [1]

(d) **(i)** Repeat **(c)(i)** and **(c)(ii)** for different values of *n*. Include your previous results. [3]

(ii) Plot a graph of R against *n* and draw the straight line of best fit. [1]



(iii) Determine the gradient, G of the line.

G = …………………… [1]

(e) Theory suggests that

$$G = \frac{4\rho x}{\pi d^2}$$

where ρ is the resistivity of the material of the wire and d is the diameter of the wire with a value of 0.28 mm. Determine a value for ρ.

ρ = …………………… Ω m [1]

[Total: 11 marks]

2 In this experiment, you will investigate the motion of a cylinder capped with a bottle cover on a wooden board.

(a) Measure and record the length *w* of the shorter side of the wooden board, as shown in Fig. 2.1.

Fig. 2.1

w = ... m [1]

(b) **(i)** Set up the wooden board as shown in Fig. 2.2.

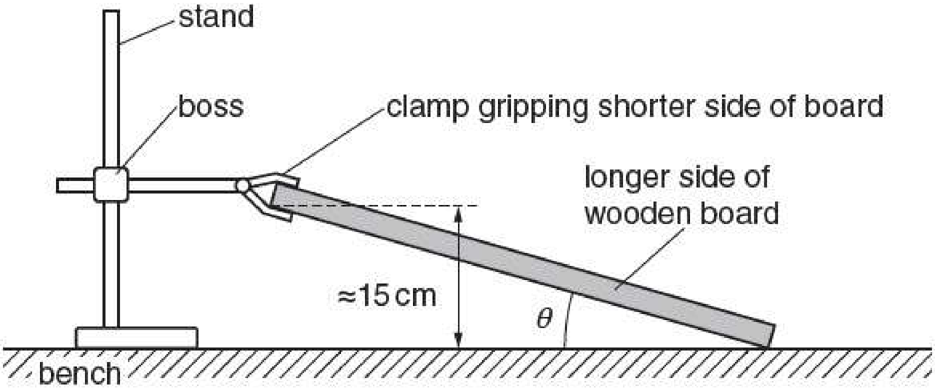


Fig. 2.2 (not to scale)

The distance between the bottom of the board and the bench should be approximately 15 cm.

(ii) Measure and record the angle θ as shown in Fig. 2.2.

θ = ... [1]

(iii) Estimate the percentage uncertainty in your value of θ.

percentage uncertainty = ... [1]

(c) (i) Place the cylinder with the bottle cover on the wooden board as shown in Fig. 2.3.

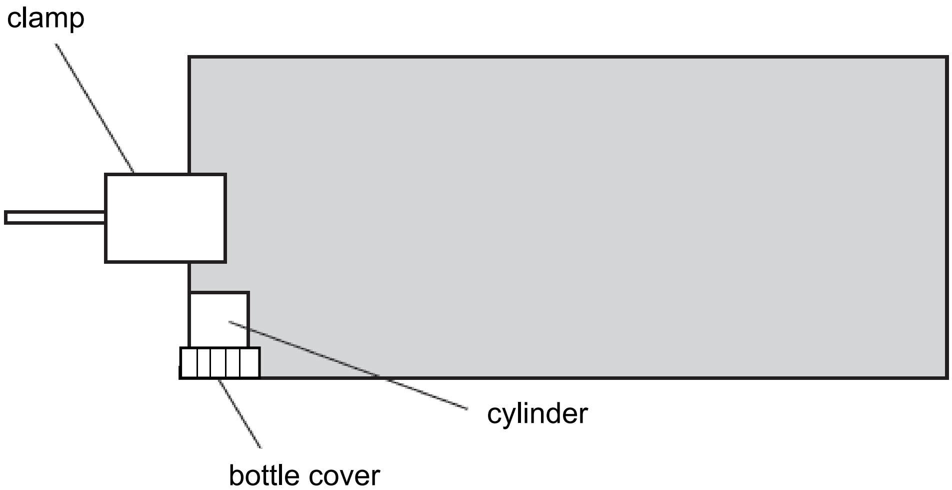


Fig. 2.3

The bottle cover of the cylinder should be aligned with the edges of the board as shown in Fig. 2.3.

(ii) Release the cylinder with the bottle cover. It will follow the path shown in Fig. 2.4.

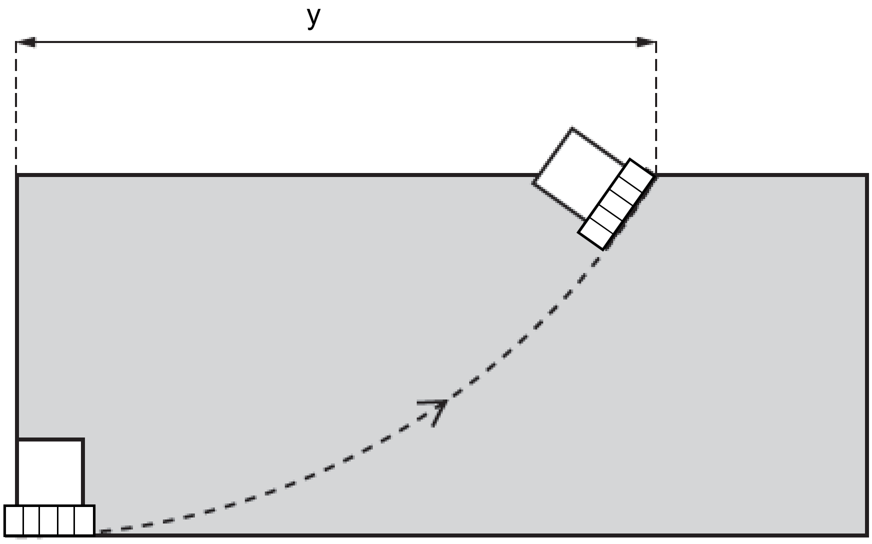


Fig. 2.4

(iii) Measure and record the distance, y, as shown in Fig. 2.4.

y = ……………….. m [2]

(iv) Calculate D using

$$D = \frac{w^2 + y^2}{w}.$$

D = ………………..m [1]

(d) **(i)** Increase the angle θ.

(ii) Repeat **(b)(ii)** and **(c)**.

θ = …………………

y = ………………….

D = ………………… [2]

(e) It is suggested that the relationship between D and θ is

$$D = k\sin\theta$$

where *k* is a constant.

(i) Using your data, calculate two values of *k*.

first value of *k* = ……………………

second value of *k* = …..………………. [1]

(ii) Explain whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your value in **(b)(iii)**.

…………………………………………………………………………………………...

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(f) **(i)** Suggest one significant source of error in this experiment.

…………………………………………………………………………………………...

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

(ii) Suggest an improvement that could be made to the experiment to address the error identified in **(f)(i)**. You may suggest the use of other apparatus or a different procedure.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….. [1]

[Total: 12 marks]

3 In this experiment, you will investigate different methods to determine the spring constant of a spring.

(a) Set up the experiment as shown in Fig. 3.1. Stabilise the base of the retort stand with the brick provided.

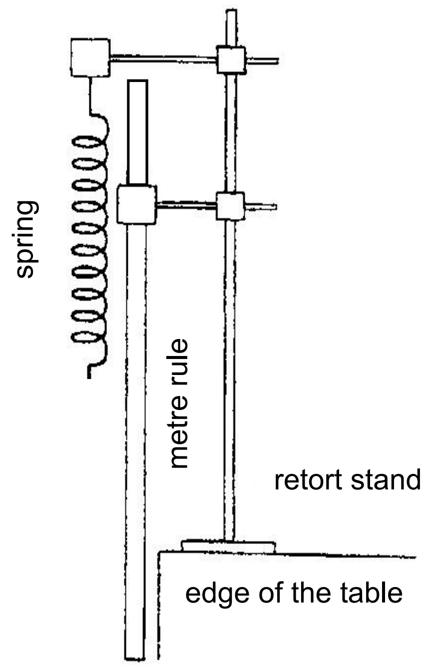


Fig. 3.1

(b) **(i)** Measure and record the natural length y_0 of the spring.

y_0 = …………………..

(ii) Attach the 450 g mass (inclusive of mass holder) to the free end of the spring and lower the mass gently until it reaches the equilibrium position. Measure and record the length y of the extended spring.

y = ………………….. [1]

(iii) Calculate the spring constant k_1 of the spring.

k_1 = ………………….. [2]

(c) **(i)** Displace the mass slightly downwards and release it so that it performs small oscillations. Determine the period T of the oscillations.

T = …………………… [2]

(ii) Repeat **(c)(i)** for different masses, m to obtain further values of T. [4]

(d) It is suggested that m and T are related by the expression

$$T^2 = \frac{4\pi^2}{k_2} m$$

where k_2 is the spring constant.

Plot a suitable graph to determine the value of k_2. [3]

k_2 = ……………………… [2]

(e) Suggest two possible reasons why there is a discrepancy in the results obtained in **(b)(iii)** and **(d)** when compared with the stated value of 450 g of mass.

………………………………………………………………………………………......

………………………………………………………………………………………......

………………………………………………………………………………………......

………………………………………………………………………………………...... [2]

(f) State and explain one effect on the experimental results in **(c)(ii)** if the oscillating mass is significantly greater than 450 g.

………………………………………………………………………………………......

………………………………………………………………………………………......

………………………………………………………………………………………......

………………………………………………………………………………………...... [1]

(g) The weight of an object in a space shuttle can be taken to be zero all the time when the space shuttle is orbiting above the Earth. However, the object still have mass, which can be measured to determine its weight on Earth.

If you were in the space shuttle, suggest a method to measure the mass of the object that experiences weightlessness using a spring-mass system.

Your account should include:

- your experimental set-up showing the equipment you would use
- details of the table of measurements
- how to determine the unknown mass of the object.

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…………………………………………………………………………………….. [3]

[Total: 20 marks]

4 A piano tuner utilises the phenomenon of beats to tune a piano string. Beat is an interference pattern between two sound waves of slightly different frequencies which are travelling in the same direction with the same wave speed.

The piano tuner will strike the piano string and tap a tuning fork at the same time. If the two sound sources – the piano string and tuning fork – produce detectable beats, then their frequencies are not identical. He will then hear a sound that alternatively interferes constructively and destructively.

He will then adjust the tension of the piano string and repeat the process until the beats can no longer be heard. At this point, he will hear the two sounds in unison. When the beats are no longer heard, the piano string is tuned to the frequency of the tuning fork. The process allows a piano tuner to match the strings' frequency to the frequency of a standardised set of tuning forks.

A student suggests that the resultant amplitude of the sound waves *R* depends on the amplitude *A* of sound sources and difference of the two sound frequencies *f* which is recorded over a period of time.

The relation between the resultant amplitude *R, A*, and *f* may be written in the form

$$R = kA^x f^y$$

where *k*, *x*, *y* are constants.

You may use any equipment usually found in a physics laboratory.

Design an experiment to determine the values of *k*, *x and y*.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account, you should pay particular attention to

(a) the identification and control of variables,

(b) the equipment you would use,

(c) the procedures to be followed,

(d) how the values of *k*, *x* and *y* are determined from your readings,

(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

[Total: 12 marks]

Diagram

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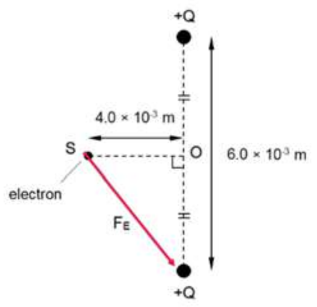
2018 PU3 H2 PHY PE2
MARK SCHEME

Paper 1 (30 Marks)

1.	A	Work, magnetic flux density
2.	C	True g = 9.81 mean <g>=9.242 – large systematic error - not accurate Δg = (9.25-9.23)/2=0.02 – small random error – precise
3.	B	At t=6 s, $S_A - S_B = 54 \rightarrow (15 \times 6) - (\frac{1}{2} \times a_B \times 6^2) = 54 \rightarrow a_B = 2.0$ m s^{-2} Let the time for B to catch up with A be T. $S_A = S_B$ 15 x T= ½ x 2 xT^2 $\rightarrow$ T= 15.0 s Hence additional time =15 – 6 = 9 s.
4.	D	The force on the racket must be equal and opposite to the force on the ball based on Newton's 3rd Law.
5.	A	Acceleration along slope: a = g sin 10^0 = 1.7 velocity of block after 3.0 s: v=u +at = 0 + 1.7(3) = 5.1 momentum p=mv = 1.8 x 5.1 = 9.18 kg m s^{-1}
6.	B	At maximum height, initial horizontal velocity = 50 cos 80^0 = 8.62 m s^{-1} At this instance when the missile explodes. Total vertical momentum is zero By conservation of momentum, total initial momentum (hor) = total final momentum of fragment Z (hor) 3M (8.62) = Mv (of fragment z) v = 25.9 m s^{-1}
7.	D	Resolving forces vertically 30 sin 30^0 + 20 Sin 10^0 = P_y P_y = 18.5 N Resolving forces horizontally -30 cos 30^0 + 20 cos 10^0 = P_x P_x = -6.28 N P= $(18.5^2 + 6.28^2)^{1/2}$ = 19.5 N
8.	D	Upthrust U= weight of fluid displaced U= (3000)(9.81)(1 x10^{-3}) = 29.4 N
9.	B	Principle of moments about X T sin60° x L = 50 x ½ L sin60° + 24 x L sin60^0 T = 25 + 24 = 49 N
10.	B	COE: gain in GPE by P + gain in KE by P and Q = Loss of GPE by Q 4 x 9.81 x 3sin30^0 + ½ (6+4) v^2 = 6 x 9.81 x 3sin40^0 v^2 = 10.9 v =3.31 m s^{-1}
11.	C	At constant speed, Driving force on boat = Total frictional drag X *P* = F v = XS
12.	A	At the top: net force = centripetal force $\frac{mv^2}{r} = mg + N$ Normal force N > 0 for ball to remain inside pail.

		$\frac{mv^2}{r} > mg$ $v > \sqrt{rg} = \sqrt{0.7 \text{ x} 9.81}$ = 2.6 m s^{-1}
13.	D	Earth's surface $g=GM/R^2$ Planet X surface $g_x = G(0.5M)/(0.5R)^2 = 2GM/R^2 = 2g$
14.	C	K.E. of a molecule = ½ m v_{rms}^2 KE = 3/2 kT T (in K) and KE are proportional to v_{rms}^2 When v increases to 2v New KE= ½ m $(2v)^2$ = ½ m v^2 x 4 = 1.6 x 10^{-23} x 4 =6.4 x 10^{-23} J New T= 573 x4 = 2292 K
15.	D	Bob has maximum PE at t = 0 means that object starts at either extreme positions at t = 0. Since acceleration is proportional to displacement, the acceleration should be either a positive maximum or negative maximum at t = 0.
16.	A	Max force = m a_{max} = m $\omega^2 x_0$ = 20 x 10^{-3} $(3\pi)^2$ (6 x 10^{-3}) = 1.07 x 10^{-2} ≈ 0.01 N
17.	D	Wavelength of wave λ =v/f =200 / 100 = 2.0 m Phase difference $\frac{x}{\lambda} = \frac{\phi}{2\pi}$ x= $\frac{\phi}{2\pi}\lambda = \frac{\frac{5\pi}{4}}{2\pi}$ x 2 = $\frac{5}{4} = 1.25m$
18.	C	Period T = *p* , frequency f=1/T=1/*p* , wavelength λ = *q* Wave speed v = fλ = *q/p*
19.	A	Malus law $I = I_0 \cos^2\theta$ ¼ M = M $\cos^2\theta$ cosθ =0.5 θ = 60^0
20.	A	String: Fundamental wavelength L=λ/2 Fundamental freq= v /λ =v/2L (v=fλ) Closed pipe: Fundamental wavelength L' =λ/4 Fundamental frequency= v /4L' Resonance: Driving frequency of string = fundamental freq of pipe v/2L = v /4L' L' = ½ L
21.	D	Fringe separation: $x = \frac{\lambda D}{a}$ Red light: $Z = \frac{(700 \text{ x } 10^{-9})(1.2)}{a}$ Blue light: $Z = \frac{(420 \text{ x } 10^{-9})(D)}{a}$ (same separation) D= (700/420) (1.2)= 2.00 m

22.	B	 $\theta = \tan^{-1}\left(\frac{4}{3}\right) = 53.13°$ $F_E = \frac{Qe}{4\pi\varepsilon_0 x^2} = \frac{(1.45\times10^{-15})(1.6\times10^{-19})}{4\pi\varepsilon_0(5.0\times10^{-3})^2} = 8.3444\times10^{-20}$ N $F_{net} = 2\times F_E \sin\theta = 1.3351\times10^{-19}$ N For circular motion, $F_{net} = ma_c$ $1.3351\times10^{-19} = \frac{(9.11\times10^{-31})v^2}{4.0\times10^{-3}}$ $v = 2.4\times10^4$ m s^{-1}
23	A	COE: E = IR + Ir E = (3.0)(1.0) + (3.0)r …………(1) E = (2.0)(2.0) + (2.0)r …………(2) Solving simultaneous equations: E = 6.0 V
24	B	To shift the balance point to near Y, only increasing the resistance of the variable resistor R will reduce the pd across wire XY (potential divider) Reducing Q will shift the point to near X. Varying P has no effect as current flow is zero at balance. Likewise, replacing the wire with one of higher resistance per unit length will shift the balance point towards X.
25	C	Currents in X and Y are in the same direction. X and Y will experience attractive force towards each other (i.e. force on Y is towards X). Currents in Y and Z are in opposite directions. Y and Z will experience repulsive force away from each other (i.e. force on Y is away from Z towards X). Resultant force is towards X.
26	B	Faraday's Law, the e.m.f. induced in the coil of wire rotating in a magnetic field is proportional to the rate of change of flux in the coil. $E = -\frac{d\phi}{dt} = -\frac{d(NBA)}{dt}$ Hence emf does not depend on resistance of coil.
27.	D	Given: peak voltage V and peak current across a resistor R Mean power of a sinusoidal cycle <p> = ½ peak power <p> = ½ x (V_{peak}^2 /R)
28.	C	Work done of electrons = energy of x-ray photons emitted (For max photon energy) eV = hf = hc/λ λ inversely proportional to potential difference When V is doubled, λ is halved.
30.	D	Background = 5 s^{-1} ; Actual Count rate C = 39 – 5 = 34 s^{-1} 20 minutes later (2 half-lives) Actual C=34 $(0.5)^2$ = 8.5 s^{-1} $C \propto 1/r^2$ $\frac{C_2}{C_1} = \frac{r_1^2}{r_2^2} = \left(\frac{40}{20}\right)^2 = 4$ Reading on detector C_2= 4 x 8.5 + **5** =39.0 s^{-1}

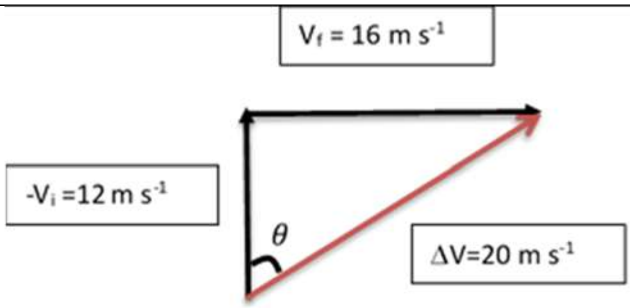
2018 Preliminary Exams

Pre-university 3 Paper 2

H2 Physics

9749

Mark Scheme

	Mark Scheme	
1 (a)		C0
	Change in Velocity = Final V – Initial V Magnitude = $\sqrt{(16^2 + 12^2)} = 20$	A1
	Direction, θ = tan^{-1} (16/12) = 53.13˚ = 53.1°	A1
(b)	This is because as different pressures are applied in closing the gap of the vernier calipers, the readings will be **inconsistent and fluctuate around the average reading.**	M1
	Random error.	A1
	OR	
	This is because the pressure applied can be consistently more than what is necessary hence resulting in a reading **consistently less than the actual reading.**	M1
	Systematic error.	A1
(c)(i)	Units of e = $\dfrac{units\ of\ P}{units\ of\ (\sigma A T^4)}$ = $\dfrac{W}{(Wm^{-2}K^{-4})(m^2)(K^4)}$	C1
	= 1 (OR No units)	A1
(ii)	e = $\dfrac{P}{\sigma A T^4}$ = $\dfrac{P}{\sigma(\pi \frac{d^2}{4})T^4}$	C1
	= $\dfrac{3}{(5.67x10^{-8})(\pi \frac{0.05^2}{4})500^4}$ = 0.4312 $\dfrac{\Delta e}{e} = \dfrac{\Delta P}{P} + 2\dfrac{\Delta d}{d} + 4\dfrac{\Delta T}{T} = \dfrac{0.2}{3} + 2(\dfrac{0.1}{5}) + \dfrac{4}{500}$	M1
	Δe = (0.115)(0.431) = 0.05 e ± Δe = (0.4312 ± 0.05) (mark is for calculating e and Δe correctly)	C1
	Therefore, e ± Δe = (0.43 ± 0.05) (Mark for correct decimal places)	A1

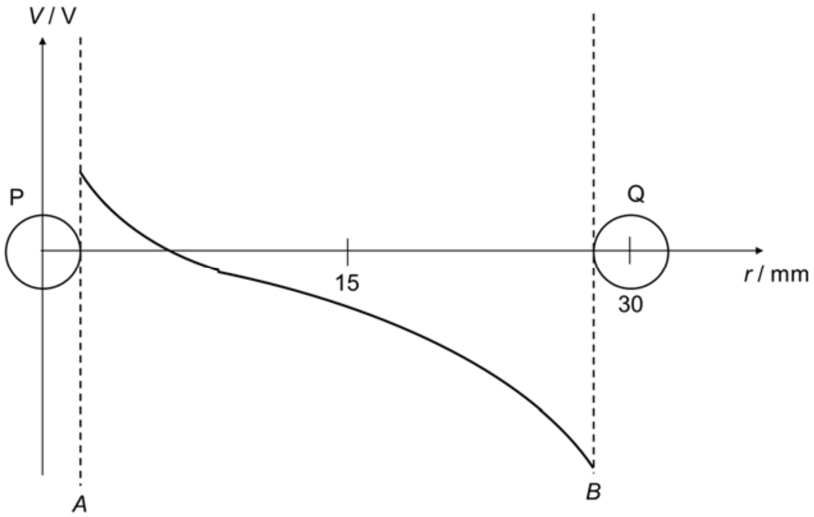
2	**Concepts tested:** Work, Energy, Power	
(a)	For an object mass *m*, moved by a force *F*, undergoing acceleration *a* through a displacement *s*, with initial velocity *u* and final velocity *v*. F = ma Work done = Fs = mas	M1
	$$v^2 = u^2 + 2as$$	M1
	$$Work\ done = mas = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Gain\ in\ kinetic\ energy$$ $$if\ u = 0, \quad work\ done = kinetic\ energy$$	M1
	$$E_k = \frac{1}{2}mv^2$$	A0
(b)(i)	EPE = ½ k s^2 = ½ (120)(10 × 10^{-2})^2 = 0.60 J	A1
(b)(ii)	Using COE: $KE_i + GPE_i + EPE_i = KE_f + GPE_f + EPE_f$ 0 + (2.0)(9.81)(Dsin40) + 0 = 0 + 0 + ½ (120)D^2	C1
	D = 0.210 m	A1
(b)(iii)	D will increase.	B1
(b)(iv)	Using COE: KE + GPE + EPE = KE + GPE + EPE + $W_{by\ box}$ 0 + (2.0)(9.81)(D'sin40) + 0 = 0 + 0 + ½ (120)D'^2 + (5.0)D'	C1
	D' = 0.127 m	A1

3 (a)	Simple harmonic motion is defined as the motion of an object whose acceleration *a* is **proportional** to its displacement *x* from a fixed point (equilibrium position)	B1
	and is always **directed towards** that fixed point.	B1
(b)(i)	forces in springs are $k(e + x)$ and $k(e - x)$ resultant = $k(e + x) - k(e - x)$ = $2kx$	C1
	By Newton's Second Law, F_{net} = ma	M1
	negative sign explained as the acceleration is always oppositely directed to the displacement. $a = -\frac{2kx}{m}$	M1 A0
(b)(ii)1	$\omega^2 = \frac{2k}{m}$ $(2\pi f)^2 = \frac{2 \cdot (120)}{0.900}$	

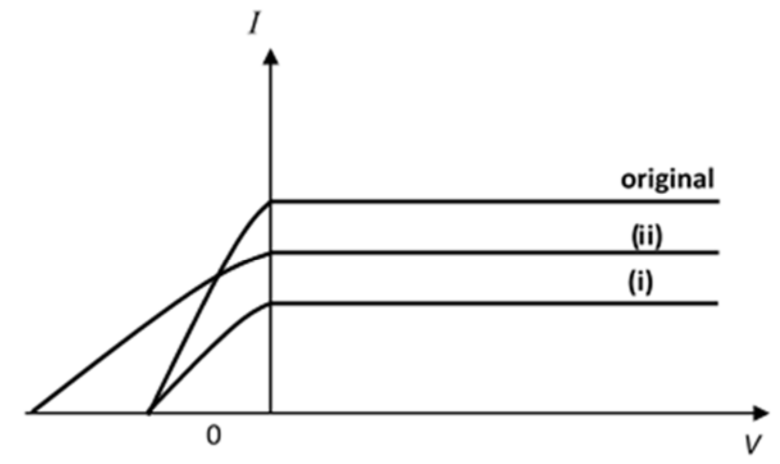
		C1
	f = 2.60 Hz	A1
(b)(ii)2	$a_0 = \omega^2 x_0 = 5.2$ $x_0 = \dfrac{5.2}{\frac{2\cdot(120)}{0.900}}$	C1
	$= 1.95 \times 10^{-2}$ m or 1.95 cm	A1
(b)(ii)3	Max kinetic energy = $\frac{1}{2} m(\omega x_0)^2$ $= \frac{1}{2}(0.900)\left(\frac{2\cdot(120)}{0.900}\right)(0.0195)^2$	M1
	= 0.0456 J	A1

4 (a)	Show understanding of how the stationary of one open and one close if formed via 2 diagrams	C1
	$\lambda_1 (\frac{n}{2}+\frac{1}{4}) = D$ $\lambda_2 (\frac{n+1}{2}+\frac{1}{4}) = D$ $\frac{343}{70.6}(\frac{n}{2}+\frac{1}{4}) = \frac{343}{90.8}(\frac{n}{2}+\frac{3}{4})$ $n = 3$	M1
	$D = 8.50\ m$	A1
(b)(i)	There are multiple lines of constructive interference apart from the middle line between the emitters.	M1
	The AGV might align itself to these other lines of constructive interference instead.	A1
(b)(ii)1	The intensity of signal is lower as the signal travels further spreads over a larger surface area as it is further from the AGV,	M1
	The signal is from Emitter B.	A1
(b)(ii)2	$\frac{\pi}{3}$ rad or 1.05 rad	B1
(b)(ii)3	Dist. from A to AGV = $\sqrt{7^2+50^2}$ = 50.488 m Dist. from B to AGV = $\sqrt{5^2+50^2}$ = 50.249m	C1
	$\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi} = \frac{\pi}{3(2\pi)}$ $\Delta x = \frac{\lambda}{6}$ Path Difference = $\frac{\lambda}{6}$ = 50.488 – 50.249 = 0.238m	

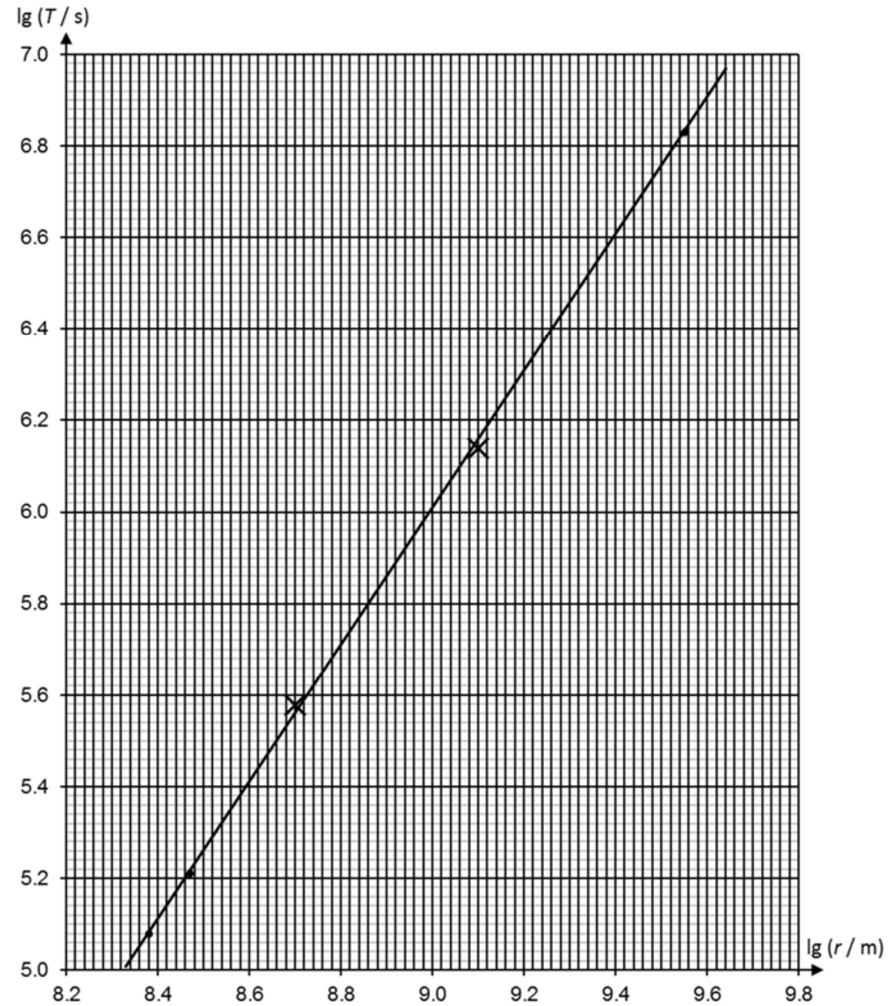
	λ = 1.429 m	C1
	$f = \dfrac{3 \times 10^8}{1.429}$	C1
	= 2.10 x 10^8 Hz (2 to 3 sf)	A1

5 (a)	Electric potential at a point is the **work done per unit positive charge to bring a small charge from infinity to that point**	B1
(b)(i)	 **[B1] shape: non-zero gradient** **[B1] r axis intercept nearer to P** **[B1] magnitude of V at B > magnitude of V at A**	
(b)(ii)1	Electric potential energy = $\dfrac{Q_P Q_Q}{4\pi\varepsilon_o r}$ $(9 \times 10^9)\dfrac{(+20 \times 10^{-6})(-40 \times 10^{-6})}{0.030}$	C1
	= – 240 J	A1
(b)(ii)2	By conservation of energy, $KE_i + EPE_i = KE_f + EPE_f$ $\frac{1}{2}(0.20 \times 10^{-3})u^2 + (-240) = 0$	C1
	u = 1550 m s^{-1}	A1

6 (a)	Max KE possessed by electron emitted from surface layer	B1
	Electrons below the surface loses energy along the way as they move towards surface, so less KE than KE_{max}	B1

(b)(i)	 ½ intensity ➔ current is reduced by half	B1
	same stopping potential	B1
(b)(ii)	wavelength is decreased but intensity is constant ➔ number of photons is reduced so current decreases. Can decrease below (i) current.	B1
	but higher stopping potential	B1
(b)(iii)1	$n = \frac{I}{e} = \frac{4.8 \times 10^{-10}}{1.6 \times 10^{-19}} = \mathbf{3.0 \times 10^9\ s^{-1}}$	A1
(b)(iii)2	The intensity, i $i = N(\frac{hc}{\lambda})(\frac{1}{A})$ where N = number of photons incident per second = 2500n	C1
	$i = \frac{Nhc}{A\lambda} = \frac{2500(3.0 \times 10^9)(6.63 \times 10^{-34})(3.0 \times 10^8)}{(24 \times 10^{-6})(410 \times 10^{-9})}$	C1
	= 0.152 W m^{-2}	A1

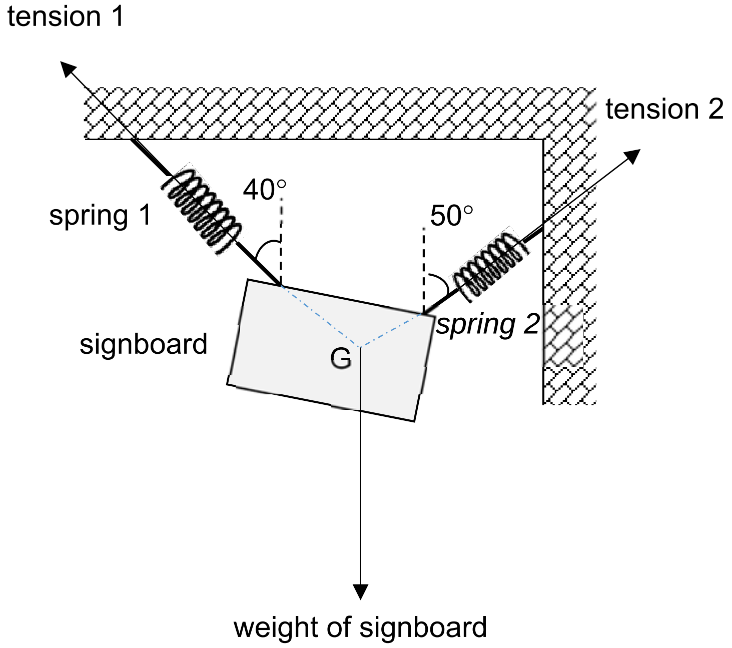
7 (a)	Let the mass of the satellite be *m*. According to Newton's Law of Gravitation, $F_G = \frac{GMm}{r^2}$ Centripetal force $F_c = mr\omega^2$	M1
	When the satellite orbits around the planet in a circular orbit, the gravitational force acting on the satellite by the planet **provides** the centripetal force for the orbit. $F_C = F_G$ $mr\omega^2 = \frac{GMm}{r^2}$	M1
	$mr(\frac{2\pi}{T})^2 = \frac{GMm}{r^2}$ $T^2 = \frac{4\pi^2}{GM} r^3$	M1 A0

(b)	Rhea: $$\lg T = \lg(0.380 \times 10^6) = 5.58$$ $$\lg r = \lg(0.501 \times 10^9) = 8.70$$	B1
	Titan: $$\lg T = \lg(1.38 \times 10^6) = 6.14$$ $$\lg r = \lg(1.26 \times 10^9) = 9.10$$	B1
(c)(i)	 correct plots	B1
(c)(ii)	Best fit line	B1
(d)(i)	Gradient $= \dfrac{6.60 - 5.11}{9.40 - 8.40}$	M1
	= 1.49 (within 1.47 – 1.53)	A1

(d)(ii)	The moons of Saturn which orbit in circular paths must obey $T^2 = \frac{4\pi^2}{GM} r^3$. Linearising this equation will lead to the equation $\lg T = \frac{1}{2}\lg\frac{4\pi^2}{GM} + \frac{3}{2}\lg r$.	M1
	On a graph showing the variation of $\lg T$ with $\lg r$, this equation is represented by a straight line with a **gradient of 1.5**. Since the gradient of the graph in Fig 7.2 is 1.49, the data supports he relationship in **(a)**.	A1
(e)	$\lg(3.78\times10^8) = 8.58$ From the graph, the corresponding value for $\lg T$ is 5.38.	C1
	Hence, $T = 10^{5.38} = 2.40\times10^5$ s	A1
(f)(i)	$\lg T = \frac{1}{2}\lg\frac{4\pi^2}{GM} + (1.49)\lg r$ Substituting (9.40, 6.60) $6.60 = \frac{1}{2}\lg\frac{4\pi^2}{(6.67\times10^{-11})M} + (1.49)(9.40)$	M1
	$M = 3.84\times10^{26}$ kg	A1
(f)(ii)	Multiple sets of readings were used in calculating the mass in **(f)(i)**, as compared to only one set used in the student's calculation. Using multiple sets of readings help to **reduce the random error** through the use of a best fit line.	B1
	This means that the student's calculation will be less accurate than the values calculated in **(f)(i)**.	B1
(f)(iii)	Using $T = 7.78\times10^4$ s, $\lg(7.78\times10^4) = \frac{1}{2}\lg\frac{4\pi^2}{(6.67\times10^{-11})(3.84\times10^{26})} + 1.49\lg r$ r = 1.79 ×10⁵ km	M1
	r is the orbital radius, which is the distance from the centre of Saturn to the centre of the Moon Mimas, not from the surface of Saturn.	M1
	Thus the report is inaccurate.	A1

2018 Millennia Institute

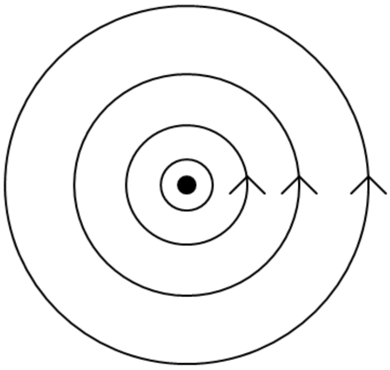
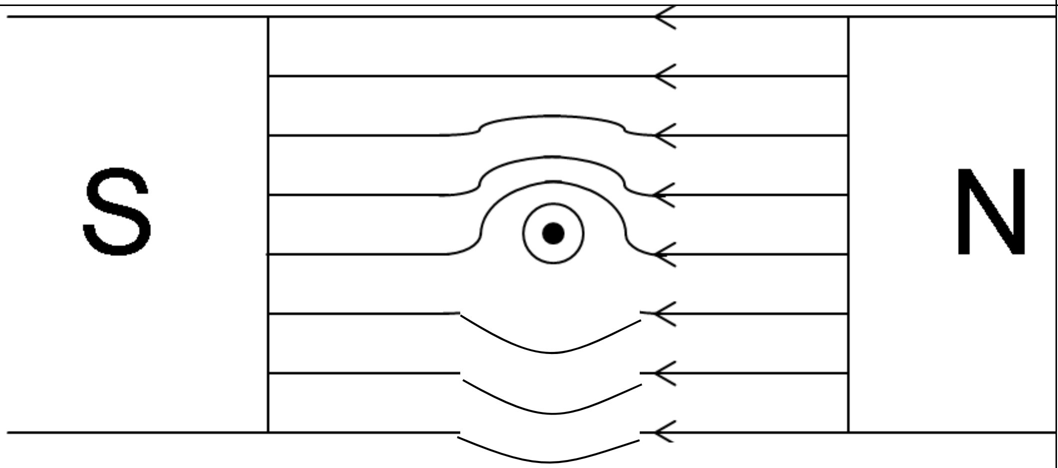
Suggested Answers for PU3 PRELIM Paper 3

1	(a)		Work done is the area under the graph of F-x graph, Area of trapezium = ½ $(F_1 + F_2)(x_2 - x_1)$ = ½ $(kx_1 + kx_2)(x_2 - x_1)$, = ½ $k(x_2^2 - x_1^2)$	M1 M1 A0
	(b)	(i)	There is <u>zero net force</u> acting on the signboard. There is <u>zero net torque about any axis</u> acting on the signboard.	B1 B1
		(ii)	 3 forces clearly labelled G is at the intersection of lines of action of *tension 1*, *tension 2* and *weight*	 B1 B1
		(iii)	Weight = $T_1 \cos 40° + T_2 \cos 50°$ = 300 cos 40° + 252 cos 50° = 391.8 = 390 N	C1 A1
		(iv)	Net force acting on the board immediately after released = 20 N Initial net acceleration = F/m = 20/(391.8/9.81) = 0.501 ≈ 0.50 m s^{-2} [allow ecf from (aiii)]	 C1 A1

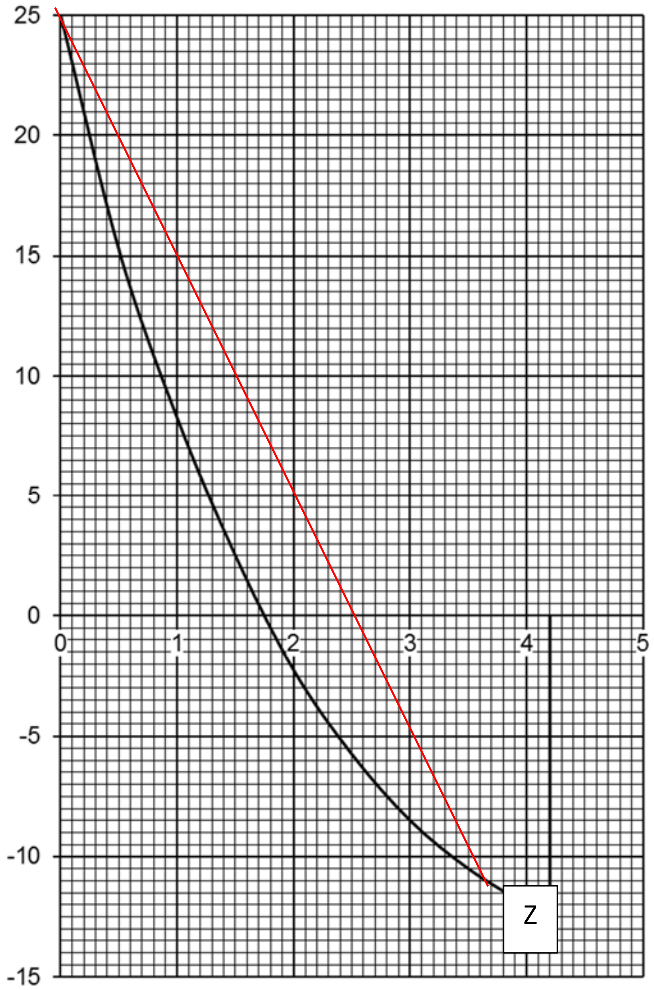
2	**(a)**	**(i)**		As r approaches zero, the potential drops lower. This corresponds to the potential near the larger mass. Therefore, r is measured from the Earth.	B1
		(ii)	**1**	It is the point where the gravitational field strength due to Earth is **equal and opposite** to the gravitational field strength due to the Moon or net gravitation field strength is zero	B1
			2	2.25×10^9 J = m x $\Delta \phi_{moon-max}$ = 1500 x $\Delta \phi_{moon-max}$ $\Delta \phi_{moon-max} = 1.5 \times 10^6$ J kg^{-1} $\phi_{max} - \phi_{moon} = \phi_{max} - (-2.5 \times 10^6) = 1.5 \times 10^6$ $\phi_{max} = -1.0 \times 10^6$ J kg^{-1} Allow ecf from (a)(i)	C1 A1
			3	$\frac{1}{2} m v^2 = m \times \Delta \phi_{earth-max}$ $\frac{1}{2} v^2 = \Delta \phi_{earth-max} = 61.5 \times 10^6$ v = 11 100 m s^{-1}	C1 A1
	(b)	**(i)**		Gravitational force provides the centripetal force. $\frac{GMm}{r^2} = mr(\frac{2\pi}{T})^2$ $\frac{6.67 \times 10^{-11} (5.98 \times 10^{24}) m}{r^2} = mr(\frac{2\pi}{27.4 \times 24 \times 3600})^2$ r = 384 000 km	M1 M1 A0
		(ii)		Linear speed = r ω $= 3.84 \times 10^8 \times \left(\frac{2\pi}{27.4 \times 24 \times 3600}\right)$ = 1020 m s^{-1}	C1 A1
	(c)	1.		Student A's explanation is not valid because both the astronaut and spacecraft will always have weight due to the force of gravity while they are orbiting around the Earth, even if it is small.	B1
		2.		Student B's claim is not correct. The centripetal force is the resultant force which is the force of gravity in this case. Both have different masses hence their centripetal force is different.	B1

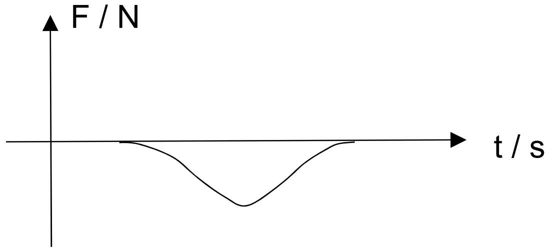
3	**(a)(i)**	Random motion of a large number of molecules in random velocity means no preferred direction of movement or the molecules move in different/all directions with a root-mean-square speed. Momentum is a **vector** given by the product of mass and velocity. Since the velocities cancel/ or idea of speed in opposite directions, the average velocity is zero and hence the average momentum of the gas molecules of same mass in a container is zero.	**M1** **A1**
	(a)(ii)	When the gas molecules hit the wall of the container, they rebound off the wall with the same speed and experiences **a rate of momentum change** normal to the wall**, implying there is force acting on the molecule by the wall.** Other molecules also have a momentum change normal to the wall when they strike and rebound. By **Newton's third law**, the molecules exert an equal and opposite force on the walls. Since there are a large number of molecules, the number of collisions at any instant in time is very large and practically constant, resulting in a constant gas pressure. The pressure on the walls of the container is the **average force per unit area exerted by the molecules on the walls of the container**.	**B1** **B1** **B1**
	(b)(i)	Increase in internal energy of a system is the sum of the work done on the system and heat supplied to the system.	**B1** **B1**
	(b)(ii)	**1.** Top surface moves down due to load acting a force on it, hence WD by load **on air** = mgx = 500 x 9.81 x 0.050 = 245 J Since system is well insulated, $Q_{to\ air}$ = 0 Using the first law of thermodynamics, Increase in U = $Q_{to\ air} + W_{on\ air}$ = 0 + 245 J = 245 J	 **C1** **C1** **A1**
		2. Using the equation of state for an ideal gas, $p_1V_1 = nRT_1$ ----- (1) $p_0V_0 = nRT_0$ ----- (2) (1) – (2): $p_1V_1 - p_0V_0 = nRT_1 - nRT_0 = nR\,(T_1 - T_0)$ Given that $U = \frac{3}{2}nRT,\ \ p_1V_1 - p_0V_0 = \frac{2}{3}\Delta U$ $p_1(1.947) - (101 \times 10^3)(2.000) = \frac{2}{3}(245)$ p_1 = 103.8 kPa = 104 kPa	 **C1** **C1** **A1**

4	**(a)**	$(5)(20) \neq (100)(1.2)$ R IS not inversely proportional to light intensity. Accept % difference, with justification	**M1** **A0**
	(b)	When the potential difference across the LDR is 7.0 V, **potential difference across the 1.2 kΩ resistor = 2.0 V** Using $V = IR$ $2.0 = (1.2 \times 10^3) I$ $I = 1.67 \times 10^{-3}$ A $R = \frac{V}{I} = \frac{7.0}{1.67 \times 10^{-3}}$ = 4200 Ω or 4.2 kΩ Alternatively, use potential divider method to determine R.	**C1** **C1** **A1**
	(c)	From **Fig. 4.1**, light intensity = 24 W m^{-2}	**A1**
	(d)	Length of strip, $\lambda = (10 \times 5.0 \times 10^{-3}) + (10.0 \times 10^{-3}) = 0.060\text{m}$ Using $R = \frac{\rho \lambda}{A}$, $\rho = \frac{RA}{l} = \frac{4200 \times 5.0 \times 10^{-7}}{0.060} = 3.5 \times 10^{-2}\ \Omega\,\text{m}$	**C1** **A1**

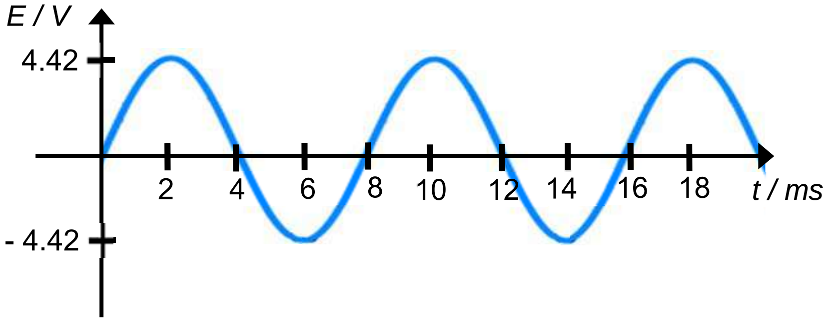
5	**(a)(i)**		
		Direction	**B1**
		At least 3 concentric circles with increasing spacing	**B1**
	(ii)		
		uniform field near magnet poles	**B1**
		stronger field on top, weaker field below	**B1**
	(b)	By Fleming's left hand rule, there is a downward force on wire by magnet.	**B1**
		By Newton's third law, there is an upward force on magnet by wire.	**B1**
		Since there is a upward force on magnet due to wire carrying current, there will be a decreased in balance reading.	**B1**

6	**(a)**	${}^{234}_{94}Pu \rightarrow {}^{234}_{92}U + {}^{4}_{2}He$	A1
	(b)(i)	Applying conservation of mass-energy, $(m_{Pu} - m_U - m_\alpha)\, c^2$ = energy released = E_k of the products $(238.0496 - m_U - 4.0026) \times (1.66 \times 10^{-27})\, c^2 = 5.649\times10^6 \times (1.60\times10^{-19})$ m_U = 234.0410 u (4 dp)	 C1 C1 A1
	(b)(ii)	By the principle of conservation of momentum $m_{Pu}v_{Pu} = m_u v_u + m_\alpha(-v_\alpha)$ $0 = m_U v_U - m_\alpha v_\alpha$ $\frac{v_\alpha}{v_U} = \frac{m_U}{m_\alpha}$ Ratio of E_k = $\frac{E_{K,\alpha}}{E_{K,U}} = \frac{\frac{1}{2}m_\alpha {v_\alpha}^2}{\frac{1}{2}m_U {v_U}^2}$ $= \frac{m_\alpha}{m_U}(\frac{m_U}{m_\alpha})^2$ $= \frac{m_U}{m_\alpha}$ $= \frac{234.0410}{4.0026}$ = 58.5	 M1 M1 A1 A0
	(b)(iii)	$E_{K,U} + E_{K,\alpha}$ = 5.649 MeV $\frac{1}{58.5} E_{K,\alpha} + E_{K,\alpha}$ = 5.649 MeV $E_{K,\alpha}$ = 5.55 MeV	 C1 A1
	(c)(i)	Radioactivity is a spontaneous process that is <u>not affected by any physical condition or the chemical combination</u> in which the nucleus exists. Hence, the properties of the nucleus remain unchanged no matter what chemical compound it is found in.	B1
	(c)(ii)	Alpha particles are readily absorbed by a sheet of paper and cannot penetrate the outer, protective layers of skin. Hence, plutonium is not a hazard as long as it remains outside the skin. When the dust is inhaled into the lungs, the emitted alpha particles deliver all their energy to sensitive internal tissues and may cause damage.	B1 B1

7	(a)	(i)	vertical height from ball launcher = (1x8) + ½ (0.8)(25-8) + 18 (0.1 x 0.5) = 15.7 m Veritical height from the level ground = 15.7 + 0.5 = 16.2 m	M1 A1
		(ii)	Acceleration at t = 1.0 s = gradient at t = 1.0s = -12.1 m s^{-2} Using F2L, mg + Fair = ma Fair = ma – mg = 0.320 (12.1 – 9.81) = 0.733 N	M1 M1 A1
		(iii) 1.	 Gradient = 9.8 m s^{-2} Negative gradient	A1 A1
		2.	At t = 1.0 s, vertical velocity = 15.25 m s^{-1} since horiztonal velocity = 12.0 m s^{-1}	M1

			Resultant velocity = $\sqrt{15.25^2 + 12^2}$ = 19.4 m s^{-1}		A1
	(b)	**(i)**	Consider a collision that occurs when X collides with Y in a straight line. By **Newton's second law** the change in momentum for X, $\Delta p_x = F_{YX}*\Delta t$, where F_{YX} is the force Y exerts on X and Δt is the duration the force is exerted while the change in momentum for Y, $\Delta p_Y = F_{XY}*\Delta t$, where F_{XY} is the force X exerts on Y. By **Newton's third law**, $F_{YX} = - F_{XY}$ since they are an action-reaction pair. Hence, $\Delta p_X = - \Delta p_B$. This implies $p_{XF} - p_{XI} = - (p_{YF} - p_{YI})$, where p_{XF} is the final momentum of X, p_{XI} is the initial momentum of X, p_{YF} is the final momentum of Y and p_{YI} is the initial momentum of Y. Rearranging, $p_{XI} + p_{YI} = p_{XF} + p_{YF}$. This implies the **total initial momentum is the same as the total final momentum if no external force acts on this system**.		B1 B1 B1
		(ii)	**1.**	$m_xu_x + m_yu_y = m_xv_x + m_yv_y$ $50(4.5) + m_y(-2.8) = 50(-1.8) + m_y(1.4)$ $m_y(1.4+2.8) = 50(4.5+1.8)$ m_y = 75 g = 0.075 kg	M1 C1 A1
			2.	total initial kinetic energy/KE not equal to the total final kinetic energy/KE or relative speed of approach is not equal to relative speed of separation, showing calculation – e.g. relative speed of approach = 4.5 – (-2.8) = 7.3 while relative speed of separation = 1.4 – (-1.8) = 3.2 so not elastic or is inelastic	M1 A1
		(iii)	**1.**	 According to Newton's 3[rd] Law, the forces exerted on the bodies by each other are equal in magnitude and act in opposite directions.	B1 B1
			2.	Change in momentum of Y or impulse on Y	A1

8	(a)	(i)	The **<u>product</u>** of the **<u>magnetic flux density</u>** **<u>normal</u>** to the surface and the **<u>area of the surface</u>**.	B1
		(ii)	$\phi = BA =$ 0.025×0.150×0.060 $\phi =$ 2.25 x 10^{-4} Wb (also accept -2.25 x 10^{-4})	A1
	(b)	(i)	As the sinusoidal magnetic flux density passing through the coil is changing, the **<u>magnetic flux linkage</u>** through the coil is **<u>changing periodically</u>**. **<u>By Faraday's law</u>**, an **<u>e.m.f. is induced</u>** or generated in the coil. At times, the magnetic flux density is increasing while at other times it is decreasing. The **<u>polarity of the induced e.m.f. would be different</u>** when **<u>magnetic flux density increases</u>** as **<u>compared</u>** to the polarity of the e.m.f. as **<u>magnetic flux density decreases</u>**, thus generating an alternating current.	B1 B1 B1
		(ii)	From Fig. 8.2, the magnetic flux density is given by, $B = B_0 \cos\left(\frac{2\pi}{T}t\right)$ By Faraday's law and Lenz' Law, the e.m.f. is given by $E = -\frac{d\Phi}{dt}$, where $\mathbf{\Phi}$ is the magnetic flux linkage. $E = -\frac{dNBA}{dt}$ $E = -NA\frac{dB}{dt} = -NA\frac{d}{dt}B_0\cos\left(\frac{2\pi}{T}t\right)$ Therefore, $E = NAB_0\frac{2\pi}{T}\sin\left(\frac{2\pi}{T}t\right)$	M1 M1 A0
		(iii)	$E = NAB_0\frac{2\pi}{T}\sin\left(\frac{2\pi}{T}t\right)$ Since the maximum magnitude of induced e.m.f. is when $\sin\left(\frac{2\pi}{T}t\right) = 1$, $E_{max} = NAB_0\frac{2\pi}{T} = 25 \times 0.150 \times 0.060 \times 0.025 \times \frac{2\pi}{0.008}$ $= 4.42$ V	C1 A1

		(iii)	 sine function max E and period	 **A1** **A1**
	(c)	**(i)**	Root-mean-square voltage of input, $V_{rms} = \frac{V_0}{\sqrt{2}}$ $V_{rms} = \frac{4.42}{\sqrt{2}} = V_P$ $\frac{N_S}{N_P} = \frac{V_S}{V_P}$ No. of turns in sec coil, $N_S = \frac{V_S}{V_P} N_P = \frac{240}{\frac{4.42}{\sqrt{2}}} \times 15 = \frac{240\sqrt{2}}{4.42} \times 15$ $N_S = 1150$	**C1** **M1** **A1**
		(ii)	For efficiency, $\frac{\text{Power output}}{\text{Power input}} \times 100\%$ $= \frac{\text{Power in secondary coil}}{\text{Power in primary coil}} \times 100\%$ $= \frac{0.25 \times 240}{12I} \times 100\% = 81\%$ Therefore, $I = 6.17$A	**C1** **A1**
	(d)	**(i)**	can change (output) voltage efficiently or to suit different consumers/appliances by using transformers	**B1** **B1**
		(ii)	for same power, current is smaller	**B1**

			less heating in cables/wires or thinner cables possible or less voltage loss in cables	**B1**

PU3 EYE Practical P4 Mark Scheme

Question		Answer	Code	Marks
1ai	MMO	Raw value(s) of d recorded to 0.1 mm. Repeated readings for d.	M1	1
aii	ACE	Correct calculated value of x correct.	A1	1
ci	MMO	First value for n. First value for V in range 0.5 < V < 2.0. First value for I with I < 1.7 A (unit required).	 M2 M3	 1 1
cii	ACE	Correct calculation of R	A2	1
di	MMO	Table 6 sets of data without intervention -1 if less than 6 sets OR -1 if significant help from Supervisor	 M4	 1
	PDO	Table of results: Raw data ALL Raw data consistent in no. of decimal places	P1	1
	PDO	Table of results: Calculated quantities ALL calculated values given to appropriate SF, that reflects the no. of SF in Raw data	P2	1
dii	PDO	Graph: plotting of points ALL observations must be plotted correctly, to accuracy of ½ a small square Graph: Trend line Line of best fit – judge by scatter of points about the line (There must be a fair scatter on either side of line)	P3	1
diii	ACE	Interpretation of graph - gradient ✓ Gradient triangle must be larger than half of line ✓ Read-offs are accurate to ½ a small square ✓ Check method = $\Delta y/\Delta x$	A3	1
e	ACE	Calculate constant	A4	1
			TOTAL	**11**

Question		Answer	Code	Marks
2a	MMO	All values of w to nearest mm, with final value in range 0.200 m to 0.300 m.	M1	1
bii	MMO	Value(s) of θ to the nearest degree. Final value < 45° with unit.	M2	1
biii	ACE	Percentage uncertainty in θ based on an absolute uncertainty in range 1° to 3°. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	A1	1
ciii	MMO	Value of y in range 0.200 m to 0.500 m. Evidence of repeat readings.	M3 M4	1 1
civ	ACE	Correct calculation of D.	A2	1
dii	MMO	Second value of θ. Second value of y. Quality: Second value of y > first value of y (if θ2 > θ1).	 M5 M6	 1 1
ei	ACE	Two values of k calculated correctly.	A3	1
eii	ACE	Sensible comment relating to the calculated values of k, testing against the criterion in (b)(iii).	A4	1
gi	ACE	Difficulty with starting position e.g. starting position of container not parallel to edge Difficult to measure y or locate position where container moves off edge with reason e.g. moves off edge too fast/short time to observe moving off edge Two readings not enough to draw a conclusion	A5	1
gii	ACE	Improved method for initial placement or release e.g. use of block with detail (aligned with side) Improved method for measuring y e.g. use marker or scale on board/use video and playback with scale/ paint on cap/ calibrate board Take more readings and plot a graph/ obtain more k values and compare	A6	1
			TOTAL	**12**

Question		Answer	Code	Marks
3(b)(i)	MMO	Value of y_o to 1 d.p. in cm		
(b)(ii)		Value of y to 1 d.p. in cm	M1	1
(b)(iii)	MMO ACE	$x = y_o - y$ calculated, $F = k_1x$, Value of k to appropriate no. of s.f. (2-3 s.f.) with unit	M2 A1	1 1
(c)(i)	MMO PDO	Time > 20.0 s, with repetition Period T calculated to the appropriate number of s.f. with unit	M3 P1	1 1
(c)(ii)	MMO	*Set up apparatus and follow of written instructions* • Award 1 mark if the student has successfully collected 6 or more sets of data without assistance/intervention.	M4	1
	PDO	Layout: column headings (Raw data & Calculated quantities) Each column heading must contain a quantity and a unit, separated by '/'	P2	1
	PDO	Table of results: Calculated quantities ALL calculated values given to appropriate SF, that reflects the no. of SF in Raw data	P3	1
	ACE	Table of results: Calculation in table correct calculations in table	A2	1
(d)	PDO	Axes must be labelled with quantity which is being plotted. Sensible scales must be used. Plotted points occupy at least half the graph grid in both x and y directions.	P4	1
	PDO	Graph: plotting of points ALL observations must be plotted correctly, to accuracy of ½ a small square	P5	1
	PDO	Graph: Trend line Line of best fit – judge by scatter of points about the line (There must be a fair scatter on either side of line)	P6	1
	ACE	Interpretation of graph - gradient ✓ Gradient triangle must be larger than half of line ✓ Read-offs are accurate to ½ a small square ✓ Check method = $\Delta y/\Delta x$	A3	1
	ACE	Drawing conclusion – calculation of k_2 Value of k_2 calculated correctly with correct unit	A4	1
(e)	ACE	Any two of the following: -Uncertainty in measurement of extension leading to inaccurate *k* -Spring may not obey Hooke's law hence affect *k* -Period *T* inaccurate due to human errors	A5 A6	1 1
(f)	ACE	A heavier mass will cause the oscillations to be slower, yielding a smaller percentage uncertainty in the period. However, it may extend the spring to the point where Hooke's Law is not obeyed.	A7	1
(g)	Planning	Acceptable experimental set-up attached to wall of shuttle *details of the table of measurement* IV – mass, m, DV – period, T. Calculate T^2. Collect another 5 sets of data. Plot T^2 vs m. Constant – free fall *how to determine the mass of the object* from the T of unknown mass, calculate T^2 and determine m by reading from the T^2 vs m graph	PL1 PL2 PL3	1 1 1
			TOTAL	**20**

Question 4

Annotation	Rubrics	Max	Actual
Diagram (D)	**(D1)** Labelled apparatus in diagram correctly **(D2)** Diagram showing a workable setup. Use of signal generator connected to loud speakers (2 sources), 3 microphones connected to CRO to detect the resultant wave (detect R) and amplitudes A of both sources.	1 1	
Basic Procedure (BP)	**(BP1)** By varying frequencies of the sources and amplitudes <u>independently</u>, obtain and <u>measure</u> different values of resultant amplitude R to obtain at least <u>6 sets of readings</u> <u>each</u>. E.g., DV (R) vs IV (f or A)	1	
Control (C)	**(C1)** Example of controlled variables: maintain the distance of the microphone from the loudspeaker which detects R and distances between 2 loudspeakers. Give at least two examples for 1 mark.	1	
Methods of Measurement (M)	**(M1)** keeping A of sound wave constant (same loudness), vary the frequencies of the sources (by adjusting the <u>frequencies of the signal generator</u>). Record the difference between the two frequencies, f. *State measuring instruments clearly.* **(M2)** Keeping f constant, vary the amplitude of the both sources (by <u>changing the loudness of the loudspeaker</u>), but increase the loudness by the same amount. *State measuring instruments clearly.* **(M3)** State what to vary while keeping A or f constant, so that 6 sets of readings can be obtained for each case.	1 1 1	
Analysis (A)	**(A1)** Plot a suitable graph of lg *R* vs lg *f* (keeping <u>*A* constant</u>). gradient = *y* ; vertical-intercept = lg k A^x Plot a suitable graph of lg *R* vs lg A (keeping <u>*f* constant</u>). gradient = *x* ; vertical-intercept = lg k f^y **(A2)** Obtain k by taking average of k values from (A1) and (A2).	1 1	
Reliability of Experiment (R) **<u>Method</u>** and **<u>reason</u>**	**(R1)** No other sound that may interfere with the experiment. **(R2)** <u>Using different *A* and f_D</u> to obtain several <u>*x*, *y*, and/or *k*</u>. Find <u>average</u> of the constants. **(R3)** State clearly how f is collected.	Max 3	
	Total	**12**	

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/01

Paper 1 Multiple Choice **20 September 2018**

1 hour

Additional Materials: Optical Mark Sheet (OMS)

	Class	Reg No
Candidate Name: ______________________________		

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Answer Sheet.

In the Index Number section, shade your index number using the first two spaces (e.g. index number 5 should be entered as "05"). Ignore the remaining numbers and letters.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

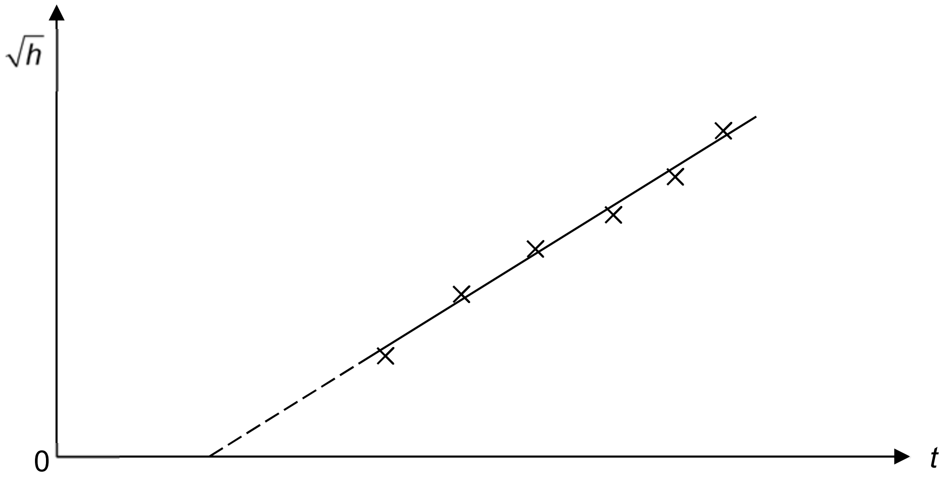
Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T /K	=	T /°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translation kinetic energy an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\, \omega\sqrt{x_o^{\,2} - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 A student measures the time t for a ball to fall from rest through a vertical distance h. The student plots his results and best-fit line in the graph shown.



Which of the following statement is true?

A The result is accurate as the line is close to the data points

B The result is not accurate as the line does not pass through the origin

C Data is precise as there are equal number of data points on both sides of the line

D Data is precise as the data points do not deviate from the line

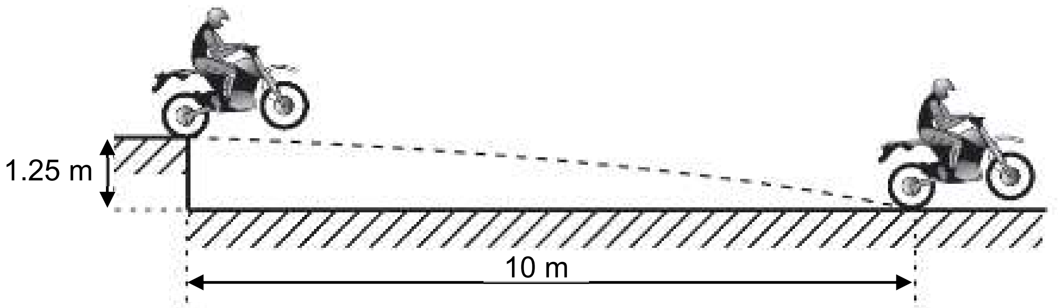
2 The experimental measurement of the heat capacity of a solid as a function of temperature T is found to fit the following expression

$$C = \alpha T^3 + \beta T$$

What are the possible base units of α and β?

	units of α	units of β
A	kg m^2 s^{-1} K^{-4}	kg m^2 s^{-1} K^{-1}
B	kg^2 m s^{-2} K^{-3}	kg^2 m s^{-2} K^{-2}
C	kg m^2 s^{-2} K^{-4}	kg m^2 s^{-2} K^{-2}
D	kg^2 m s^{-2} K^{-3}	kg^2 m s^{-2} K^{-1}

3 A motorcycle stunt-rider moving horizontally takes off from a point 1.25 m above the ground, landing 10 m away as shown in the diagram.



What was the speed at take-off?

A 5 m s^{-1} **B** 10 m s^{-1} **C** 15 m s^{-1} **D** 20 m s^{-1}

4 A body of mass 3.0 kg is thrown with a velocity of 20 m s^{-1} at an angle of 60° above horizontal. It reaches the maximum height after 1.8 s. Air resistance is negligible.

What is the rate of change of momentum of the body at the maximum height?

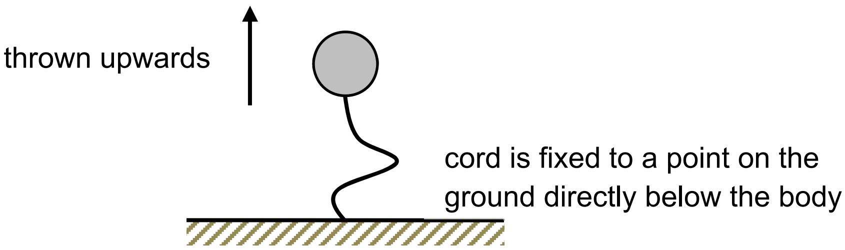
A zero **B** 17 kg m s^{-2} **C** 29 kg m s^{-2} **D** 33 kg m s^{-2}

5 A body P of mass 2.0 kg and moving with velocity +3.0 m s^{-1} makes a head-on inelastic collision with a stationary body Q of mass 4.0 kg.

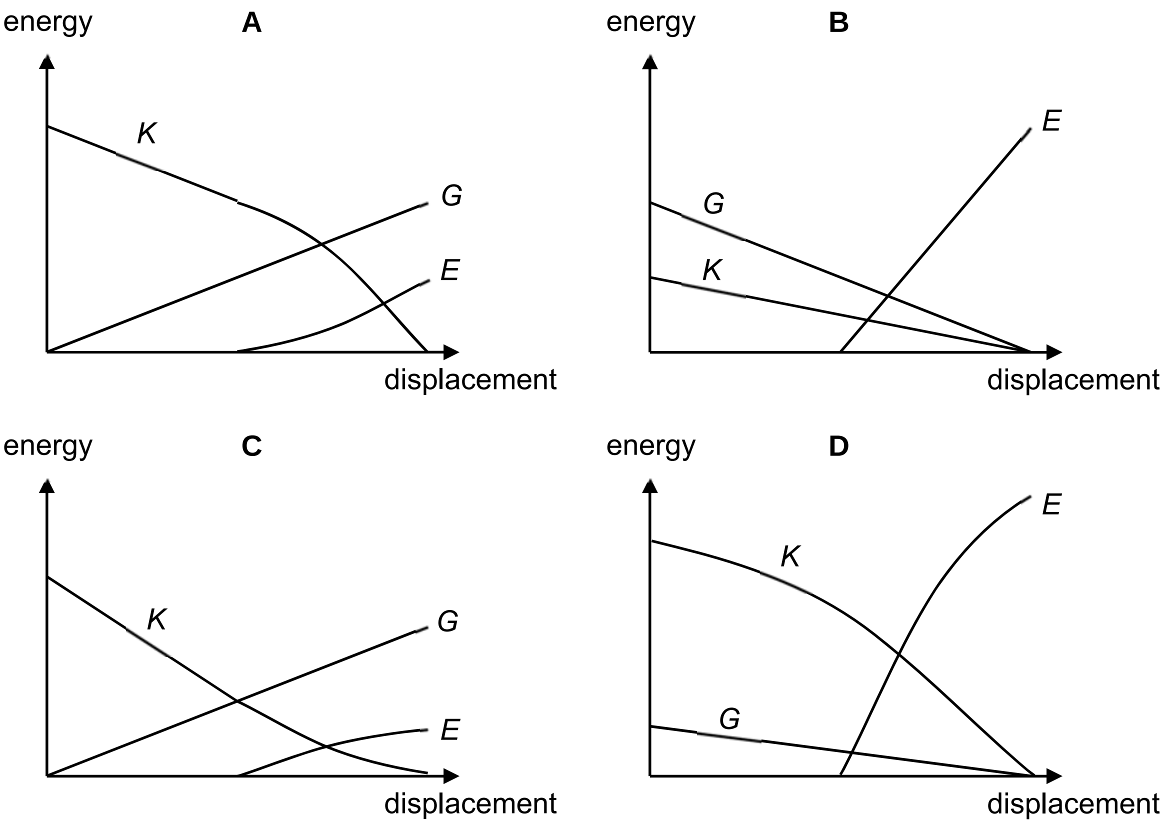
Which of the following could be the velocities of P and Q after the collision?

	velocity of P after collision	velocity of Q after collision
A	+0.5 m s^{-1}	+0.5 m s^{-1}
B	+0.0 m s^{-1}	+3.0 m s^{-1}
C	–1.0 m s^{-1}	+2.0 m s^{-1}
D	–0.6 m s^{-1}	+1.8 m s^{-1}

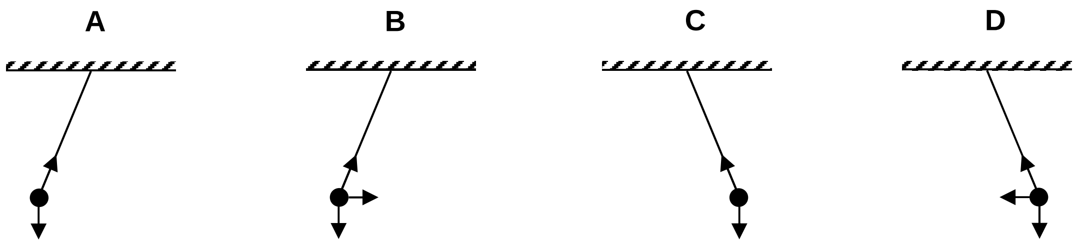
6 The diagram shows a body attached to an elastic cord being thrown vertically upwards. Initially the cord is unstretched but after a while it becomes stretched. The cord obeys Hooke's law and air resistance is ignored.



Which of the following shows the variation with displacement of the kinetic energy *K*, gravitational potential energy *G* and elastic potential energy *E*?



7 A passenger is sitting in a railway carriage facing in the direction in which the train is travelling. A pendulum hangs down in front of him from the carriage roof. The train travels along a circular arc bending to the left. Which one of the following diagrams shows the position of the pendulum as seen by the passenger, and the directions of the forces acting on it?



8 In two widely-separated planetary systems whose suns have masses S_1 and S_2, planet P_1 of mass M_1 (orbiting sun S_1) and planet P_2 of mass M_2 (orbiting sun S_2) are observed to have circular orbits of equal radii. If P_1 completes an orbit in half the time taken by P_2, it may be deduced that

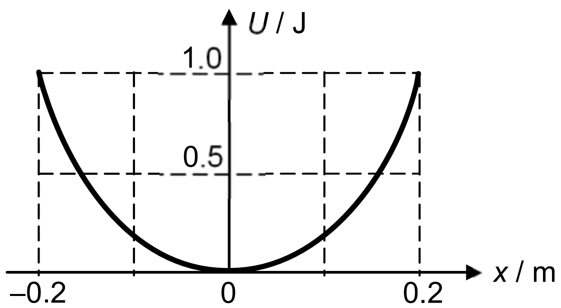
A $S_1 = S_2$ and $M_1 = 0.25\ M_2$

B $S_1 = 4S_2$ only

C $S_1 = 4S_2$ and $M_1 = M_2$

D $S_1 = 0.25\ S_2$ only

9 A particle of mass 4.0 kg moves in simple harmonic motion. Its potential energy U varies with position x as shown in the figure below.



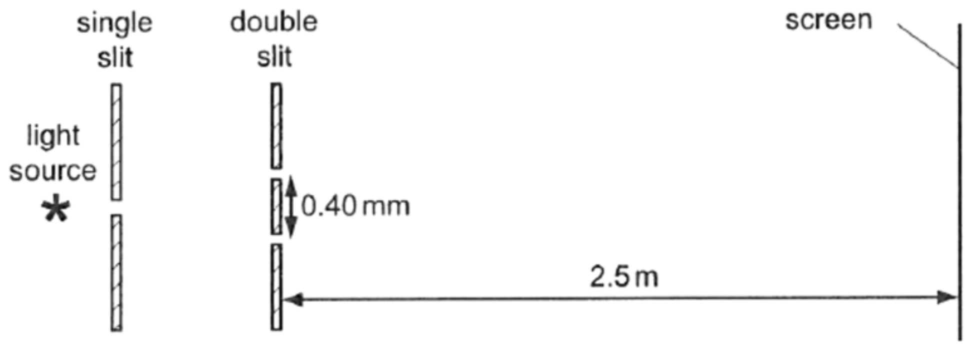
What is the period of oscillation of the mass?

A $\frac{2\pi}{25}$ s **B** $\frac{2\pi\sqrt{2}}{5}$ s **C** $\frac{8\pi}{25}$ s **D** $\frac{4\pi}{5}$ s

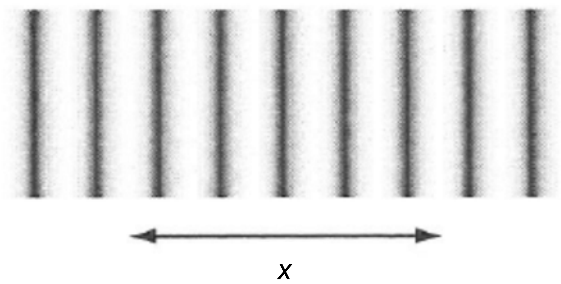
10 A toy car moving along a horizontal plane in simple harmonic motion starts from the amplitude at time $t = 0$ s. If the amplitude of its motion is 5.0 cm and frequency is 2.0 Hz, the magnitude of the acceleration of the toy car at 1.7 s is

A 0.25 m s^{-2} **B** 0.51 m s^{-2} **C** 6.4 m s^{-2} **D** 7.4 m s^{-2}

11 A two source interference experiment is set up as shown.



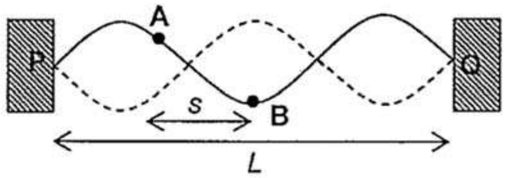
The source emits light of wavelength 600 nm. The interference pattern on the screen is shown below.



What is the distance x?

A 3.8×10^{-4} m **B** 1.9×10^{-3} m **C** 3.8×10^{-3} m **D** 1.9×10^{-2} m

12 A guitar string of length L is stretched between two fixed points **P** and **Q** and made to vibrate transversely as shown.



Two particles **A** and **B** on the string are separated by a distance s. The maximum kinetic energies of **A** and **B** are K_A and K_B respectively.

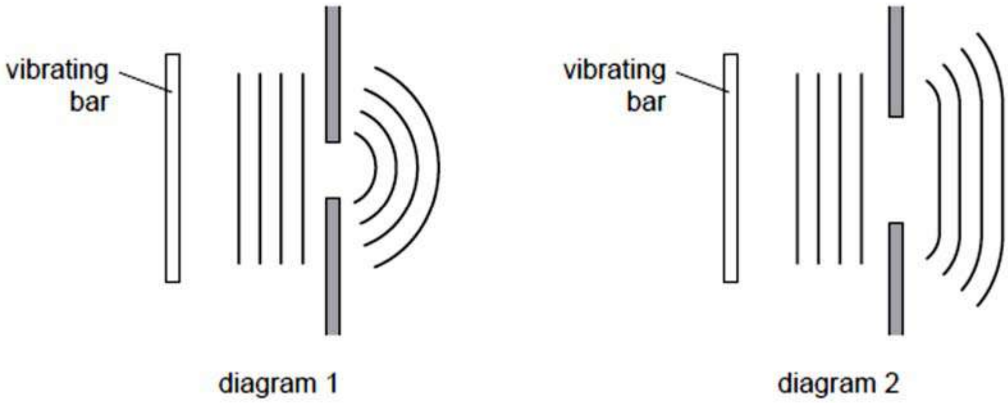
Which of the following gives the correct phase difference and maximum kinetic energies of the particles?

	Phase difference	Maximum kinetic energy
A	$\left(\frac{3s}{2L}\right)\times 360°$	$K_A < K_B$
B	$\left(\frac{3s}{2L}\right)\times 360°$	same
C	180°	$K_A < K_B$
D	180°	same

13 Diagram 1 shows a ripple tank experiment in which plane waves are diffracted through a narrow slit in a metal sheet.

Diagram 2 shows the same tank with a slit of greater width.

In each case, the pattern of the waves incident on the slit and the emergent pattern are shown.



Which action would cause the waves in diagram 1 to produce an emergent pattern closer to that shown in diagram 2?

A Increasing the frequency of vibration of the bar.

B Increasing the speed of the waves by making the water in the tank deeper.

C Reducing the amplitude of vibration of the bar.

D Reducing the length of the vibrating bar.

14 An ideal gas in a container of fixed volume 1.0 m^3 has a pressure of 3.0×10^5 Pa at a temperature of 200 K. The gas is heated until the temperature reaches 400 K. Some gas is released from the container during the heating to keep the pressure constant.

What volume does the gas released from the container occupy, if it is at atmospheric pressure of 1.0×10^5 Pa and at a room temperature of 300 K?

A 0.500 m^3 **B** 2.00 m^3 **C** 2.25 m^3 **D** 4.50 m^3

15 When a volatile liquid evaporates it cools down.

What is the reason for this cooling?

A All the molecules slow down.

B Fast molecules leave the surface so the mean speed of those left behind is reduced.

C Molecular collisions result in loss of kinetic energy of the molecules.

D The molecules collide with one another less frequently.

16 The molecules of an ideal gas at thermodynamic temperature *T* have a root-mean-square speed *c*.

The gas is heated to temperature 2*T*.

What is the new root-mean-square speed of the molecules?

A $\sqrt{2}c$ **B** $2\sqrt{2}c$ **C** $2c$ **D** $4c$

17 Which one of the following statements about the electric potential at a point is correct?

A The potential is given by the rate of change of electric field strength with distance.

B The potential is equal to the work done per unit positive charge in moving a small point charge from infinity to that point.

C Two points in an electric field are at the same potential when a small positive charge placed along the line joining them remains stationary.

D An alternative unit for electric potential is J m^{-1}.

18 The electric potentials V are measured at distance x from P along a line PQ. The results are:

V / V	13	15	18	21	23
x / m	0.020	0.030	0.040	0.050	0.060

The electric field at x = 0.040 m is approximately

A 300 V m^{-1} towards Q

B 300 V m^{-1} towards P

C 450 V m^{-1} towards Q

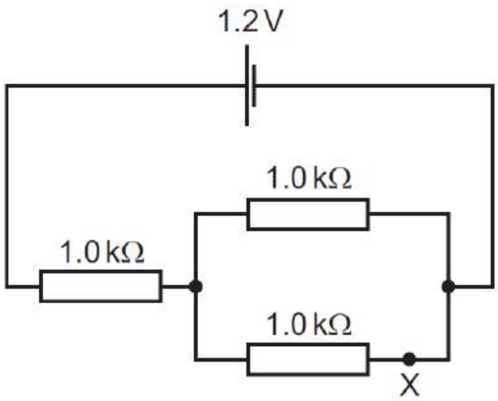
D 450 V m^{-1} towards P

19 A piece of wire of original length L, has a resistance of R. It is then melted and made into a new wire of length 1.7 L.

What is the resistance of the new wire?

A 0.59 R **B** R **C** 1.7 R **D** 2.9 R

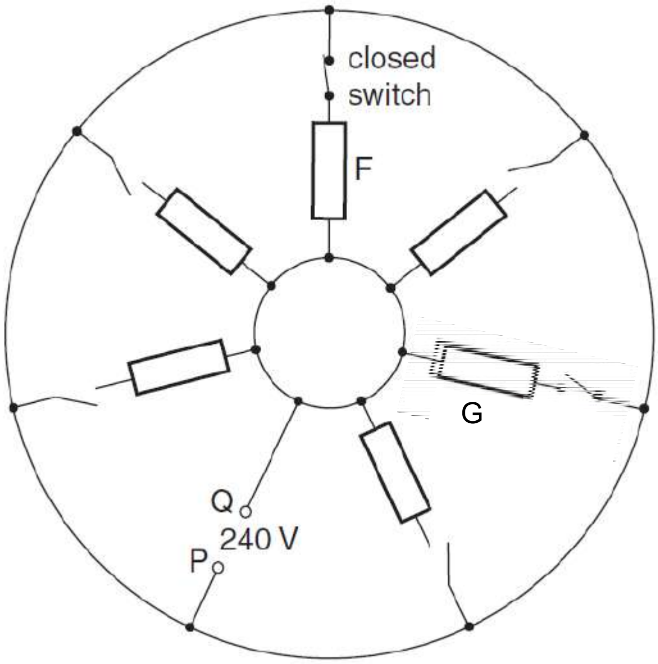
20 In the circuit below, 3 identical resistors of resistance 1.0 kΩ are connected to a cell of 1.2 V with negligible internal resistance as shown.



How many electrons pass through point X in a minute?

A 2.5×10^{15} **B** 1.5×10^{17} **C** 2.5×10^{18} **D** 1.5×10^{20}

21 Electrical sockets in a house are connected to a circuit called a ring main. The circuit is connected between P and Q to the 240 V power supply as shown.

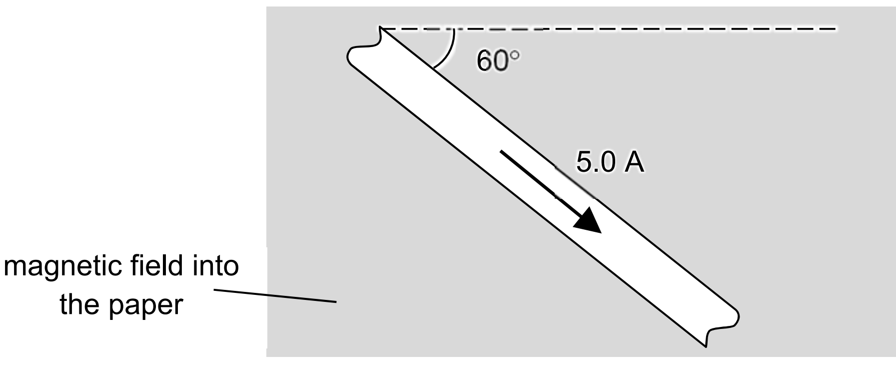


Two devices, F and G, are currently switched on. They have resistances of 1200 Ω and 1700 Ω respectively.

What is the current supplied by the power supply and total power dissipated by both devices?

	current / A	total power dissipated / W
A	0.083	20
B	0.083	82
C	0.34	20
D	0.34	82

22 A wire of length 3.0 cm is placed in the plane of the paper, along a line 60° clockwise from the *x*-axis. A magnetic field of flux density 0.040 T acts into the paper. The wire carries a current of 5.0 A.



What is the magnitude of the force which the field exerts on the wire?

A 0.0060 N **B** 0.0030 N **C** 0.0052 N **D** 0.0104 N

23 An electron is moving along the axis of a solenoid carrying a current.

Which of the following is a correct statement about the electromagnetic force acting on the electron?

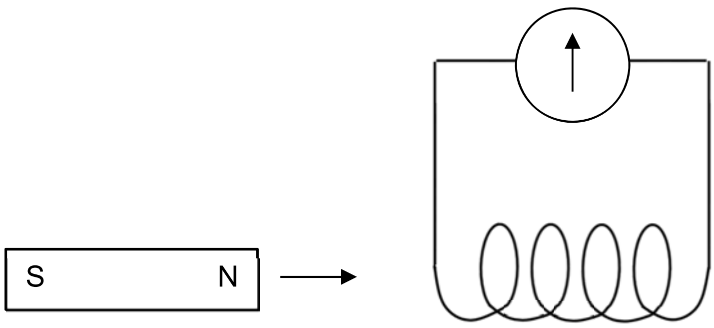
A No force acts on the electron.

B The force acts in the direction of motion.

C The force acts opposite to the direction of motion.

D The force causes the electron to move along a helical path.

24 The North pole of a bar magnet is pushed into the end of a coil of wire. The maximum movement of the meter needle is 10 units to the left.



The South pole of the magnet is then pushed into the other end of the coil at half the speed.

What is the maximum movement of the meter needle?

A less than 10 units to the left

B less than 10 units to the right

C more than 10 units to the left

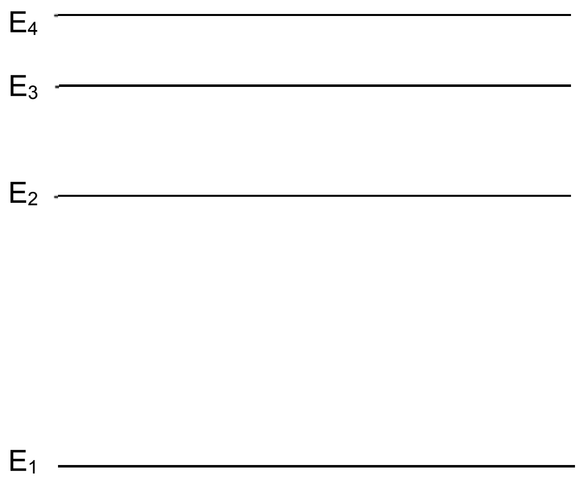
D more than 10 units to the right

25 The secondary coil of an ideal transformer delivers an r.m.s. current of 1.5 A to a load resistor of resistance 10 Ω. The r.m.s. current in the primary coil is 5 A.

What is the r.m.s. potential difference across the primary coil?

A 4.5 V **B** 6.4 V **C** 15 V **D** 50 V

26 The diagram represents in simplified form some of the energy levels of the hydrogen atom.



The transition of an electron from E_3 to E_2 is associated with the emission of red light.

Which transition could be associated with the emission of blue light?

A E_4 to E_1 **B** E_1 to E_4

C E_4 to E_2 **D** E_2 to E_4

27 An electron has a kinetic energy of 1.0 MeV. If its momentum is measured with an uncertainty of 1.0%, what is the uncertainty in its position?

A 7.7×10^{-10} m **B** 1.2×10^{-10} m **C** 2.9×10^{-12} m **D** 4.1×10^{-19} m

28 When the number of protons and the number of neutrons in a nuclide are both "magic numbers", it is more stable than expected. Such nuclides are termed "doubly magic".

The first few "magic numbers" are 2, 8, 20, 28, 50, 82, and 126.

How many of the following five nuclides are "doubly magic"?

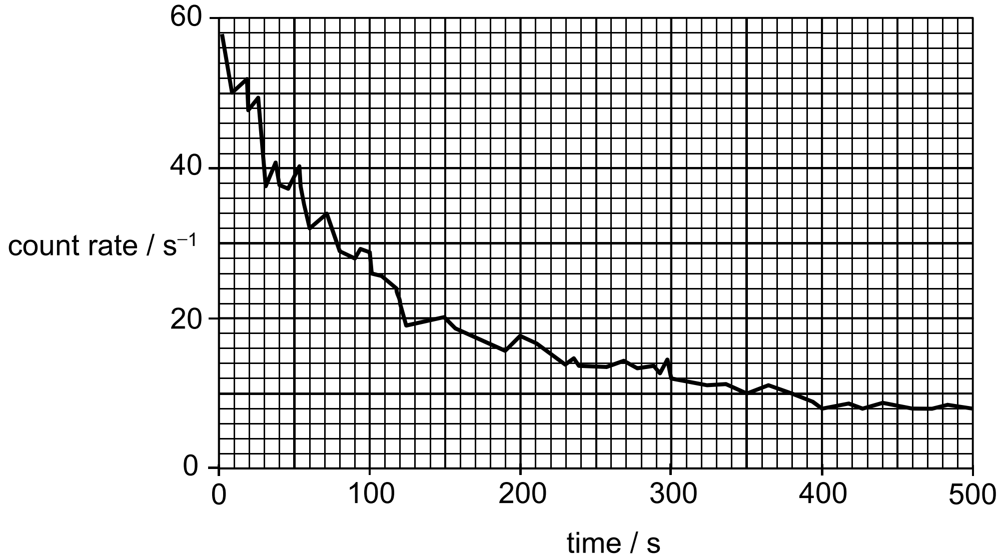
$^{28}_{8}O$	$^{40}_{20}Ca$	$^{56}_{26}Fe$	$^{50}_{28}Ni$	$^{126}_{50}Sn$

A 1 **B** 2 **C** 3 **D** 4

29 Radon-222, $^{222}_{86}Rn$ decays to Lead-210, $^{210}_{82}Pb$ via a series of three alpha and two beta decays through a series of intermediate nuclides. Which of the following cannot be one of the intermediate nuclides produced?

A $^{214}_{82}Pb$ **B** $^{214}_{83}Bi$ **C** $^{218}_{84}Po$ **D** $^{216}_{85}At$

30 An experiment is carried out in which the count rate is measured at a fixed distance from a sample of a certain radioactive material. The figure below shows the variation of count rate with time.



What is the approximate half-life of the material?

A 60 s **B** 80 s **C** 100 s **D** 120 s

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MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/02

Paper 2 Structured Questions **12 September 2018**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

Class	Reg No

Candidate Name: ____________________

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**/ 6**
2	**/ 8**
3	**/ 11**
4	**/ 10**
5	**/ 10**
6	**/ 8**
7	**/ 7**
8	**/ 20**
Deductions	
Total	**/ 80**

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translation kinetic energy an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\,\omega\sqrt{x_o^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Answer **all** the questions in the spaces provided.

1 **(a)** For an oscillating body, state what is meant by

(i) natural frequency of vibration,

....

....

.... [1]

(ii) resonance.

....

....

....[1]

(b) State and explain one situation where resonance is useful.

....

....

....

....[2]

(c) In some situations, resonance should be avoided.

State one such situation and how the effects of resonance are reduced.

....

....

....

....[2]

2 A particle in a medium is oscillating because of the passage of a transverse wave W_1.

The wave has intensity I at this point. The amplitude of the oscillation is A.

Fig. 2.1 shows the variation with time t of the displacement x of the particle.

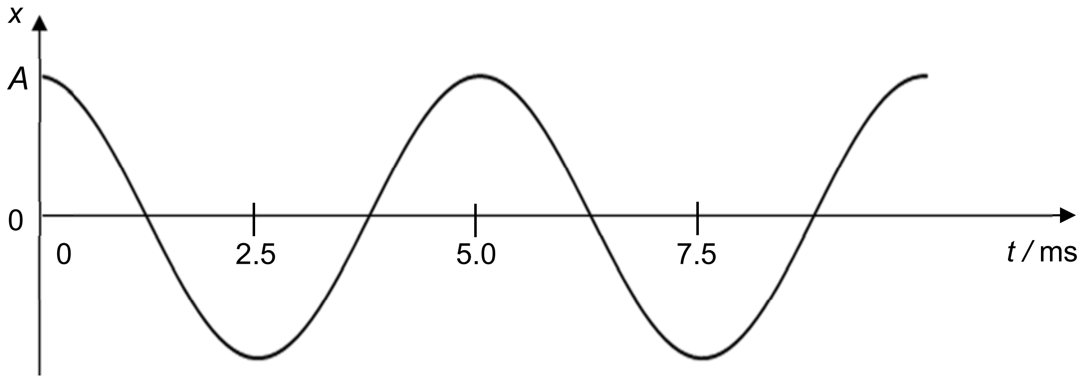


Fig. 2.1

A second, similar transverse wave W_2 has the same frequency and is incident on the same particle. The amplitude of the oscillation due to W_2 alone is $\frac{5}{2}A$ at this point.

(a) Calculate

(i) the frequency of the waves,

frequency = ... Hz [1]

(ii) the intensity, in terms of I, of the wave W_2.

intensity = ... I [2]

[Turn over

(b) **(i)** State two conditions which are necessary for the waves W_1 and W_2 to produce an observable interference pattern.

....

....[2]

(ii) State the condition that must be satisfied if the waves are to interfere to produce a minimum resultant intensity at a point.

....

....[1]

(iii) Calculate, in terms of I, this minimum intensity.

minimum intensity = ... I [2]

3 **(a)** State two differences between stationary waves and progressive waves.

1. ....

....

2. ....

....[2]

(b) **(i)** A laser produces a narrow beam of coherent light of wavelength 632 nm. The beam is incident normally on a diffraction grating as shown in Fig. 3.1.

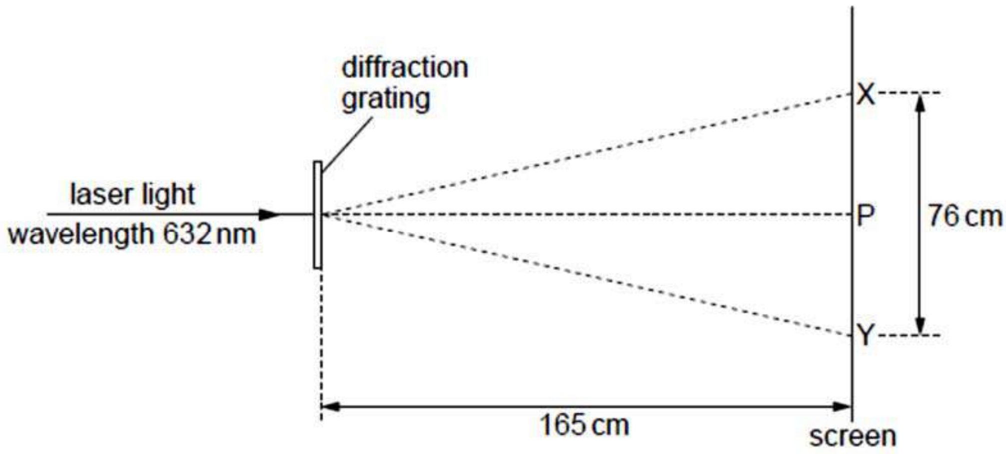


Fig. 3.1 (Top view)

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.

The brightest spot is P. The spots formed closest to P and on each side of P are X and Y.

X and Y are separated by a distance of 76 cm.

Calculate the number of lines per metre on the grating.

number per metre = ... m^{-1} [2]

(ii) The grating in **(b)(i)** is now rotated about an axis parallel to the incident laser beam, as shown in Fig. 3.2.

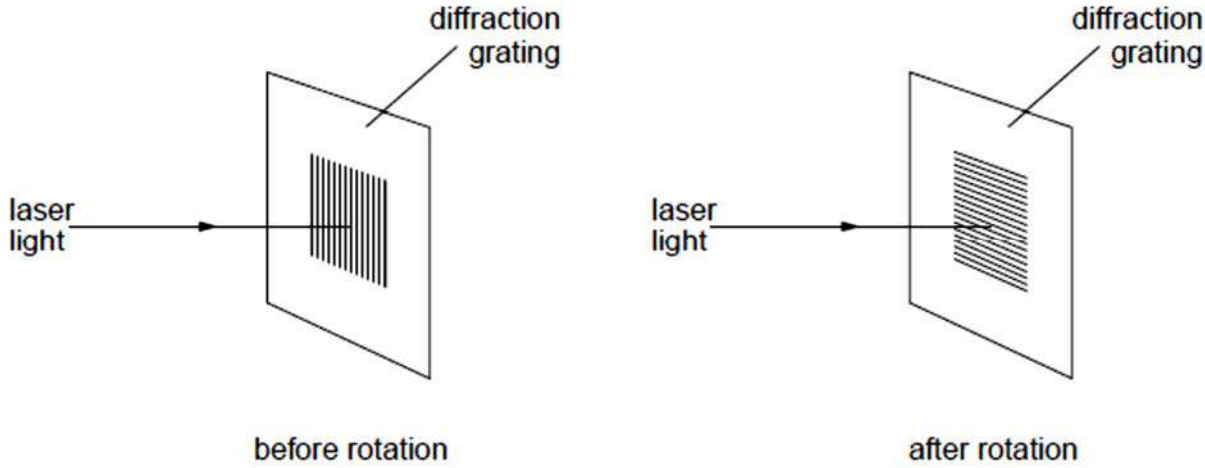


Fig. 3.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

....

....[2]

(iii) In another experiment using the apparatus in **(b)(i)**, a student notices that the distances XP and PY, as shown in Fig. 3.1 are not equal.

Suggest a reason for this difference.

....

....

....[1]

(c) A cord is held under tension between two fixed points A and B, as shown in Fig. 3.3. The distance AB is 0.40 m.

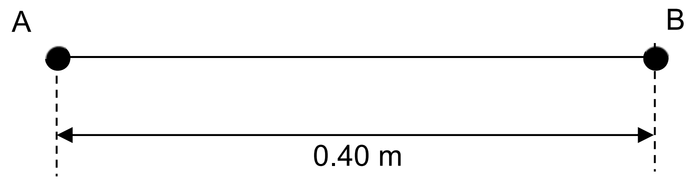


Fig. 3.3

(i) Explain why only stationary waves of certain frequencies are able to form between A and B.

....

....

....[1]

(ii) The string is made to resonate in a mode with the third lowest possible frequency. Calculate the wavelength of this wave.

wavelength = ...m [1]

(iii) By reference to the formation of the stationary wave, explain the significance of the product of frequency and wavelength for a stationary wave.

....

....

....

....[2]

4 **(a)** Fig. 4.1 shows a piece of metal, of mass 50 g, held in the flame of a Bunsen burner for several minutes. The metal is then quickly transferred and immersed in 130 g of water contained in a calorimeter.

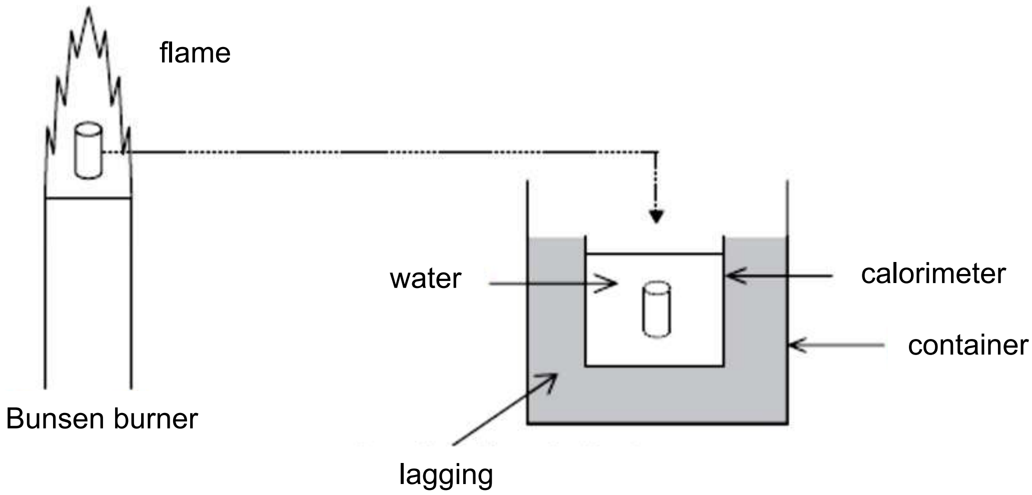


Fig. 4.1

The water into which the metal has been placed is stirred until it reaches a steady temperature. The following data are available:

heat capacity of metal	82.7 J K^{-1}
specific heat capacity of the water	4.2×10^3 J kg^{-1} K^{-1}
heat capacity of the calorimeter	54.6 J K^{-1}
initial temperature of the water	25 °C
final temperature of the water	90 °C

Use the data to calculate the temperature of the Bunsen flame and state an assumption made for your calculation.

temperature = ...°C

Assumption: ....

....[3]

(b) The gas in the cylinder of a diesel engine can be considered to undergo a cycle of changes of pressure, volume and temperature. One such cycle, for an ideal gas, is shown in Fig. 4.2. Processes A to B and C to D take place without heat exchange with the surroundings.

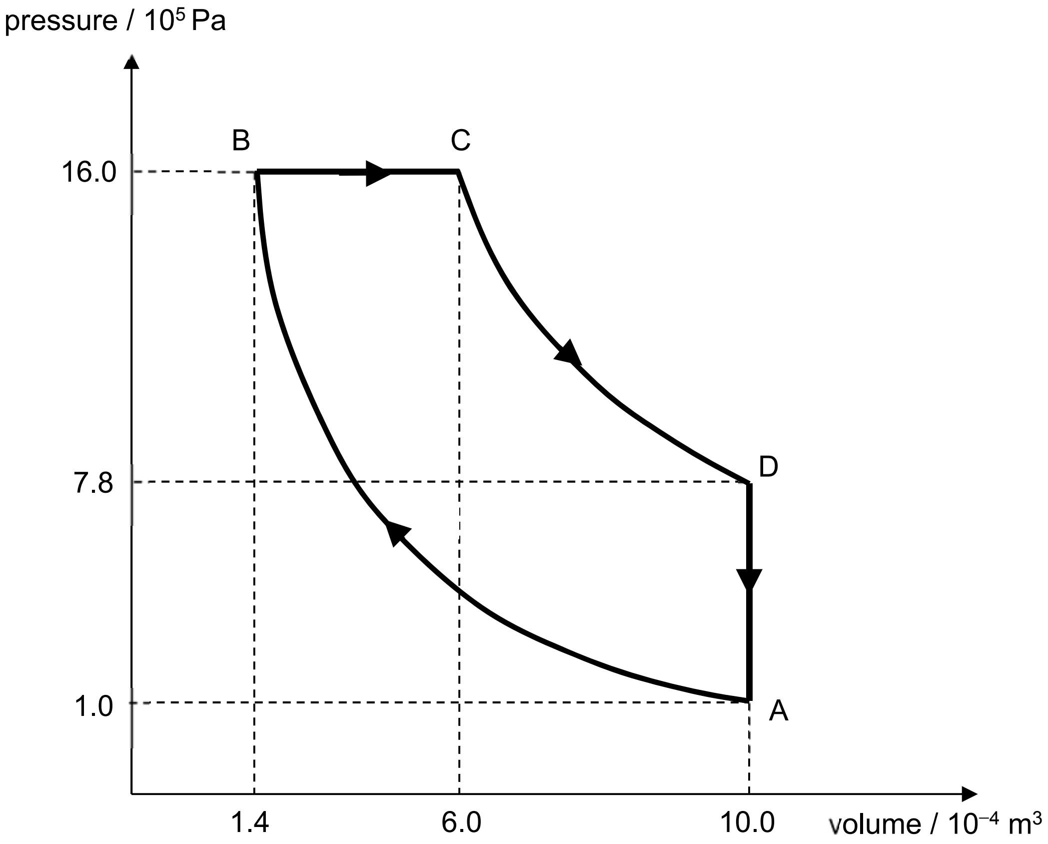


Fig. 4.2

Complete the table below.

Process	**Heat supplied to gas / J**	**Work done on gas / J**	**Increase in internal energy of gas / J**
A to B		300	
B to C	2580		
C to D		–440	
D to A	–1700		

[4]

(c) A fixed mass of ideal gas is heated from temperature T_1 to T_2 at constant volume. Explain why a greater amount of heat is required to heat the same mass of ideal gas from T_1 to T_2 at constant pressure.

....

....

....

....[3]

5 **(a)** Define *magnetic flux*.

....

....[1]

(b) Fig. 5.1 shows a 1.6 m long solenoid with 400 turns and a cross-sectional diameter of 4.0 cm. A coil Y, with 80 turns, is wounded tightly around the centre region of the solenoid.

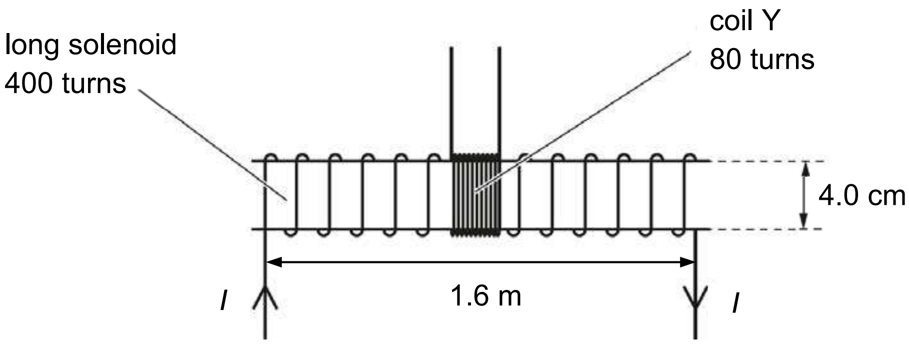


Fig. 5.1

(i) Show that, for a current *I* of 3.8 A in the solenoid, the magnetic flux linkage of coil Y is 1.2×10^{-4} Wb.

[2]

(ii) The current *I* in the solenoid in **(b)(i)** is reversed in 0.30 s.

Calculate the mean e.m.f. induced in coil Y.

mean e.m.f. = ... V [2]

[Turn over

(iii) The current *I* in the solenoid in **(b)(ii)** varies with time *t* as shown in Fig. 5.2.

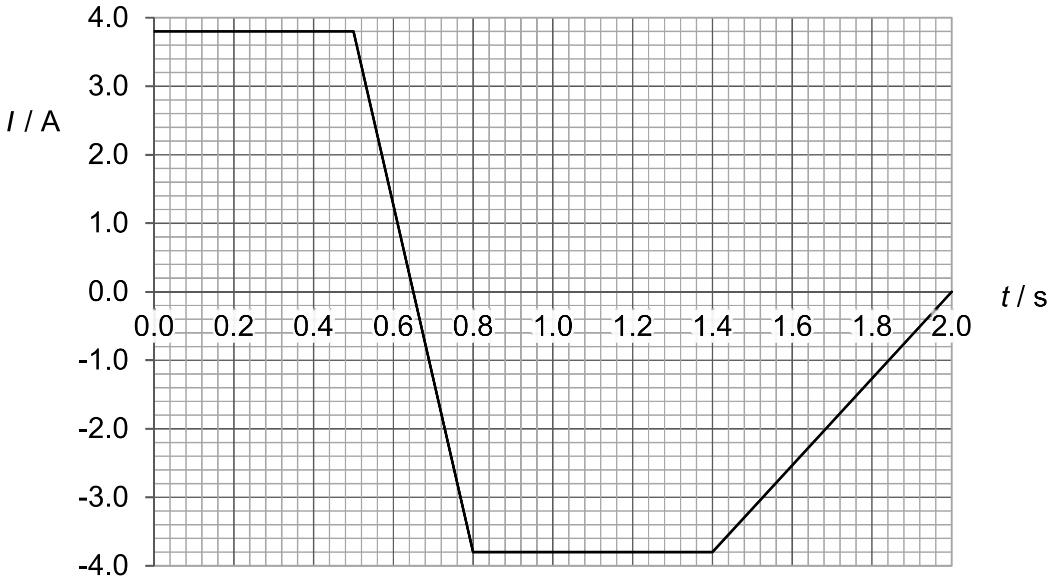
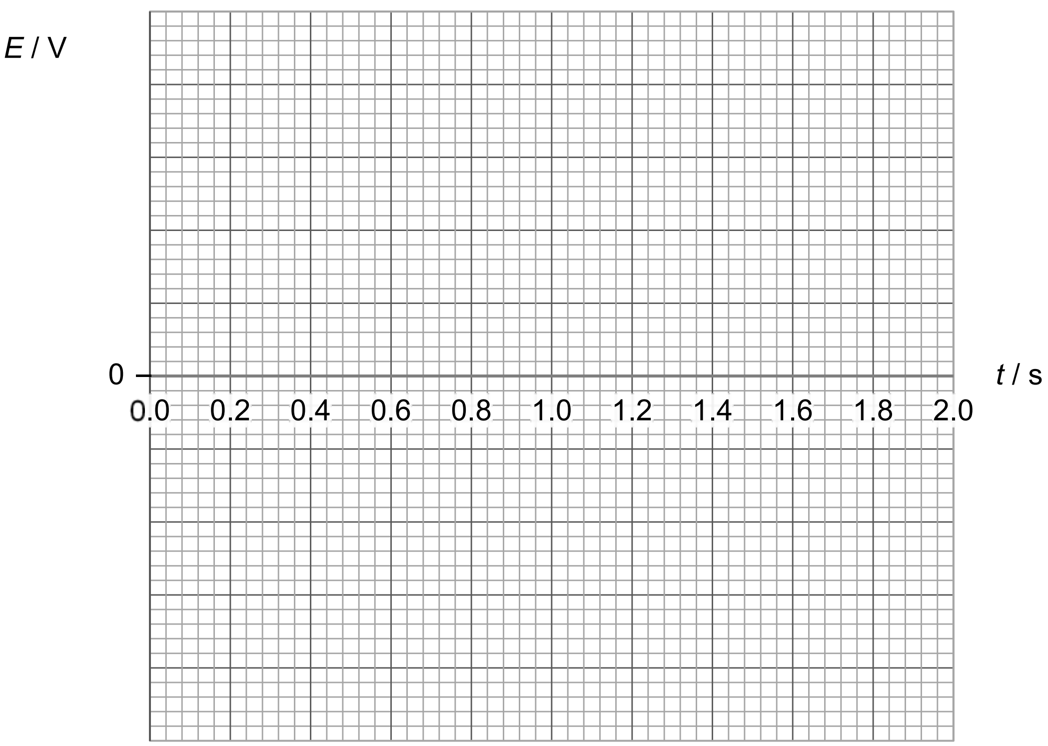


Fig. 5.2

Use your answer to **(b)(ii)** to sketch, on Fig. 5.3, the variation with time *t* of the e.m.f. *E* induced in coil Y.



[3]

(iv) An iron core is inserted into the solenoid and then held stationary within the solenoid. Explain the effect on the e.m.f. induced in coil Y.

....

....

....[2]

6 (a) The photoelectric effect provides evidence for the particulate nature of electromagnetic radiation. State two experimental observations that could not be fully explained using the classical wave theory.

1...

....

....

2. ....

....

....[2]

(b) In an experiment to investigate the photo-electric effect, the wavelength of the radiation incident on the metal surface was varied. For two values of wavelength λ, the stopping potential V_s was measured. The results are shown in Fig. 6.1.

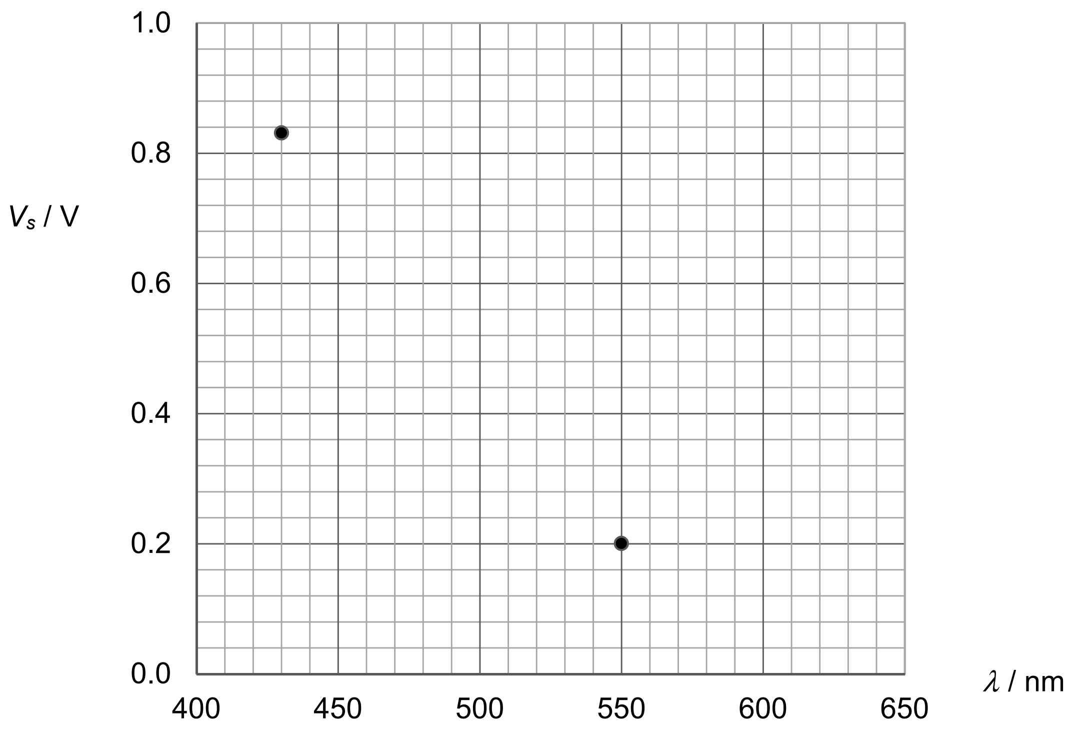


Fig. 6.1

(i) Determine the maximum kinetic energy of a photo-electron emitted from the metal surface by radiation of wavelength 550 nm.

maximum kinetic energy = ... J [1]

(ii) Hence, calculate the threshold wavelength of the metal.

threshold wavelength = ...m [2]

(iii) Suggest why it is not possible to deduce the threshold wavelength of the metal surface directly from Fig. 6.1.

....

....[1]

(iv) The intensity of the radiation incident on the metal surface was kept constant as the wavelength was decreased from 550 nm to 430 nm.

State and explain the effect, if any, on the photocurrent.

....

....

....[2]

7 X-ray photons are produced when electrons are accelerated through a potential difference towards a metal target. An X-ray spectrum is shown in Fig. 7.1.

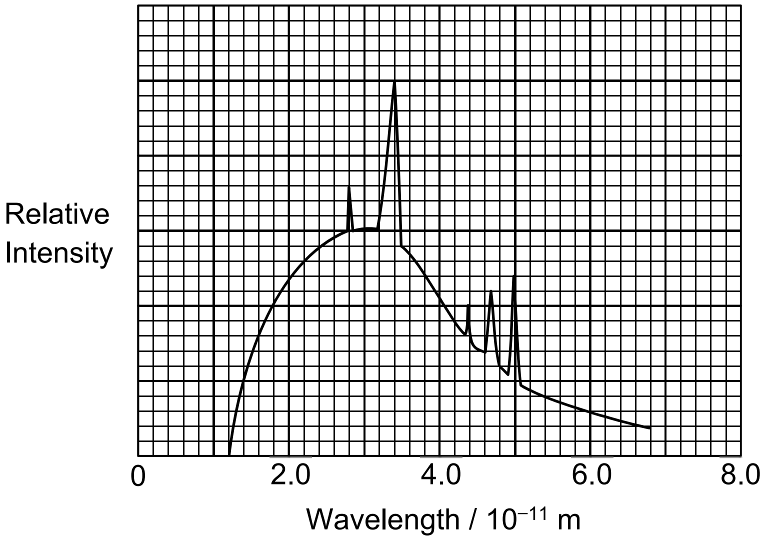


Fig. 7.1

(a) Explain how the most energetic X-ray photons are produced.

....

....

....[2]

(b) **(i)** Explain how the characteristic X-ray K_α photons are produced.

....

....

....[2]

(ii) Determine the momentum of the K_α X-ray photon.

momentum = ... N s [2]

(c) The potential difference used to accelerate the electrons is increased. On Fig. 7.1, sketch the new spectrum obtained. [1]

8 This question is about the movement of water from the roots of a tree to its leaves.

Water moves up a tree through its vast network of conduits. These conduits are similar to capillary tubes. It is suspected that water moves up the conduits due to low pressure in the conduits which "sucks" the water upwards, or by capillary action, or a combination of both. Capillary action is a phenomenon whereby water rises up a small tube due to upward forces caused by the adhesion of water to the walls of the tube.

To investigate capillary action, a capillary tube, open at both ends, is supported vertically with one end immersed in water, as shown in Fig. 8.1. The water in the narrow bore of the tube forms a column of height *h*.

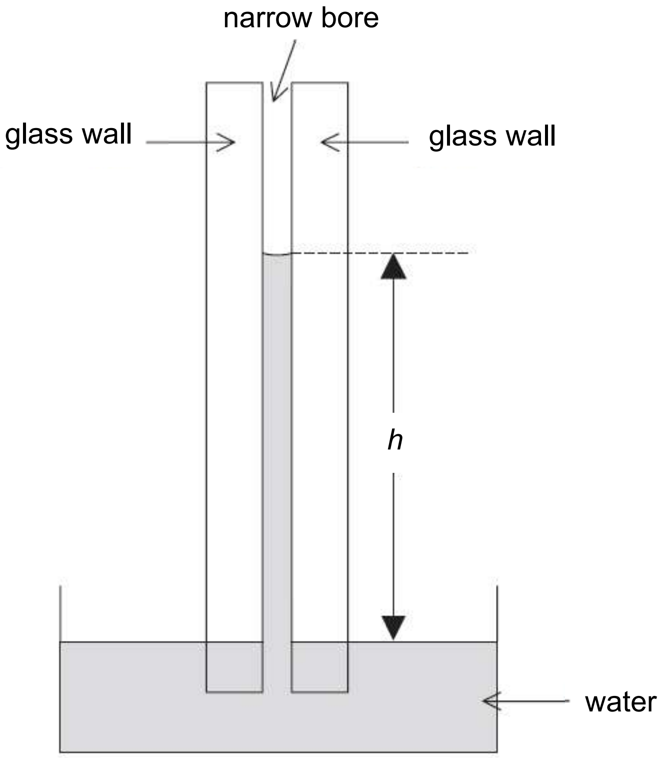


Fig. 8.1
(not to scale)

(a) The height *h* of the water column for a particular capillary tube was measured as the temperature of water θ was varied. Fig. 8.2 shows the data collected.

θ / °C	*h* / cm
30	14.0
40	13.2
50	12.5
60	11.5
70	10.9
80	10.0

Fig. 8.2

Fig. 8.3 shows the variation with temperature θ of height h.

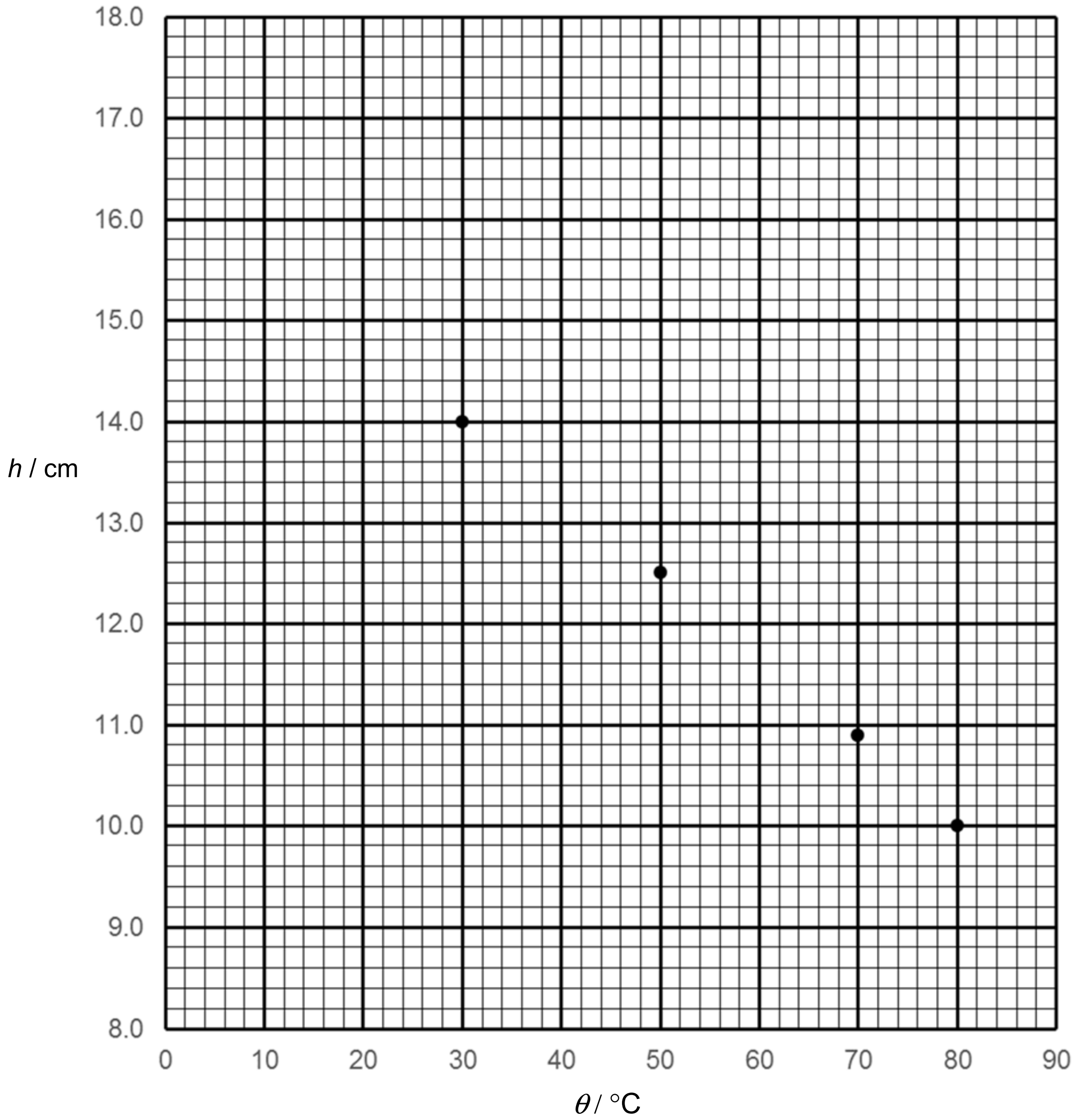


Fig. 8.3

(i) On Fig. 8.3, plot the points for θ = 40 °C and θ = 60 °C. Draw a line of best fit through the data points. [2]

(ii) Using Fig 8.3, determine the height h_0 of the water column when the temperature is 0 °C.

h_0 = ... cm [1]

(iii) It is suggested that the relationship between θ and h is

$$\frac{h}{h_0} = 1 - k\theta$$

where k is a constant.

Explain why the results of this experiment supports the relationship suggested.

....

....

....

....[3]

(iv) Using the line drawn in **(a)(i)**, determine the value of k, including its units.

k = ... [3]

(b) The experiment is repeated using capillary tubes with bores of different radii *r* but keeping the water temperature constant. Fig. 8.4 shows the variation with $\frac{1}{r}$ of height *h* for a water temperature of 20 °C.

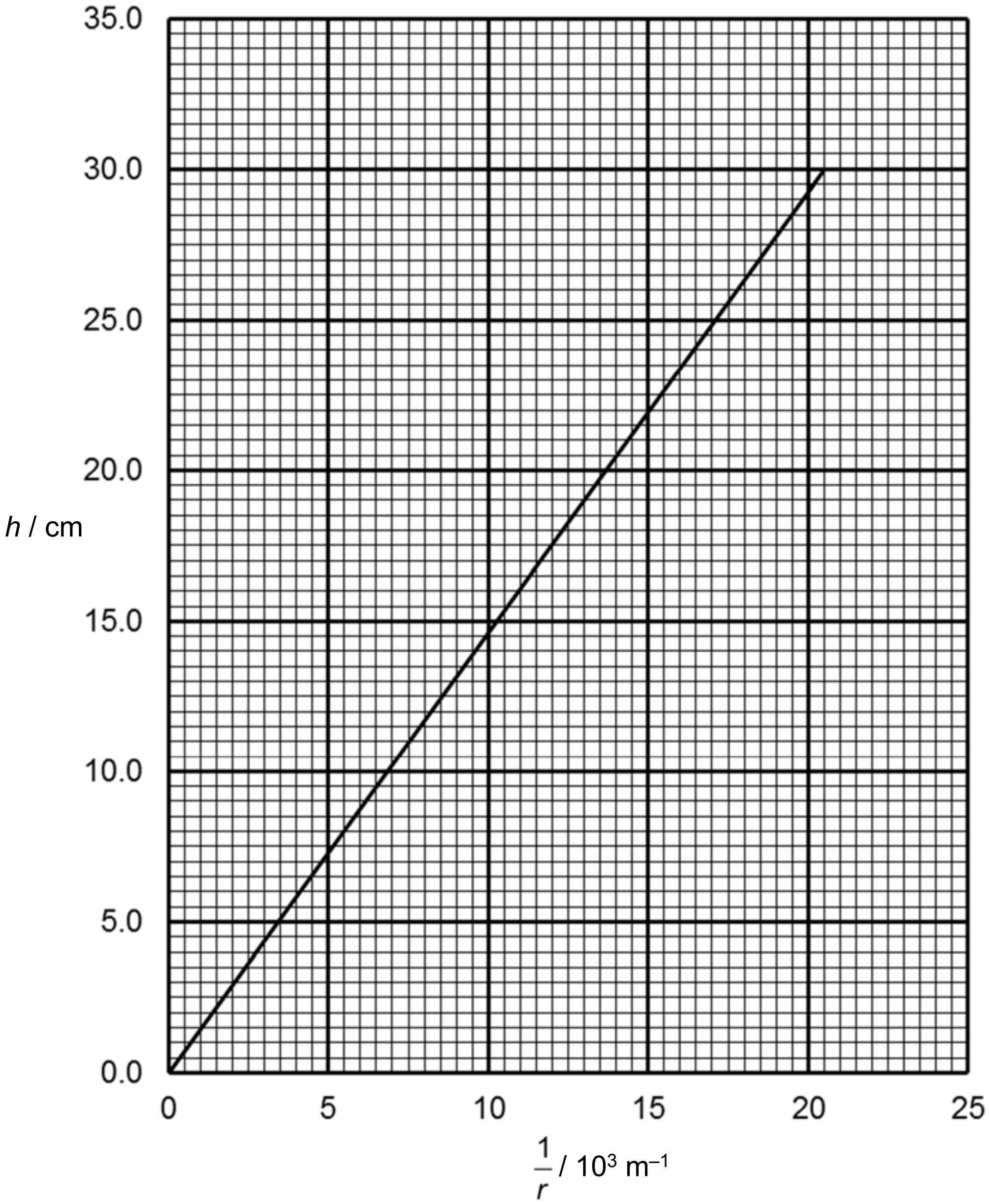


Fig. 8.4

(i) Use Fig. 8.4 to estimate the radius of the bore of the tubes in a 25-metre tall tree, which will enable water to be raised by capillary action from ground level to the top of the tree.

radius = ...m [3]

(ii) State one assumption made in your estimation in **(b)(i)**.

....

....[1]

(iii) Comment on your answer obtained in **(b)(i)**.

....

....

....[2]

(c) The other means of moving water up a tree is to create a low pressure in the bore of the tubes in the tree.

(i) Suggest how low pressure can be created in the bore of the tubes in a tree.

....

....[1]

(ii) Using the following data, calculate the height which water can be moved up a tree via low pressure in the bore of the tubes.

Atmospheric pressure = 101 kPa

Pressure in the bore of the tubes in the tree = 7.8 kPa

Density of water = 1000 kg m^{-3}

height = ... [2]

(iii) Suggest and explain how the height in **(c)(ii)** will change during a hot day.

....

....

....[2]

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/03

Paper 3 Longer Structured Questions

17 September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

Candidate Name: ______________________

Class	Reg No

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend about one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	**/ 10**
2	**/ 7**
3	**/ 9**
4	**/ 4**
5	**/ 5**
6	**/ 10**
7	**/ 15**
Section B	
8	**/ 20**
9	**/ 20**
Deductions	
Total	**/ 80**

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T /K	=	T /°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translation kinetic energy an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\, \omega\sqrt{x_o^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** **(i)** State Newton's first law of motion.

....

....[1]

(ii) State the conditions for equilibrium.

....

....

....

....[2]

(b) Fig. 1.1 shows a uniform ladder of weight 80 N resting on a smooth wall and a rough floor. The ladder makes an angle of 60° with the floor.

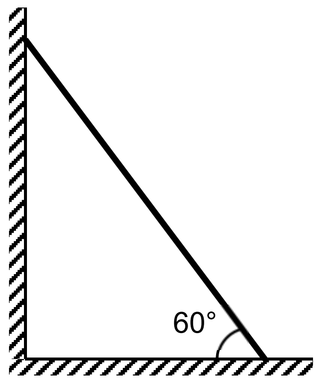


Fig. 1.1

(i) Show that the force exerted by the wall on the ladder is 23 N.

[2]

(ii) Calculate the force exerted by the floor on the ladder.

magnitude of force = ... N

direction of force : ....[3]

(iii) A person now stands on the ladder. The ladder remains stationary.

State and explain the effects, if any, on

1. the vertical force exerted by the floor on the ladder.

....

....

....[1]

2. the horizontal force exerted by the wall on the ladder.

....

....

....[1]

2 In an experiment to determine the specific heat capacity of a liquid, a student heated a fixed mass of the liquid for a fixed duration of time, using an electric heater. The student repeated the experiment three times to find the rise in temperature of the liquid. The following measurements were obtained:

Mass of liquid, *m*	309 ± 3 g
Voltage applied across heater, *V*	11.8 ± 0.3 V
Current flow in the heater, *I*	4.125 ± 0.002 A
Time taken, *t*	200.0 ± 0.5 s

The rise in temperature θ was recorded for each attempt:

Attempt:	1st	2nd	3rd
θ / K	10.2	9.7	10.5

(a) Estimate the uncertainty in θ.

uncertainty in θ = ... K [1]

(b) Calculate the specific heat capacity *c* of the liquid.

c = ... J kg^{-1} K^{-1} [2]

(c) Calculate the uncertainty in specific heat capacity *c* of the liquid and express the specific heat capacity *c* together with its uncertainty.

c = ... ± .... J kg^{-1} K^{-1} [3]

(d) State an assumption made in your calculation of the specific heat capacity *c* of the liquid.

....

....[1]

3 **(a)** State Newton's second law of motion.

....

....

....[1]

(b) A car of mass 800 kg was travelling on a horizontal road at a constant speed of 20 m s^{-1} before a net horizontal constant forward force of 4800 N acts on the car for 12 s.

Calculate

(i) the distance travelled by the car over the 12 s,

distance = ...m [2]

(ii) the speed of the car at the end of the 12 s,

speed = ... m s^{-1} [2]

(iii) the work done on the car during the 12 s

1. using the answer to **(b)(i)**;

work done = ...J [1]

2. using the answer to **(b)(ii)**.

work done = ...J [1]

(iv) the impulse exerted on the car over the 12 s.

impulse = ... N s [2]

4 A person threw a ball vertically upwards.

(a) Fig. 4.1 shows the variation with time of the velocity when air resistance is absent.

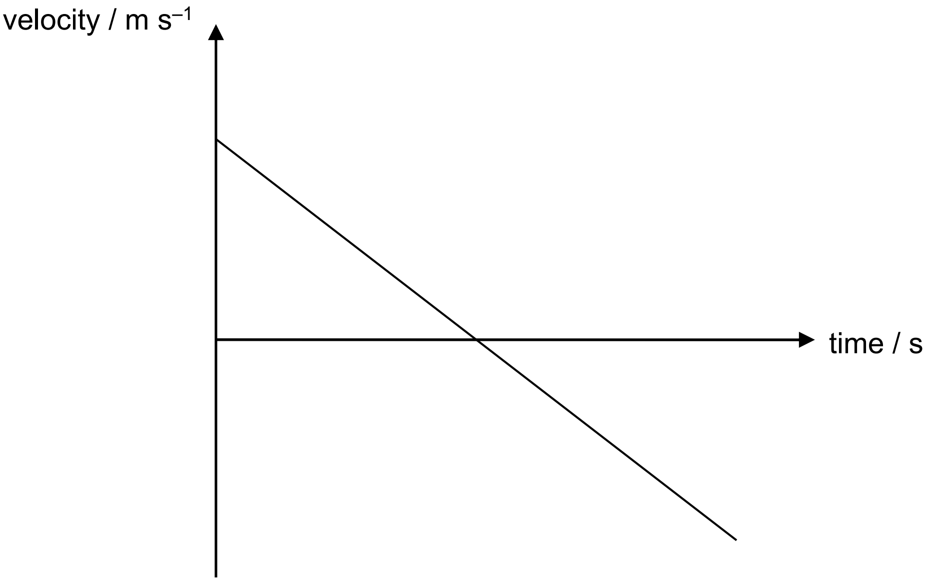


Fig. 4.1

Draw on Fig. 4.1 a second graph for the case where air resistance is present. [3]

(b) Explain how the presence of air resistance would affect the maximum height reached by the ball.

....

....

....[1]

5 Ball A, of mass 800 g and travelling with a speed of 9.2 m s^{-1}, collided head-on with a stationary ball B of mass 2400 g. The collision is completely inelastic.

(a) Explain whether the total momentum is conserved during the collision.

....

....

....[1]

(b) Calculate the percentage loss in total kinetic energy.

percentage loss = ... % [2]

(c) Shortly after the collision, Ball B comes into contact with a spring of spring constant 2500 N m^{-1}. Calculate the maximum compression of the spring.

maximum compression = ...m [2]

6 Fig. 6.1 shows an isolated conducting sphere which has been charged. Dashed lines (−−−−) join points of equal potential *V*. The potential difference between successive lines of equal potential is equal.

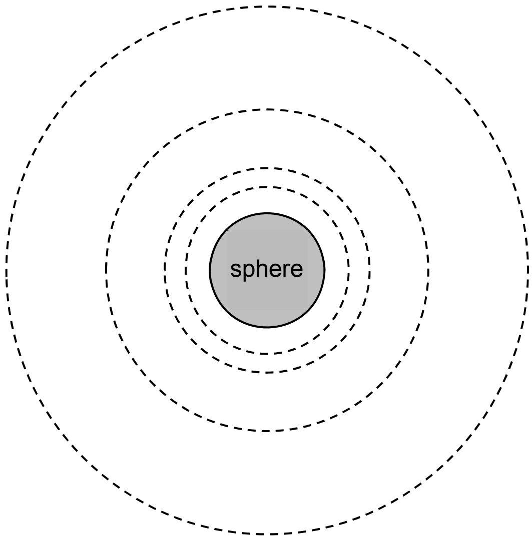


Fig. 6.1

For points on the surface or outside the sphere, the charge on the sphere behaves as if it were concentrated at the centre.

Measurements of the distance *x* from the centre of the sphere and the corresponding values of the potential *V* are given in Fig. 6.2. The values in Fig. 6.2 do not correspond to the dashed lines in Fig. 6.1.

x / m	V / V
0.19	-1.50×10^5
0.25	-1.14×10^5
0.32	-0.89×10^5
0.39	-0.73×10^5

Fig. 6.2

(a) On Fig. 6.1, draw the electric field lines. Label these lines *E*. [2]

(b) Explain how your drawing in **(a)** shows the relationship between electric potential *V* and the electric field *E*.

....

....

....[2]

(c) **(i)** Use the data in Fig. 6.2 to show that the potential *V* is inversely proportional to the distance *x*. Explain your reasoning.

[2]

(ii) The potential at the surface of the sphere is -1.9×10^5 V. Calculate the radius of the sphere.

radius of sphere = ...m [2]

(iii) Determine the charge on the sphere.

charge = ...C [2]

[Turn over

7 **(a)** A power bank (which is basically a battery) can be used to power many devices at the same time. A power bank of e.m.f. 12.0 V and internal resistance 3.0 Ω is connected to multiple devices in the circuit shown in Fig. 7.1.

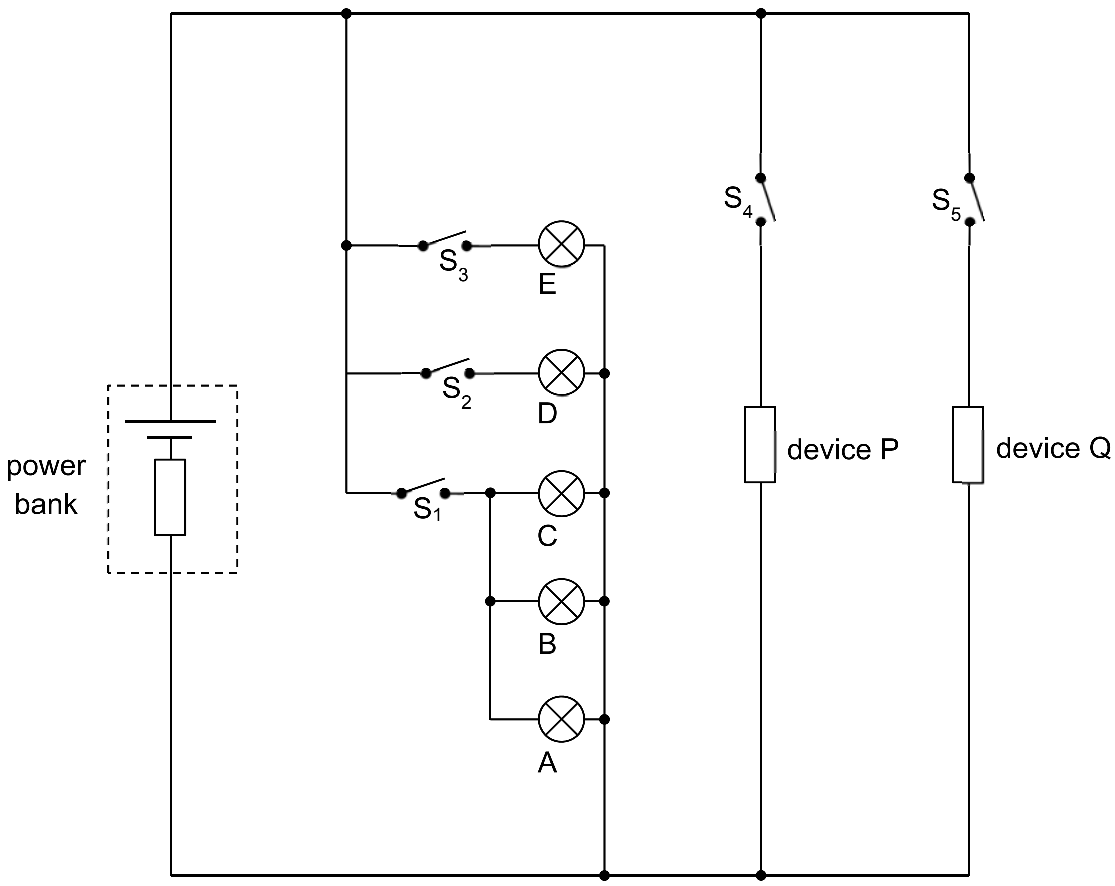


Fig. 7.1

The power bank is connected to 5 identical lamps (A, B, C, D and E) and 2 devices (P and Q). The lamps and devices can be turned on and off using the various switches (S_1, S_2, S_3, S_4 and S_5).

(i) Explain what is meant by "*e.m.f. of 12.0 V*" with reference to the power bank.

....

....[2]

(ii) State the effect of closing switch S_1.

....

....[1]

(iii) All the switches are now closed. Given the data below, calculate the current supplied by the power bank.

Resistance of each lamp = 25.0 Ω

Resistance of device P = 38.0 Ω

Resistance of device Q = 42.0 Ω

current = ... A [2]

(iv) Calculate the terminal potential difference of the power bank when all the switches are closed.

terminal potential difference = ... V [2]

(v) State and explain the effect, if any, on the brightness of the lamps if switches S_4 and S_5 are now opened while the rest remain closed.

....

....

....

....[2]

(b) The same power bank from **(a)** is now connected in a potentiometer circuit as shown in Fig. 7.2.

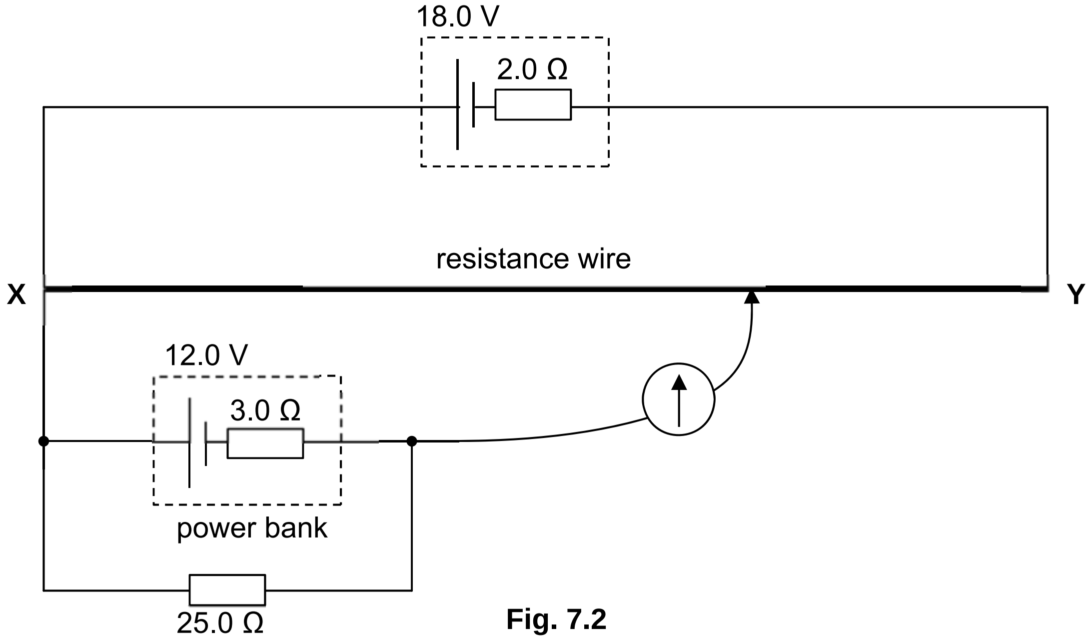


Fig. 7.2

A 18.0 V battery with internal resistance of 2.0 Ω is connected to a resistance wire XY. XY is 1.00 m long and has resistance of 7.2 Ω. A resistor of 25.0 Ω is connected in parallel to the power bank.

(i) Calculate the balance length when the galvanometer shows a reading of zero.

balance length = ...m [3]

(ii) Explain why it is desirable to obtain a balance point which is closer to end Y.

....

....[1]

(iii) State and explain the effect, if any, on the balance length if resistance wire XY is now made of a material with higher resistivity.

....

....[2]

Section B

Answer **one** question from this Section in the spaces provided.

8 **(a)** A binary star consists of two stars that orbit about a fixed point C, as shown in Fig. 8.1.

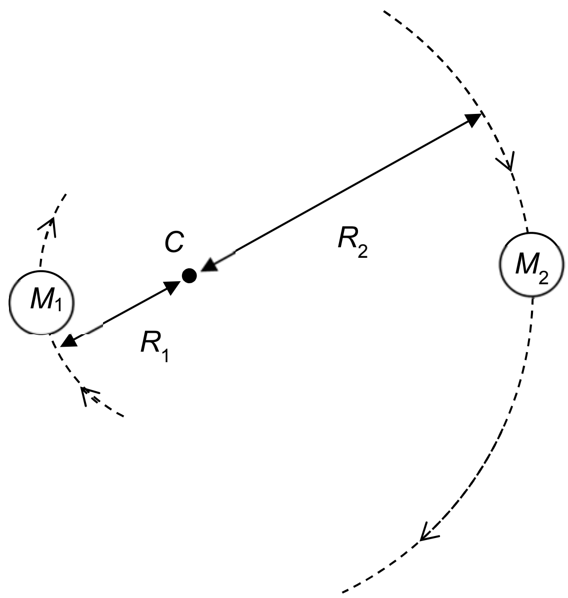


Fig. 8.1

The star of mass M_1 has a circular orbit of radius R_1 and the star of mass M_2 has a circular orbit of radius R_2. Both stars have the same angular speed ω about C.

(i) State the formula, in terms of G, M_1, M_2, R_1, R_2 and ω for

1. The gravitational force between the two stars

....[1]

2. The centripetal force on the star of mass M_1.

....[1]

(ii) The stars orbit each other in a time of 1.26×10^8 s. Calculate the angular speed ω for each star.

ω = ... rad s^{-1} [1]

[Turn over

(iii) Show that the ratio of the masses of the stars is given by the expression $\frac{M_1}{M_2} = \frac{R_2}{R_1}$.

[1]

(iv) The ratio $\frac{M_1}{M_2} = \frac{R_2}{R_1}$ is equal to 3.0 and the separation of the stars is 3.2 × 10^{11} m.

Determine the radii R_1 and R_2.

R_1 = ...m

R_2 = ...m [1]

(v) By considering the expressions in **(i)** and using the data calculated in **(ii)** and **(iv)**, determine M_2.

M_2 = ...kg [3]

(b) Fig. 8.2 shows an electron entering a region between two oppositely-charged parallel metal plates. The plates have length 5.1 cm.

The electric field in the region between the plates is uniform and is zero outside this region.

The original direction of motion of the electron is normal to the electric field.

The original speed of the electron is $v = 1.7 \times 10^{7}$ m s^{-1}.

The electric field strength between the plates E is 4000 V m^{-1}.

The electron exits the plates at an angle θ to the horizontal.

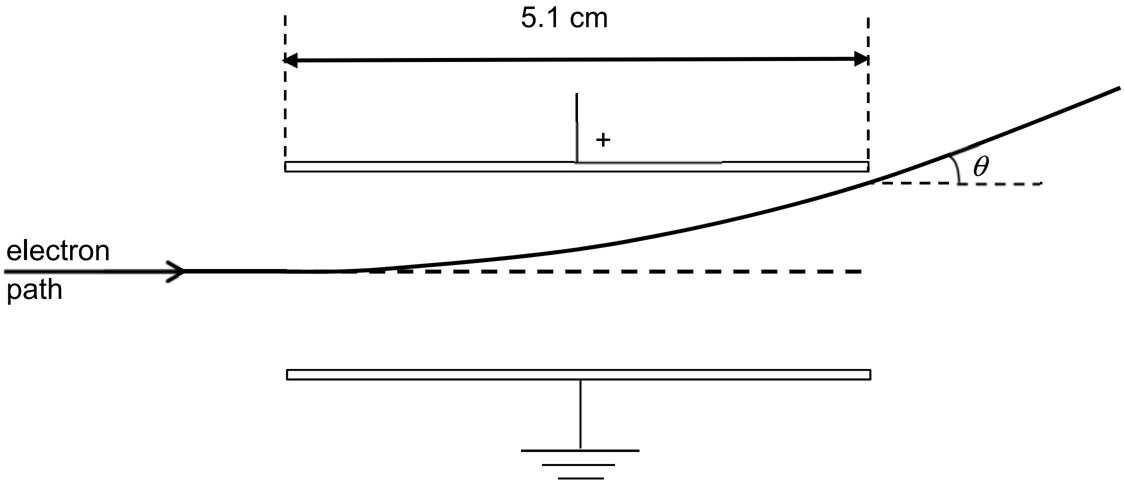


Fig. 8.2

(i) Show that the acceleration of the electron inside the electric field is 7.0×10^{14} m s^{-2}.

[1]

(ii) Calculate the magnitude of the final velocity of the electron, and the angle θ.

final velocity = ... m s^{-1}

θ = ... ° [4]

(iii) A proton is projected with the same initial velocity along the same line. Without detailed calculation, draw the path that the proton takes on Fig. 8.2. Explain your answer.

....

....

....[2]

(c) Fig. 8.3 shows a uniform magnetic field *B* denoted by the shaded area. An electron moves into the field at the same speed *v* as in **(b)**, and is also deflected from its original path. The original direction of motion of the electron is normal to the magnetic field.

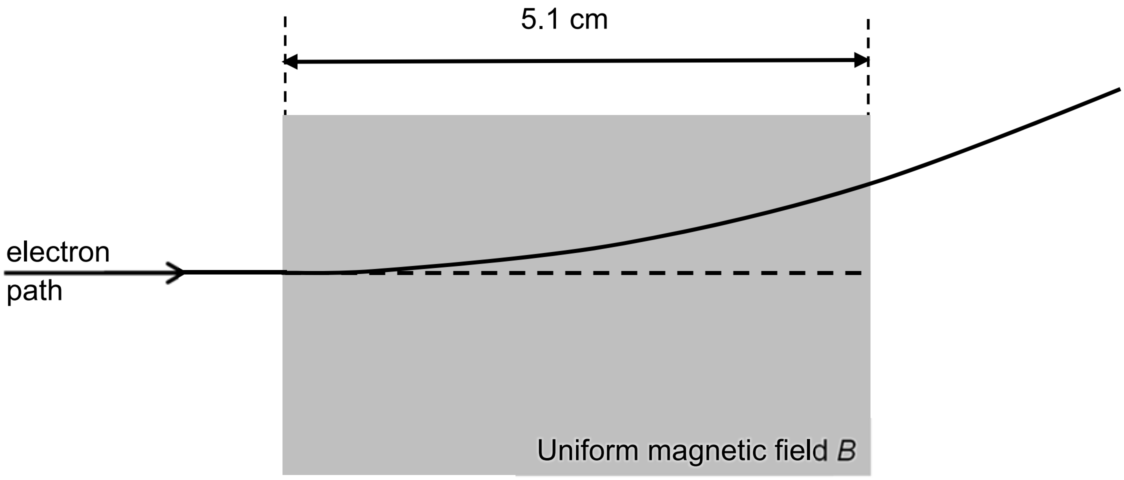


Fig. 8.3

(i) State the difference between the shape of the path taken by the electron in the magnetic field, and the shape of the path taken by the electron in the electric field described in **(b)**. Explain this difference.

....

....

....

....

....

....

....[3]

(ii) State and explain how the final speed of the electron after passing through the magnetic field compares with the final speed of the electron after passing through the electric field in **(b)**.

....

....

....[2]

9 A radon-222 ($^{222}_{86}\text{Rn}$) nucleus, originally at rest, spontaneously decays to form a polonium-218 ($^{218}_{84}\text{Po}$) nucleus and an alpha particle. It may be assumed that no gamma ray is emitted.

(a) Explain what is meant by *spontaneous*.

....

....[1]

The rest masses of the nuclei are shown in Fig. 9.1.

$^{222}_{86}\text{Rn}$	222.0176 u
$^{218}_{84}\text{Po}$	218.0090 u
alpha particle	4.0026 u
proton	1.00727 u
neutron	1.00866 u

Fig. 9.1

(b) **(i)** Calculate the total kinetic energy of the decay products.

total kinetic energy = ... J [3]

(ii) Describe the subsequent motion of the decay products. Explain your answer with reference to the principle of conservation of momentum.

....

....

....

....

....[2]

(iii) Show that the ratio $\dfrac{\text{kinetic energy of alpha particle}}{\text{kinetic energy of Po-218 nucleus}} \approx 54.5$.

[1]

(c) **(i)** Calculate the value of mass defect per nucleon $\left(\text{i.e. } \dfrac{\text{mass defect}}{\text{number of nucleons}}\right)$ for Radon-222. Leave your answer in terms of atomic mass units (u).

mass defect per nucleon for Radon-222 = ...u [3]

(ii) The mass defect per nucleon for Polonium-218 has a value of 8.08312×10^{-3} u. With reference to your answer in **(c)(i)**, explain whether Polonium-218 or Radon-222 is more stable.

....

....

....

....

....

....[3]

(d) Radon-222 has a half-life of 3.8 days.

(i) State what is meant by *half-life*.

....

....[1]

(ii) Calculate the probability of a given radon-222 nucleus decaying per second.

probability = ... s^{-1} [2]

(iii) A student stated that “radioactive materials with a short half-life always have a high activity”. Discuss whether the student’s statement is valid.

....

....

....[1]

(e) A sample of Radon-222 was carefully measured out and sealed in a container. The rate of radioactive decay was measured using an accurate instrument, taking into account background radiation. The number of alpha particles detected was significantly higher than expected. State what this suggests about the stability of Polonium-218. Explain your answer.

....

....

....

....

....[3]

Apparatus list

JC2 Preliminary Examination 28 Aug 2018

SS to check Q1 & 2 during change over

Question 1:

- 1 x retort stand + boss and clamp *(to dismantle fully during change over)*
- 1 x half-metre rule
- 1 x cork with optical pin *(to insert back if taken out by student)*
- 1 x stopwatch
- 1 x protractor
- 1 x 30 cm wire *(to replace with new wire during change over)*

Question 2:

- 1 x 100 ml beaker *(pour away water during change over)*
- 1 x rubber band
- 1 x thermometer
- Hot water of at least 90 °C *(to top up water when planning starts)*
- 1 x cloth
- 1 x styrofoam cup *(pour away water during change over)*
- 1 x stopwatch
- 1 x insulating material

Lab staff to check Q3 during change over

Question 3:

- 1 x 2 V accumulator
- 2 x DMM with connecting leads *(leads take out, turn dial to 12 o'clock, during change over)*
- 3 x connecting wire
- 1 x switch
- 1 x variable resistor
- 1 x 10Ω resistor, labelled "Q".

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
Higher 2

H2 Physics 9749/4

Paper 4 Practical

28 August 2018

2 hours 30 minutes

Class	Reg Number

Candidate Name: ______________________________

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page, page **9** and **13**.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **ALL** the questions.

You are allowed 1 hour to answer Questions 1 and 2; and you are allowed another 1 hour to answer Question 3.

Question 4 is a question on the planning of an investigation and does not require apparatus.

Write your answers in the space provided in the question paper. The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

Examiner's Use	
1	
2	
3	
4	
Total	**/55**

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1 In this question you will investigate how the period of oscillation of a bent metal wire varies with the angle between the straight parts of the wire.

(a) **(i)** Secure the cork in the clamp so that the pin is mounted horizontally.

(ii) Make a sharp bend in the wire at its centre so that the angle θ between the straight parts of the wire is about 130° as shown in Fig. 1.1.

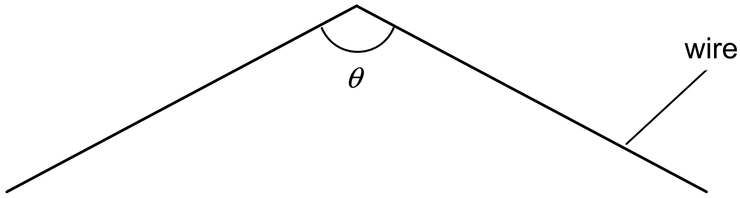


Fig. 1.1

(iii) Measure and record the angle θ.

θ = ... [1]

(iv) Estimate the percentage uncertainty in this measurement of θ. Show your working.

percentage uncertainty in θ = ... [1]

(b) **(i)** Suspend the wire from the pin so that the arrangement is as shown in Fig. 1.2.

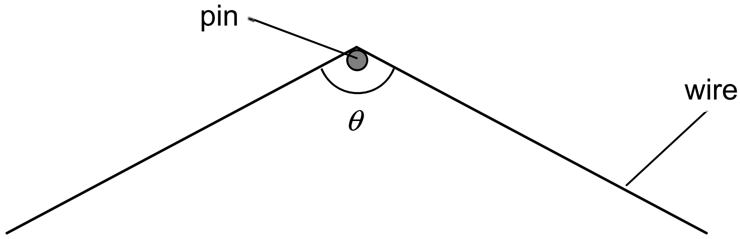


Fig. 1.2

(ii) Displace the wire from its equilibrium position and release it so that it performs small oscillations in a vertical plane, as shown in Fig. 1.3.

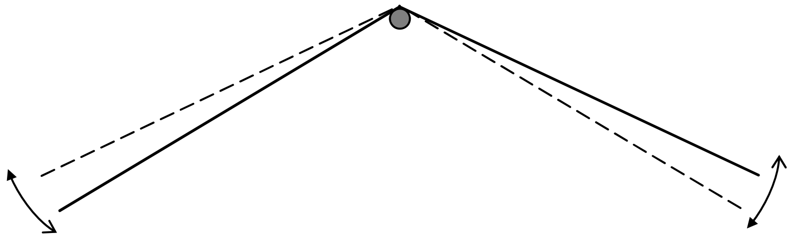


Fig. 1.3

(iii) Make and record measurements to determine the period *T* of these oscillations.

T = ... [2]

(c) Remove the wire from the pin. Change the value of θ by gently bending the wire. The new value of θ should be in the range $60° \leq \theta \leq 90°$. Record down the value of θ and repeat steps in **(b)** to obtain period *T*.

θ = ...

T = ... [2]

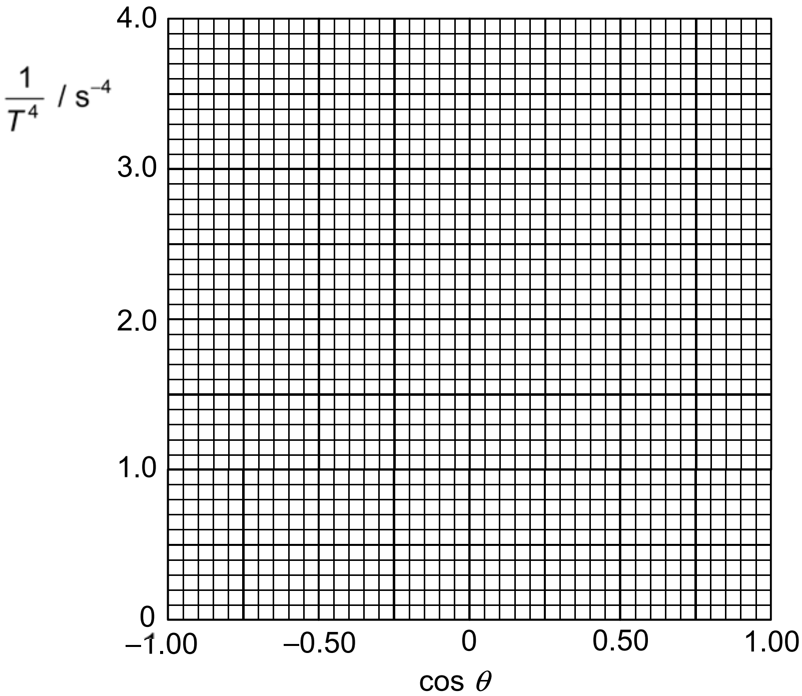
(d) The experiment is repeated using a wire with another length and the angle θ of the bent wire is varied. The results are shown in Fig. 1.4. Values of $\frac{1}{T^4}$ and $\cos\theta$ are included.

θ / °	$\cos\theta$	T / s	$\frac{1}{T^4}$ / s^{-4}
159		1.56	0.169
135		1.16	0.552
110		0.942	1.27
96		0.884	1.64
74		0.816	2.26
45		0.745	3.25

Fig. 1.4

(i) Complete Fig. 1.4. [1]

(ii) Plot the points on the grid and draw the straight line of best fit.



[2]

(iii) Using the graph in **(d)(ii)**, state and explain whether $\frac{1}{T^4}$ is proportional to $\cos\theta$.

....

.... [2]

[Total: 11 marks]

[Turn over

2 In this experiment, you will investigate how the rate of heat loss from a beaker of hot water depends on the insulation of the container.

(a) Measure the room temperature T_{room}.

T_{room} = ...

(b) Pour hot water into a beaker until it reaches the 80 ml mark.

(c) **(i)** Place the thermometer in the water.

(ii) When the temperature of the water decreases to 80 °C, start the stopwatch.

Measure and record the water temperature T_0 when time t = 60 s and t = 120 s in Fig. 2.1. [1]

t / s	T_0 / °C	$T_{\text{insulated}}$ / °C	$(T_{\text{insulated}} - T_0)$ / °C
60			
120			

Fig. 2.1

(d) **(i)** Empty the beaker.

(ii) Pour hot water into beaker until it reaches the 80 ml mark.

(iii) Wrap insulating material around the sides of the beaker. Secure the insulating material to the beaker using a rubber band, as shown in Fig. 2.2.

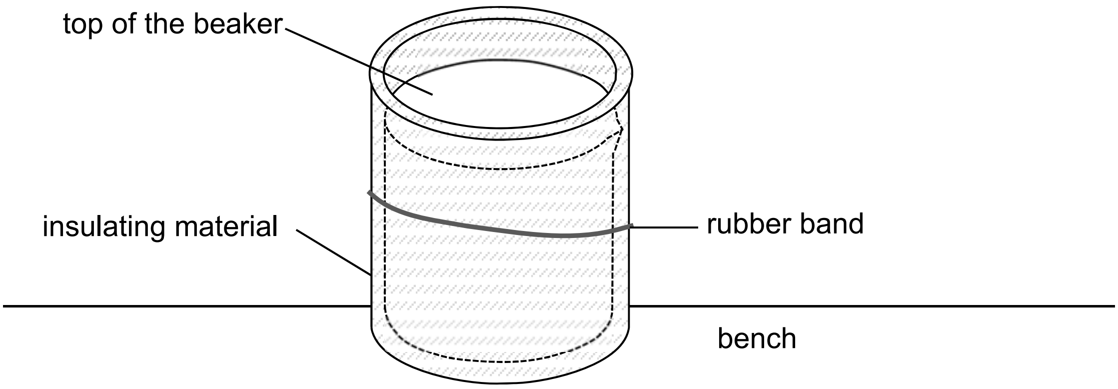


Fig. 2.2

(iv) Repeat **(c)** to measure the water temperature $T_{\text{insulated}}$ at the same time intervals.

Record the values of $T_{\text{insulated}}$ and $(T_{\text{insulated}} - T_0)$ in Fig. 2.1. [2]

(e) It is suggested that T_0 and $T_{insulated}$ for the corresponding t are related by the expression

$$\left(T_{insulated} - T_0\right) = AT_0 + B$$

where A and B are constants.

Using your results from Fig. 2.1, determine the values of A and B.

A = ...

B = ... [3]

(f) Use your values from **(a)** and **(e)** to determine the value of $T_{insulated}$ when T_0 reaches room temperature T_{room}.

$T_{insulated}$ = ... [1]

(g) **(i)** State and explain two significant sources of error or limitations of the procedures for this experiment.

1. ....

....

2. ....

.... [2]

(ii) Suggest one improvement that could be made to the experiment to address one of the errors identified in **(g)(i)**. You may suggest the use of other apparatus or different procedures.

....

.... [1]

(h) A vacuum flask is an insulating storage vessel that lengthens the time over which its contents remain hotter or cooler than the flask's surroundings.

A vacuum flask manufacturer wishes to investigate how evaporation affects the heat retention of the vacuum flask.

Suggest changes that could be made to your experiment to investigate how the rate of heat loss from an insulated container depends on evaporation.

....

....

....

....

.... [2]

[Total: 12 marks]

Candidate Name: ______________________________ (   )   Class: ________________

3 In this experiment you will investigate how the power *P* generated in a resistor varies with the resistance *R* of the resistor.

(a) You are supplied with a fixed resistor labelled Q and a variable resistor of resistance *R*. Construct the circuit shown in Fig. 3.1.

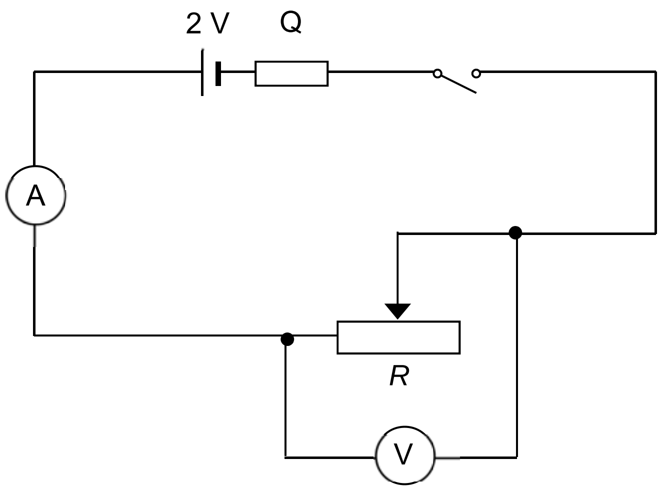


Fig. 3.1

(b) **(i)** Close the switch.

(ii) Adjust the slider of the variable resistor such that the voltmeter reading *V* is approximately 0.5 V.

(iii) Measure and record the potential difference *V* and the current *I*.

V = ...

I = ... [2]

(iv) Open the switch.

(v) Calculate the values of resistance *R* of the variable resistor and power *P* where $R = \frac{V}{I}$ and $P = IV$.

R = ...

P = ...

(vi) Justify the number of significant figures which you have quoted for *R* and *P*.

....

.... [1]

(c) Change the resistance of the variable resistor to increase the value of *V*. Repeat steps **(b)(i)**, **(iii)**, **(iv)** and **(v)** to obtain at least 7 further sets of readings for $V < 1.3$ V.

[7]

(d) **(i)** Plot a graph of *P* against *R*. [3]

(ii) Hence, state the value of *R* when *P* is a maximum.

R = ... [2]

(e) By drawing a tangent to the curve, determine the rate of change of P with R when R = 6 Ω.

rate of change of P = ... [3]

(f) The power P and the current I are related by the expression

$$P = I^2R$$

By drawing a second line on your graph in page 11, determine the value(s) of P when I = 100 mA. Label this line **Z**.

P = ... W [2]

[Total: 20 marks]

Candidate Name: ______________________________ (   ) Class: ________________

4 A student wishes to investigate projectile motion.

A small ball is rolled with velocity v along a horizontal surface. When the ball reaches the end of the horizontal surface, it falls and lands on a lower horizontal surface. The vertical displacement of the ball is h and the horizontal displacement of the ball is d, as shown in Fig. 4.1.

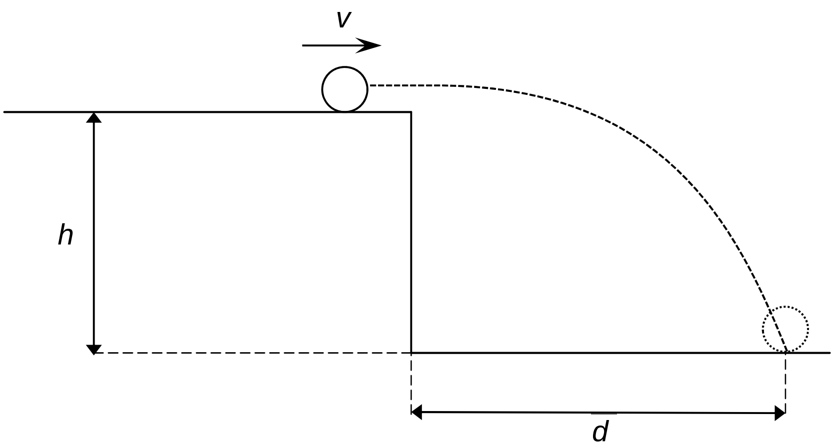


Fig. 4.1

The student suggests that d is dependent on h and v according to the equation

$$d = kh^p v^q$$

where k, p and q are constants to be determined.

Design a laboratory experiment to determine the values of k, p and q.

You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the identification and control of variables,

(b) the equipment you would use and measurements to be taken,

(c) procedure to be followed,

(d) the analysis of the data,

(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

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[Total: 12 marks]

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MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/01

Paper 1 Multiple Choice **20 September 2018**

1 hour

Additional Materials: Optical Mark Sheet (OMS)

	Class	Reg No
Candidate Name: ______________________		

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Answer Sheet.

In the Index Number section, shade your index number using the first two spaces (e.g. index number 5 should be entered as “05”). Ignore the remaining numbers and letters.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

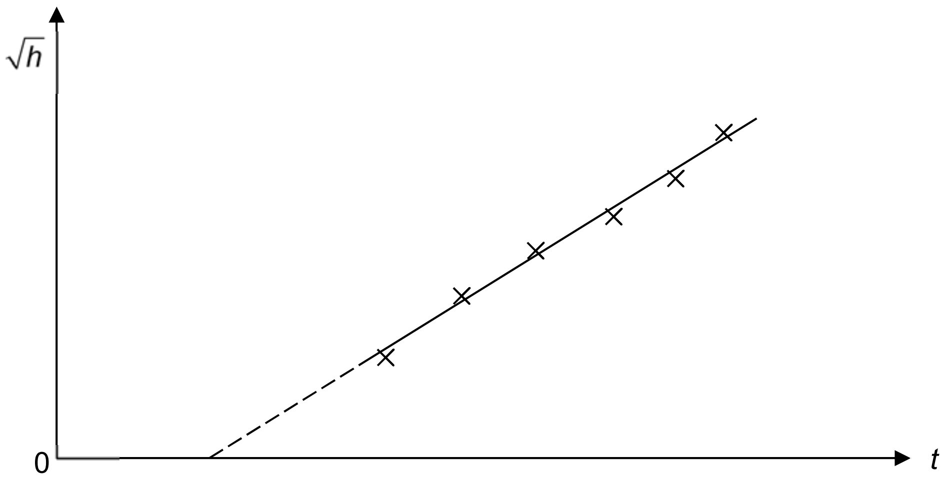
Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translation kinetic energy an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
	v	=	$\pm\, \omega\sqrt{x_o{}^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	X	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

1	B	11	D	21	D
2	C	12	C	22	A
3	D	13	A	23	A
4	C	14	C	24	A
5	D	15	B	25	A
6	A	16	A	26	C
7	C	17	B	27	B
8	B	18	B	28	B
9	B	19	D	29	D
10	C	20	B	30	A

1 A student measures the time *t* for a ball to fall from rest through a vertical distance *h*. The student plots his results and best-fit line in the graph shown.



Which of the following statement is true?

A The result is accurate as the line is close to the data points

B The result is not accurate as the line does not pass through the origin

C Data is precise as there are equal number of data points on both sides of the line

D Data is precise as the data points do not deviate from the line

Ans: (B)
At time = 0, the height fallen should be zero since the ball is still at the starting point.

2 The experimental measurement of the heat capacity of a solid as a function of temperature *T* is found to fit the following expression

$$C = \alpha T^3 + \beta T$$

What are the possible base units of α and β?

units of α units of β

A	kg m^2 s^{-1} K^{-4}	kg m^2 s^{-1} K^{-1}
B	kg^2 m s^{-2} K^{-3}	kg^2 m s^{-2} K^{-2}
C	kg m^2 s^{-2} K^{-4}	kg m^2 s^{-2} K^{-2}
D	kg^2 m s^{-2} K^{-3}	kg^2 m s^{-2} K^{-1}

Ans: (C)

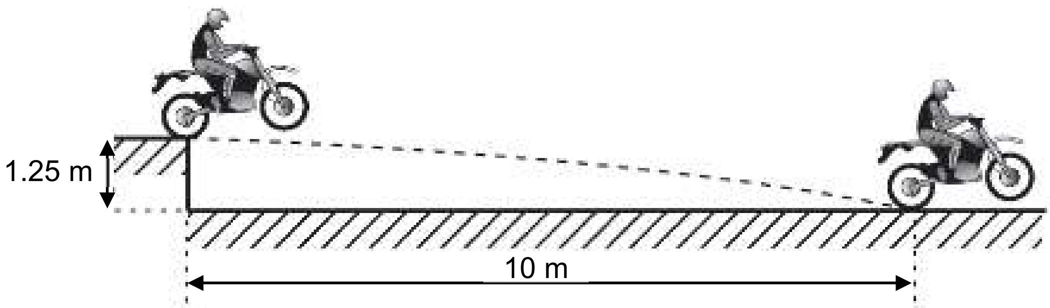
$C = \alpha T^3 + \beta T$

$\text{J K}^{-1} = [\alpha](\text{K}^3) = [\beta](\text{K})$

Using $E = \frac{1}{2}mv^2$ $\quad \text{J} = \text{kg m}^2\ \text{s}^{-2}$

$\text{kg m}^2\ \text{s}^{-2}\ \text{K}^{-1} = [\alpha](\text{K}^3) = [\beta](\text{K})$

3 A motorcycle stunt-rider moving horizontally takes off from a point 1.25 m above the ground, landing 10 m away as shown in the diagram.



What was the speed at take-off?

A 5 m s^{-1} **B** 10 m s^{-1} **C** 15 m s^{-1} **D** 20 m s^{-1}

Ans: D

$\downarrow s_y = u_y t + ½ a_y t^2 \Rightarrow 1.25 = 0 + ½ (9.81) t^2 \Rightarrow t = 0.50$ s

$\rightarrow s_x = u_x t \Rightarrow 10 = u_x (0.50) \Rightarrow u_x = 20$ m s^{-1}

4 A body of mass 3.0 kg is thrown with a velocity of 20 m s^{-1} at an angle of 60° above horizontal. It reaches the maximum height after 1.8 s. Air resistance is negligible.

What is the rate of change of momentum of the body at the maximum height?

A zero **B** 17 kg m s^{-2} **C** 29 kg m s^{-2} **D** 33 kg m s^{-2}

Ans: C

rate of change of momentum = net force = weight = 3.0 × 9.81 = 29 N

OR use $(mv_y - mu_y)/t = (0 - 3.0 \times 20 \sin 60°) / 1.8 = -29$ kg m s^{-2}

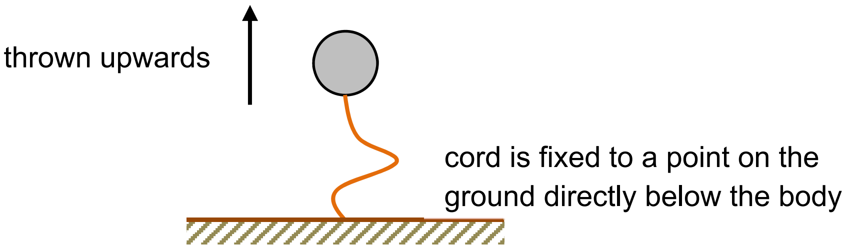
5 A body P of mass 2.0 kg and moving with velocity +3.0 m s^{-1} makes a head-on inelastic collision with a stationary body Q of mass 4.0 kg.

Which of the following could be the velocities of P and Q after the collision?

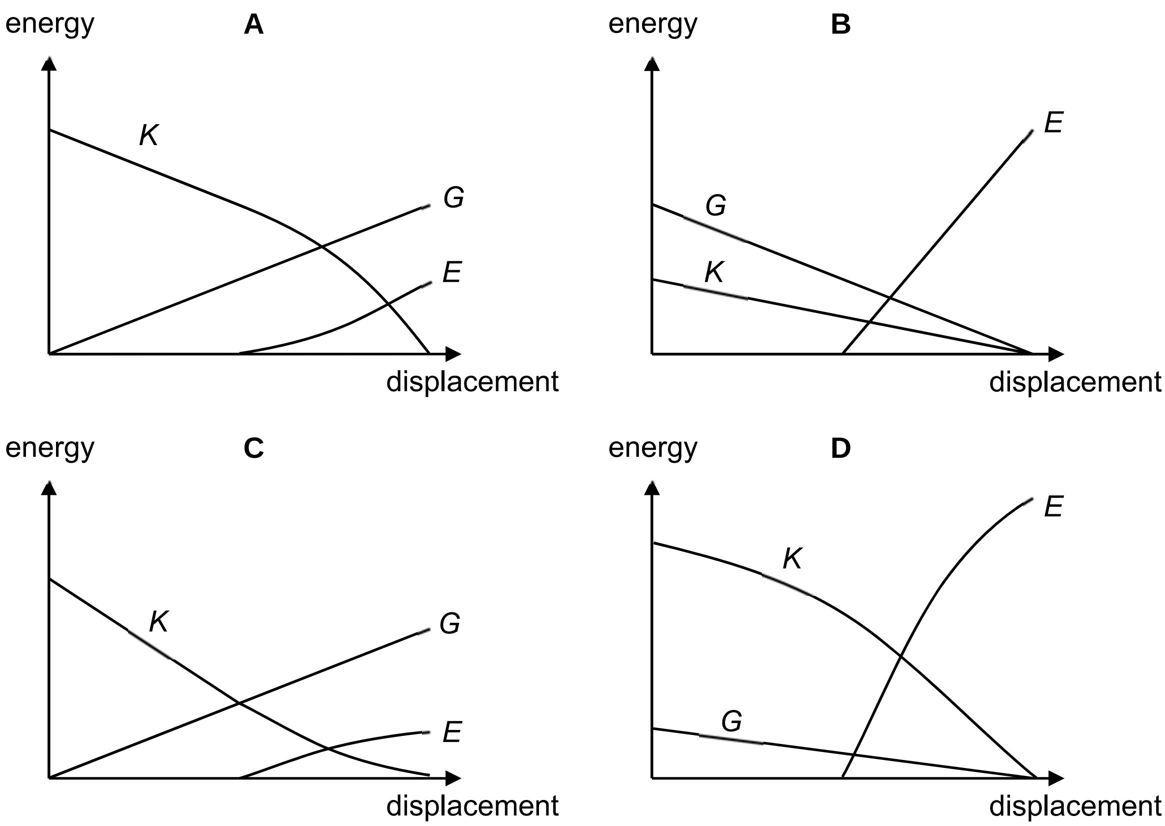
	velocity of P after collision	velocity of Q after collision
A	+0.5 m s^{-1}	+0.5 m s^{-1}
B	+0.0 m s^{-1}	+3.0 m s^{-1}
C	–1.0 m s^{-1}	+2.0 m s^{-1}
D	–0.6 m s^{-1}	+1.8 m s^{-1}

Ans: D
Initial momentum = 2.0 × 3.0 = +6.0 Ns
Final momentum = 2.0(–0.6) + 4.0(1.8) = –1.2 + 7.2 = +6.0 Ns
only D has momentum conserved but KE not conserved (or has lesser relative speed of separation than relative speed of approach)
Both momentum and KE are conserved for C (elastic collision)

6 The diagram shows a body attached to an elastic cord being thrown vertically upwards. Initially the cord is unstretched but after a while it becomes stretched. The cord obeys Hooke's law and air resistance is ignored.

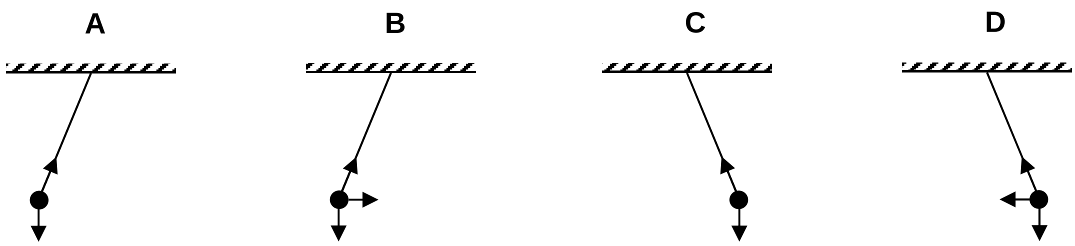


Which of the following shows the variation with displacement of the kinetic energy *K*, gravitational potential energy *G* and elastic potential energy *E*?



Ans: A
GPE increases linearly with displacement
EPE starts later, increases with extension squared (parabolic upwards)
KE decreases linearly with displacement at first (vs GPE), then decreases at greater and greater rate due to increasing EPE

7 A passenger is sitting in a railway carriage facing in the direction in which the train is travelling. A pendulum hangs down in front of him from the carriage roof. The train travels along a circular arc bending to the left. Which one of the following diagrams shows the position of the pendulum as seen by the passenger, and the directions of the forces acting on it?



Ans: C

8 In two widely-separated planetary systems whose suns have masses S_1 and S_2, planet P_1 of mass M_1 (orbiting sun S_1) and planet P_2 of mass M_2 (orbiting sun S_2) are observed to have circular orbits of equal radii. If P_1 completes an orbit in half the time taken by P_2, it may be deduced that

A $S_1 = S_2$ and $M_1 = 0.25\ M_2$

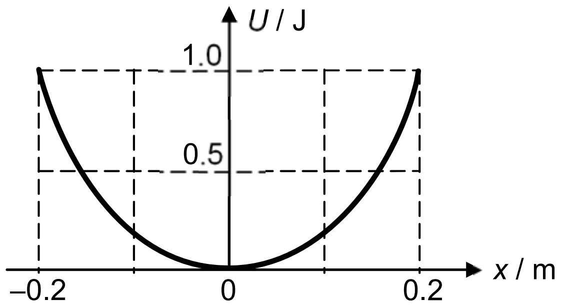
B $S_1 = 4S_2$ only

C $S_1 = 4S_2$ and $M_1 = M_2$

D $S_1 = 0.25\ S_2$ only

Ans: (B)

9 A particle of mass 4.0 kg moves in simple harmonic motion. Its potential energy *U* varies with position *x* as shown in the figure below.



What is the period of oscillation of the mass?

A $\dfrac{2\pi}{25}$ s **B** $\dfrac{2\pi\sqrt{2}}{5}$ s **C** $\dfrac{8\pi}{25}$ s **D** $\dfrac{4\pi}{5}$ s

Ans B

Total energy of system is constant.

Max PE = 1.0 J = Max KE = ½ m v_{max}^2

$$v_{max} = \frac{1}{\sqrt{2}}$$

$$v_{max} = \omega x_o = \frac{2\pi}{T} x_o$$

$$T = \left(\frac{2\pi}{v_{max}}\right) x_o$$

$$= 2\pi\left(\sqrt{2}\right)(0.2)$$

$$= \frac{2\pi\sqrt{2}}{5}$$

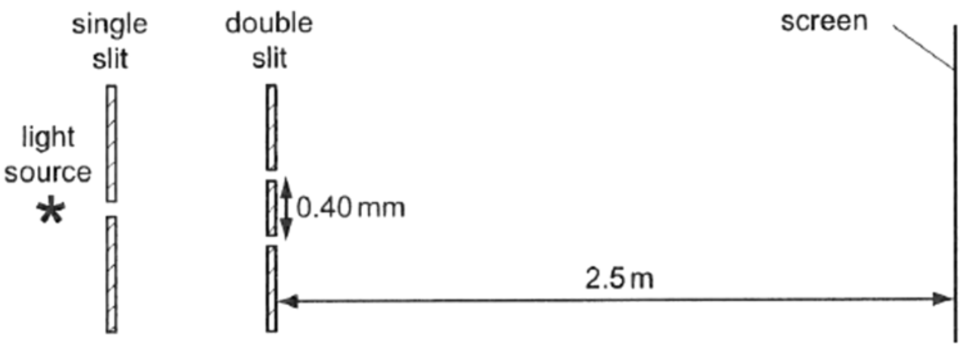
10 A toy car moving along a horizontal plane in simple harmonic motion starts from the amplitude at time *t* = 0 s. If the amplitude of its motion is 5.0 cm and frequency is 2.0 Hz, the magnitude of the acceleration of the toy car at 1.7 s is

A 0.25 m s^{-2} **B** 0.51 m s^{-2} **C** 6.4 m s^{-2} **D** 7.4 m s^{-2}

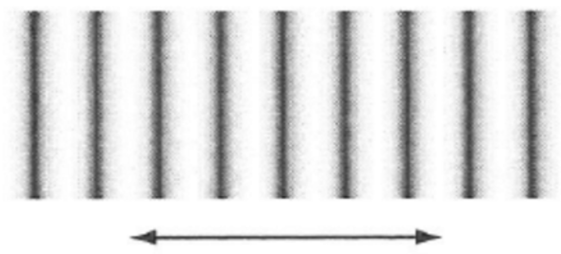
Ans C

$$x = x_o \cos(\omega t)$$
$$= 5.0\cos(2\pi(2)\times 1.7)$$
$$= -4.05 \text{ cm}$$
$$a = \left|\omega^2 x\right|$$
$$= (4\pi)^2 (4.05\times 10^{-2})$$
$$= 6.4 \text{ m s}^{-2}$$

11 A two source interference experiment is set up as shown.



The source emits light of wavelength 600 nm. The interference pattern on the screen is shown below.



What is the distance *x*?

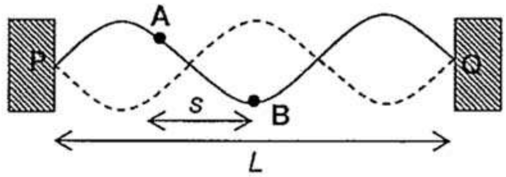
A 3.8×10^{-4} m **B** 1.9×10^{-3} m **C** 3.8×10^{-3} m **D** 1.9×10^{-2} m

Ans D

$$\Delta x = \frac{\lambda D}{a} = \frac{600\times 10^{-9}(2.5)}{0.40\times 10^{-3}} = 3.75\times 10^{-3} \text{ m}$$

$$x = 5\Delta x = 5(3.75\times 10^{-3}) = 1.9\times 10^{-2} \text{ m}$$

12 A guitar string of length *L* is stretched between two fixed points **P** and **Q** and made to vibrate transversely as shown.



Two particles **A** and **B** on the string are separated by a distance *s*. The maximum kinetic energies of **A** and **B** are K_A and K_B respectively.

Which of the following gives the correct phase difference and maximum kinetic energies of the particles?

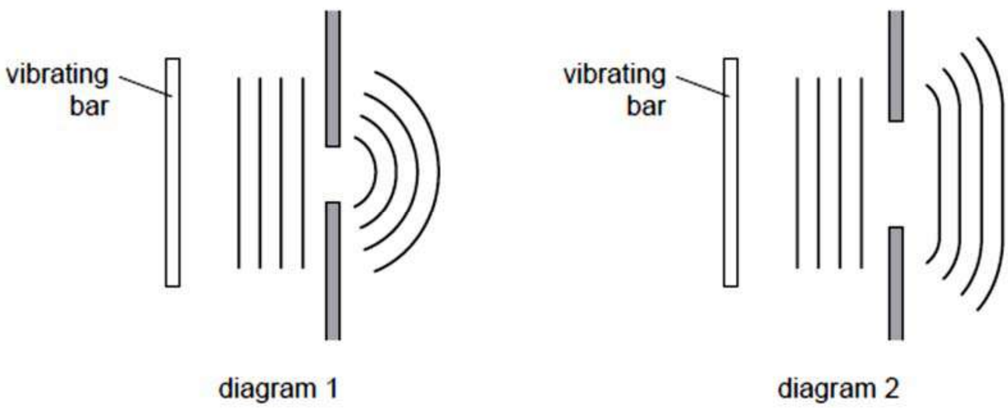
	Phase difference	Maximum kinetic energy
A	$\left(\frac{3s}{2L}\right)\times 360°$	$K_A < K_B$
B	$\left(\frac{3s}{2L}\right)\times 360°$	same
C	180°	$K_A < K_B$
D	180°	same

Ans: C
Since particles A and B are at two sides of a node of a stationary wave, they are anti-phase. Hence phase difference is 180°
Maximum KE is proportional to amplitude. Since amplitude of A < amplitude of B,
$K_A < K_B$

13 Diagram 1 shows a ripple tank experiment in which plane waves are diffracted through a narrow slit in a metal sheet.

Diagram 2 shows the same tank with a slit of greater width.

In each case, the pattern of the waves incident on the slit and the emergent pattern are shown.



Which action would cause the waves in diagram 1 to produce an emergent pattern closer to that shown in diagram 2?

A Increasing the frequency of vibration of the bar.

B Increasing the speed of the waves by making the water in the tank deeper.

C Reducing the amplitude of vibration of the bar.

D Reducing the length of the vibrating bar.

Ans: A

14 An ideal gas in a container of fixed volume 1.0 m^3 has a pressure of 3.0 x 10^5 Pa at a temperature of 200 K. The gas is heated until the temperature reaches 400 K. Some gas is released from the container during the heating to keep the pressure constant.

What volume does the gas released from the container occupy, if it is at atmospheric pressure of 1.0 x 10^5 Pa and at a room temperature of 300 K?

A 0.500 m^3 **B** 2.00 m^3 **C** 2.25 m^3 **D** 4.50 m^3

Ans C

$$n_1 = \frac{p_1V_1}{RT_1} = \frac{3.0\times10^5(1)}{8.31(200)} = 180.5 \text{ mol}$$

$$n_2 = \frac{p_2V_2}{RT_2} = \frac{3.0\times10^5(1)}{8.31(400)} = 90.25 \text{ mol}$$

$$n_{released} = n_1 - n_2 = 90.25 \text{ mol}$$

$$V_{released} = \frac{n_{released}RT}{p} = \frac{90.25(8.31)(300)}{1.0\times10^5} = 2.25 \text{ m}^3$$

15 When a volatile liquid evaporates it cools down.

What is the reason for this cooling?

A All the molecules slow down.

B Fast molecules leave the surface so the mean speed of those left behind is reduced.

C Molecular collisions result in loss of kinetic energy of the molecules.

D The molecules collide with one another less frequently.

Ans B

16 The molecules of an ideal gas at thermodynamic temperature *T* have a root-mean-square speed *c*.

The gas is heated to temperature 2*T*.

What is the new root-mean-square speed of the molecules?

A $\sqrt{2}c$ **B** $2\sqrt{2}c$ **C** $2c$ **D** $4c$

Ans A

$$\frac{1}{2}m(c)^2 = \frac{3}{2}kT$$
$$c \propto \sqrt{T}$$
$$\frac{c_{new}}{c} = \sqrt{\frac{2T}{T}}$$
$$c_{new} = \sqrt{2}c$$

17 Which one of the following statements about the electric potential at a point is correct?

A The potential is given by the rate of change of electric field strength with distance.

B The potential is equal to the work done per unit positive charge in moving a small point charge from infinity to that point.

C Two points in an electric field are at the same potential when a small positive charge placed along the line joining them remains stationary.

D An alternative unit for electric potential is V m^{-1}.

Ans: B

18 The electric potentials V are measured at distance x from P along a line PQ.

The results are:

V / V	13	15	18	21	23
x / m	0.020	0.030	0.040	0.050	0.060

The electric field at x = 0.040 m is approximately

A 300 V m^{-1} towards Q

B 300 V m^{-1} towards P

C 450 V m^{-1} towards Q

D 450 V m^{-1} towards P

Ans: B

19 A piece of wire of original length *L*, has a resistance of *R*. It is then melted and made into a new wire of length 1.7 *L*.

What is the resistance of the new wire?

A 0.59 *R* **B** *R* **C** 1.7 *R* **D** 2.9 *R*

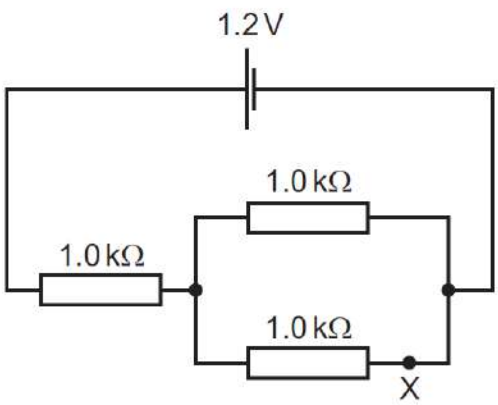
Ans: D
Since volume remains constant,

$$A_{old}L_{old} = A_{new}L_{new}$$

$$A_{new} = \frac{L}{1.7L}A_{old} = 0.59A_{old}$$

$$R_{new} = \rho\frac{L_{new}}{A_{new}} = \rho\frac{1.7L}{0.59A_{old}} = \frac{1.7}{0.59}R = 2.9R$$

20 In the circuit below, 3 identical resistors of resistance 1.0 kΩ are connected to a cell of 1.2 V with negligible internal resistance as shown.



How many electrons pass through point X in a minute?

A 2.5×10^{15} **B** 1.5×10^{17} **C** 2.5×10^{18} **D** 1.5×10^{20}

Ans: B

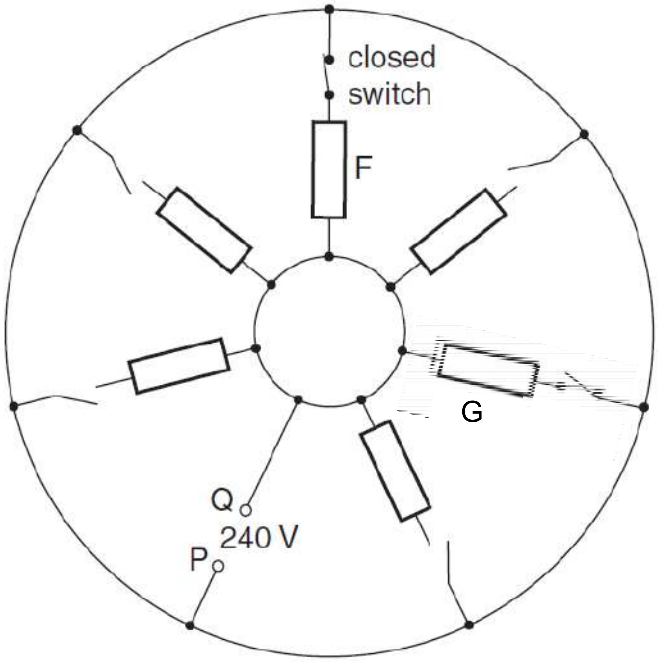
$$V_{parallel} = \frac{0.5}{1.5}(1.2) = 0.4 \text{ V}$$

$$I = \frac{0.4}{1000} = 0.0004 \text{ A}$$

$$\frac{N_e}{t} = \frac{0.0004}{1.6\times10^{-19}} = 2.5\times10^{15}$$

$$N_e = 2.5\times10^{15}\times60 = 1.5\times10^{17}$$

21 Electrical sockets in a house are connected to a circuit called a ring main. The circuit is connected between P and Q to the 240 V power supply as shown.



Two devices, F and G, are currently switched on. They have resistances of 1200 Ω and 1700 Ω respectively.

What is the current supplied by the power supply and total power dissipated by both devices?

	current / A	total power dissipated / W
A	0.083	20
B	0.083	82
C	0.34	20
D	0.34	82

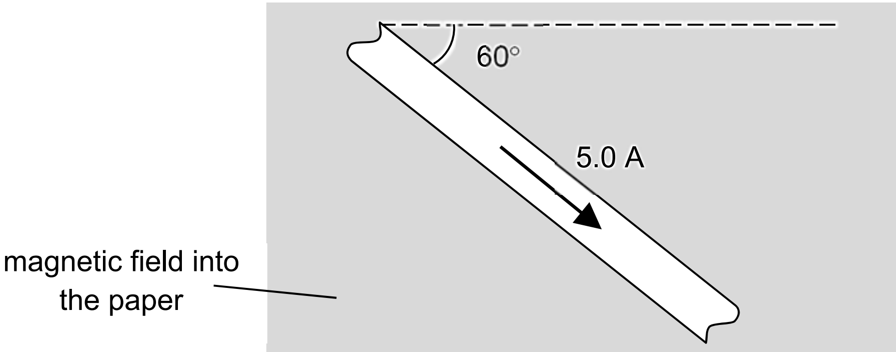
Ans: D
F and G are connected in parallel to the power supply.

$$R_{effective} = \left(\frac{1}{1200} + \frac{1}{1700}\right)^{-1} = 703\ \Omega$$

$$I = \frac{240}{703} = 0.34\ \text{A}$$

$$P_{total} = \frac{240^2}{1200} + \frac{240^2}{1700} = 82\ \text{W}$$

22 A wire of length 3.0 cm is placed in the plane of the paper, along a line 60° clockwise from the *x*-axis. A magnetic field of flux density 0.040 T acts into the paper. The wire carries a current of 5.0 A.



What is the magnitude of the force which the field exerts on the wire?

A 0.0060 N **B** 0.0030 N **C** 0.0052 N **D** 0.0104 N

Ans: (A)
F = BIL = (0.040)(5.0)(0.030) = 0.0060 N
The angle does not play a part.

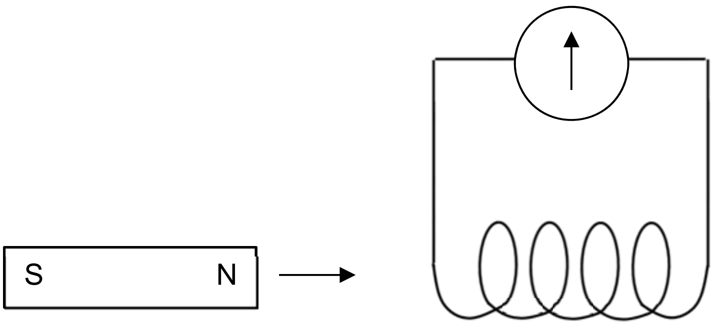
23 An electron is moving along the axis of a solenoid carrying a current.

Which of the following is a correct statement about the electromagnetic force acting on the electron?

A No force acts on the electron.
B The force acts in the direction of motion.
C The force acts opposite to the direction of motion.
D The force causes the electron to move along a helical path.

Ans: (A)
Magnetic field is along the axis. Since velocity of electron is parallel to magnetic field, no electromagnetic force acts on the electron.

24 The North pole of a bar magnet is pushed into the end of a coil of wire. The maximum movement of the meter needle is 10 units to the left.



The South pole of the magnet is then pushed into the other end of the coil at half the speed.

What is the maximum movement of the meter needle?

A less than 10 units to the left

B less than 10 units to the right

C more than 10 units to the left

D more than 10 units to the right

Ans: A

Applying Lenz's law, a North will be induced on the left side of the coil when the North pole is pushed into the left end; A South pole will be induced on the right side when South is pushed into the right end. Polarity of the induced B-field in the coil is the same for both cases.

Since speed is halved, rate of change of magnetic flux linkage in the coil is less and a lower (e.m.f. and hence) current is induced.

25 The secondary coil of an ideal transformer delivers an r.m.s. current of 1.5 A to a load resistor of resistance 10 Ω. The r.m.s. current in the primary coil is 5 A.

What is the r.m.s. potential difference across the primary coil?

A 4.5 V **B** 6.4 V **C** 15 V **D** 50 V

Ans: A

$$P = I^2R = 1.5^2 \times 10 = 22.5 \text{ W}$$

$$V_s = \frac{P}{I_s} = \frac{22.5}{5} = 4.5 \text{ V}$$

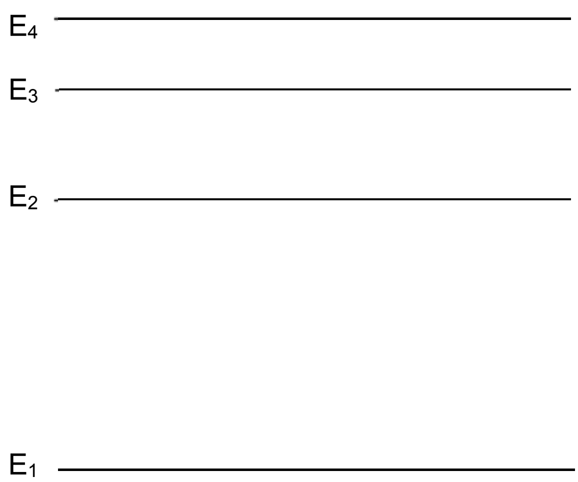
alt: $V_s = RI = 10 \times 1.5 = 15$ V

$$\frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$$V_p = \frac{1.5}{5} \times 15$$

$$= 4.5 \text{ V}$$

26 The diagram represents in simplified form some of the energy levels of the hydrogen atom.



The transition of an electron from E_3 to E_2 is associated with the emission of red light.

Which transition could be associated with the emission of blue light?

A E_4 to E_1 **B** E_1 to E_4

C E_4 to E_2 **D** E_2 to E_4

Ans: C

$\lambda_{red} \approx 700$ nm, $\lambda_{blue} \approx 400$ nm, $E = \dfrac{hc}{\lambda}$ hence the energy transition for blue light should be about 1.75 x that of red light.

Transition is from a higher energy level to lower energy level for emission of light.

27 An electron has a kinetic energy of 1.0 MeV. If its momentum is measured with an uncertainty of 1.0%, what is the uncertainty in its position?

A 7.7×10^{-10} m **B** 1.2×10^{-10} m **C** 2.9×10^{-12} m **D** 4.1×10^{-19} m

Ans: (B)

$$E = \frac{p^2}{2m}$$

$$p = \sqrt{2mE} = \sqrt{2\left(9.11\times10^{-31}\right)\left(1.0\times10^6\times1.6\times10^{-19}\right)}$$

$$= 5.399\times10^{-22} \text{ kg m s}^{-1}$$

$$\Delta x \cdot \Delta p \gtrsim h$$

$$\Delta x \gtrsim \frac{h}{\%\Delta p} = \frac{6.63\times10^{-34}}{0.01\times5.399\times10^{-22}} = 1.2\times10^{-10} \text{ m}$$

28 When the number of protons and the number of neutrons in a nuclide are both “magic numbers”, it is more stable than expected. Such nuclides are termed “doubly magic”.

The first few “magic numbers” are 2, 8, 20, 28, 50, 82, and 126.

How many of the following five nuclides are “doubly magic”?

$^{28}_{8}O$	$^{40}_{20}Ca$	$^{56}_{26}Fe$	$^{50}_{28}Ni$	$^{126}_{50}Sn$

A 1 **B** 2 **C** 3 **D** 4

Ans: (B)

$^{28}_{8}O$: 8 protons, 20 neutrons (doubly magic)

$^{40}_{20}Ca$: 20 protons, 20 neutrons (doubly magic)

$^{56}_{26}Fe$: 26 protons, 30 neutrons (not)

$^{50}_{28}Ni$: 28 protons, 22 neutrons (not)

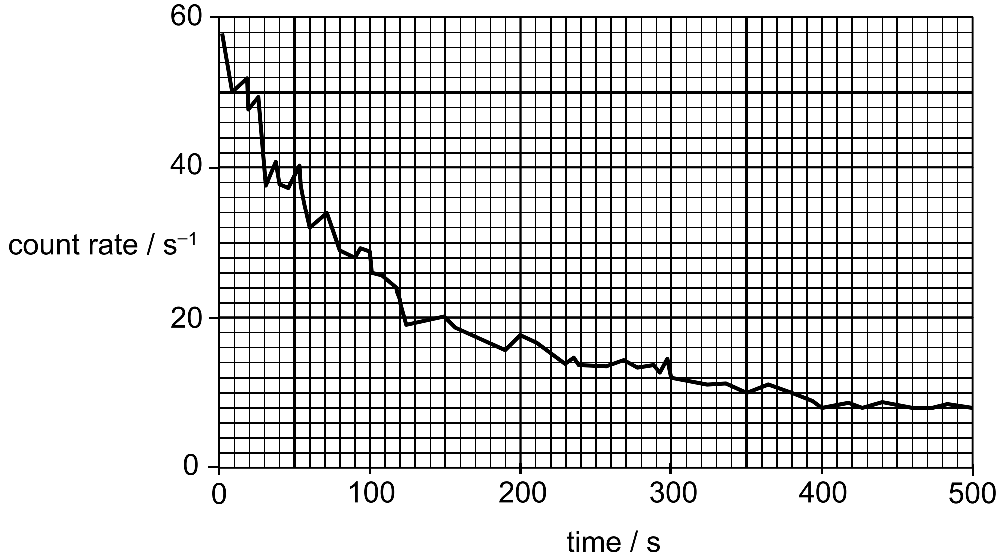
$^{126}_{50}Sn$: 50 protons, 76 neutrons (not)

29 Radon-222, ${}^{222}_{86}\text{Rn}$ decays to Lead-210, ${}^{210}_{82}\text{Pb}$ via a series of three alpha and two beta decays through a series of intermediate nuclides. Which of the following cannot be one of the intermediate nuclides produced?

A ${}^{214}_{82}\text{Pb}$ **B** ${}^{214}_{83}\text{Bi}$ **C** ${}^{218}_{84}\text{Po}$ **D** ${}^{216}_{85}\text{At}$

Ans: D
Alpha decays cause nucleon number to decrease by 4 each time.
Beta decays do not affect nucleon number.
Possible nuclides can only have nucleon numbers of 218, 214, 210.
(Sufficient to only consider nucleon number in this case.)

30 An experiment is carried out in which the count rate is measured at a fixed distance from a sample of a certain radioactive material. The figure below shows the variation of count rate with time.



What is the approximate half-life of the material?

A 60 s **B** 80 s **C** 100 s **D** 120 s

Ans: A
Considering background count rate to be 8 counts s^{-1},
Half life is when count rate decreases from 58 (=50+8) to 33 (=25+8).
Best option is 60 s.

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/02

Paper 2 Structured Questions

12 September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

Class	Reg No

Candidate Name: ______________________________

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**/ 6**
2	**/ 8**
3	**/ 11**
4	**/ 10**
5	**/ 10**
6	**/ 8**
7	**/ 7**
8	**/ 20**
Deductions	
Total	**/ 80**

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T /K	=	T /°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translation kinetic energy an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\, \omega\sqrt{x_o^{\,2} - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 **(a)** For an oscillating body, state what is meant by

(i) natural frequency of vibration,

When the system oscillates without any external periodic force applied, its frequency is called its natural frequency.

.... [1]

(ii) resonance.

Resonance occurs when the frequency of the driving force (driving frequency) is equal to the natural frequency of the system, giving a maximum amplitude of vibration.

....[1]

(b) State and explain one situation where resonance is useful.

1) Microwave Cooking

In a microwave oven, microwaves with a frequency similar to the natural frequency of vibration of water molecules are used. When food containing water molecules is placed in the oven and radiated by microwave, the water molecules resonate, absorb energy from the microwaves and get heated up. This absorbed energy then spreads through the food and cooks it. The plastic or glass containers do not heat up as much since they do not contain water molecules.

2) Radio Receiver

Our air is filled with radio waves of many different frequencies which the aerial (antenna) picks up. The tuner can be adjusted so that the natural frequency of the electrical oscillations in the circuits is the same as that of the radio wave transmitted from a particular station (the desired station). The radio waves of that particular frequency cause much larger oscillations (due to resonance) resonance compared to the radio waves of other frequencies.

3) Magnetic resonance imaging

Strong, electromagnetic fields of varying radio frequencies are used to cause oscillations in atomic nuclei. When resonance occurs, energy is absorbed by the molecules. By analysing the pattern of energy absorption, a computer-generated image can be produced. The advantage of MRI scanner is that no ionising radiation (as in the process of producing X-ray images) is involved.

4) Swing

The swinging of the legs has to be synchronised and at the same frequency as the natural frequency of the swing so that a large amplitude of oscillation can be obtained.

5) Voice

6) Guitar / Musical instrument

....[2]

(c) In some situations, resonance should be avoided.

State one such situation and how the effects of resonance are reduced.

1) Earthquakes and tidal waves
During an earthquake, when the frequencies of the vibration match with the natural frequencies of buildings, resonance may occur and result in serious damages. In regions of the world where earthquakes happen regularly, buildings may be built on foundations that absorb the energy of the shock waves. In this way, the vibrations are damped and the amplitude of the oscillations cannot reach dangerous levels.

2) Vibrations in machines / metal panels
If a loose part in a car rattles when the car is travelling at a certain speed, it is likely that a resonant vibration is occurring. A washing machine with an unbalanced load which has natural frequency matching the spinning frequency will get violent vibrations as resonance occurs. Place dampers in the machine / place strengthening struts across the panel or change its shape/area of panel

....[2]

2 A particle in a medium is oscillating because of the passage of a transverse wave W_1.

The wave has intensity I at this point. The amplitude of the oscillation is A.

Fig. 2.1 shows the variation with time t of the displacement x of the particle.

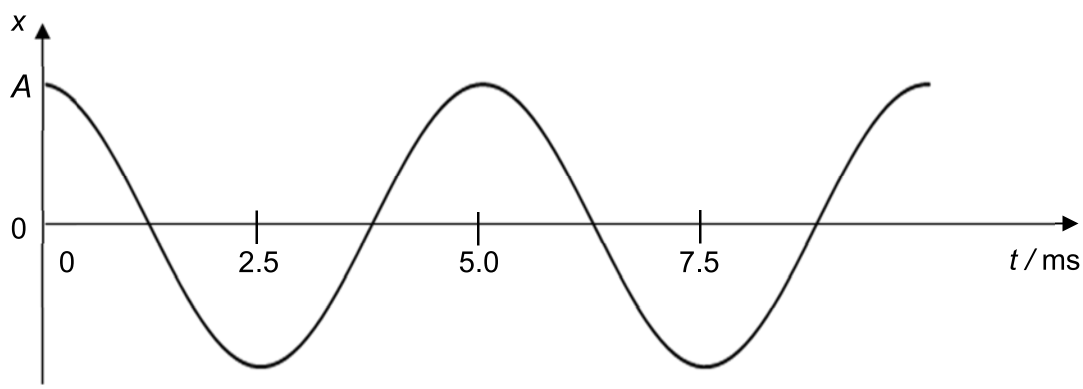


Fig. 2.1

A second, similar transverse wave W_2 has the same frequency and is incident on the same particle. The amplitude of the oscillation due to W_2 alone is $2.5\,A$ at this point.

(a) Calculate

(i) the frequency of the waves,

$$f = \frac{1}{T} = \frac{1}{5.0 \times 10^{-3}} = 200 \text{ Hz} \qquad \text{[B1]}$$

frequency = ... Hz [1]

(ii) the intensity, in terms of *I*, of the wave W_2.

Intensity ∝ Amplitude^2

$$\frac{I_2}{I_1} = \frac{A_2^2}{A_1^2}$$

$$\frac{I_2}{I} = \frac{\left(\frac{5A}{2}\right)^2}{A^2} \qquad \text{[M1]}$$

$$I_2 = \frac{25}{4} I = 6.25\, I \qquad \text{[A1]}$$

intensity = ... *I* [2]

(b) **(i)** State two conditions which are necessary for the waves W_1 and W_2 to produce an observable interference pattern.

The two waves must be coherent, (with constant phase difference between the two waves). [B1]
They must either be unpolarised, or polarised in the same plane. [B1]

....[2]

(ii) State the condition that must be satisfied if the waves are to interfere to produce a minimum resultant intensity at a point.

If the source is in phase, their path difference must be equal to (n+½) wavelengths where n is an integer. [B1]
Or
The two waves must be in antiphase with each other. [B1]

....[1]

(iii) Calculate, in terms of *I*, this minimum intensity.

For minimum intensity, the resultant amplitude is $\frac{5A}{2} - A$ [M1]

$$\frac{I_{\text{min}}}{I} = \frac{\left(\frac{5A}{2} - A\right)^2}{A^2}$$

$$I_2 = \frac{9}{4} I = 2.25\, I \qquad \text{[A1]}$$

minimum intensity = ... *I* [2]

3 (a) State two differences between stationary waves and progressive waves.

	Stationary Wave	**Progressive Wave**
Wave profile	• Varies from one extreme position to another, but does not advance.	• Advances with the speed of the wave.
Energy of wave	• Energy is retained within the vibratory motion of the wave.	• Energy is transferred in the direction of wave propagation.
Amplitude of oscillation of individual particles	• Depends on position along the wave • Particles at the antinodes oscillate with maximum amplitude • Particles at the nodes do not oscillate	• Same for all particles in the wave regardless of position (assuming no energy loss).
Wavelength	• Twice the distance between 2 adjacent nodes/ antinodes. • Equal to the wavelength of the component waves.	• Distance between any 2 consecutive points on the wave with the same phase.
Phase of wave particles in a wavelength	• All particles between 2 adjacent nodes are in phase. • Particles in alternate segments are in anti-phase (have a phase difference of π).	• Wave particles have different phases (0 to 2π) within a wavelength.
Any 2 rows [B1, B1]		

....[2]

(b) (i) A laser produces a narrow beam of coherent light of wavelength 632 nm. The beam is incident normally on a diffraction grating as shown in Fig. 3.1.

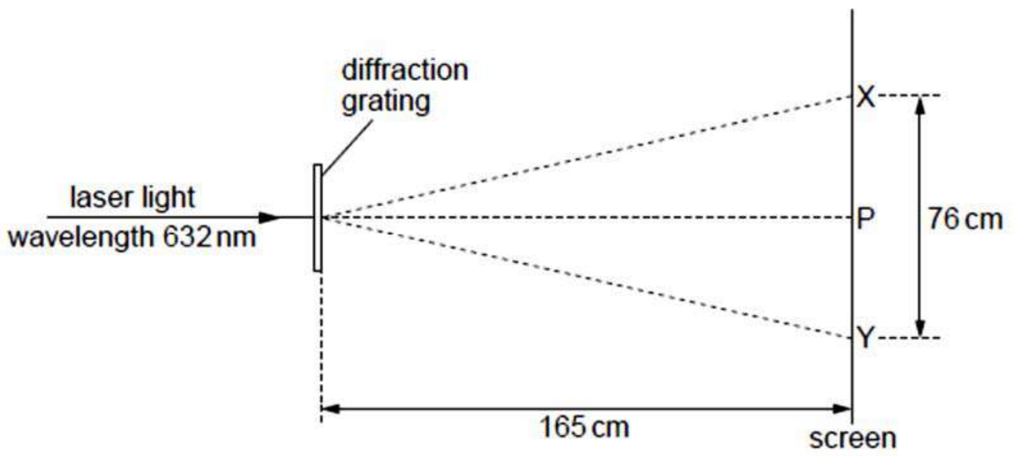


Fig. 3.1 (Top view)

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.

The brightest spot is P. The spots formed closest to P and on each side of P are X and Y.

X and Y are separated by a distance of 76 cm.

Calculate the number of lines per metre on the grating.

$$\tan\theta = \frac{38}{165}$$

$$\theta = 12.97° \ (13°)$$

$$d\sin\theta = n\lambda$$

$$d = \frac{632\times10^{-9}}{\sin 12.97°} = 2.82\times10^{-6} \qquad \text{[M1]}$$

$$\text{number of lines per metre} = \frac{1}{d} = \frac{1}{2.82\times10^{-6}} = 3.6\times10^{5} \qquad \text{[A1]}$$

number per metre = ... m^{-1} [2]

(ii) The grating in **(b)(i)** is now rotated about an axis parallel to the incident laser beam, as shown in Fig. 3.2.

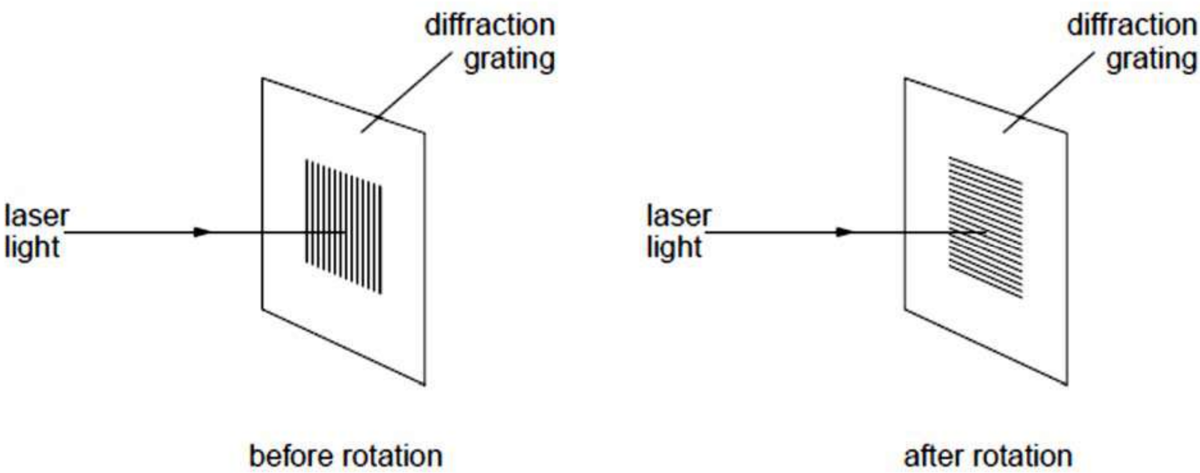


Fig. 3.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

P remains in the same position [B1]
X and Y rotate through 90° [B1]

....[2]

(iii) In another experiment using the apparatus in **(b)(i)**, a student notices that the distances XP and PY, as shown in Fig. 3.1 are not equal.

Suggest a reason for this difference.

Screen is not parallel to the diffraction grating. [B1]
or

The diffraction grating is not normal to the incident light. [B1]

....[1]

(c) A cord is held under tension between two fixed points A and B, as shown in Fig. 3.3. The distance AB is 0.40 m.

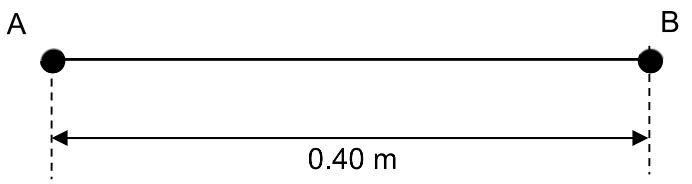


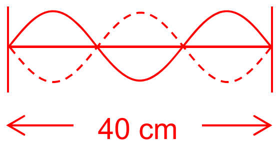
Fig. 3.3

(i) Explain why only stationary waves of certain frequencies are able to form between A and B.

Only standing waves that have a wavelength that fits the boundary conditions are possible. [B1]
OR
Standing waves are formed only when the length AB is an integer multiple of half wavelengths. [B1]

....[1]

(ii) The string is made to resonate in a mode with the third lowest possible frequency. Calculate the wavelength of this wave.



3 loops / 3 segments

$\frac{3}{2}\lambda = 40$ cm
$\lambda = 26.7$ cm [A1]

wavelength = ...m [1]

(iii) By reference to the formation of the stationary wave, explain the significance of the product of frequency and wavelength for a stationary wave.

Stationary wave is formed by two oppositely moving waves of the same type and frequency. [B1]
This product is the speed of propagation of the individual wave that results in the stationary wave. [B1]

....[2]

4 (a) Fig. 4.1 shows a piece of metal, of mass 50 g, held in the flame of a Bunsen burner for several minutes. The metal is then quickly transferred and immersed in 130 g of water contained in a calorimeter.

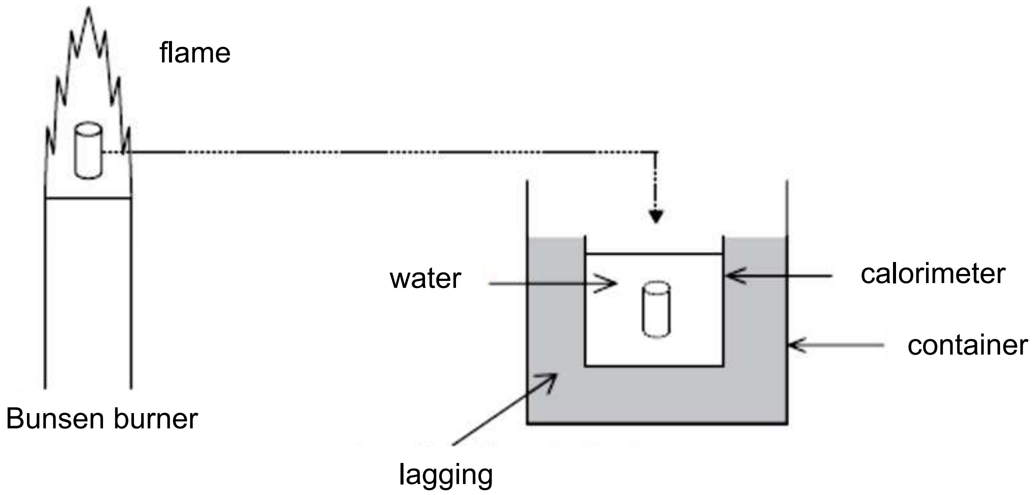


Fig. 4.1

The water into which the metal has been placed is stirred until it reaches a steady temperature. The following data are available:

heat capacity of metal	82.7 J K^{-1}
specific heat capacity of the water	4.2×10^3 J kg^{-1} K^{-1}
heat capacity of the calorimeter	54.6 J K^{-1}
initial temperature of the water	25 °C
final temperature of the water	90 °C

Use the data to calculate the temperature of the Bunsen flame and state an assumption made for your calculation.

energy lost by metal = energy gained by water + energy gained by calorimeter

$$82.7(T-90) = (0.130 \times 4.2 \times 10^3)(90-25) + 54.6(90-25) \quad [M1]$$

$$T = 562 \text{ °C} \quad [A1]$$

temperature = ...°C

There is no heat loss when the metal was transferred from the flame to the water. [B1]

Assumption: ....[3]

(b) The gas in the cylinder of a diesel engine can be considered to undergo a cycle of changes of pressure, volume and temperature. One such cycle, for an ideal gas, is shown in Fig. 4.2. Processes A to B and C to D take place without heat exchange with the surroundings.

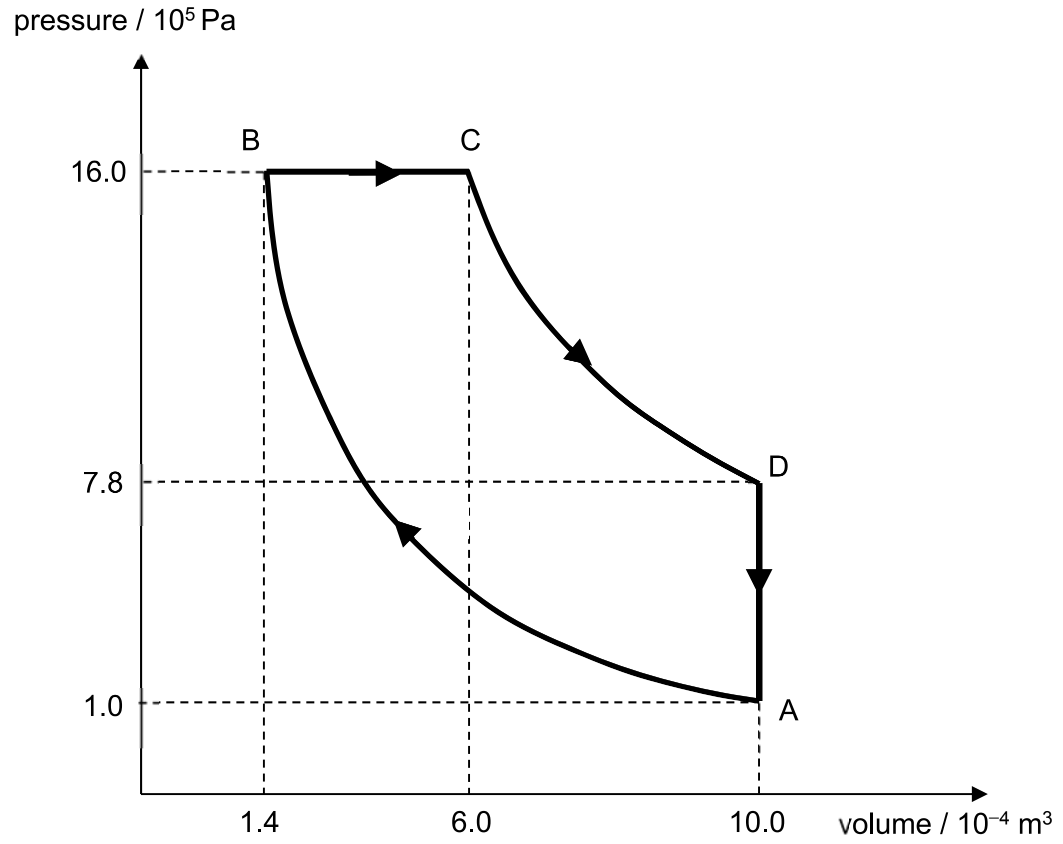


Fig. 4.2

Complete the table below.

Process	**Heat supplied to gas / J**	**Work done on gas / J**	**Increase in internal energy of gas / J** $\Delta U = Q + W$
A to B	0	300	300
B to C	2580	-740 $-p(\Delta V) = -1.6\times10^5(4.6\times10^{-4})$	1840
C to D	0	-440	-440
D to A	-1700	0 $\Delta V = 0$	-1700

Each process (row) correct, award one mark.

[4]

(c) A fixed mass of ideal gas is heated from temperature T_1 to T_2 at constant volume. Explain why a greater amount of heat is required to heat the same mass of ideal gas from T_1 to T_2 at constant pressure.

Amount of energy required is greater at constant pressure. [A0]
For an ideal gas, internal energy is proportional to temperature. The change in internal energy ΔU is the same for both cases. [B1]
By 1st law of thermodynamics, $\Delta U = Q + W$.
At constant volume, internal energy increases, but no work is done. ($Q = \Delta U$)
[B1]
At constant pressure and with volume increase, internal energy increases and work is done by the gas ($Q = \Delta U - W_{on} = \Delta U - (-W_{by})$) [B1]

....[3]

5 **(a)** Define *magnetic flux*.

The magnetic flux through a plane surface is the product of the flux density normal to the surface and the area of the surface

....[1]

(b) Fig. 5.1 shows a 1.6 m long solenoid with 400 turns and a cross-sectional diameter of 4.0 cm. A coil Y, with 80 turns, is wounded tightly around the centre region of the solenoid.

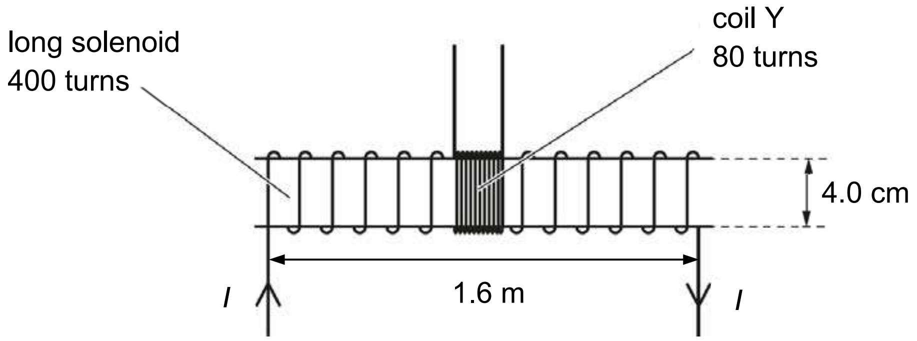


Fig. 5.1

(i) Show that, for a current I of 3.8 A in the solenoid, the magnetic flux linkage of coil Y is 1.2×10^{-4} Wb.

$$B = \mu_0 n I = 4\pi \times 10^{-7}\left(\frac{400}{1.6}\right)3.8$$ [C1]

$$= 3.8 \times 10^{-4}\pi$$

$$\Phi = NBA$$

$$= 80 \times \left(3.8 \times 10^{-4}\pi\right) \times \pi\left(\frac{0.040}{2}\right)^2$$ [M1]

$$= 1.2 \times 10^{-4}\ \text{Wb}$$ [A0]

[2]

(ii) The current *I* in the solenoid in **(b)(i)** is reversed in 0.30 s.

Calculate the mean e.m.f. induced in coil Y.

$$E_{mean} = \frac{\Delta\Phi}{\Delta t}$$

$$= \frac{2 \times 1.2 \times 10^{-4}}{0.30}$$ [M1]

$$= 8.0 \times 10^{-4}\ \text{V}$$ [A1]

mean e.m.f. = ... V [2]

(iii) The current *I* in the solenoid in **(b)(ii)** varies with time *t* as shown in Fig. 5.2.

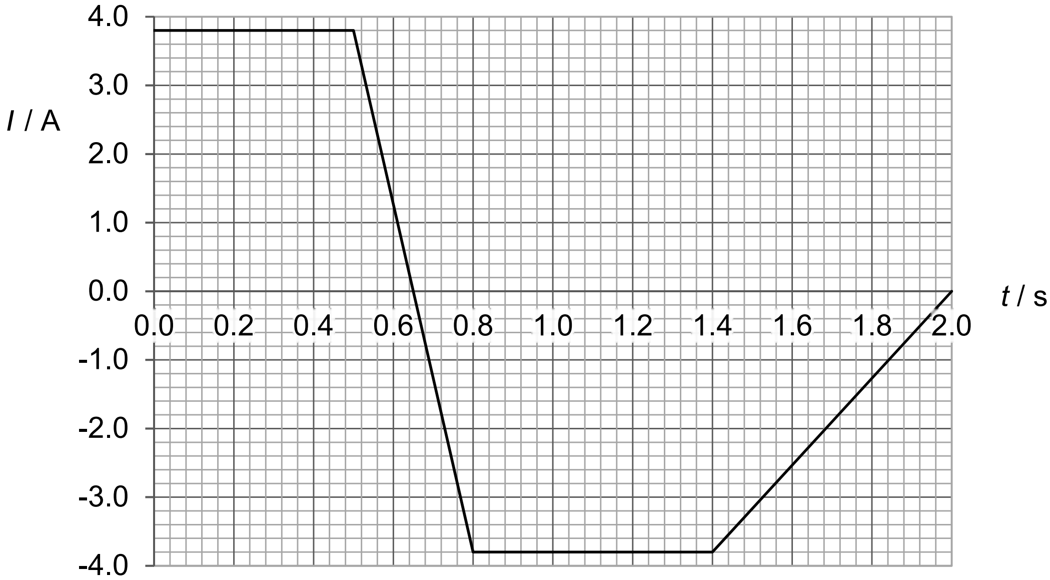
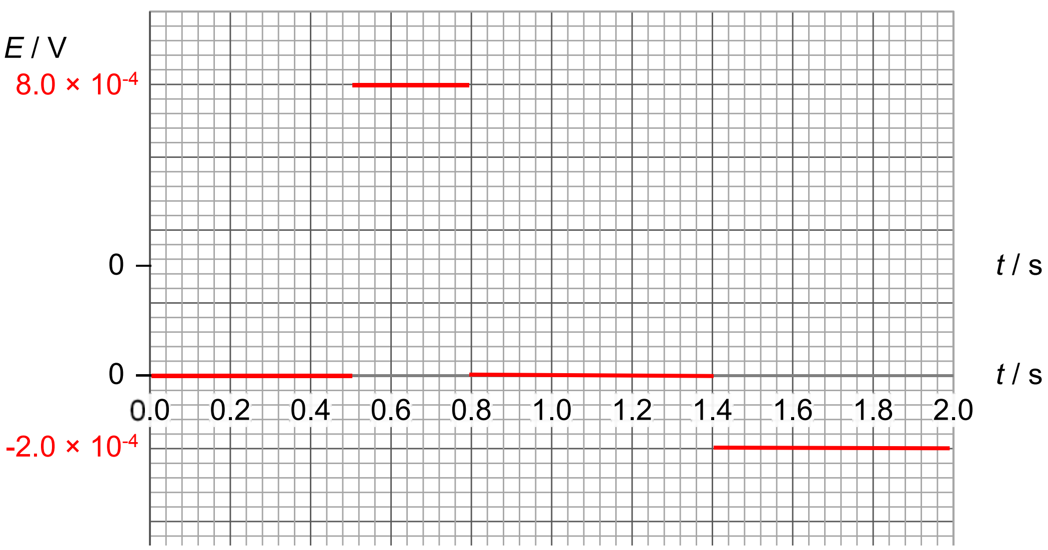


Fig. 5.2

Use your answer to **(b)(ii)** to sketch, on Fig. 5.3, the variation with time *t* of the e.m.f. *E* induced in coil Y.



E_1 = 0 V from *t* = 0 s to 0.3 s and 0.8 s to 1.4 s [B1]
E_2 = 8.0 × 10^{-4} V from *t* = 0.3 s to 0.8 s [B1]
E_3 = 2.0 × 10^{-4} V from *t* = 1.4 s to 2.0 s, in reverse polarity [B1]
No label but ratio between E_2 and E_3 is draw to scale = -1 mark
No label and wrong ratio between E_2 and E_3 = -2 marks

[3]

(iv) An iron core is inserted into the solenoid and then held stationary within the solenoid. Explain the effect on the e.m.f. induced in coil Y.

The iron core increases the magnetic flux density, resulting in a larger rate of change of flux linkage. [M1]
Hence, the e.m.f. induced in coil Y is <u>larger</u> (when it is not zero). [A1]

....[2]

6 **(a)** The photoelectric effect provides evidence for the particulate nature of electromagnetic radiation. State two experimental observations that could not be fully explained using the classical wave theory.

-the existence of threshold frequency
-max ke independent of intensity / max ke dependent on frequency (note: NOT proportional)
-instantaneous emission of photoelectrons
[NOT: photocurrent depends on intensity (this observation corresponded to the prediction)]
[any 2 correct - 2 marks]

1. ....

2. ....[2]

(b) In an experiment to investigate the photo-electric effect, the wavelength of the radiation incident on the metal surface was varied. For two values of wavelength λ, the stopping potential V_s was measured. The results are shown in Fig. 6.1.

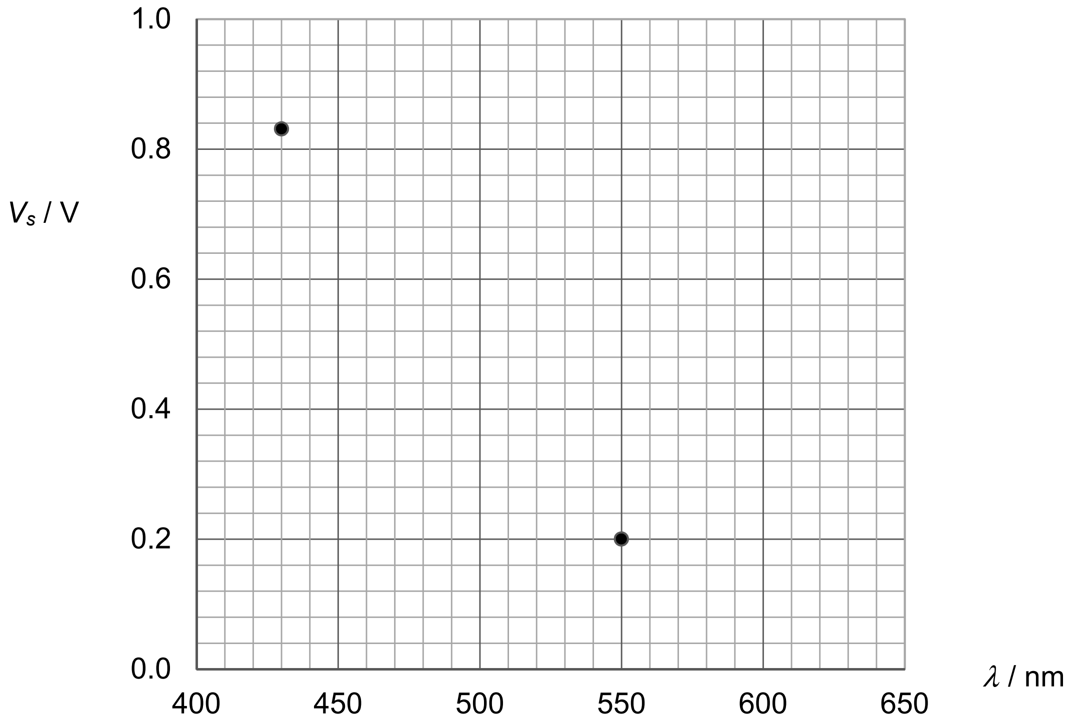


Fig. 6.1

(i) Determine the maximum kinetic energy of a photo-electron emitted from the metal surface by radiation of wavelength 550 nm.

$$KE_{max} = eV_s$$
$$= (1.6 \times 10^{-19})0.2$$
$$= 3.2 \times 10^{-20} \text{ J}$$ [B1]

maximum kinetic energy = ... J [1]

(ii) Hence, calculate the threshold wavelength of the metal.

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + eV_s$$

$$\frac{6.63 \times 10^{-34}(3.0 \times 10^8)}{550 \times 10^{-9}} = \frac{6.63 \times 10^{-34}(3.0 \times 10^8)}{\lambda_0} + 3.2 \times 10^{-20}$$ [M1]

$$\lambda_0 = 6.03 \times 10^{-7} \text{ m}$$ [A1]

threshold wavelength = ... m [2]

(iii) Suggest why it is not possible to deduce the threshold wavelength of the metal surface directly from Fig. 6.1.

The relationship between *Vs* and radiation wavelength is <u>not linear</u>, hence the curve cannot be extrapolated with 2 data points [B1]

....[1]

(iv) The intensity of the radiation incident on the metal surface was kept constant as the wavelength was decreased from 550 nm to 430 nm.

State and explain the effect, if any, on the photocurrent.

Each photon has more energy, but rate of incident photon is lower [M1]
lower rate of emission of electrons, hence photocurrent decreases. [A1]

....[2]

7 X-ray photons are produced when electrons are accelerated through a potential difference towards a metal target. An X-ray spectrum is shown in Fig. 7.1.

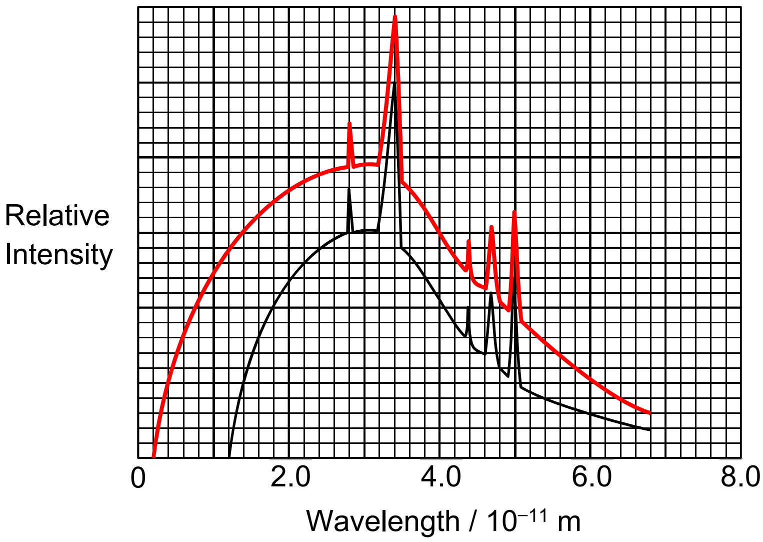


Fig. 7.1

(a) Explain how the most energetic X-ray photons are produced.

When the highly energetic electrons strikes the target metal and are suddenly decelerated by collision with the metal atoms, [B1]
the electrons lose all its energy and the energy lost is emitted as X-ray photons of equivalent energy. [B1]

....[2]

(b) **(i)** Explain how the characteristic X-ray K_α photons are produced.

When the highly energetic electrons knock out the electrons in the K-shell of the atoms and leave a vacancy.
Electrons in the next higher energy level, L-shell, transit down to the vacancy and K_α photons are produced with energy equal to the energy difference between the 2 energy levels.

....[2]

(ii) Determine the momentum of the K_α X-ray photon.

$\lambda \approx 3.4\times10^{-11}$ m

$$p=\frac{h}{\lambda}=\frac{(6.63\times10^{-34})}{3.4\times10^{-11}}=1.9488\text{ J}=1.95\text{ J}$$

momentum = ... N s [2]

(c) The potential difference used to accelerate the electrons is increased. On Fig. 7.1, sketch the new spectrum obtained. [1]

Same characteristic wavelengths, lower threshold wavelength, higher intensity

8 This question is about the movement of water from the roots of a tree to its leaves.

Water moves up a tree through its vast network of conduits. These conduits are similar to capillary tubes. It is suspected that water moves up the conduits due to low pressure in the conduits which “sucks” the water upwards, or by capillary action, or a combination of both. Capillary action is a phenomenon whereby water rises up a small tube due to upward forces caused by the adhesion of water to the walls of the tube.

To investigate capillary action, a capillary tube, open at both ends, is supported vertically with one end immersed in water, as shown in Fig. 8.1. The water in the narrow bore of the tube forms a column of height *h*.

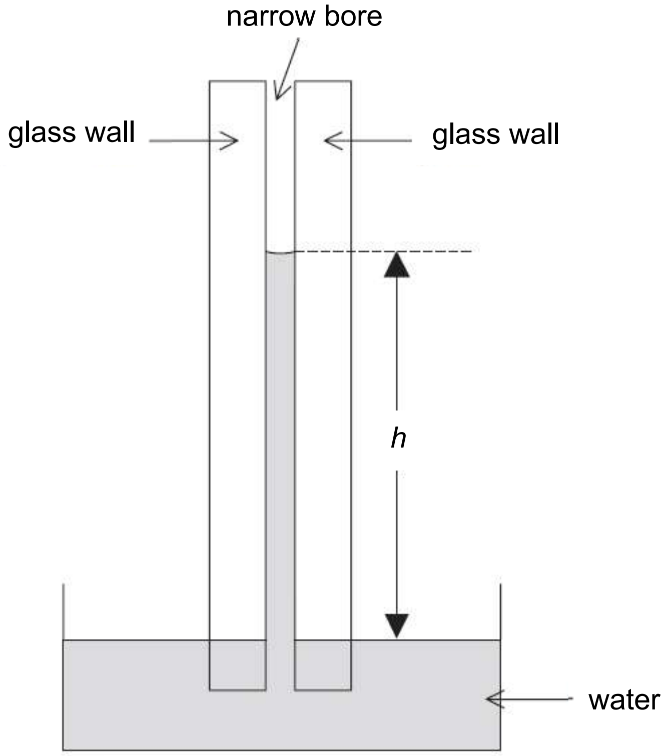


Fig. 8.1
(not to scale)

(a) The height h of the water column for a particular capillary tube was measured as the temperature of water θ was varied. Fig. 8.2 shows the data collected.

θ / °C	h / cm
30	14.0
40	13.2
50	12.5
60	11.5
70	10.9
80	10.0

Fig. 8.2

Fig. 8.3 shows the variation with temperature θ of height h.

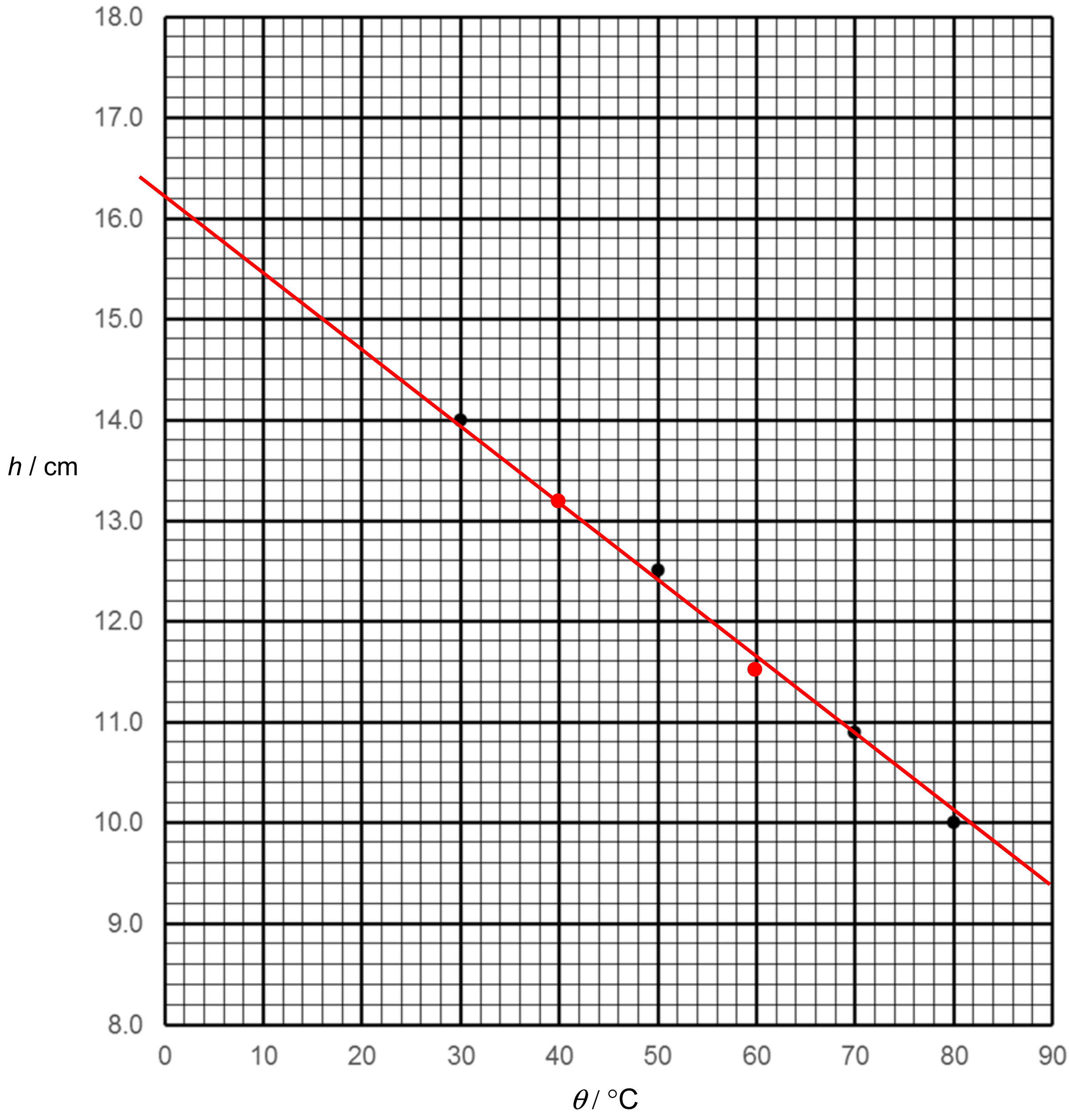


Fig. 8.3

(i) On Fig. 8.3, plot the points for θ = 40 °C and θ = 60 °C. Draw a line of best fit through the data points. [2]

Both points plotted correctly [B1]
Appropriate line of best fit [B1]

(ii) Using Fig 8.3, determine the height h_0 of the water column when the temperature is 0 °C.

Correct read off from vertical intercept [B1]
h_0 = 16.2 cm

h_0 = ... cm [1]

(iii) It is suggested that the relationship between θ and h is

$$\frac{h}{h_0} = 1 - k\theta$$

where k is a constant.

Explain why the results of this experiment supports the relationship suggested.

Rearrange to linear form: $h = h_0 - h_0 k\theta$ [B1]

State that a linear line is obtained / linear trend of data [B1]

State that gradient = $-h_0 k$, and vertical intercept = h_0 [B1]

Last B1 not awarded if student state gradient = $h_0 k$

....[3]

(iv) Using the line drawn in **(a)(i)**, determine the value of k, including its units.

Gradient $= \frac{13.8 - 10.6}{32 - 74}$ [M1]

$= -0.0762$

$k = -\frac{\text{gradient}}{h_0} = -\frac{-0.0762}{16.2} = 4.70 \times 10^{-3}$ [A1]

Units = $°C^{-1}$ [B1]

Substitution of coordinates into equation to find k (no credit given)
If gradient coordinates used does not lie on line (e.g. use data point), minus 1 mark.
Minus 1 mark if gradient coordinates cannot be traced back to the graph (ie. Show 2 pairs of coordinates in the gradient calculations).

k = ... [3]

(b) The experiment is repeated using capillary tubes with bores of different radii r but keeping the water temperature constant. Fig. 8.4 shows the variation with $\frac{1}{r}$ of height h for a water temperature of 20 °C.

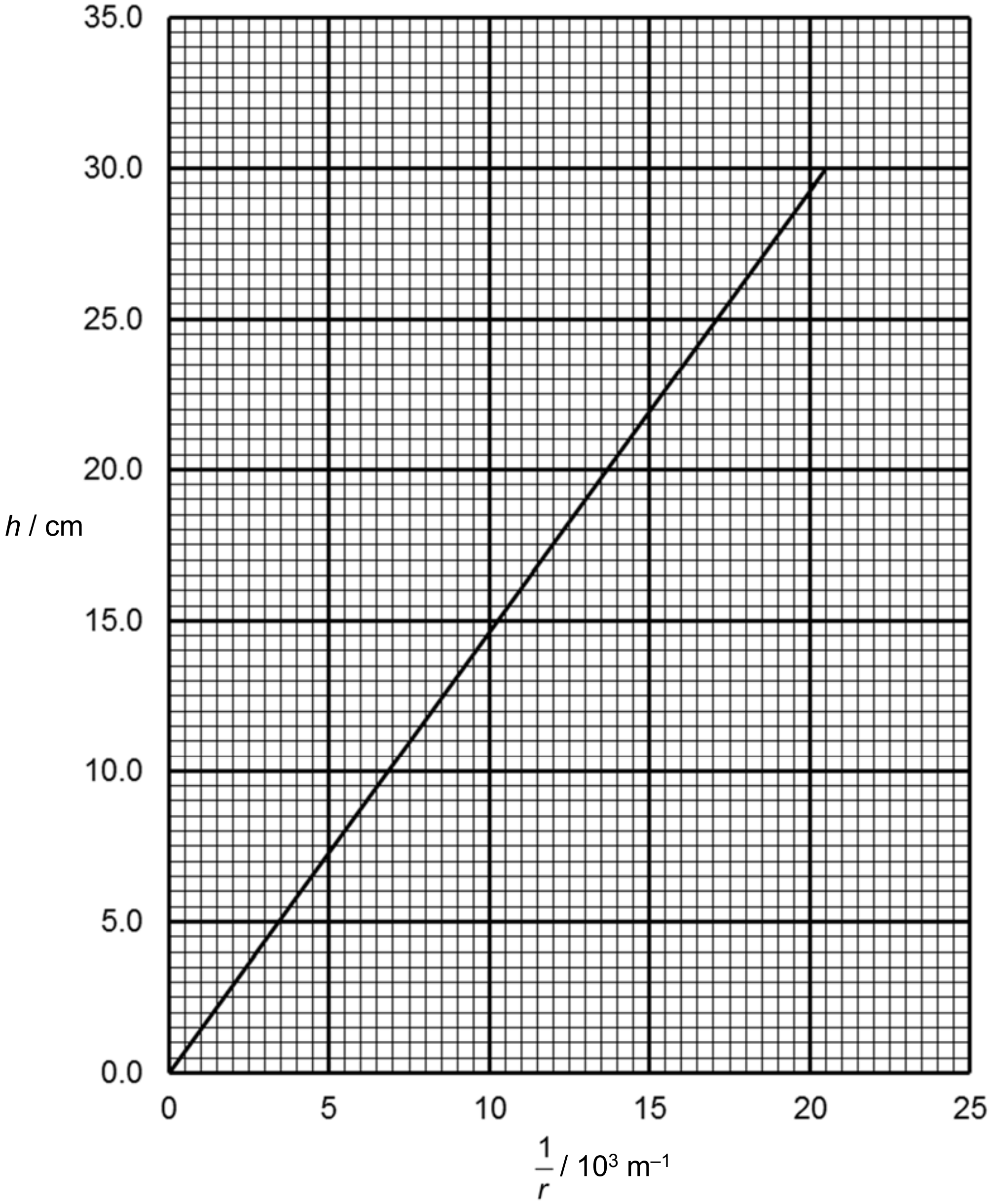


Fig. 8.4

(i) Use Fig. 8.4 to estimate the radius of the bore of the tubes in a 25-metre tall tree, which will enable water to be raised by capillary action from ground level to the top of the tree.

Graph is of form $h = \frac{C}{r}$ where C is a constant (= gradient) [M1]

$$C = \frac{(30.0 - 0) \times 10^{-2}}{(20.5 - 0) \times 10^{3}} = 1.46 \times 10^{-5} \quad \text{[M1]}$$

$$r = \frac{C}{h} = \frac{1.46 \times 10^{-5}}{25} = 5.85 \times 10^{-7} \text{ m} \quad \text{[A1]}$$

radius = ...m [3]

(ii) State one assumption made in your estimation in **(b)(i)**.

The trend of graph remains linear <u>throughout all values of *h* (or up to 25 m)</u> /
h is inversely proportional to *r* <u>throughout all values of *h* (or up to 25 m)</u> [B1]

....[1]

(iii) Comment on your answer obtained in **(b)(i)**.

Radius of bore obtained is too small [B1]
Unlikely that capillary action is the only means [B1]

....[2]

(c) The other means of moving water up a tree is to create a low pressure in the bore of the tubes in the tree.

(i) Suggest how low pressure can be created in the bore of the tubes in a tree.

Evaluation of water through leaves (transpiration) [B1]
creates a low water vapour pressure in the bore

....[1]

(ii) Using the following data, calculate the height which water can be moved up a tree via low pressure in the bore of the tubes.

Atmospheric pressure = 101 kPa

Pressure in the bore of the tubes in the tree = 7.8 kPa

Density of water = 1000 kg m^{-3}

$\Delta p = h\rho g$

$(101 - 7.8) \times 10^3 = h(1000)(9.81)$ [M1]

$h = 9.5$ m [A1]

height = ... [2]

(iii) Suggest and explain how the height in **(c)(ii)** will change during a hot day.

Evaporation rate will be higher; pressure difference will be greater [M1]
Hence height increases [A1]
OR
Water density will be lower [M1]
Hence height increases [A1]
OR
Bores of the capillary tubes becomes wider; lesser capillary action [M1]
Hence height decreases [A1]

....[2]

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/03

Paper 3 Longer Structured Questions **17 September 2018**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

Candidate Name: ______________________

Class	Reg No

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend about one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	**/ 10**
2	**/ 7**
3	**/ 9**
4	**/ 4**
5	**/ 5**
6	**/ 10**
7	**/ 15**
Section B	
8	**/ 20**
9	**/ 20**
Deductions	
Total	**/ 80**

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T /K	=	T /°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translation kinetic energy an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\, \omega\sqrt{x_o^{\,2} - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in the spaces provided.

1 (a) (i) State Newton's first law of motion.

Newton's first law of motion states that a body continues at rest or at constant / uniform velocity unless acted on by a resultant (external) force. [A1]

....[1]

(ii) State the conditions for equilibrium.

resultant force (in any direction) is zero [B1]
resultant moment / torque (about any axis) is zero [B1]

....[2]

(b) Fig. 1.1 shows a uniform ladder of weight 80 N resting on a smooth wall and a rough floor. The ladder makes an angle of 60° with the floor.

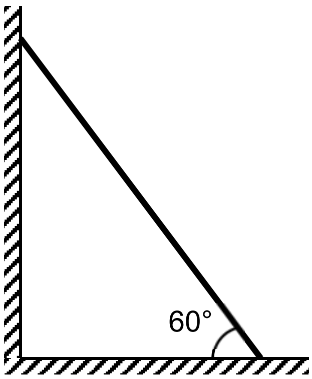


Fig. 1.1

(i) Show that the force exerted by the wall on the ladder is 23 N.

Using principle of moment and taking moment about the bottom of ladder: [B1]
clockwise moment = anticlockwise moment

$N \times L \sin 60° = W \times \frac{L}{2} \cos 60°$

$N \times L \sin 60° = 80 \times \frac{L}{2} \cos 60°$ [B1]

N = 23 N [A0]

[2]

(ii) Calculate the force exerted by the floor on the ladder.

Resolve vertically: ↑ Y = W = 80 N

Resolve horizontally ← X = N = 23 N [C1 for both equations]

force R = $\sqrt{X^2 + Y^2}$ = $\sqrt{23^2 + 80^2}$ = 83 N [A1]

angle R makes with floor = $\tan^{-1}\left(\frac{Y}{X}\right)$ = $\tan^{-1}\left(\frac{80}{23}\right)$ = 74°

Direction: 74° clockwise above horizontal [A1]

OR by vector triangle [C1]

get R [A1]

get angle above [A1]

magnitude of force = ... N

direction of force : ....[3]

(iii) A person now stands on the ladder. The ladder remains stationary.

State and explain the effects, if any, on

1. the vertical force exerted by the floor on the ladder.

(Due to the person's weight) there is now greater downward force on the ladder, and so (to maintain equilibrium) the floor exerts a larger upward vertical force on the ladder. [A1]

....[1]

2. the horizontal force exerted by the wall on the ladder.

(Due to the person's weight) there is now a greater anticlockwise moment about the ladder bottom, and so (to maintain equilibrium) the wall exerts a greater clockwise moment and hence greater horizontal force. [A1]

....[1]

2 In an experiment to determine the specific heat capacity of a liquid, a student heated a fixed mass of the liquid for a fixed duration of time, using an electric heater. The student repeated the experiment three times to find the rise in temperature of the liquid. The following measurements were obtained:

Mass of liquid, *m*	309 ± 3 g
Voltage applied across heater, *V*	11.8 ± 0.3 V
Current flow in the heater, *I*	4.125 ± 0.002 A
Time taken, *t*	200.0 ± 0.5 s

The rise in temperature θ was recorded for each attempt:

Attempt:	1st	2nd	3rd
θ / K	10.2	9.7	10.5

(a) Estimate the uncertainty in θ.

$$\text{uncertainty in } \Delta\theta = \frac{10.5 - 9.7}{2} = 0.4 \text{ K}$$

Accept:

$$\text{average } \Delta\theta = \frac{10.2 + 9.7 + 10.5}{3} = 10.13 \text{ K}$$

$$\text{uncertainty in } \Delta\theta = 10.13 - 9.7 = 0.433 = 0.4 \text{ K}$$

uncertainty in θ = ... K [1]

(b) Calculate the specific heat capacity *c* of the liquid.

$$c = \frac{Q}{m\theta} = \frac{IVt}{m\theta}$$

$$= \frac{4.125 \times 11.8 \times 200.0}{0.309 \times 10.13} \quad \text{[C1]}$$

$$= 3018.2 \quad \text{[A1]}$$

c = ... J kg^{-1} K^{-1} [2]

(c) Calculate the uncertainty in specific heat capacity *c* of the liquid and express the specific heat capacity *c* together with its uncertainty.

$$\frac{\Delta c}{c} = \frac{\Delta V}{V} + \frac{\Delta I}{I} + \frac{\Delta t}{t} + \frac{\Delta m}{m} + \frac{\Delta(\theta)}{\theta}$$

$$= \frac{0.3}{11.8} + \frac{0.002}{4.125} + \frac{0.5}{200.0} + \frac{3}{309} + \frac{0.4}{10.1} \quad \text{[M1]}$$

$$= 0.077721$$

$$\Delta c = 3018.2 \times 0.077721 = 200 \quad \text{[M1]}$$

$$c = 3000 \pm 200 \text{ J kg}^{-1} \text{ K}^{-1} \quad \text{[A1]}$$

c = ... ± .... J kg^{-1} K^{-1} [3]

(d) State an assumption made in your calculation of the specific heat capacity c of the liquid.

No heat loss to surrounding. [B1]

....[1]

3 **(a)** State Newton's second law of motion.

Newton's second law of motion states that the rate of change of momentum is proportional to the net / resultant (external) force (acting on it)
and the change (of momentum) takes place in the direction of the (net) force [A1]

....[1]

(b) A car of mass 800 kg was travelling on a horizontal road at a constant speed of 20 m s^{-1} before a net horizontal constant forward force of 4800 N acts on the car for 12 s.

Calculate

(i) the distance travelled by the car over the 12 s,

$$s = ut + \frac{1}{2}at^2 = (20)(12) + \frac{1}{2}\frac{4800}{800}(12)^2 \quad \text{[C1]}$$

$$= 672 \text{ m} \quad \text{[A1]}$$

distance = ...m [2]

(ii) the speed of the car at the end of the 12 s,

$$v = u + at = 20 + \frac{4800}{800}(12) \quad \text{[C1]}$$

$$= 92 \text{ m s}^{-1} \quad \text{[A1]}$$

speed = ... m s^{-1} [2]

(iii) the work done on the car during the 12 s

1. using the answer to **(b)(i)**;

$$\text{work} = Fs = (4800)(672) \quad \text{[M0]}$$

$$= 3.23 \times 10^6 \text{ J} \quad \text{[A1]}$$

work done = ...J [1]

2. using the answer to **(b)(ii)**.

$$\text{work} = \text{gain in KE}$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}(800)(92)^2 - \frac{1}{2}(800)(20)^2 \quad \text{[M0]}$$

$$= 3.23 \times 10^6 \text{ J} \quad \text{[A1]}$$

work done = ...J [1]

(iv) the impulse exerted on the car over the 12 s.

impulse = change in momentum
= $mv - mu$ = (800)(92) – (800)(20) [C1]
= 5.76×10^4 N s [A1]
OR use impulse = Ft = (4800)(12) = 5.76×10^4 N s

impulse = ... N s [2]

4 A person threw a ball vertically upwards.

(a) Fig. 4.1 shows the variation with time of the velocity when air resistance is absent.

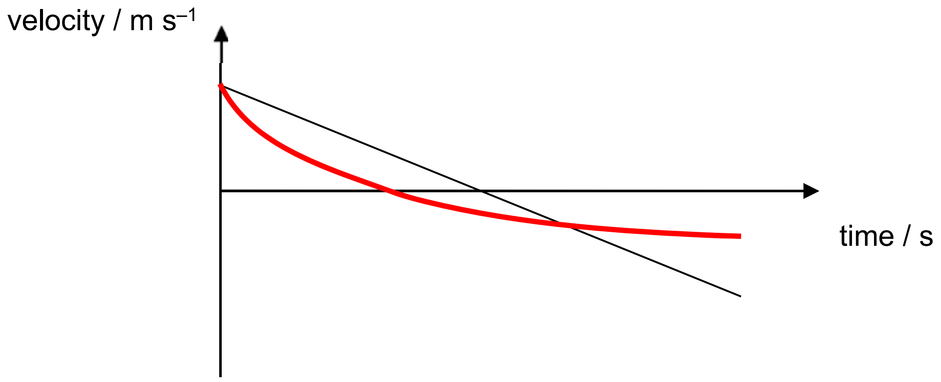


Fig. 4.1

Draw on Fig. 4.1 a second graph for the case where air resistance is present. [3]

curve from +15 m s^{-1} steepest at first then gentler and gentler [B1]
gradient at v = 0 should be same as that of original line. [B1]
areas under graph above and below x-axis are similar. [B1]

(b) Explain how the presence of air resistance would affect the maximum height reached by the ball.

greater resultant (downward opposing) force, so lesser height [A1]

....[1]

5 Ball A, of mass 800 g and travelling with a speed of 9.2 m s^{-1}, collided head-on with a stationary ball B of mass 2400 g. The collision is completely inelastic.

(a) Explain whether the total momentum is conserved during the collision.

No resultant (external) force (acts on the car-truck system) so (by principle of conservation of momentum) the total momentum is conserved. [A1]

....[1]

(b) Calculate the percentage loss in total kinetic energy.

conservation of momentum: $\rightarrow$ (0.800)(9.2) + 0 = (3.200) V $\Rightarrow$ V = 2.3 m s^{-1} [C1]

initial kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2}(0.800)(9.2)^2 = 33.856$ J [A1]

final kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2}(3.200)(2.3)^2 = 8.464$ J

percentage loss in kinetic energy = $\frac{33.856 - 8.464}{33.856} \times 100\% = 75\%$

percentage loss = ... % [2]

(c) Shortly after the collision, Ball B comes into contact with a spring of spring constant 2500 N m^{-1}. Calculate the maximum compression of the spring.

conservation of energy: $\frac{1}{2}m_{A\&B}v^2 = \frac{1}{2}kx^2$

$\frac{1}{2}(3.2)(2.3)^2 = \frac{1}{2}(2500)x^2$ [M1]

$x = 0.082$ m [A1]

maximum compression = ...m [2]

6 Fig. 6.1 shows an isolated conducting sphere which has been charged. Dashed lines (– – – –) join points of equal potential *V*. The potential difference between successive lines of equal potential is equal.

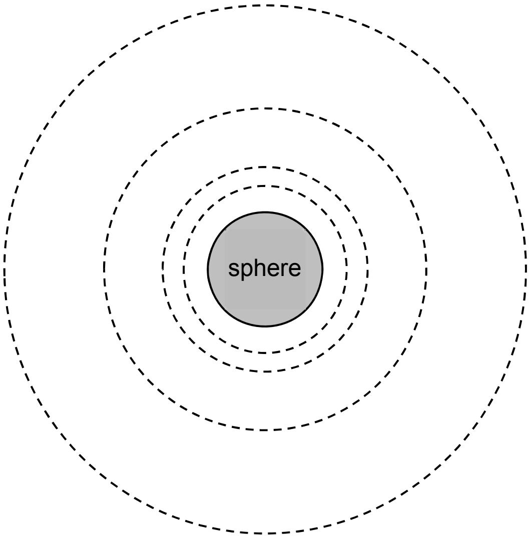


Fig. 6.1

For points on the surface or outside the sphere, the charge on the sphere behaves as if it were concentrated at the centre.

Measurements of the distance *x* from the centre of the sphere and the corresponding values of the potential *V* are given in Fig. 6.2. The values in Fig. 6.2 do not correspond to the dashed lines in Fig. 6.1.

x / m	V / V
0.19	-1.50×10^5
0.25	-1.14×10^5
0.32	-0.89×10^5
0.39	-0.73×10^5

Fig. 6.2

(a) On Fig. 6.1, draw the electric field lines. Label these lines *E*. [2]

Straight lines in uniform radial pattern centred on charge [B1]
Arrows pointing inwards [B1]

(b) Explain how your drawing in **(a)** shows the relationship between electric potential *V* and the electric field *E*.

Electric field points inwards, because *E* points from points of higher potential to lower potential.
OR potential is negative suggests that the sphere is negatively charged and hence electric field points inwards. [B1]

Electric field is numerically equal to the potential gradient and is stronger where the potential gradient is stronger (closer to the charged sphere). The stronger E field is shown by the closer spacing between the E field lines. [B1]

....[2]

(c) **(i)** Use the data in Fig. 6.2 to show that the potential *V* is inversely proportional to the distance *x*. Explain your reasoning.

If V is inversely proportional to x, then Vx = constant [B1]
Multiplying **any 2** values [B1] to conclude that Vx is constant:

x / m	*V* / V	*Vx* / V m
0.19	-1.50×10^5	-28.5×10^3
0.25	-1.14×10^5	-28.5×10^3
0.32	-0.89×10^5	-28.48×10^3 $= -28.5 \times 10^3$
0.39	-0.73×10^5	-28.47×10^3 $= -28.5 \times 10^3$

[2]

(ii) The potential at the surface of the sphere is -1.9×10^5 V. Calculate the radius of the sphere.

Using value of $V_x = -28.5 \times 10^3$ V m [M1]
$R = -28.5 \times 10^3 / -1.9 \times 10^5 = 0.15$ m [A1]

radius of sphere = ...m [2]

(iii) Determine the charge on the sphere.

$$V = \frac{Q}{4\pi\varepsilon_0 r} \text{ [C1]}$$

$$\begin{aligned} Q &= 4\pi\varepsilon_0 rV \\ &= 4\pi\left(8.85\times10^{-12}\right)(0.15)\left(-1.9\times10^5\right) \\ &= -3.17\times10^{-6}\text{C} \\ &= -3.2\times10^{-6}\text{C [A1]} \end{aligned}$$

charge = ...C [2]

7 **(a)** A power bank (which is basically a battery) can be used to power many devices at the same time. A power bank of e.m.f. 12.0 V and internal resistance 3.0 Ω is connected to multiple devices in the circuit shown in Fig. 7.1.

[Turn over

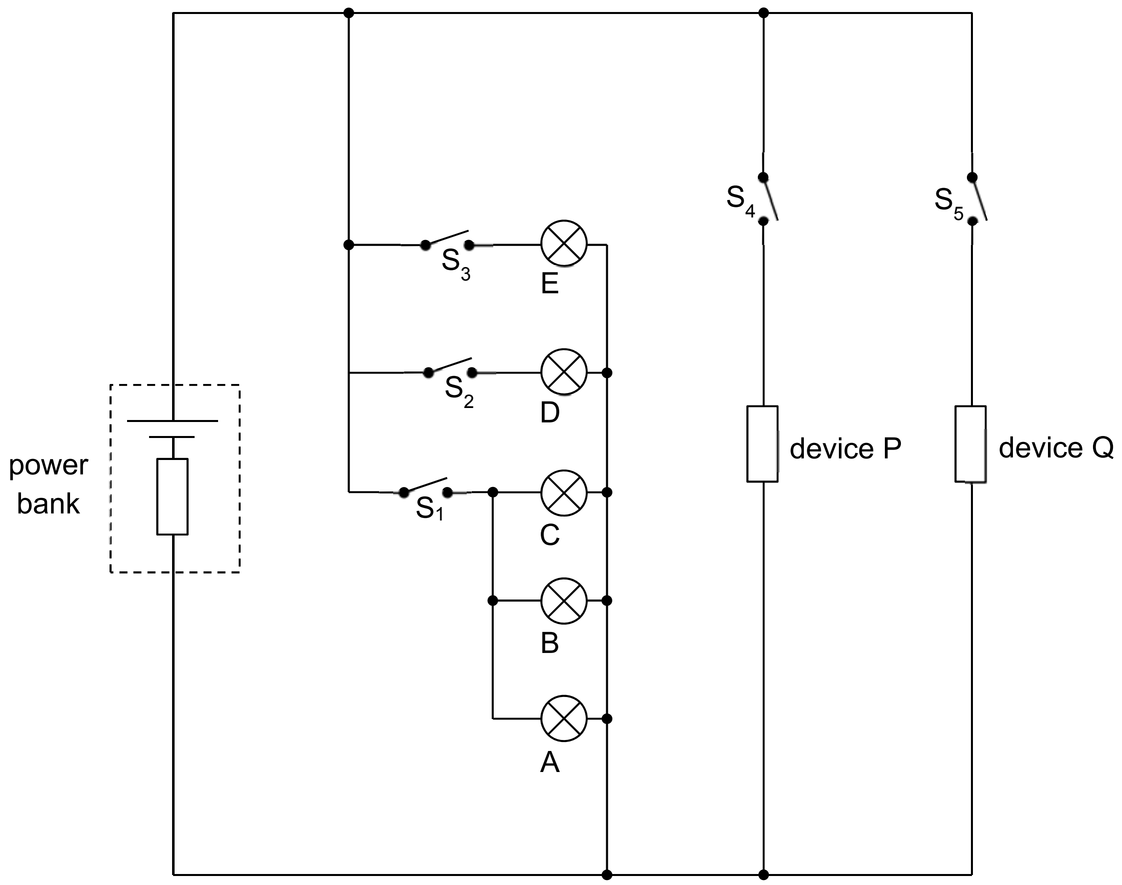


Fig. 7.1

The power bank is connected to 5 identical lamps (A, B, C, D and E) and 2 devices (P and Q). The lamps and devices can be turned on and off using the various switches (S_1, S_2, S_3, S_4 and S_5).

(i) Explain what is meant by "*e.m.f. of 12.0 V*" with reference to the power bank.

The power bank converts 12.0 J of electrical energy from chemical energy (or other forms) [B1]
when one coulomb of charge passes through [B1]

....[2]

(ii) State the effect of closing switch S_1.

Lamps A, B and C will be turned on with equal brightness [B1]

....[1]

(iii) All the switches are now closed. Given the data below, calculate the current supplied by the power bank.

Resistance of each lamp = 25.0 Ω

Resistance of device P = 38.0 Ω

Resistance of device Q = 42.0 Ω

Note that all the lamps and devices are parallel to each other.
Total effective resistance

$$= 3.0 + \left(\frac{1}{25.0} + \frac{1}{25.0} + \frac{1}{25.0} + \frac{1}{25.0} + \frac{1}{25.0} + \frac{1}{38.0} + \frac{1}{42.0}\right)^{-1} \quad [C1]$$

$$= 6.998\ \Omega$$

$$I = \frac{V}{R} = \frac{12.0}{6.998} = 1.71\ \text{A} \quad [A1]$$

current = ... A [2]

(iv) Calculate the terminal potential difference of the power bank when all the switches are closed.

$$V_{\text{terminal}} = E - Ir$$

$$= 12.0 - (1.71)(3.0) \quad [C1]$$

$$= 6.86\ \text{V} \quad [A1]$$

terminal potential difference = ... V [2]

(v) State and explain the effect, if any, on the brightness of the lamps if switches S_4 and S_5 are now opened while the rest remain closed.

Effective resistance across the lamps increase, hence p.d. across lamps increase (by potential divider principle). [B1]

Since $P = \frac{V^2}{R}$, power dissipated by lamps increase, hence brightness increase. [B1]

....[2]

(b) The same power bank from **(a)** is now connected in a potentiometer circuit as shown in Fig. 7.2.

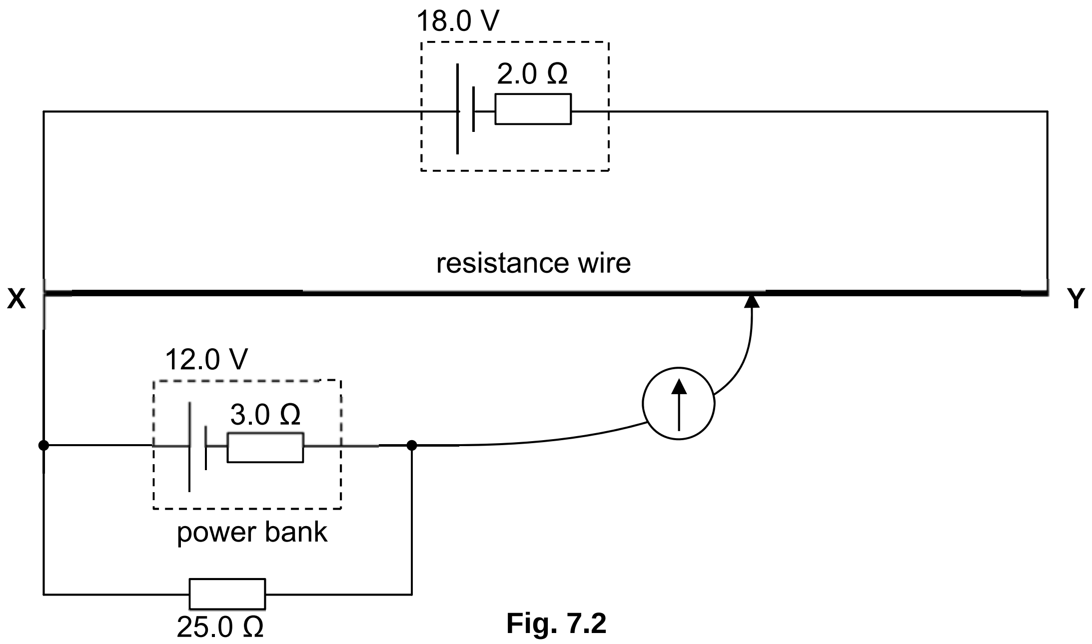


Fig. 7.2

A 18.0 V battery with internal resistance of 2.0 Ω is connected to a resistance wire XY. XY is 1.00 m long and has resistance of 7.2 Ω. A resistor of 25.0 Ω is connected in parallel to the power bank.

(i) Calculate the balance length when the galvanometer shows a reading of zero.

$$V_{XY} = \frac{7.2}{7.2+2.0}(18.0) = 14.087\text{ V} \quad [C1]$$

$$V_{\text{power bank}} = \frac{25.0}{25.0+3.0}(12.0) = 10.714\text{ V} \quad [M1]$$

$$V_{\text{power bank}} = \frac{L}{L_{XY}} V_{XY}$$

$$10.714 = \frac{L}{1.00}(14.087)$$

$$L = 0.761\text{ m} \quad [A1]$$

balance length = ...m [3]

(ii) Explain why it is desirable to obtain a balance point which is closer to end Y.

To reduce percentage or fractional uncertainty of balance length [B1]

....[1]

(iii) State and explain the effect, if any, on the balance length if resistance wire XY is now made of a material with higher resistivity.

XY will have higher resistance, thus <u>higher p.d. across XY</u> by potential divider principle. [M1]
Thus a <u>smaller balance length</u> is needed to balance p.d. across the power bank. [A1]

....[2]

Section B

Answer **one** question from this Section in the spaces provided.

8 **(a)** A binary star consists of two stars that orbit about a fixed point C, as shown in Fig. 8.1.

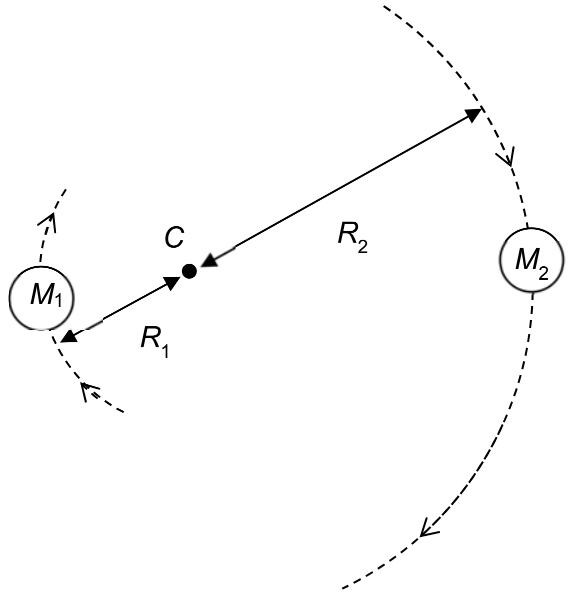


Fig. 8.1

The star of mass M_1 has a circular orbit of radius R_1 and the star of mass M_2 has a circular orbit of radius R_2. Both stars have the same angular speed ω about C.

(i) State the formula, in terms of G, M_1, M_2, R_1, R_2 and ω for

1. The gravitational force between the two stars

$$\frac{GM_1M_2}{(R_1+R_2)^2}$$

....[1]

2. The centripetal force on the star of mass M_1.

$M_1R_1\omega^2$

....[1]

(ii) The stars orbit each other in a time of 1.26 × 10^8 s. Calculate the angular speed ω for each star.

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{1.26\times10^8} = 5.0\times10^{-8}$$

ω = ... rad s^{-1} [1]

(iii) Show that the ratio of the masses of the stars is given by the expression $\frac{M_1}{M_2} = \frac{R_2}{R_1}$.

Force on each of the stars is the same, $\frac{GM_1M_2}{(R_1+R_2)^2}$

$$\frac{GM_1M_2}{(R_1+R_2)^2} = M_1R_1\omega^2 = M_2R_2\omega^2$$

Since angular velocity is the same,

$$M_1R_1 = M_2R_2$$

Hence $\frac{M_1}{M_2} = \frac{R_2}{R_1}$

[1]

(iv) The ratio $\frac{M_1}{M_2} = \frac{R_2}{R_1}$ is equal to 3.0 and the separation of the stars is 3.2 × 10^{11} m.

Determine the radii R_1 and R_2.

R_1 = 0.80 × 10^{11} m
R_2= 2.4 × 10^{11} m

R_1 = ...m

R_2 = ...m [1]

(v) By considering the expressions in **(i)** and using the data calculated in **(ii)** and **(iv)**, determine M_2.

$$\frac{GM_1M_2}{(R_1+R_2)^2} = M_1R_1\omega^2 \qquad \text{[C1]}$$

$$M_2 = \frac{R_1\omega^2(R_1+R_2)^2}{G}$$

$$= \frac{(0.80\times10^{11})(5.0\times10^{-8})^2(3.2\times10^{11})^2}{6.67\times10^{-11}} \qquad \text{[M1]}$$

$$= 3.1\times10^{29} \qquad \text{[A1]}$$

M_2 = ...kg [3]

(b) Fig. 8.2 shows an electron entering a region between two oppositely-charged parallel metal plates. The plates have length 5.1 cm.

The electric field in the region between the plates is uniform and is zero outside this region.

The original direction of motion of the electron is normal to the electric field.

The original speed of the electron is $v = 1.7 \times 10^7$ m s^{-1}.

The electric field strength between the plates E is 4000 V m^{-1}.

The electron exits the plates at an angle θ to the horizontal.

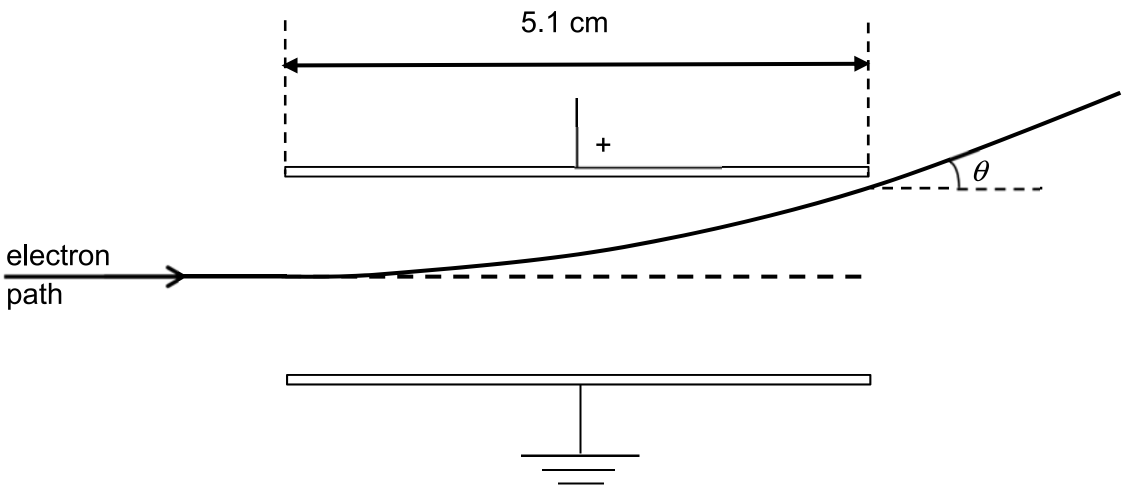


Fig. 8.2

(i) Show that the acceleration of the electron inside the electric field is 7.0×10^{14} m s^{-2}.

Force on electron = qE = $(1.6\times10^{-19})(4000) = 6.4 \times10^{-16}$ N
Acceleration of electron $a_y = F / m = (6.4 \times10^{-16}) / (9.11 \times10^{-31})$ [M1]
$= 7.025 \times 10^{14}$ m s^{-2} [A0]

[1]

(ii) Calculate the magnitude of the final velocity of the electron, and the angle θ.

Time taken = length / horizontal speed = $(5.1 \times10^{-2}) / 1.7 \times 10^7 = 3.0 \times10^{-9}$ s[C1]
Final vertical component of velocity $v_y = u_y + a_y t = 0 + (7.025 \times 10^{14})(3.0 \times10^{-9}) = 2.1\times10^6$ m s^{-1} [C1]
Final velocity =

$$\sqrt{v_x^2 + v_y^2} = \sqrt{(1.7\times10^7)^2 + (2.1\times10^6)^2} = 1.713\times10^7 \text{ m s}^{-1}$$

[A1]

$$\theta = \tan^{-1}\left(\frac{2.1\times10^6}{1.7\times10^7}\right) = 7.04°$$ [A1]

final velocity = ... m s^{-1}

θ = ... ° [4]

(iii) A proton is projected with the same initial velocity along the same line. Without detailed calculation, draw the path that the proton takes on Fig. 8.2. Explain your answer.

Deflection in opposite direction [A0] due to different sign of charge [M1]
Path is less curved [A0] because proton is less strongly deflected. Proton has same magnitude of charge as electron, experiences same magnitude of electric force, but proton has much larger mass -> acceleration is much smaller [M1]

....[2]

(c) Fig. 8.3 shows a uniform magnetic field *B* denoted by the shaded area. An electron moves into the field at the same speed *v* as in **(b)** and is also deflected from its original path. The original direction of motion of the electron is normal to the magnetic field.

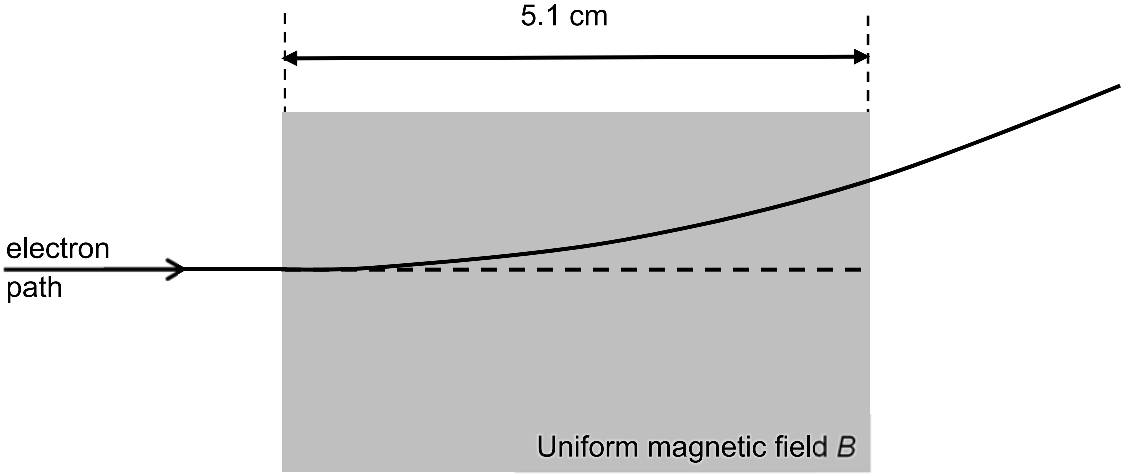


Fig. 8.3

(i) State the difference between the shape of the path taken by the electron in the magnetic field, and the shape of the path taken by the electron in the electric field described in **(b)**. Explain this difference.

Path in B-field is circular, Path in E-field is parabolic. [B1]
Circular – because magnetic force is (constant in magnitude and) always perpendicular to the velocity, so provides constant centripetal force toward a centre, causing uniform circular motion [B1]
Parabolic – because electric force is constant (in magnitude and direction) and in only one direction (perpendicular to the initial velocity), so acceleration in one direction and constant velocity in perpendicular direction. [B1]

....[3]

(ii) State and explain how the final speed of the electron after passing through the magnetic field compares with the final speed of the electron after passing through the electric field in **(b)**.

Because centripetal force only changes direction and not magnitude of velocity [M1]
(Electron is in uniform circular motion),
Final speed of electron is the same as initial speed = 5.1×10^{7} m s^{-1}
Higher than the final speed of electron in (b) [A1]

....[2]

9 A radon-222 ($^{222}_{86}Rn$) nucleus, originally at rest, spontaneously decays to form a polonium-218 ($^{218}_{84}Po$) nucleus and an alpha particle. It may be assumed that no gamma ray is emitted.

(a) Explain what is meant by *spontaneous*.

Not affected by external stimuli / conditions [B1]

....[1]

The rest masses of the nuclei are shown in Fig. 9.1.

$^{222}_{86}Rn$	222.0176 u
$^{218}_{84}Po$	218.0090 u
alpha particle	4.0026 u
proton	1.00727 u
neutron	1.00866 u

Fig. 9.1

(b) **(i)** Calculate the total kinetic energy of the decay products.

Total mass of products = 218.0090 + 4.0026 = 222.0116 u
Total mass of reactant = 222.0176 u
Difference in total mass = 0.0060 u [M1]
Conversion from u to kg = 00060 × 1.66 × 10^{27} = 9.96 × 10^{30} kg
Energy liberated = mc^2 = (9.96 × 10^{30})× (3.0 × 10^{8})^2 = [C1]
= 8.96 × 10^{-13} J [A1]

total kinetic energy = ...J [3]

(ii) Describe the subsequent motion of the decay products. Explain your answer with reference to the principle of conservation of momentum.

Since total momentum is conserved, and initial momentum of Rn-222 was zero,
The total momentum of the decay products must add up to zero. [M1]
The Po-218 and alpha particle move in opposite directions with equal (magnitude of) momentum. [B1]

....[2]

(iii) Show that the ratio $\dfrac{\text{kinetic energy of alpha particle}}{\text{kinetic energy of Po-218 nucleus}} \approx 54.5$.

Since the mass of alpha particle / mass of Po-218 = 4 / 218
The speed of alpha particle / speed of Po-218 = 218 / 4 [B1]
Hence the kinetic energy of alpha particle / kinetic energy of Po-218 = 218/4 = 54.5 [A0]
(Using exact values given, 54.47)

[1]

(c) **(i)** Calculate the value of mass defect per nucleon $\left(\text{i.e. } \dfrac{\text{mass defect}}{\text{number of nucleons}}\right)$ for Radon-222. Leave your answer in terms of atomic mass units (u).

	Number of neutrons	Number of protons	Mass of constituent nucleons in u	Mass defect in u	$\dfrac{\text{mass defect}}{\text{number of nucleons}}$
$^{222}_{86}Rn$	222-86 = 136	86	(86×1.00727) + (136×1.00866) = 223.80298	223.80298 – 222.0176 = 1.78538	1.78538 / 222 = 8.04225×10^{-3}

Number of
[C1 for correct number of neutrons and protons for both Rn-222 or Po-218]
[C1 for correct substitution / value for mass defect for Rn-222 and Po-218]
[A1 for correct final answers]

mass defect per nucleon for Radon-222 = ...u [3]

(ii) The mass defect per nucleon for Polonium-218 has a value of 8.08312×10^{-3} u. With reference to your answer in **(c)(i)**, explain whether Polonium-218 or Radon-222 is more stable.

Since mass defect is directly proportional to binding energy, a higher value of mass defect per nucleon means a higher binding energy per nucleon. [B1]
On average, it requires higher energy to break apart Po-218 into its constituent nucleons, compared to Rn-222. [B1]
Hence, Po-218 is more stable. [A1]

....[3]

(d) Radon-222 has a half-life of 3.8 days.

(i) State what is meant by *half-life*.

It is the time taken for half the original number of radioactive nuclei to decay. [B1]

....[1]

(ii) Calculate the probability of a given radon-222 nucleus decaying per second.

Decay constant = ln2 / $t_{1/2}$ = ln 2 / (3.82 x 24 x 60 x 60)

probability = ... s^{-1} [2]

(iii) A student stated that "radioactive materials with a short half-life always have a high activity". Discuss whether the student's statement is valid.

Not valid [A0] as activity also depends on amount of radioactive material present [M1], and not just the half-life. ($A = \lambda N$)

....[1]

(e) A sample of Radon-222 was carefully measured out and sealed in a container. The rate of radioactive decay was measured using an accurate instrument, taking into account background radiation. The number of alpha particles detected was significantly higher than expected. State what this suggests about the stability of Polonium-218. Explain your answer.

The observation suggests that Po-218 is unstable [B1]

The additional alpha particles detected come from the decay of Po-218 (and its daughter nuclides). [B1]

The almost-immediate decay of Po-218 (and its daughter nuclides) after it is produced shows that Po-218 has a very short half-life (half-lives), i.e. further alpha decays [B1]

....[3]

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
Higher 2

H2 Physics 9749/4

Paper 4 Practical

28 August 2018

2 hours 30 minutes

Class	Reg Number

Candidate Name: ______________________________

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page, page **9** and **13**.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **ALL** the questions.

You are allowed 1 hour to answer Questions 1 and 2; and you are allowed another 1 hour to answer Question 3.

Question 4 is a question on the planning of an investigation and does not require apparatus.

Write your answers in the space provided in the question paper. The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

Examiner's Use	
1	
2	
3	
4	
Total	**/55**

1 In this question you will investigate how the period of oscillation of a bent metal wire varies with the angle between the straight parts of the wire.

(a) **(i)** Secure the cork in the clamp so that the pin is mounted horizontally.

(ii) Make a sharp bend in the wire at its centre so that the angle θ between the straight parts of the wire is about 130° as shown in Fig. 1.1.

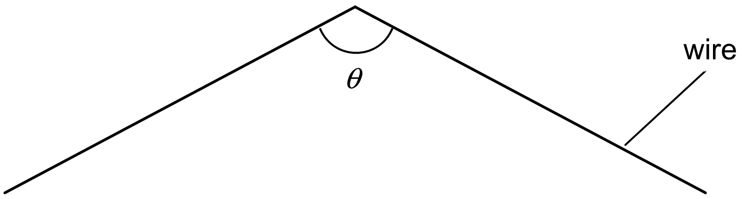


Fig. 1.1

(iii) Measure and record the angle θ.

$$\theta = \frac{129+131}{2} = 130°$$

θ = ...130°...... [1]

(iv) Estimate the percentage uncertainty in this measurement of θ. Show your working.

$$\text{percentage uncertainty} = \frac{2}{130} \times 100\% = 1.5\%$$

Accept $\Delta\theta$ from 2° - 5°

percentage uncertainty in θ = ...1.5%...... [1]

(b) **(i)** Suspend the wire from the pin so that the arrangement is as shown in Fig. 1.2.

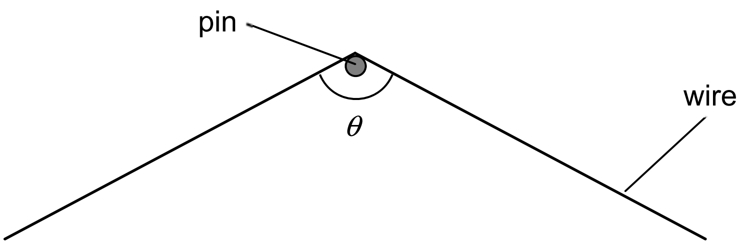


Fig. 1.2

(ii) Displace the wire from its equilibrium position and release it so that it performs small oscillations in a vertical plane, as shown in Fig. 1.3.

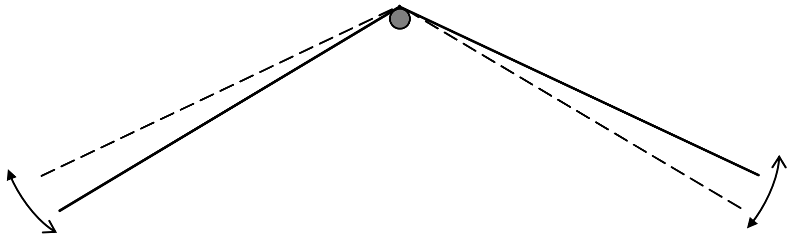


Fig. 1.3

(iii) Make and record measurements to determine the period *T* of these oscillations.

$n = 14$ oscillations

$t = \dfrac{13.8 + 13.6}{2} = 13.7$ s

$T = \dfrac{13.7}{14} = 0.977$ s

t should be more than 20 s.

Repeated readings of *t* and *t* > 20 s. *t* record to nearest 0.1 s. [M1]

Correct calculation of *T* with correct s.f. & units [A1]

T = 0.977 s .... [2]

(c) Remove the wire from the pin. Change the value of θ by gently bending the wire. The new value of θ should be in the range $60° \leq \theta \leq 90°$. Record down the value of θ and repeat steps in **(b)** to obtain period *T*.

$\theta = \dfrac{69 + 68}{2} = 69°$

Check for correct range of θ. Repeated reading. Nearest degree. [B1]

$n = 30$ oscillations

$t = \dfrac{21.2 + 21.2}{2} = 121.2$s

$T = \dfrac{21.2}{30} = 0.707$ s

Repeated readings of *t* and *t* > 10 s. *t* record to nearest 0.1 s.

Correct calculation of *T* with correct s.f. & units [B1]

θ = 69° ....

T = 0.707 s .... [2]

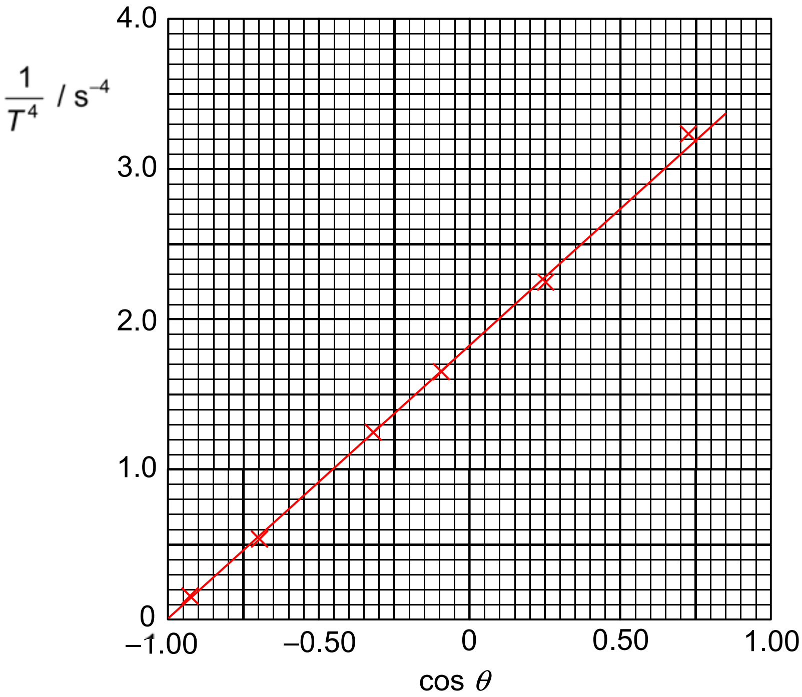
(d) The experiment is repeated using a wire with another length and the angle θ of the bent wire is varied. The results are shown in Fig. 1.4. Values of $\frac{1}{T^4}$ and $\cos\theta$ are included.

θ / °	cos θ	T / s	$\frac{1}{T^4}$ / s^{-4}
159	–0.934	1.56	0.169
135	–0.707	1.16	0.552
110	–0.342	0.942	1.27
96	–0.10	0.884	1.64
74	0.28	0.816	2.26
45	0.71	0.745	3.25

Fig. 1.4

(i) Complete Fig. 1.4. [1]

(ii) Plot the points on the grid and draw the straight line of best fit.



[2]

(iii) Using the graph in **(d)(ii)**, state and explain whether $\frac{1}{T^4}$ is proportional to cos θ.

Since the vertical intercept is not zero [M1]

$\frac{1}{T^4}$ is not proportional to cos θ. [A1]

.... [2]

[Total: 11 marks]

2 In this experiment, you will investigate how the rate of heat loss from a beaker of hot water depends on the insulation of the container.

(a) Measure the room temperature T_{room}.

T_{room} = 31.5 °C ....

(b) Pour hot water into a beaker until it reaches the 80 ml mark.

(c) **(i)** Place the thermometer in the water.

(ii) When the temperature of the water decreases to 80 °C, start the stopwatch.

Measure and record the water temperature T_0 when time t = 60 s and t = 120 s in Fig. 2.1. [1]

t / s	T_0 / °C	$T_{insulated}$ / °C	($T_{insulated} - T_0$) / °C
60	**76.5**	**77.0**	**0.5**
120	**73.5**	**74.5**	**1.0**

Fig. 2.1

(d) **(i)** Empty the beaker.

(ii) Pour hot water into beaker until it reaches the 80 ml mark.

(iii) Wrap insulating material around the sides of the beaker. Secure the insulating material to the beaker using a rubber band, as shown in Fig. 2.2.

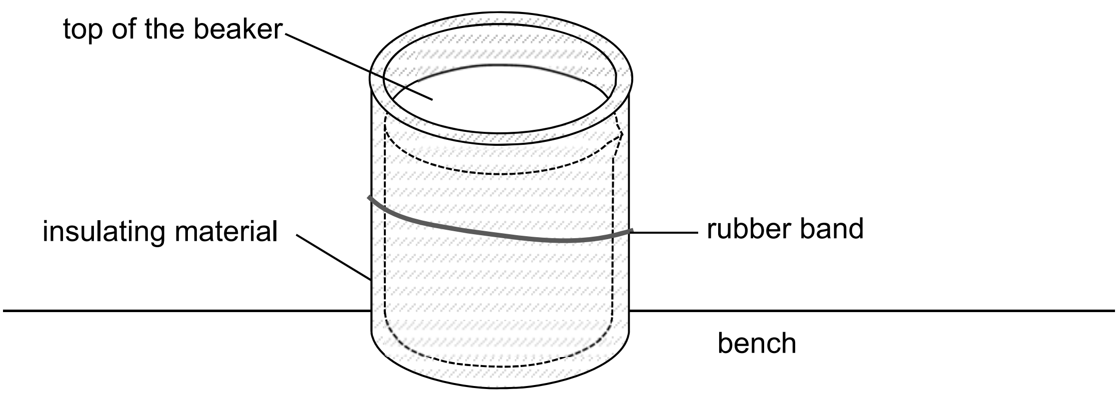


Fig. 2.2

(iv) Repeat **(c)** to measure the water temperature $T_{insulated}$ at the same time intervals.

Record the values of $T_{insulated}$ and ($T_{insulated} - T_0$) in Fig. 2.1. [2]

(e) It is suggested that T_0 and $T_{insulated}$ for the corresponding t are related by the expression

$$(T_{insulated} - T_0) = AT_0 + B$$

where A and B are constants.

Using your results from Fig. 2.1, determine the values of A and B.

77.0 – 76.5 = A (76.5) + B

75.0 – 73.5 = A (73.5) + B

A = –0.333 (unitless)

B = 26.0 °C

A = –0.333 ....

B = 26.0 °C .... [3]

(f) Use your values from **(a)** and **(e)** to determine the value of $T_{insulated}$ when T_0 reaches room temperature T_{room}.

T_2 – 27.0 = -0.333(27.0) + 26.0
T_2 = 44.0 °C

$T_{insulated}$ = 44.0 °C .... [1]

(g) **(i)** State and explain two significant sources of error or limitations of the procedures for this experiment.

1. Temperature differences are small compared to precision of the instrument
Heat escaping from the bottom of the beaker
2. Reading stopwatch and thermometer simultaneously
2 sets of data not sufficient to draw a conclusion

[2]

(ii) Suggest one improvement that could be made to the experiment to address one of the errors identified in **(g)(i)**. You may suggest the use of other apparatus or different procedures.

Use thermometer with greater precision
Insulate bottom of the beaker
Use a temperature probe with data logger
Collect 6 sets of data, plot a graph of $T_2 - T_1$ against T_1 and determine gradient A and vertical intercept B

[1]

(h) A vacuum flask is an insulating storage vessel that lengthens the time over which its contents remain hotter or cooler than the flask's surroundings.

A vacuum flask manufacturer wishes to investigate how evaporation affects the heat retention of the vacuum flask.

Suggest changes that could be made to your experiment to investigate how the rate of heat loss from an insulated container depends on evaporation.

Method to reduce evaporation. e.g. adding a lid + show how the thermometer should be inserted through a hole of the lid / use a layer of oil.
Use insulated beaker for both runs and compare the temperature of the contents at equal intervals

.... [2]

[Total: 12 marks]

Candidate Name: ______________________________ (   )   Class: ________________

3 In this experiment you will investigate how the power P generated in a resistor varies with the resistance R of the resistor.

(a) You are supplied with a fixed resistor labelled Q and a variable resistor of resistance R. Construct the circuit shown in Fig. 3.1.

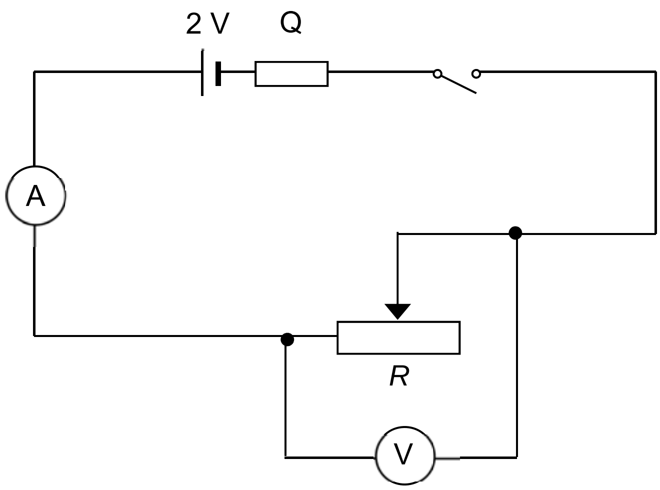


Fig. 3.1

(b) **(i)** Close the switch.

(ii) Adjust the slider of the variable resistor such that the voltmeter reading V is approximately 0.5 V.

(iii) Measure and record the potential difference V and the current I.

V = 0.506 V

I = 141.2 mA [2]

(iv) Open the switch.

(v) Calculate the values of resistance R of the variable resistor and power P where $R = \frac{V}{I}$ and $P = IV$.

$R = 3.58\ \Omega$

$P = (0.506)(0.1412) = 0.0714$ W

R = 3.58 Ω ....

P = 7.14 × 10^{-2} W ....

(vi) Justify the number of significant figures which you have quoted for R and P.

Since P and R are calculated with I and V values, they follow the least significant figure of I and V values used (or least s.f. plus 1).

.... [1]

(c) Change the resistance of the variable resistor to increase the value of V. Repeat steps **(b)(i)**, **(iii)**, **(iv)** and **(v)** to obtain at least 7 further sets of readings for V < 1.3 V.

V / V	**I / mA**	**R / Ω**	**P / W**
0.506	141.2	3.58	7.14 × 10^{-2}
0.601	132.9	4.52	7.99 × 10^{-2}
0.729	121.7	5.99	8.87 × 10^{-2}
0.840	111.9	7.51	9.40 × 10^{-2}
0.982	99.3	9.87	9.75 × 10^{-2}
1.115	87.8	12.7	9.79 × 10^{-2}
1.201	80.1	15.0	9.62 × 10^{-2}
1.287	72.8	17.7	9.37 × 10^{-2}

[7]

(d) **(i)** Plot a graph of P against R. [3]

(ii) Hence, state the value of R when P is a maximum.

R = 11.7 Ω .... [2]


0.1000
0.0975
0.0950
0.0925
0.0900
0.0875
0.0850
0.0825
0.0800
0.0775
0.0750
0.0725
0.0700
2
4
6
8
10
12
14
16
18

(e) By drawing a tangent to the curve, determine the rate of change of *P* with *R* when *R* = 6 Ω.

Tangent drawn correctly. [M1]

$$\text{gradient} = \frac{0.09975 - 0.07625}{8.4 - 3.2} \quad \text{[M1]}$$

$$= 4.52 \times 10^{-3}\ \text{W}\ \Omega^{-1} \quad \text{[A1]}$$

rate of change of *P* = 4.52×10^{-3} W Ω^{-1} .... [3]

(f) The power *P* and the current *I* are related by the expression

$$P = I^2R$$

By drawing a second line on your graph in page 11, determine the value(s) of *P* when I = 100 mA. Label this line **Z**.

Plot *P* against *R*, a straight line graph passing through the origin will be obtained with I^2 as the gradient.

When *R* = 7 Ω, *P* = $(10 \times 10^{-3})^2(7)$ = 70 mW
R = 10 Ω, *P* = $(10 \times 10^{-3})^2(10)$ = 100 mW

Reading off intersection point, P = 97.25 mW

P = 97.3×10^{-3} ....W [2]

[Total: 20 marks]

Candidate Name: ____________________________ (   ) Class: _______________

4 A student wishes to investigate projectile motion.

A small ball is rolled with velocity v along a horizontal surface. When the ball reaches the end of the horizontal surface, it falls and lands on a lower horizontal surface. The vertical displacement of the ball is h and the horizontal displacement of the ball is d, as shown in Fig. 4.1.

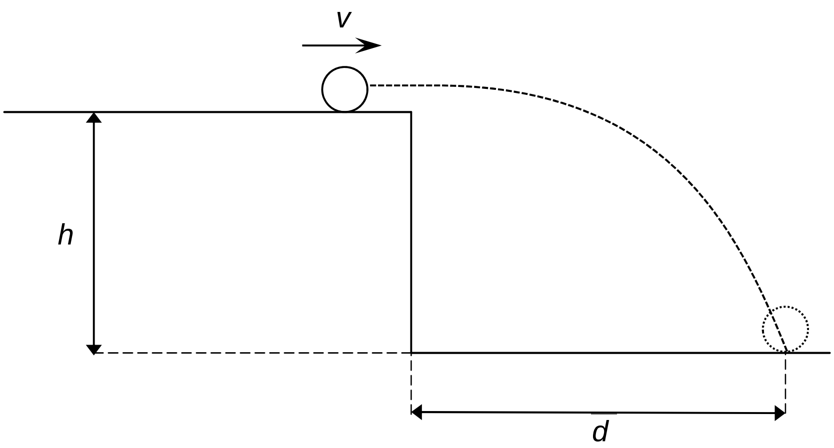


Fig. 4.1

The student suggests that d is dependent on h and v according to the equation

$$d = kh^p v^q$$

where k, p and q are constants to be determined.

Design a laboratory experiment to determine the values of k, p and q.

You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the identification and control of variables,

(b) the equipment you would use and measurements to be taken,

(c) procedure to be followed,

(d) the analysis of the data,

(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Basic Procedure (1)	BP1: Vary *h* while keeping v constant + Vary *v* while keeping h constant
Diagram (1)	D1: Labelled diagram showing way of launching ball and determining speed that the ball leaves the edge
Control (1)	C1: Method to ensure that the surfaces remain horizontal, e.g. spirit level/check height at different places. C2: Any other valid points
Measurements (4)	M1: Workable method to vary *h*. (eg. stacking of multiple planks to raise the height of ground. / table with adjustable height) M2: Workable method to launch ball so that it can be varied or kept constant as required (eg. ball roll down a slope of varying steepness / ball launched from spring compressed to different extent) M3: Workable method to measure v (e.g. using video analysis, light gates with distance and method, motion sensor etc) or determine v by calculation M4: Use ruler/measuring tape to measure *d* and *h*.
Analysis of data (1)	A1: Plot a suitable graph of ln *d* vs ln *h* (keeping <u>*v* constant</u>). gradient = *p* ; vertical-intercept = ln (kv^q) and: Plot a suitable graph of ln *d* vs ln v (keeping <u>*h* constant</u>). gradient = *q* ; vertical-intercept = ln (kh^p) Use both graphs to determine *p* and *q* and *k*
Reliability (3)	R1: Detail on method of improving precision of measurement of *d* e.g. slow motion playback including scale / marking on A4 using a carbon paper / sand. R2: Method to ensure *d* is measured from just below edge of upper surface e.g. use set square, plumb line. R3: Show understanding of random error in experiment: Take many readings of *d* for each *h* and *v* and average R4: Take 6 sets of readings for each graph
	R5: Method to ensure that velocity of ball is horizontal only when it reaches table, e.g. curved track. R6: Ensure that the ball leaves the table at 90°, e.g. set square/protractor on upper surface. R7: Detail on measuring *d* – location of landing position e.g. centre of crater/start of track. R8: Use of high density ball to minimise the effects of air resistance R9: Any other valid points
Safety precaution (1)	S1: Experiment is relatively safe S2: Reasoned method to prevent ball rolling on floor e.g. box below / storage box for balls / sand box. Reasoned method to prevent ball causing injury e.g. goggles / safety screen.

[Total: 12 marks]

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

PHYSICS

Paper 1 Multiple Choice

Additional Materials: Multiple Choice Answer Sheet

9749/01

11 Sep 2018

1 hour

READ THE INSTRUCTION FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Subject Class and index number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

The Index Number is a 5 digit format, which is made up of the 2nd digit and the last four digits of the student's Registration Number. For e.g. If student's Reg Number is 0905123, then the OAS registration number will be 95123.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of 13 printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ ms^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ C$
the Planck constant	$h = 6.63 \times 10^{-34}\ Js$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ kg$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\ kg$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\ kg$
molar gas constant	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ Nm^{2}kg^{-2}$
acceleration of free fall	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	$T/K = T/°C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^{\,2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \cdots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{ln2}{t_{\frac{1}{2}}}$

1 The diameter of a wire, known to be 0.27 mm at room temperature, is measured with an instrument that gives readings to 0.001 mm.
Readings are taken, at room temperature, at three different points along the wire. Two perpendicular values are taken at each point.
The six readings obtained, in mm, are 0.247, 0.247, 0.248, 0.248, 0.249 and 0.247.

Which statement is true?

A The readings are accurate since the spread of the values is within 0.002 mm.
B The readings are precise since all the values are recorded to the third decimal place.
C The readings are inaccurate since the readings are consistently less than the actual value.
D The readings are not precise since the readings are consistently less than the actual value.

2 A radio antenna of length *L* emits electromagnetic waves of wavelength *λ* and power *P* when an alternating current I flows through it. These quantities are related by the expression

$$P = kI^2L^2\lambda^{-2}$$

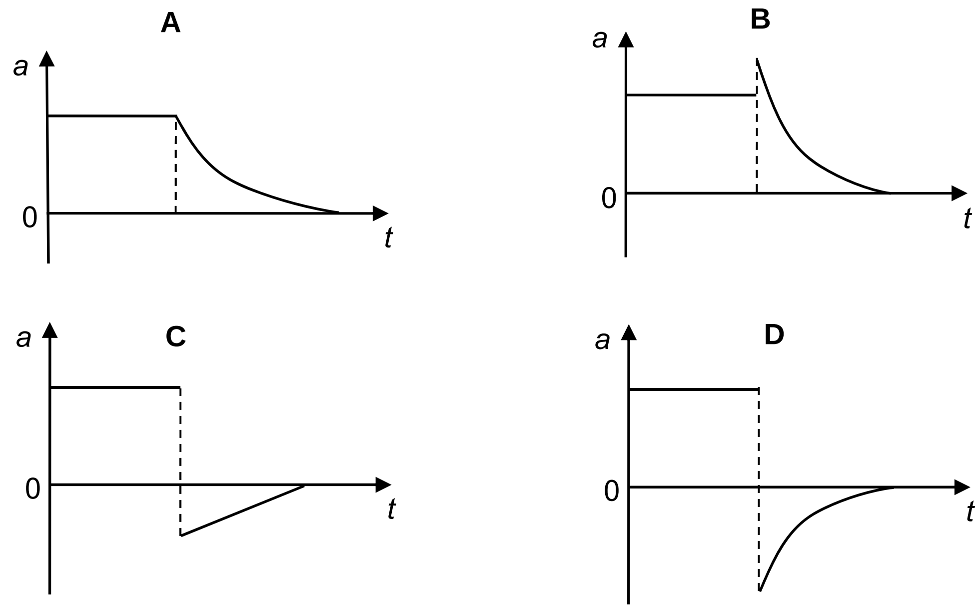
where *k* is a constant.

What is the S.I. base unit of the constant *k*?

A kg m^2 s^{-3} A^{-1}
B kg m^2 s^{-3} A^{-2}
C kg m^2 s^{-3}
D no unit

3 A small metal sphere is released from rest one metre above the surface of a viscous fluid. The sphere experience a viscous force that is proportional to its velocity when moving in the fluid.

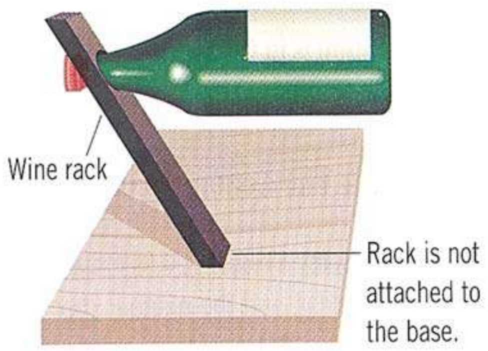
Which of the following graphs best represents the variation of the acceleration *a* of the sphere with time *t*?



4 In an ice-hockey match, two players skated towards each other. After colliding head-on, only one of them was thrown backward.
The player was thrown backwards because he

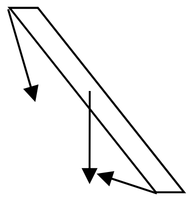
- **A** exerted a smaller force on the other player.
- **B** had a smaller initial momentum.
- **C** had a lower initial speed.
- **D** had a smaller mass.

5 The diagram shows a wine rack with a bottle of wine that is balanced on the table.

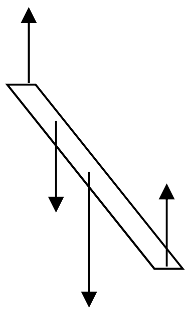


Which of the following diagrams correctly shows the directions of the forces acting on the wine rack?

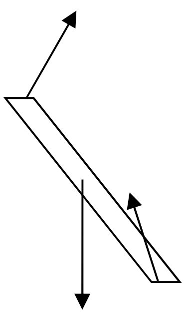
A



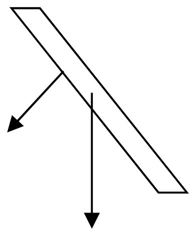
B



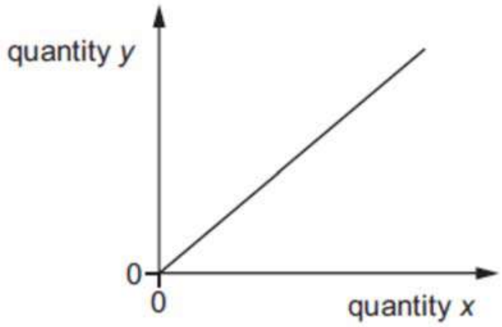
C



D



6 The graph shows the variation of a quantity *y* with a quantity *x* for a body that is falling in air at terminal velocity in a uniform gravitational field.



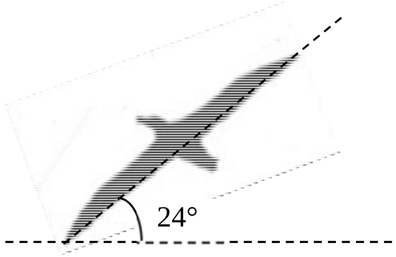
Which quantities could *x* and *y* represent?

	x	*y*
A	air resistance	acceleration
B	loss of height	gain in kinetic energy
C	loss of potential energy	work done against air resistance
D	time	velocity

7 A stone is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point and the stone moves in a vertical circle.
Which of the following statements is false?

A The angle of the string to the vertical cannot be zero as it rotates.
B The velocity of the stone is the same as long as the stone is at the same height from the ground.
C The magnitude of the tension is increasing when the stone moves from the highest position to the lowest position.
D The difference in the tension when the stones is at the top and the bottom of the circle is proportional to the mass of the stone.

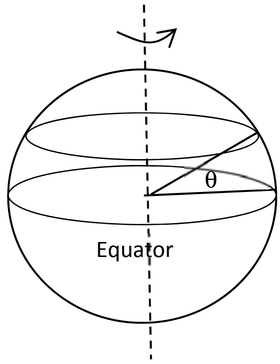
8 A bird is soaring in a horizontal circular path of radius 2.0 m. Its bank angle relative to the horizontal is 24° as shown in the diagram below.



What is the speed of the bird?

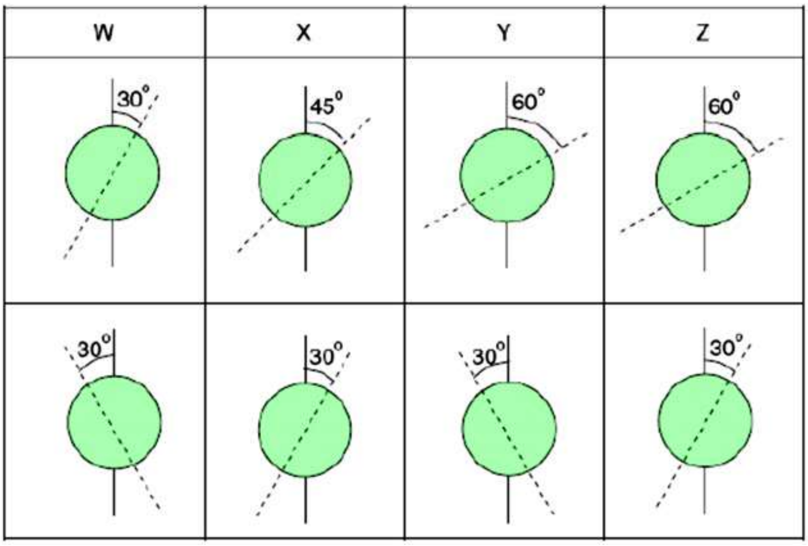
A 1.5 m s^{-1} **B** 3.0 m s^{-1} **C** 6.6 m s^{-1} **D** 8.7 m s^{-1}

9 The Earth has a radius of 6.38×10^6 m, and rotates on its axis once every 24 hours. At what latitude (i.e., the angle in the drawing) is the tangential speed of a person one third that of a person living at the equator?



A 20.5° **B** 30.5° **C** 60.5° **D** 70.5°

10 The table below shows four pairs of polarizers W, X, Y and Z. Each pair is mounted so that they overlap exactly. A beam of unpolarised light is then incident normally onto the surface of each pair of polarizers. The polarizing direction of each polarizer is indicated by the dotted line.



Which of the following gives the correct order for the intensity of the emergent light in decreasing order?

A XYZW **B** YWZX **C** XZWY **D** YXWZ

11 A student sets up a simple harmonic oscillator comprising a mass *m* and a light spring with force constant *k* which oscillates with a period *T*. At equilibrum, the extension of this spring is x_0.

To overcome air resistance, the length of the spring is halved and the oscillator is attached to an actuator (driver). At the new equilibrium point, the extension of this spring is now $\frac{1}{2}x_0$.

What frequency should the actuator be set so that the oscillator can achieve maximum amplitude?

A $\frac{1}{T\sqrt{2}}$ **B** $\frac{\sqrt{2}}{T}$ **C** $\frac{1}{T}$ **D** $\frac{2}{T}$

12 Body X and body Y have the same temperature. Body Y is in thermal equilibrium with body Z. The three bodies are of different materials. Body X has the largest mass and body Z has the least mass.

Which one of the following statements is correct?

A X and Y have the same internal energy
B Y and Z have the same specific heat capacity.
C If X is placed in thermal contact with Z, there is no net transfer of heat.
D If X is placed in thermal contact with Z, heat will be transferred from X to Z.

13 A mole of monatomic ideal gas has pressure P_A and volume V_A initially. The gas undergoes a change to a final pressure P_B and volume V_B such that $V_B > V_A$.

Which of the following statements is true?

A The heat supplied to the gas during the process can be determined using only the values P_A, V_A, P_B and V_B.
B The change in the internal energy of the gas during the process can be determined using only the values P_A, V_A, P_B and V_B.
C The work done by the gas during the process can be determined using only the values P_A, V_A, P_B and V_B.
D None of the above.

14 A boy blows gently across the top of a piece of glass tubing the lower end of which is closed by his finger so that the tube gives its fundamental note of frequency- *f*. While blowing, he removes his finger from the lower end. The note he then hears will have a frequency of approximately

A $f / 4$ **B** $f / 2$ **C** $2f$ **D** $4f$

15 Light of wavelength λ is incident on a pair of slits, forming fringes 3.0 mm apart on a screen.

What is the fringe spacing when light of wavelength 0.5λ is used and the slit separation is doubled?

A 0.75 mm **B** 1.5 mm **C** 3.0 mm **D** 6.0 mm

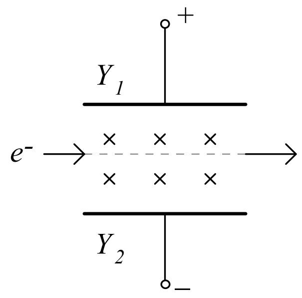
16 A beam of monochromatic light is incident normally on a diffraction grating with number of lines per millimetre N_1. The second order diffracted beam makes an angle of 45° with the grating.

The grating is then replaced by one a different number of lines per millimetre N_2. The third order diffracted beam is now observed at the same angle.

What is the ratio of N_1/N_2?

A 0.47 **B** 0.67 **C** 1.1 **D** 1.5

17 An electron is accelerated from rest through a potential difference V (not shown in the diagram). It then passes without any deflection through a region with mutually perpendicular electric and magnetic fields.



The electric field is provided by a pair of deflecting plates Y_1 and Y_2 with potential difference V and separation d. The applied uniform magnetic field is B. The charge to mass ratio of an electron is given by

A $\dfrac{2B^2d^2}{V}$ **B** $\dfrac{V}{2B^2d^2}$ **C** $\dfrac{B^2d^2}{2V}$ **D** $\dfrac{2V}{B^2d^2}$

18 *A*, *B*, *C* and *D* are four points on a straight line as shown.

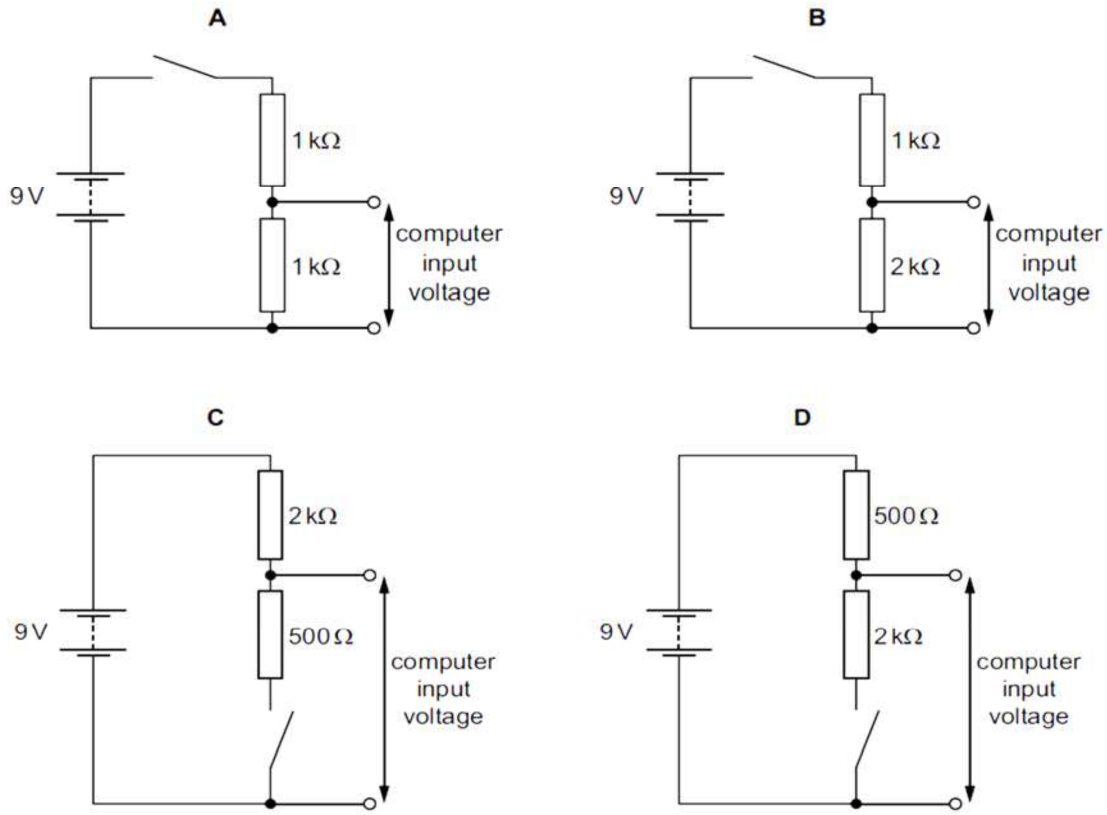
A point charge +Q is fixed at *A* and a point charge –Q is moved from *B* to *C*.

Which of the following statements is false?

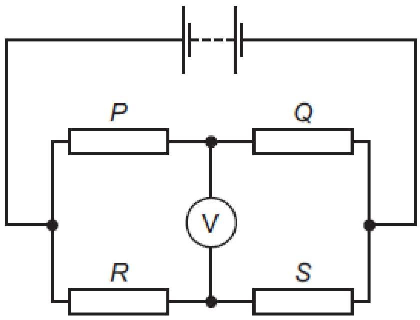
A The electric potential at point *D* increases.
B The magnitude of the electric field strength at point *D* increases.
C The electric potential energy of the system of two charges increases.
D The electric field strength at the mid-point between point *A* and point *B* decreases.

19 A computer is used to detect the change of position of a switch. To detect the change of position, the computer requires a potential difference (p.d.) of 0 V to its input at one switch position and a p.d. between 5 V and 7 V for the other switch position.

Which of the following circuits provides an input voltage to the computer that enables it to detect the change of position of the switch? (The battery and computer in each circuit has negligible internal resistance and infinite resistance respectively.)



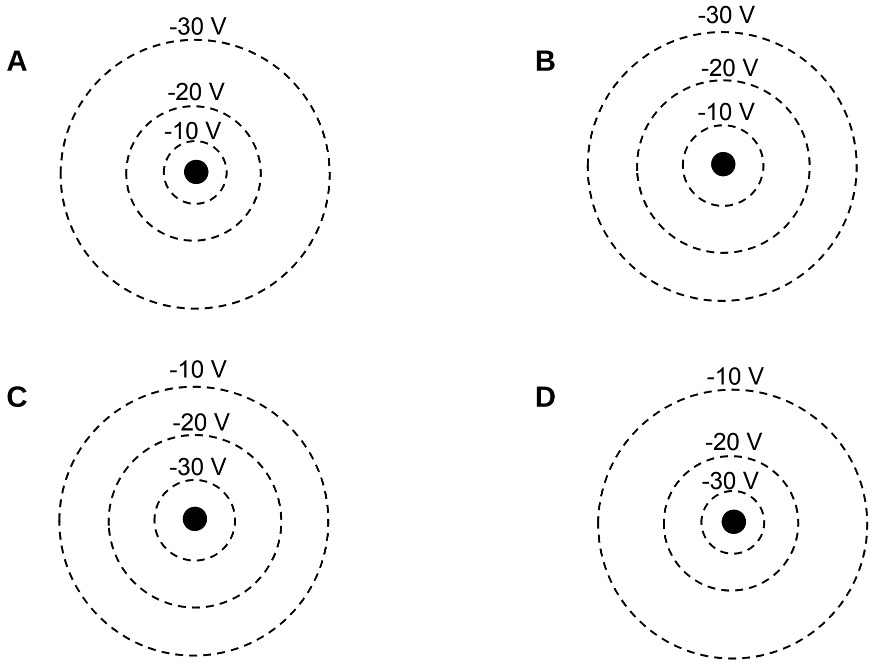
20 The diagram shows a circuit with four resistors with resistance *P*, *Q*, *R* and *S* connected to a battery.



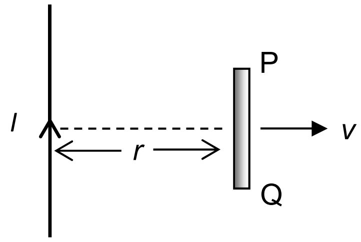
The voltmeter reading is zero. Which of the following equations is correct?

A $P - Q = R - S$
B $P - S = Q - R$
C $PQ = RS$
D $PS = QR$

21 Which of the following diagrams best represents the equipotential lines around a negative point charge?



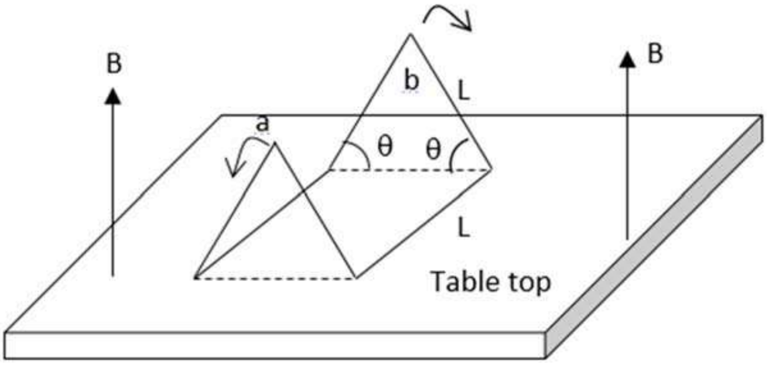
22 The diagram shows a wire carrying a current I and a straight conductor PQ is placed on the same vertical plane as the wire. PQ is moved at constant speed v away from the wire.



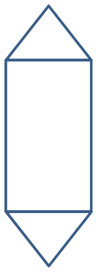
How will the magnitude of the induced e.m.f. in PQ vary and which end will be at a higher potential?

	magnitude of induced e.m.f.	end at higher potential
A	decrease	P
B	decrease	Q
C	increase	P
D	increase	Q

23 The wire shown in the figure below is bent into the shape of a tent, with θ = 60° and L = 1.5 m, and is placed in a 0.30 T magnetic field directed perpendicular to the table-top.

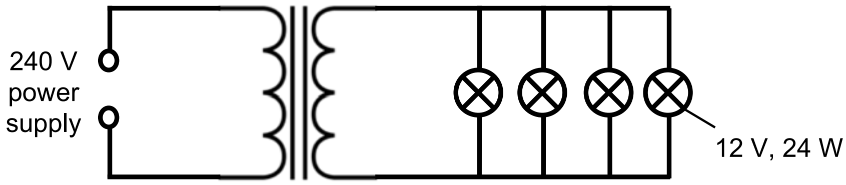


If the tent is flatten out on the table in 0.10 s as shown below (top view), what is the average e.m.f. induced in the wire during this time?



A 2.92 V **B** 5.85 V **C** 7.15 V **D** 9.21 V

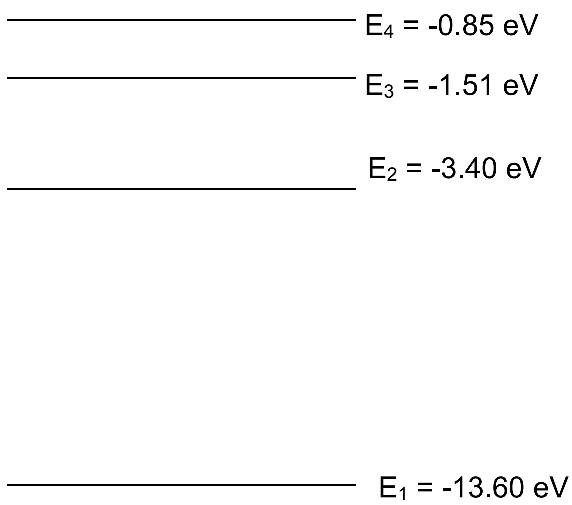
24 The primary coil of a transformer is connected to a 240 V supply. Four identical lamps are connected to the secondary coil as shown below. The lamps are rated 12 V and 24 W and are operating at normal brightness and the transformer is not 100% efficient.



What could be the possible value of the current that can be drawn from the power supply?

A 0.10 A **B** 0.20 A **C** 0.40 A **D** 0.45 A

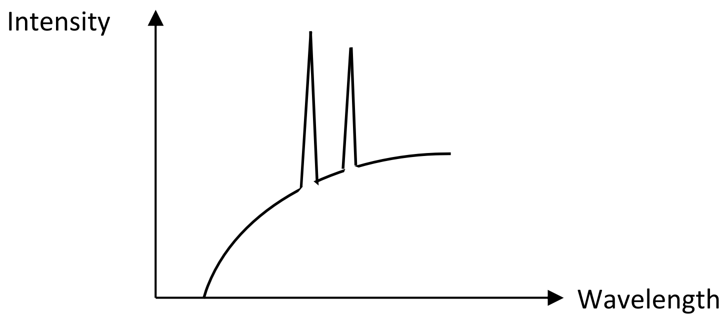
25 The diagram shows some of the energy levels (not drawn to scale) of hydrogen atom. Four photons of wavelength 7.5 nm, 8.0 nm, 11.4 nm and 74.6 nm respectively, strike a sample containing these hydrogen atoms in their ground state.



Calculate the maximum speed of the ejected electron.

A 1.04×10^6 m s^{-1}
B 2.36×10^6 m s^{-1}
C 7.31×10^6 m s^{-1}
D 7.61×10^6 m s^{-1}

26 The graph shows the spectrum of X-rays emitted from an X-ray tube.



1 The wavelengths at which the peaks appear are independent of the voltage across the tube.

2 The minimum (cut-off) wavelength is independent of the atomic number of the target in the X-ray tube.

3 The continuous part of the spectrum is due to the very high temperature attained by the target in the X-ray tube.

Which of the above statement(s) is/are correct?

A 1 only **B** 2 only **C** 1 and 2 only **D** 1 and 3 only

27 In the lungs, there are tiny sacs of air known as alveoli. The average diameter of an alveolus is 0.250 mm. Consider an oxygen molecule of mass 5.30×10^{-26} kg that is trapped in an alveolus. What is the order of magnitude of the uncertainty in the velocity of this oxygen molecule?

A 10^{-5} m s^{-1}
B 10^{-8} m s^{-1}
C 10^{-10} m s^{-1}
D 10^{-12} m s^{-1}

28 The number of radioactive nuclides in two different samples *P* and *Q* are initially 4*N* and *N* respectively. If the half-life of *P* is *t* and that of *Q* is 2*t*, the number of radioactive nuclides in *P* will be the same as the number of radioactive nuclides in *Q* after a time of

A $t / 2$ **B** $2t$ **C** $4t$ **D** $8t$

29 A parent nucleus, initially at rest, decays into two particles of masses m_1 and m_2, moving away from each other in opposite directions. If the decay releases energy *E*, what is the kinetic energy of mass m_1?

A $\frac{m_1}{m_2}E$ **B** $\frac{m_2}{m_1}E$ **C** $\frac{m_2}{m_1 + m_2}E$ **D** $\frac{m_1}{m_1 + m_2}E$

30 Hydrogen bombs operate with tritium, a radioactive isotope of hydrogen with a half-life of 1.7×10^8 s. It has been proposed that if the production of tritium were halted, countries storing hydrogen bombs would have to replenish supplies from existing bombs. Eventually there would not be enough tritium to make any bombs.

A country has a stockpile of 2000 hydrogen bombs. What is the shortest duration that the world had to wait for the country to be unable to make a single bomb?

A 54 years **B** 59 years **C** 10 800 years **D** 1.7×10^9 years

END OF PAPER

NATIONAL JUNIOR COLLEGE
SENIOR HIGH 2 Preliminary Examination
Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9749/02**
Paper 2 Structured Questions

23 August 2018
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THE INSTRUCTION FIRST
Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answers **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**/ 10**
2	**/ 10**
3	**/ 10**
4	**/ 10**
5	**/ 9**
6	**/ 11**
7	**/ 20**
Total (80m)	

This document consists of 18 printed pages.

[Turn over

Data

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permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1} = $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ Js
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
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rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
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hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = - GM/r$
temperature	$T/K = T/°C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \cdots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{ln2}{t_{\frac{1}{2}}}$

1 A disc moves on a smooth horizontal surface. Fig. 1.1 shows the top view of the disc moving from point P at $t = 0.0$ s with an initial velocity of 0.200 m s^{-1} in the north-east direction. From $t = 0.0$ s to $t = 10.0$ s, the disc has a constant acceleration of 0.100 m s^{-2} in the easterly direction.

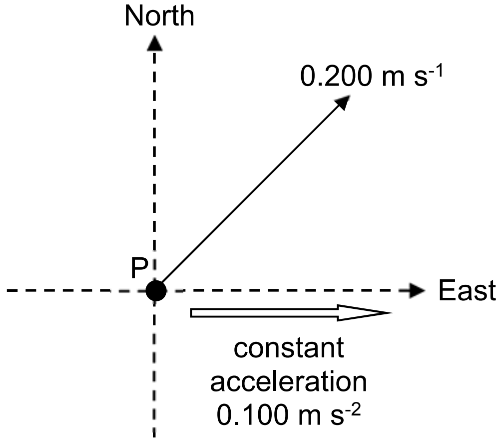


Fig. 1.1

(a) Determine the disc's velocity at t = 10.0 s.

speed = …………………. m s^{-1}

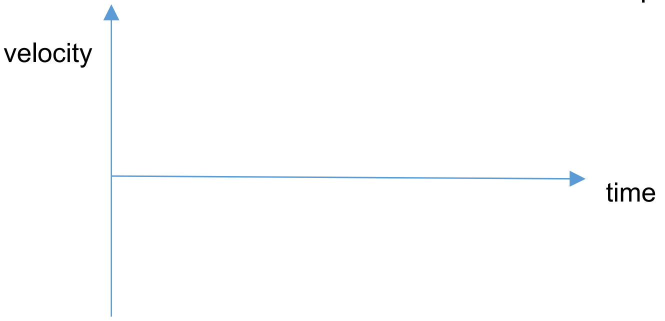
bearing = …………………. ° from north [3]

(b) Determine the distance of the disc from the point P at t = 10.0 s.

distance = ……………….m [3]

(c) From $t = 10.0$ s to $t = 20.0$ s, the acceleration of the disc has a constant value of 0.100 m s^{-2} directed towards the west.

1. Sketch the velocity-time graph along the East-West direction between t = 10.0 to t = 20.0 s. Take the eastward direction as positive.



[2]

2. Sketch in Fig. 1.2 the path of the disc from t = 0.0 s to t = 20.0 s.

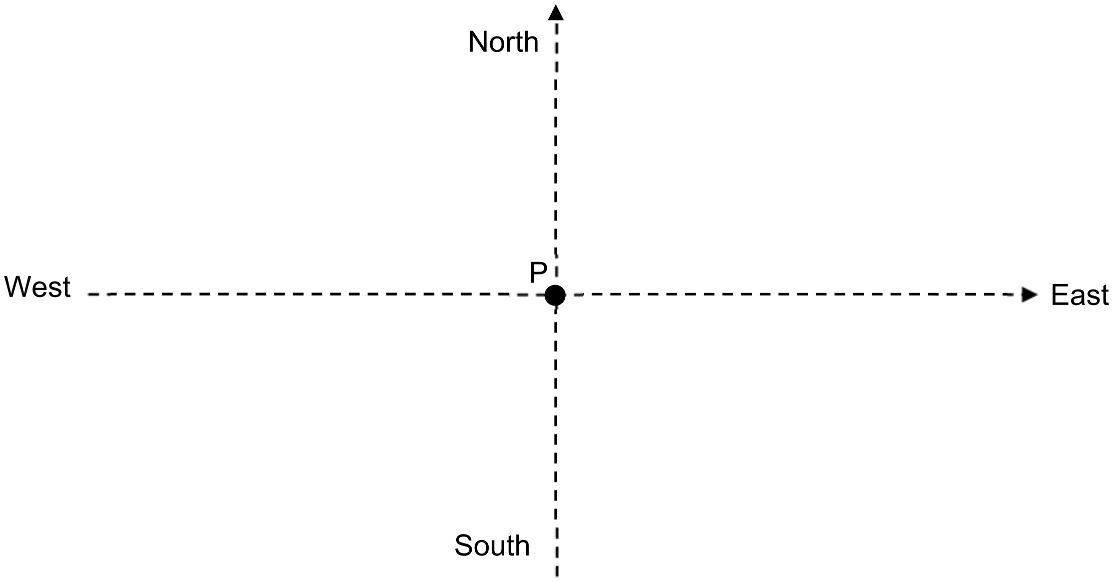


Fig. 1.2

[2]

2 **(a)** By reference to Newton's laws of motion, explain why when two particles, which are isolated, collide, the total momentum of the particles is conserved.

....

....

....

....

....[3]

(b) A ferryboat of mass M_1 = 7.0 x 10^5 kg moves toward a docking bumper of mass M_2 that is attached to a shock absorber, as shown in Fig. 2.1.

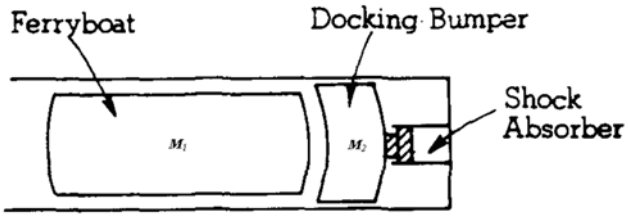


Fig. 2.1

Just before hitting the bumper, the ferryboat is travelling at a speed v = 3.0 m s^{-1}. After colliding inelastically with the bumper, the ferryboat and bumper move together with an initial speed of 2.0 m s^{-1}. The ferryboat comes to a complete stop 4.0 s after the collision. Fig. 2.2 shows the variation with time t of the velocity v of the ferryboat, where t = 0 s is the instant of collision.

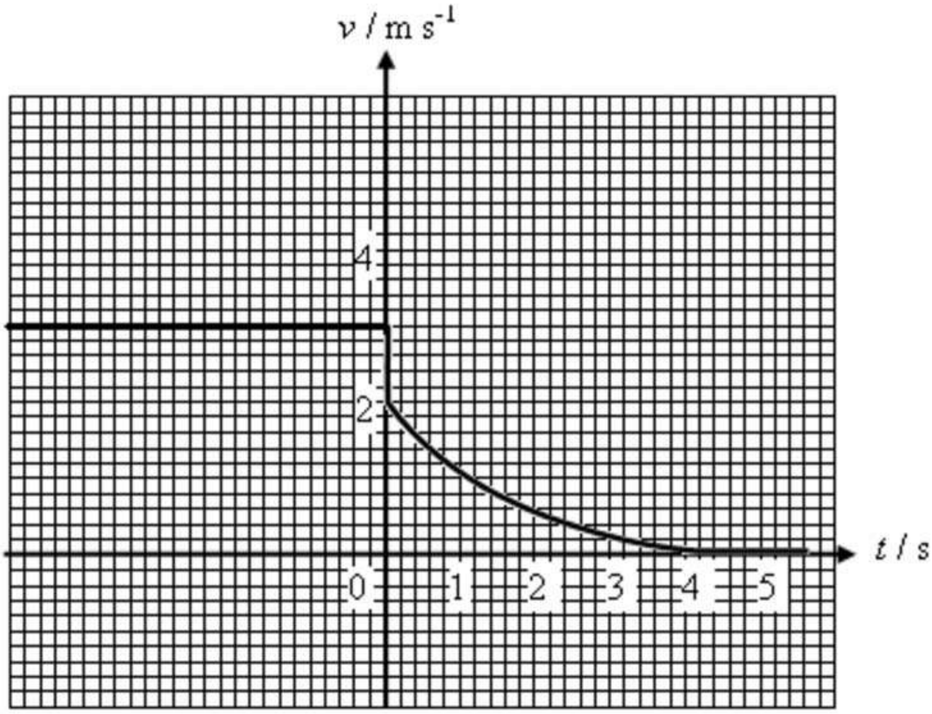


Fig. 2.2

(b) **(i)** Explain what is meant by *an inelastic collision*.

....

....[1]

(ii) Calculate the mass of the bumper M_2. State an important assumption that you have made in the calculation.

mass = …………………. kg [2]

(iii) Use the graph to determine the acceleration of the ferryboat at t = 1.0 s. Show your working on the graph clearly. State the direction of the acceleration.

acceleration = …………………. m s^{-2}

direction = …………………. [3]

(iv) Hence calculate the retarding force on the ferryboat at t = 1.0 s.

force = …………………. N [1]

3 A boy fills a flask with fluid and places it on a mass balance. The boy records the reading on the mass balance x in grams. He inserts two similar cubes, one on top of the other, into the flask as shown in Fig. 3.1.

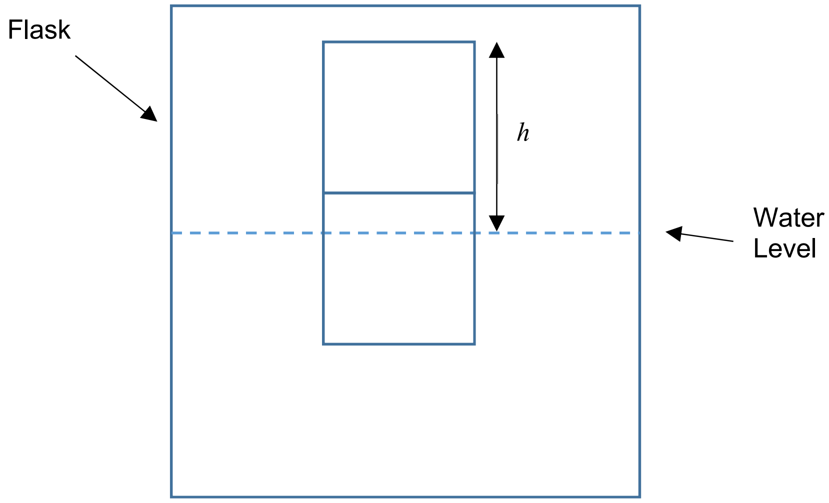


Fig. 3.1

Each side of the cube is r in cm. Both cubes stay afloat with one cube being partially immersed. After some time, the boy records that height of the two cubes above the fluid surface is h in cm while the reading on the mass balance is now y in grams.

(a) Express the density of the fluid in terms of x, y, r and h in g cm^{-3}.

[2]

(b) The cube on top is removed. Suggest and explain the subsequent motion of the cube in the fluid.

....

....

....

....

....

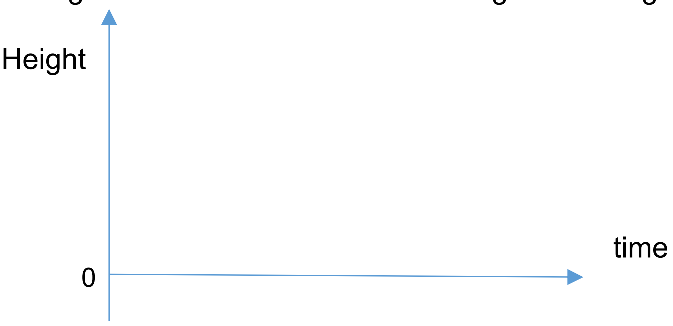
....

....

....[4]

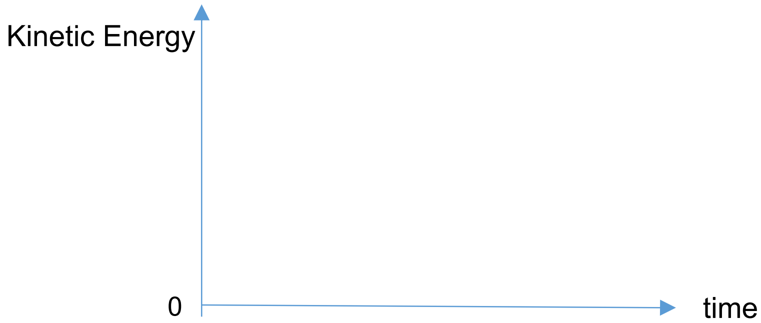
3(c) Given the values of r = 2.00 cm and h = 3.30 cm, sketch, without numerical values, the following graphs for the cube that remains in the fluid. Note that the bottom cube has a height of 1.30 cm above the fluid surface before the top cube is removed.

(i) Height of cube above fluid surface against time graph,



[2]

(ii) Kinetic Energy against time graph.



[2]

4 (a) The *I-V* characteristics of resistor **R** and resistor **X** are investigated. The results obtained are shown in Fig. 4.1.

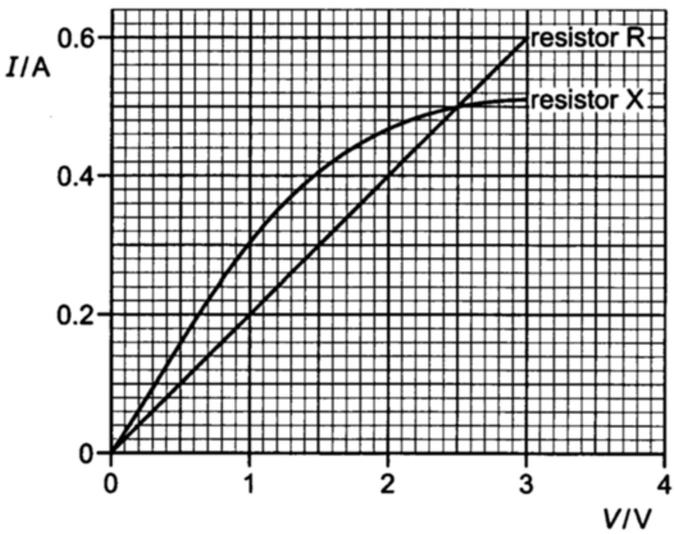


Fig. 4.1

(i) Student 1 sets up the circuit with resistors R and X in series across an unknown e.m.f. source with negligible internal resistance as shown in Fig. 4.2.

Fig. 4.2

Determine the value of the unknown e.m.f. source if the current through resistor X is 0.22 A.

Value of unknown e.m.f. source = …………….. V [2]

(ii) Student 2 sets up the circuit using a variable resistor, resistors R and X as shown in Fig. 4.3 using the same e.m.f. source.

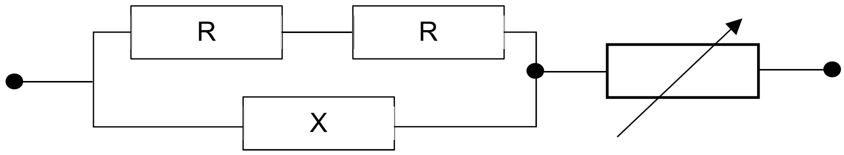


Fig. 4.3

Determine the resistance of the variable resistor given that the ratio of

$$\frac{\text{resistance of X}}{\text{resistance of R}} = 0.80$$

Resistance = ……………….Ω [3]

(iii) Student 2 modifies his circuit by adding an ideal ammeter and a voltmeter as shown in Fig. 4.4.

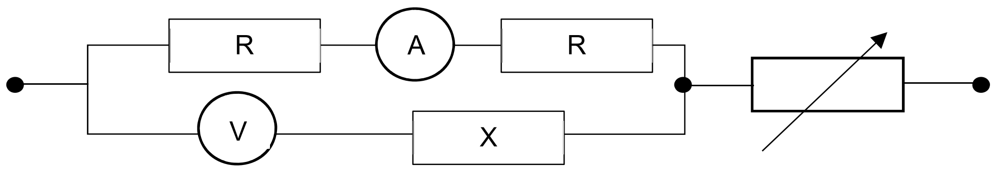


Fig. 4.4

Explain if this circuit is appropriate for determining the graphs over the range of V and I as shown in Fig. 4.1.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[3]

4(b) A student uses the equation $I = Anvq$ to determine the drift velocity of the electrons, v, in the wire.
State, with a reason, whether this is the maximum velocity of the free electrons in the wire.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

5 **(a)** This question is about an americium-241 radionuclide source used in a smoke detector.

A smoke detector works by detecting a decrease in the arrival of alpha particles from the americium when they are absorbed by the smoke. It is advised that the smoke detector be replaced after five years.

Here are some data about the source:
activity of source = 3.3×10^4 Bq
decay constant = 4.8×10^{-11} s^{-1}

(i) Radioactive decay is *random* in nature. State what is meant by the word *random* in this context.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) Use the equation $\Delta N = -\lambda N \Delta t$ with N taken as the original number of nuclei to show that about 5×10^{12} nuclei decay in the five years of use.

[2]

(iii) Explain why it is reasonable to use the equation $\Delta N = -\lambda N \Delta t$ (as above) to estimate the number of nuclei decaying over a five year period, but not over a few hundred years.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(iv) A decrease in activity of the sample is not likely to be the reason that the smoke detector should be replaced after five years. Suggest a more likely reason that the detector might need replacing.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(b) Strontium-90 is a radioactive waste product of nuclear power stations. Strontium-90 emits beta particles of energy up to 0.54 MeV. Should any of this isotope get into our food, it would be quickly absorbed into bones and teeth.
Explain why these beta particles are more of a risk to humans than gamma photons of the same energy.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

6 **(a)** A dust particle is suspended in the air between two parallel plates with the direction of electric field shown in Fig. 6.1. The electric field strength between the two parallel plate is 3.0×10^3 Vm^{-1}. The particle has charges of $+1.4 \times 10^{-15}$ C and -1.4×10^{-15} C near its ends. The charges may be considered to be static point charges separated by a distance of 3.0 mm, as shown in Fig. 6.1.

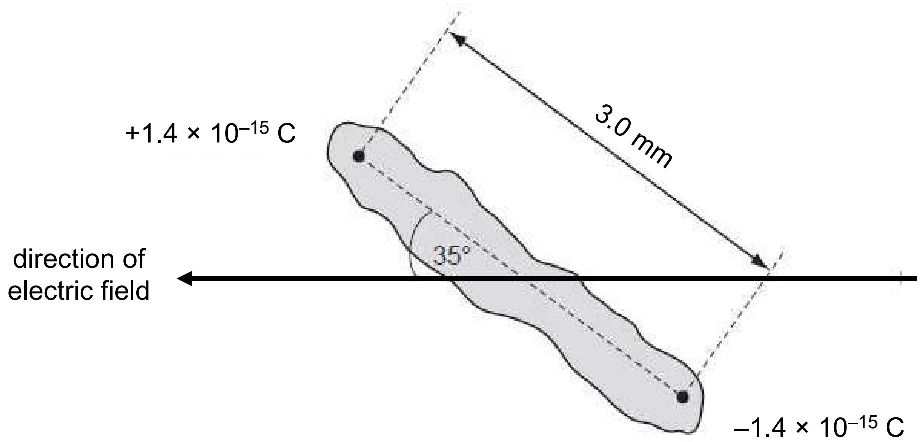


Fig. 6.1

The particle makes an angle of 35° with the direction of the electric field.

(i) Calculate the magnitude of the force on each charge due to the electric field.

force =…………………….. N [1]

(ii) Describe and explain the subsequent motion of the particle in the electric field.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [3]

6 (b) Fig. 6.2 and Fig 6.3 show the electric field pattern near two point charges respectively.

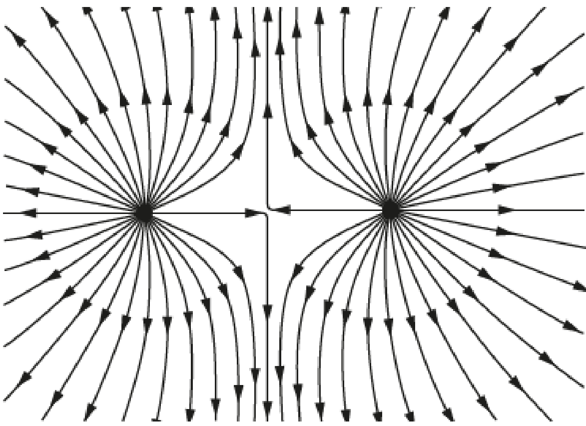


Fig. 6.2

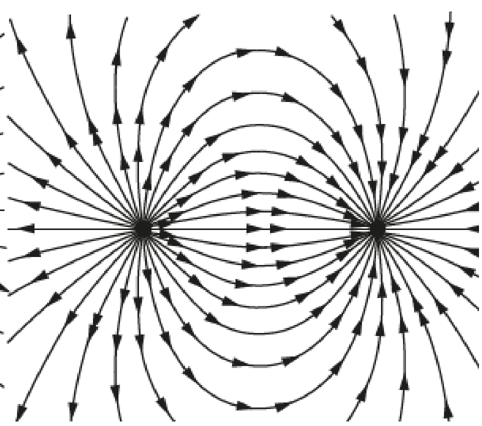


Fig. 6.3

(i) On the appropriate figure(s) mark the point(s)

1. with zero electric field and label it with the letter "N"

2. with zero electric potential and label it with the letter "E" [1]

(ii) On Fig. 6.2, draw **three** complete equipotential lines. [2]

6 **(c)** Fig. 6.4 shows the electrical potential *V* and the magnitude of the electric field *E* against distance *R* for an isolated – 1.0 C charge.

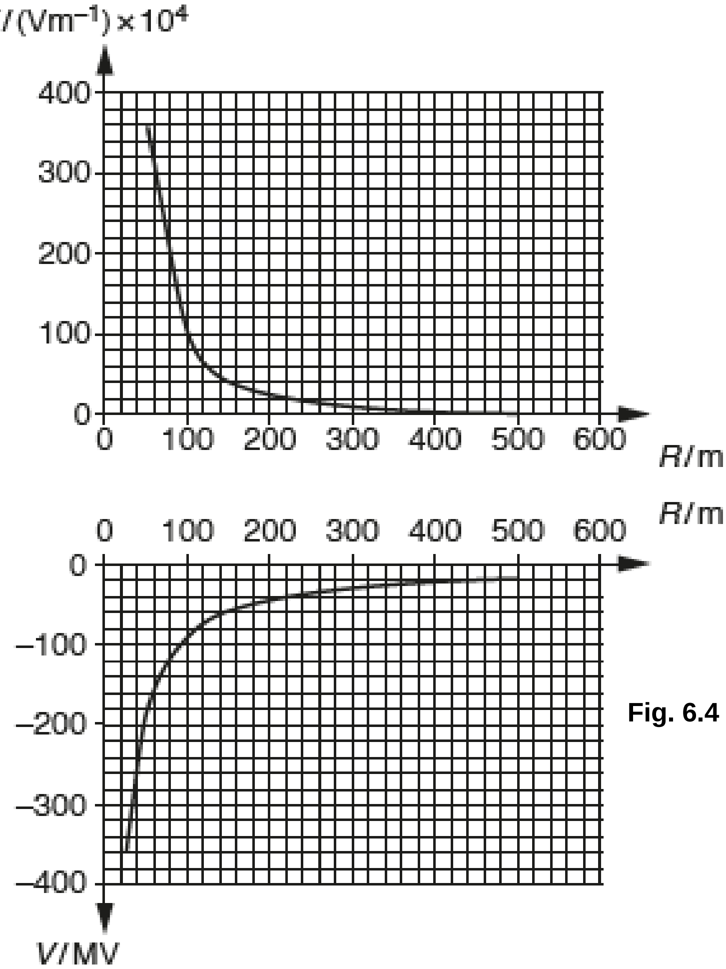


Fig. 6.4

Use Fig. 6.4 to explain the relationship between the electric field strength and the electric potential. (You may annotate on the figure and make clear reference to these annotations to support your answer.)

…………………………………………………………………………………………

…………………………………………………………………………………………

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…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………….[4]

7 (a) In 1913, Niels Bohr combined Planck's quantum theory, Einstein's concept of the photon, Rutherford's planetary model of the atom and Newtonian mechanics to derive a new model for the hydrogen atom. Several postulates were put forth.

Postulate 1. The electron moves in circular orbit, with radius r, around the proton due to the electric force of attraction, as shown in Fig. 7.1. In his model, the proton was considered to be stationary because its mass was very large compared to that of the electron.

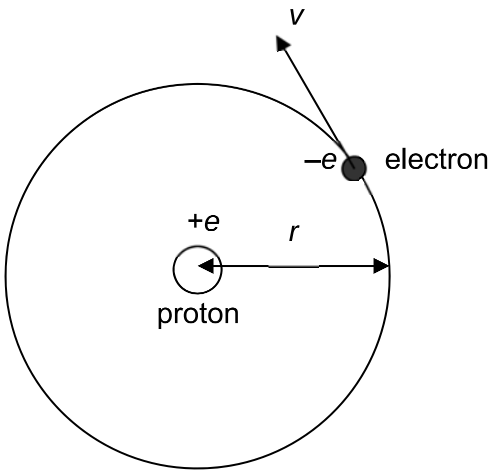


Fig. 7.1

Postulate 2. The angular momentum of the electron was quantised and this led to the hydrogen atom having allowable energies given by

$$E_n = -\frac{13.6}{n^2} \qquad \text{...... equation (1)}$$

where n = 1, 2, 3, …

Postulate 3. The atom emits radiation or photon when the electron made a transition from a higher energy to a lower-energy orbit. The frequency f of the photon emitted is related to the change in the energy of the atom rather than the orbital motion of the electron.

(i) With reference to postulate 3, write a word equation relating the change in the energy of the atom and the energy of the photon emitted.

.... [1]

(ii) Hence, with reference to postulate 3, explain the characteristic emission spectrum of hydrogen atoms.

....

....

....[2]

[Turn over

(iii) By considering matter waves in the orbital motion of the electron, the radii of the orbits were found to be quantized. The smallest radius is 5.29×10^{-11} m.

1. By considering the forces acting on an electron, show that the momentum p of the electron in an orbit of radius r is given by

$$p = \sqrt{\frac{me^2}{4\pi\varepsilon_o r}}$$

where m is the mass of the electron.

[3]

2. Hence, determine the wavelength of the electron when $r = 5.29 \times 10^{-11}$ m.

wavelength = ………………m [2]

(iv) Explain why this model of the hydrogen atom, where the electron orbits in a circular path with a fixed radius, will violate the Heisenberg uncertainty principle.

……………………………………………………………………………………………

………………………………………………………………………………………….. [1]

(b) When high-energy electrons or any other charged particles bombard a metal target, x-rays are emitted.
The origin of the characteristic x-rays is due to the removal of the inner-shell electron from the atom by the bombarding electrons that have sufficient energies. The vacancy that is created in the inner shell is filled when an electron that is at a higher energy level in the atom transits into the energy level containing the vacancy. Fig. 7.2 shows the shells (*K*, *L*, *M*, *N* and *O*) present in the atom and how the characteristic x-rays, K-lines and other peaks, are obtained.

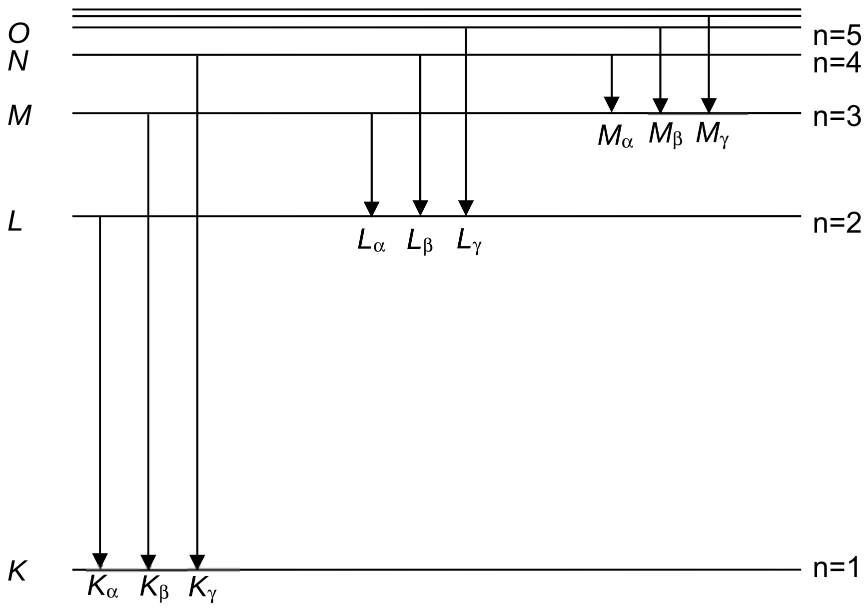


Fig. 7.2

Equation (1) in part **(a)** may be modified to describe the energy for the *L*-shell. Due to the presence of one *K*-shell electron, the other electron in *L*-shell will 'see' an effective nuclear charge of approximately (Z – 1)e, where e is the elementary charge and Z is the atomic number of the element.

As such equation (1) in part **(a)** can be approximated as

$$E_n = -\frac{(13.6\ eV)(Z-1)^2}{n^2}$$

(i) For an electron that makes a transition from the *L* shell (with n = 2) to the *K* shell (with n = 1), derive the relationship between the frequency f of the radiation and Z.

[3]

[Turn over

(ii) It is thought that the wavelength λ of K_α x-ray radiation, varies with atomic number of element Z according to the expression below as suggested by Mosley in 1914.

$$\sqrt{\frac{1}{\lambda}} = A(Z - B)$$ where A and B are constants

The frequency f of K_α x-ray radiation, of a few elements are given in Fig. 7.3.

Element	Atomic number Z	Frequency f / 10^{18} Hz	$\sqrt{\frac{1}{\lambda}}$ / 10^4 $m^{-1/2}$
Titanium	22	1.08	6.01
Chromium	24	1.30	6.59
Iron	26	1.54	7.16
Nickel	28	1.79	
Zinc	30	2.07	8.30
Gallium	31	2.21	8.59

Fig. 7.3

Complete Fig. 7.3 for Nickel. [1]

(iii) The data from Fig. 7.3 are used to plot the graph of Fig. 7.4.

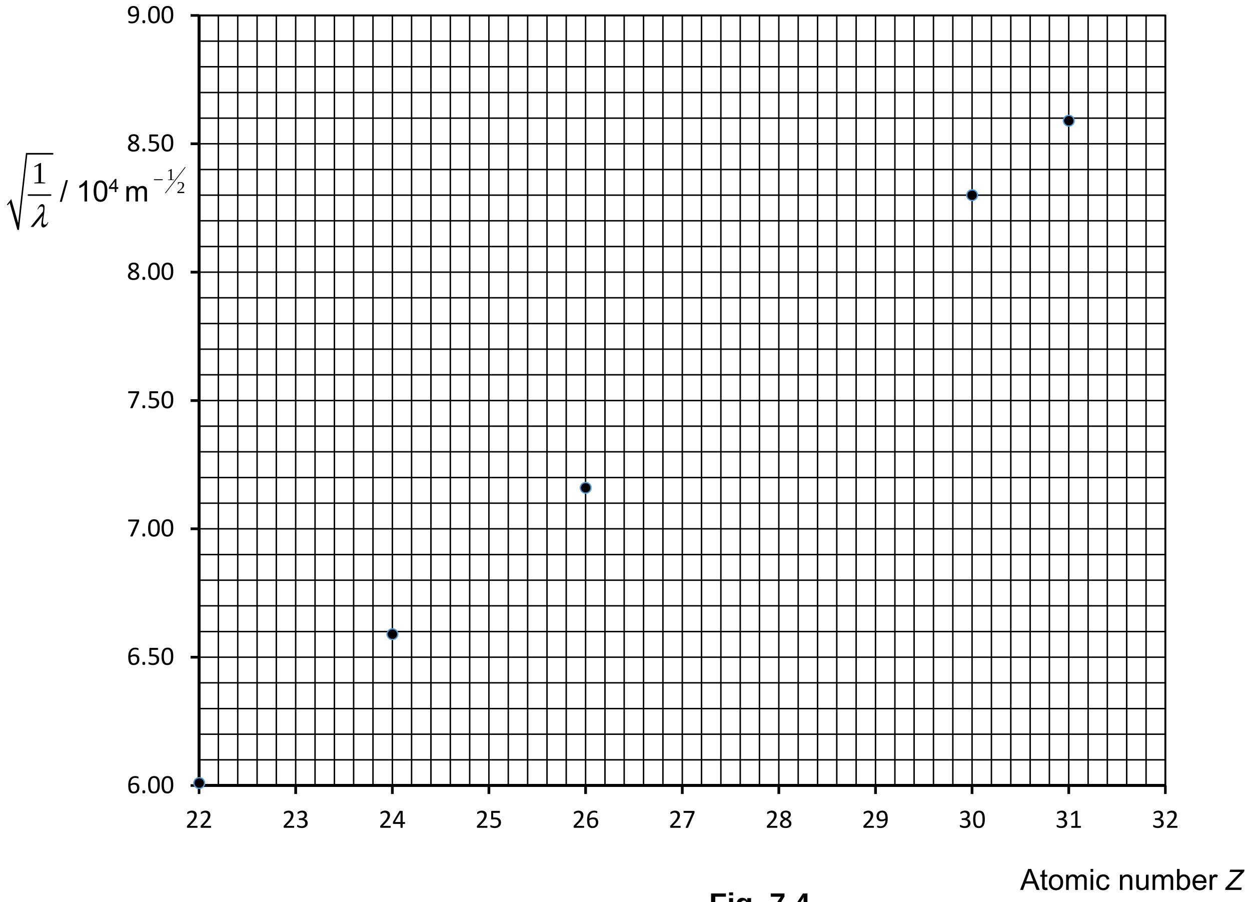


Fig. 7.4

On Fig. 7.4,

1 Plot the point corresponding to Nickel. [1]

2 Draw the best-fit line for all the points. [1]

(iii) Use the line drawn in **Fig. 7.4** to determine the magnitude of the constants *A* and *B* in the expression in **b(ii)**.

A = ………………..$m^{-1/2}$

B = …………………[3]

(c) One of the possible use for characteristic spectrum is to allow impurity in specimens to be detected by scientists. A cobalt target is bombarded with electrons, and the wavelengths of its characteristic x-ray spectrum are measured. There is also a second fainter characteristic spectrum, which is due to an impurity in the cobalt. The wavelengths of the K_α lines are 178.9 pm (cobalt) and 143.5 pm (impurity), and the atomic number *Z* for cobalt is 27.
Using Fig. 7.3, deduce the impurity in the cobalt.

[2]

END OF PAPER

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

PHYSICS

9749/03

Paper 3 Longer Structured Questions **(Section A)**

28 Aug 2018
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THE INSTRUCTION FIRST
Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answers **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use

1	**/ 10**
2	**/ 10**
3	**/ 10**
4	**/ 10**
5	**/ 10**
6	**/ 10**
Total	**/ 60**

This document consists of 14 printed pages.

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1} = $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = - GM/r$
temperature	$T/K = T/°C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^{\,2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \cdots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{ln2}{t_{\frac{1}{2}}}$

Section A (60 marks)

1 **(a)** Distinguish between *gravitational potential energy* and *elastic potential energy*.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

(b) A child's pogo stick comprises of a spring with spring constant of 1.50×10^4 N m^{-1}. The combined mass of the child and pogo stick is 25.0 kg.

Fig. 1.1 shows the various instances of a child jumping vertically on the pogo stick.

At instance **A**, the spring compression is a maximum and the child is momentarily at rest. The foot rest is 0.200 m below the reference level.

At instance **B**, the spring is relaxed and the child is moving upward.

At instance **C**, the child is again momentarily at rest and at the top of the jump.

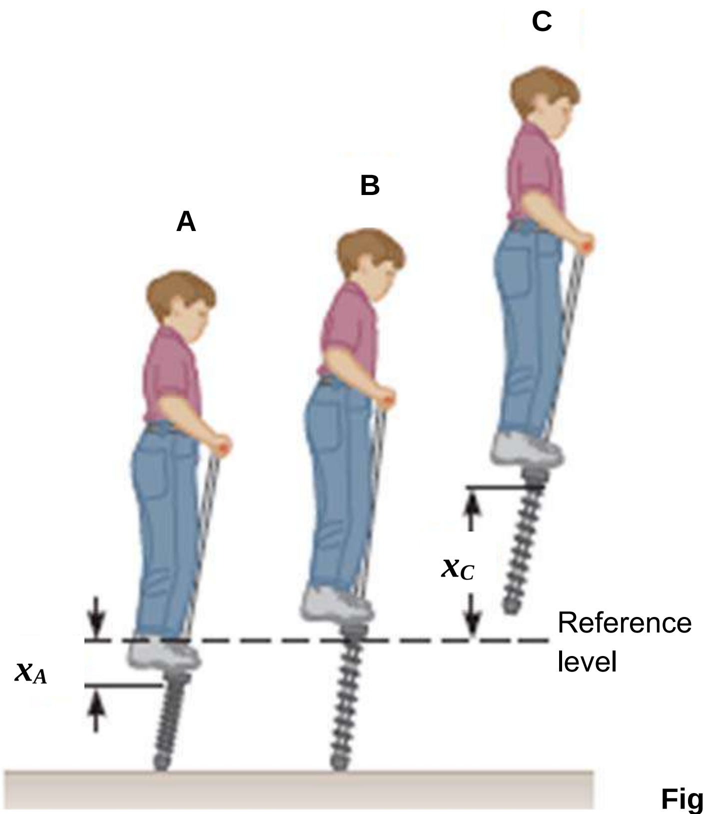


Fig. 1.1

(i) State the energy changes from instance A to C. Numerical values are not required.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[3]

(b) **(ii)** Determine the value for x_C.

x_C. =……………………m [2]

(iii) Determine the maximum speed of the child.

maximum speed = ……………….. m s^{-1} [3]

(iv) State and explain the position of the footrest, with respect to the reference level, when maximum speed is attained.

………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………[1]

2 An executive toy consists of five identical steel spheres of mass m suspended so that they are free to move in a vertical plane as shown in Fig. 2.1. Each sphere is suspended using thin inextensible strings of negligible mass.

You may assume that collisions between the spheres are perfectly elastic and air resistance is negligible

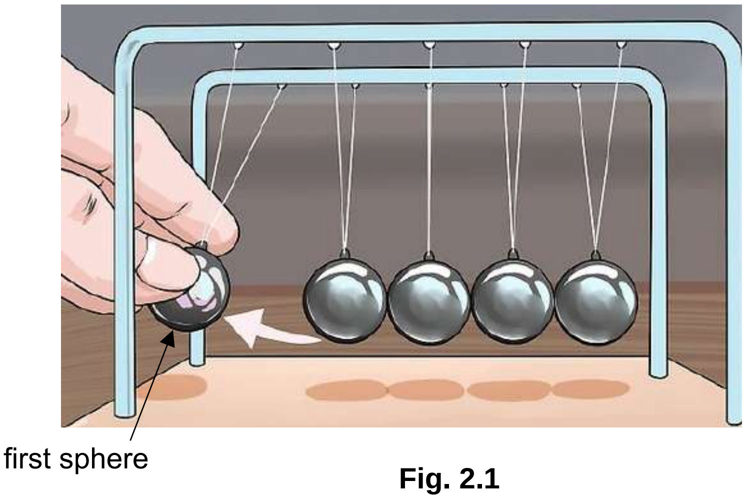


Fig. 2.1

(a) The first sphere is displaced to the left and then released. Describe and explain the resulting motion of the five spheres.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[3]

(b) **(i)** Object **A** has a velocity of u and moves horizontally towards Object **B** which is at rest. The collision between both objects is head-on and perfectly elastic.
The ratio of the mass of Object **A** to the mass of Object **B** is **1:2**.
Determine the ratio of the **final** velocity of Object **B** to the initial velocity of Object **A**.

ratio = …………………….[2]

[Turn over

(b) **(ii)** Object **C** has a velocity of u and moves horizontally towards Object **D** which is at rest. The collision between both objects is head-on and perfectly elastic.
The ratio of the mass of Object **C** to the mass of Object **D** is **2:1**.
Determine the ratio of the final velocity of Object **D** to the initial velocity of Object **C**.

ratio = …………………..[1]

(iii) Hence, if the **second and fourth spheres are replaced with steel spheres of mass 2*m*** of the executive toy in Fig. 2.1, determine the ratio of

$$\frac{\text{Maximum vertical displacement of the first sphere}}{\text{Maximum vertical displacement of the last sphere}}$$

Assume that the collision between both objects is head-on and perfectly elastic.

ratio = …………………..[2]

(c) The five identical steel spheres in Fig. 2.1 are of mass m.

State and explain one significant difference to the motion observed if all the thin inextensible strings are replaced by springs of negligible mass.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………[2]

3 **(a)** Fig. 3.1 shows a circuit containing three identical lamps A, B and C. It also contains three switches, S_1, S_2 and S_3.

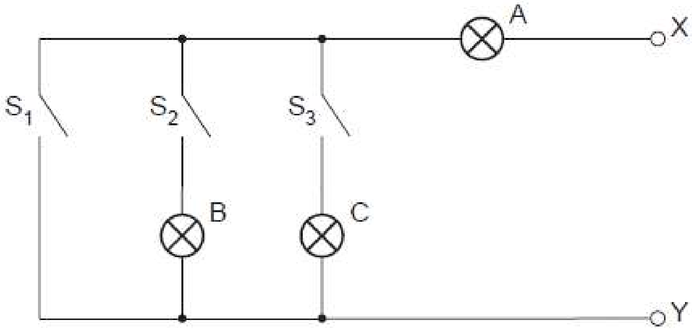


Fig. 3.1

One of the lamps is faulty. In order to detect the fault, an ohm-meter is connected between terminal X and Y. When measuring resistance with the ohm-meter, negligible current flows in the circuit.

Fig. 3.2 shows the readings of the ohm-meter for different switch positions.

switch S_1	S_2	S_3	meter reading / Ω
open	open	open	∞
closed	open	open	15 Ω
open	closed	open	30 Ω
open	closed	closed	15 Ω

Fig. 3.2

(i) Identify the faulty lamp, and the nature of the fault.

Faulty lamp: ……………………………………………………………………………

Nature of fault: …………………………………………………………………….[2]

(ii) Suggest why it is advisable to test the circuit using an ohm-meter rather than with a power supply.

…………………………………………………………………………………………

………………………………………………………………………………………..[1]

(a) **(iii)** Determine the resistance of the lamp when it is functioning properly.

resistance = …………………….Ω [1]

[Turn over

(b) A battery of e.m.f. 4.50 V and negligible internal resistance is connected to a fixed resistor of resistance 1200 Ω and a thermistor, as shown in Fig. 3.3.

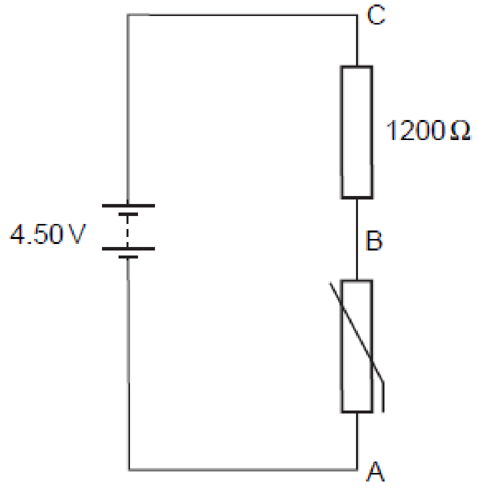


Fig. 3.3

At room temperature, the thermistor has a resistance of 1800 Ω.

A uniform resistance wire PQ of length 1.00 m is now connected to the resistor and the thermistor, as shown in Fig. 3.4.

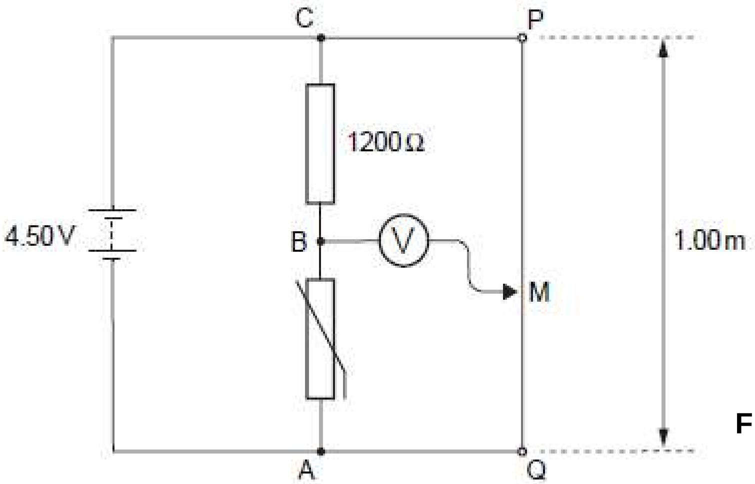


Fig. 3.4

A voltmeter is connected between point B and a movable contact M on the wire.

(i) Explain why, for constant current in the wire, the potential difference between any two points on the wire is proportional to the distance between the points.

....

....

....

....[2]

(b) **(ii)** The contact M is moved along PQ until the voltmeter shows zero reading. Calculate the length of the wire between M and Q.

length = ……………………m [2]

(iii) The temperature of the thermistor increases slightly during the measurement. Explain the effect on the length of wire between M and Q for the voltmeter to show zero reading.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

4 Fig. 4.1 shows a mass spectrometer comprising a velocity selector (Stage 1) and an ion separator (Stage 2). A stream of alpha particles is sent into the mass spectrometer.

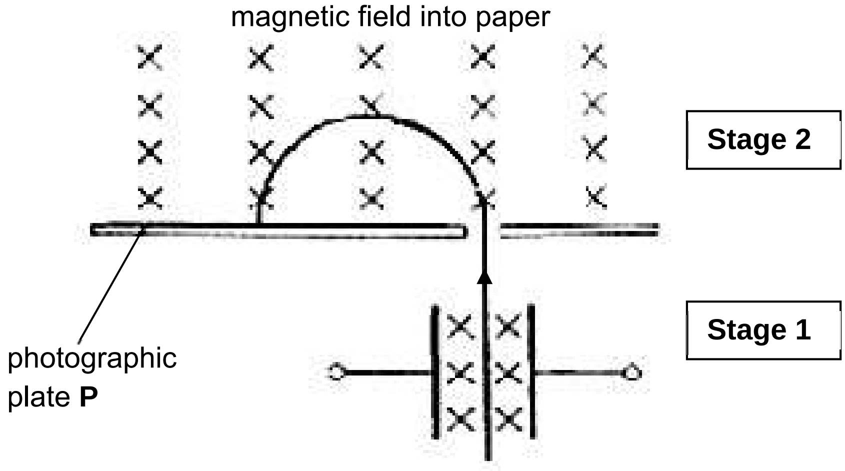
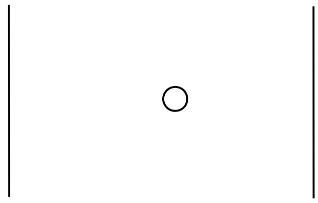


Fig. 4.1

(a) **Stage 1**

The alpha particles have a range of speeds enter Stage 1 which isolates particles with a specific speed, *v*. The plates producing the electric field have a separation of 1.0 cm. A uniform magnetic field is applied between the plates.

(a) **(i)** On the diagram below, draw arrows to represent the electric force F_E and the magnetic force F_B. [2]



(ii) Describe and explain the path of alpha particles with speed less than *v*.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

(b) **Stage 2**

After Stage 1, alpha particles of speed 1.00×10^5 m s^{-1} are sent into stage 2. The alpha particles are travelling at right angles to the uniform magnetic field and are detected using a photographic plate P placed at the appropriate position. Determine the distance between the point of entry and the point of impact of the alpha particles with the photographic plate when the magnetic flux density 0.050 T is used.

distance = ……………………m [2]

(c) A similar spectrometer can be used with beta particle. Beta particles typically travel more than 100 times faster than the alpha particles. State and explain the necessary modifications to the spectrometer for it to work with beta particles.

Stage 1:

……

……

……

……

Stage 2:

……

……

……

……

[4]

5 **(a)** **(i)** State what is meant by *a line of force in a gravitational field*.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(ii) By reference to the lines of force of the gravitational field near the surface of the Earth, explain why the acceleration of free fall near the surface of Earth is approximately constant.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[3]

(b) The table below shows some data for Mercury and Pluto.

	Mass/kg	Radius/m	Mean distance from Sun/m
Mercury	3.30×10^{23}	2.44×10^{6}	57.9×10^{9}
Pluto	0.131×10^{23}	1.19×10^{6}	5910×10^{9}

(i) Show that the escape velocity *v* of a gas molecule on the surface of Pluto is given by the equation

$$v = \sqrt{\frac{2GM}{r}}$$

where *M* is the mass of Pluto and *r* is its radius. [2]

(ii) Calculate the escape velocity of a gas molecule on the surface of Pluto.

escape velocity = ……………………m s^{-1} [1]

(iii) Suggest, using data from the table, why Mercury has no detectable atmosphere while Pluto has a thin atmosphere.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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………………………………………………………………………………………………

………………………………………………………………………………………………[3]

6 **(a)** A mass of 24 g of ice at –15 ℃ is taken from a freezer and placed in an insulated container with 200g of water at 28 ℃. Some data for the ice and the water are given in the table below.

	specific heat capacity / $J\,kg^{-1}\,K^{-1}$	specific latent heat of fusion / $J\,kg^{-1}$
ice	2.1×10^3	3.3×10^5
water	4.2×10^3	–

Calculate the final temperature of the water in the container.

final temperature = ………………………..℃ [2]

(b) Some air, assumed to be an ideal gas, is contained within a cylinder. Initially, the volume of gas is 540 cm^3, its pressure is 1.1 x 10^5 Pa and its temperature is 27 ℃. The air is compress to 30 cm^3 suddenly such that no heat enters or leaves the gas. The pressure of the gas is 6.5 x 10^6 Pa immediately after the compression.

(i) Determine the temperature of the gas immediately after the compression.

temperature = ………………………..◦C [2]

[Turn over

(b) **(ii)** Explain, using the first law of thermodynamics, why the temperature of the air changes during the compression.

………………………………………………………………………………………...

………………………………………………………………………………………....

………………………………………………………………………………………...

………………………………………………………………………………………...

………………………………………………………………………………………...

……………………………………………………………………………………….[3]

(c) The first law of thermodynamics can be expressed in the form

$$\Delta U = q + w$$

where U is the internal energy of the system,
ΔU is the increase of the internal energy of the system,
q is the thermal energy supplied to the system,
w is the work done on the system.

The table below shows different processes. Complete the table with symbols '+' for an increase, '–' for a decrease and the symbol '0' for no change, for the respective quantities U, q and w. [3]

Process	U	q	w
the compression of an ideal gas at constant temperature			
the heating of a solid with no expansion			
The melting of ice at 0 ◦C into water at 0 ◦C. (Note: ice is less dense than water)			

End of Section A

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS

9749/03

Paper 3 Longer Structured Questions **(Section B)**

28 Aug 2018
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THE INSTRUCTION FIRST
Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

For Examiner's Use	
7	**/ 20**
8	**/ 20**
Total	**/ 20**

The use of an approved scientific calculator is expected, where appropriate.

Section B
Answer any **one** question.

You are advised to spend half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of 11 printed pages.

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1} = $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = - GM/r$
temperature	$T/K = T/°C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \cdots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{ln2}{t_{\frac{1}{2}}}$

Section B (20 marks)

7 **(a)** **(i)** State and explain the effect of the width of aperture on the diffraction of the wave.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) The band is practising in the band room down the corridor with the door left slightly ajar. Explain why notes of a certain range of frequencies can be heard more clearly than others at the other end of the corridor.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

(b) A plane diffraction grating is illuminated normally by a monochromatic light source of wavelength λ. Light rays from each slit travel a different distance before arriving at a particular point on the screen. In order to derive an expression for the path difference, the light rays that meet at the same point on the screen can be approximated as parallel rays.

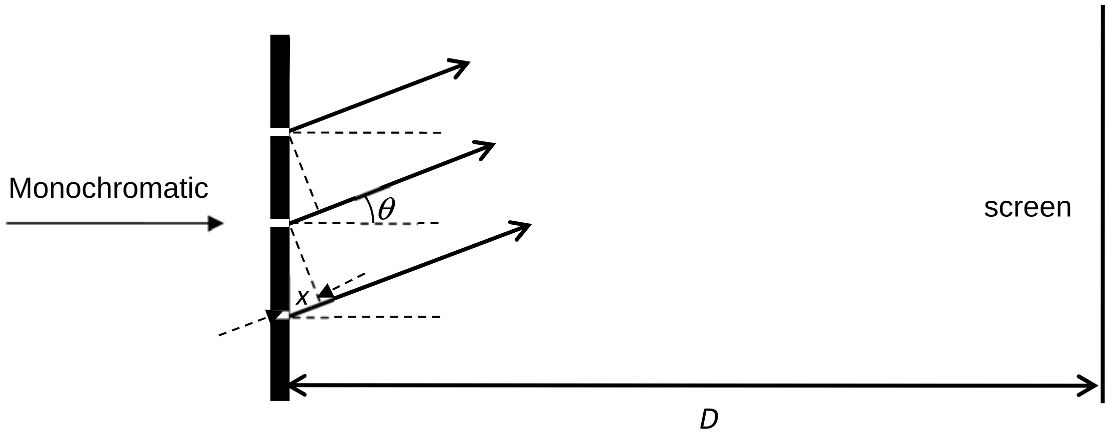


Fig. 7.1

(i) State the condition where the rays can be assumed to be parallel.

……………………………………………………………………………………………

…………………………………………………………………………………………[1]

7 **(b)** **(ii)** Derive an expression for the path difference x between adjacent rays in terms of p and θ, where p is the number of lines per unit length of the grating, and θ is the angle between the emergent ray and the normal. [2]

(iii) Hence, derive an expression relating p and θ for the constructive interference of the rays. Define any additional symbol you use. [2]

7 (c) A diffraction grating is set up at the centre of a rotating table which completes a revolution every 3.0 s. The grating is illuminated normally by monochromatic light of wavelength λ from a source which is also mounted on the table, see Fig. 7.2.

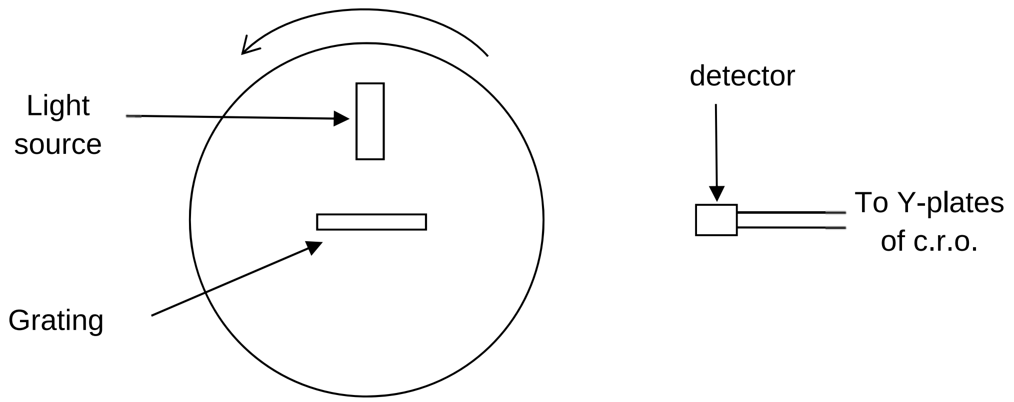


Fig. 7.2

The emergent beams of light from the grating are monitored by means of a stationary opto-electrical detector. The output from detector is displayed on a cathode ray oscilloscope (c.r.o.). With the time-base set at 0.10 s cm^{-1}, the trace obtained is shown in Fig. 7.3. The relative positions of the peaks are as indicated.

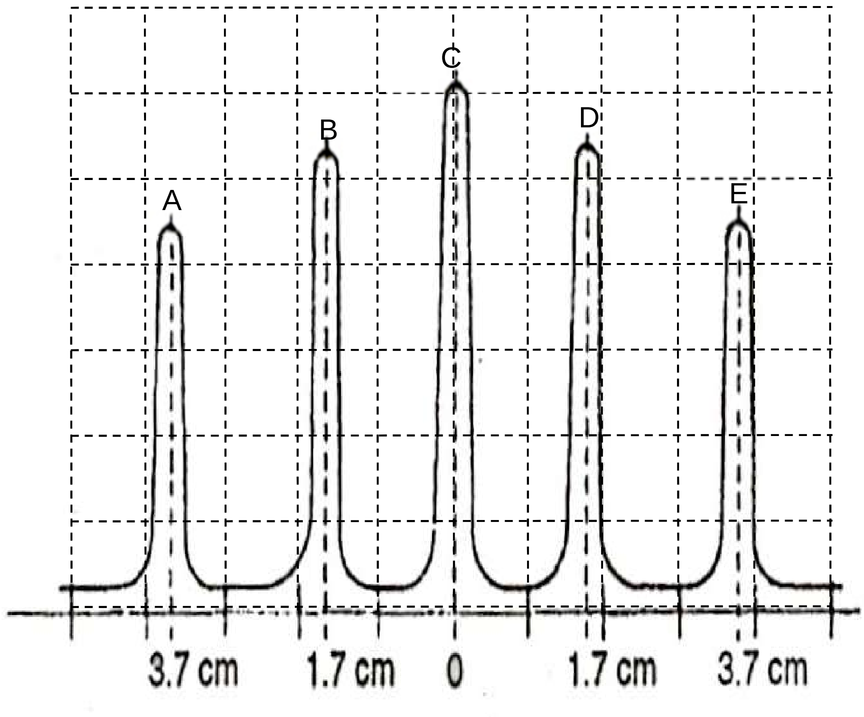


Fig. 7.3

7 **(c)** **(i)** Calculate the angular speed of rotation of the grating.

angular speed = …………………….rad s^{-1} [1]

(ii) Explain the appearance of the trace in Fig. 7.3.

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………..[2]

(iii) Calculate the angle θ in radians, as defined in (b) (ii), for peaks D and E.

θ for D = …………….radians

θ for E = …………… radians

[3]

7 **(c)** **(iv)** Using peak E, calculate the wavelength of the light if the grating has 550 lines per mm.

wavelength = …………………….nm [2]

(v) Explain why it is preferable to calculate the wavelength using peak E rather than peak D.

……………………………………………………………………………………………

……………………………………………………………………………………….[1]

(vi) Sketch in Fig. 7.4, the c.r.o. display, if the diffraction grating is replaced by a double slit of the same slit separation as the diffraction grating. [2]

.

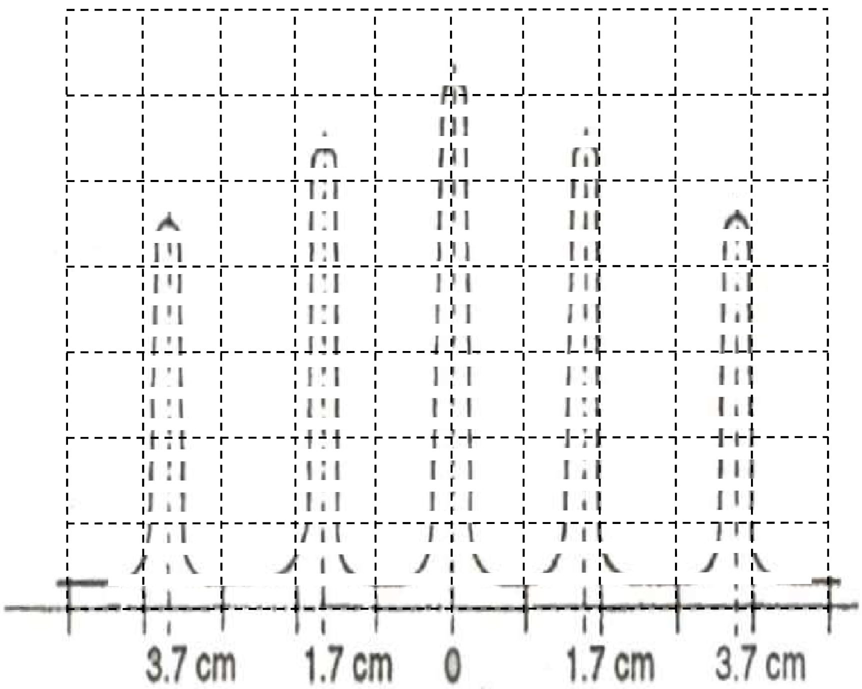


Fig. 7.4

(The original display from the grating is shown in dotted line)

8 **(a)** Describe how the alpha scattering experiment provides evidence for

(i) the small size of the nucleus,

………………………………………………………………………………………

……………………………………………………………………………………….[1]

(ii) a charged nucleus.

………………………………………………………………………………………

……………………………………………………………………………………….[1]

(b) In 1914, James Chadwick showed that the energies of the beta particles emitted for a radioactive source had a distribution of energies rather than with a distinct single value of energy.

Figure 8.1 shows the energy spectrum for beta particles emitted during the decay of Bismuth-210 ($^{210}_{83}Bi$). The intensity (vertical axis) indicates the number of beta particles emitted with each particular kinetic energy (horizontal axis).

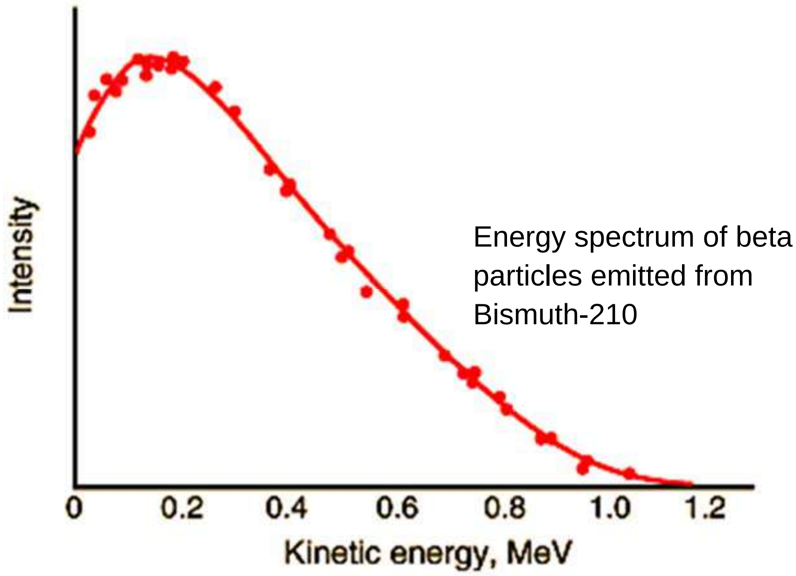


Fig. 8.1

(i) **1.** Determine, from Fig.8.1, *Q*, the maximum possible energy of the beta particle emitted.

Q =……………………. MeV [1]

2. Hence calculate the maximum speed of the beta particle.

Maximum speed =……………………. m s^{-1}

3. Comment on the value you obtained in **b(i)2**.

………………………………………………………………………………

………………………………………………………………………………[2]

8 **(b)** **(ii)** The radioactive isotope of Bismuth, $^{210}_{83}\mathrm{Bi}$, decays into Polonium (chemical symbol: Po) with the emission of a beta particle.

Determine the mass of the resultant Polonium nucleus, in terms of *u*, and express your answer to 3 decimal places. (mass of a $^{210}_{83}\mathrm{Bi}$ nucleus is 209.939 *u*; mass of proton m_p is 1.00729 *u*; mass of neutron m_n is 1.00867 *u*).

mass=……………………. *u* [3]

(iii) From Fig. 8.1, identify the most probable energy for the beta particle.

most probable energy value = ………………… MeV [1]

(iv) It is noted that the stable isotopes of heavy elements have an optimal neutron to proton ratio. Unstable isotopes will undergo transmutation into another element through radioactive decay such that product achieve the optimal ratio.

Suggest, with a reason, whether Bismuth-210 has an excess of neutrons or protons, as compared to the optimal ratio.

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………..[2]

(v) The continuous spectrum of kinetic energy values of the beta particle presented a problem to physicists up to 1930s. If a stationary nucleus decayed into a beta particle and a stable daughter nucleus only, it should lead to a distinct single value of energy.

Explain, using conservation of linear momentum and energy, how the continuous spectrum of beta particle energies gave rise to this problem.

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

………………………………………………………………………………… [2]

8 **(b)** **(vi)** Suggest what was proposed by physicists to resolve the problem in **(v)**.

………………………………………………………………………………………

……………………………………………………………………………………….[1]

(c) In an experiment, a detector is held a fixed distance from a sample of a radioactive material and the data provided is used to plot a graph of count-rate against time, as shown in Fig 8.2.

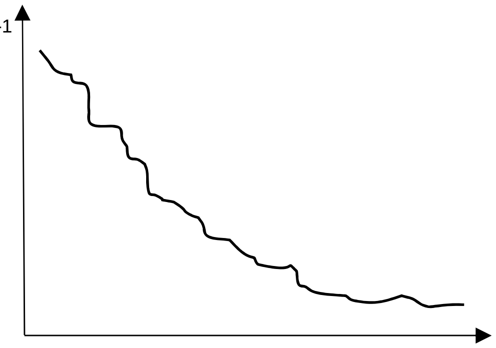


Fig. 8.2

(i) Explain why the data points on the graph do not lie on a smooth curve.

………………………………………………………………………………………

……………………………………………………………………………………….[1]

(ii) Suggest two reasons why the count-rate recorded is not equal to the activity of the radioactive sample.

1. ………………………………………………………………………………………

………………………………………………………………………………………

2. ………………………………………………………………………………………

……………………………………………………………………………………….[2]

(iii) The count rate from a counter near a radioactive source is 7.6×10^{8} s^{-1}. The decay constant of the source is 4.6×10^{-3} s^{-1}.

1. Calculate the time taken for the count rate to fall to 8.3×10^{3} s^{-1}.

time = …………………… s [1]

8 (c) (iii) 2. When the detector is at a distance *y* from the radioactive source, the count rate is 234 counts per minute.

Calculate the count rate when the detector is at a distance 3*y* from the source.

average count rate = ……………………. counts per minute [2]

End of Section B

Q1	C			Q16	D
Q2	B			Q17	B
Q3	D			Q18	A
Q4	B			Q19	B
Q5	B			Q20	D
Q6	C			Q21	D
Q7	B			Q22	A
Q8	B			Q23	B
Q9	D			Q24	D
Q10	C			Q25	C
Q11	B			Q26	C
Q12	C			Q27	A
Q13	B			Q28	C
Q14	C			Q29	C
Q15	A			Q30	B

2018 H2 Physics Prelim P2 Suggested Solution

1(a) at t = 10.0 s,

its velocity towards East $v_E = 0.141 + (0.100)(10) = 1.14 \; m\,s^{-1}$

its velocity towards North = 0.141 m s^{-1}

its resultant velocity $v_R = \sqrt{(1.14)^2 + (0.141)^2} = 1.15 \; m\,s^{-1}$

at $\theta = \tan^{-1}(1.14/0.141) = 82.9^o$

(b) displacement towards East,

$x = 0.200\cos 45^o(10.0) + \frac{1}{2}(0.100)(10.0)^2 = 6.41\,m$

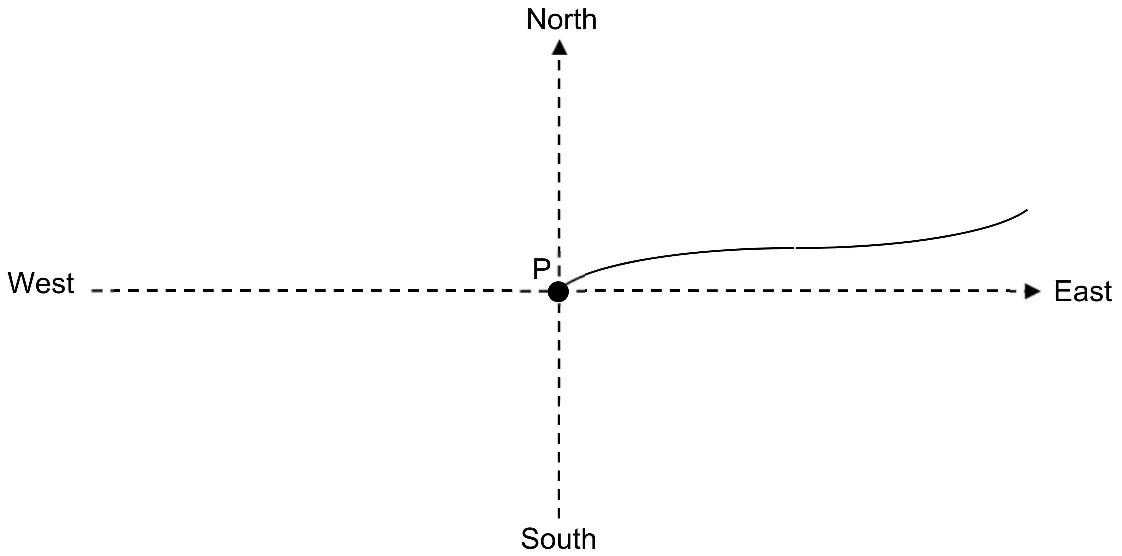
displacement towards North,

$y = 0.200\sin 45^O(10.0) = 1.41m$

Distance from point P , $r = \sqrt{(6.14)^2 + (1.41)^2} = 6.57m$

(c) Straight-line with negative gradient. Non-zero ending.

(d)



2. (a) Taking the two particles as A and B, according to **Newton's 3rd law**, when the two particles collide, the force that A exerts on B is equal in magnitude but opposite in direction to the force that B exerts on A.

According to **Newton's 2nd law**, the net/resultant force on a particle is proportional to the rate of change of its momentum.

Since the **time of contact for A and B is equal**, the change in momentum of A is exactly equal in magnitude, and opposite in sign/direction, to the change in momentum of B.

Hence the total momentum is conserved.

(b) **(i)** **Total kinetic energy** of the **system** is not conserved in the collision. [1]

(ii) By the principle of conservation of momentum,

$M_1 u = (M_1 + M_2) v$

$(7.0 \times 10^5)(3.0) = (7.0 \times 10^5 + M_2)(2.0)$

$M_2 = 3.5 \times 10^5$ kg.

(iii) Drawing of a suitable tangent at t = 1.0 s and showing of relevant working. (Tangent triangle should be as large as possible and coordinates read to half a small square).

Magnitude of acceleration = 0.65 m s^{-2}
Direction: left

(iv) Magnitude of retarding force = $7.0 \times 10^5 \times 0.65 = 4.6 \times 10^5$ N

3

(a) Since the system is in equilibrium, net force = 0

Upthrust on cube = Weight of two cubes

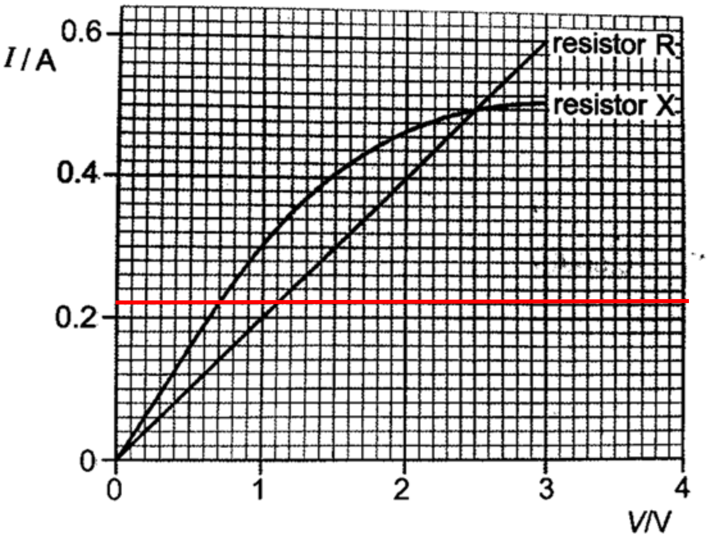
$$\rho_{fluid} r^2(2r - h)g = (y - x)g$$
$$\rho_{fluid} = \frac{(y-x)}{r^2(2r-h)}$$

(b) - The cube that remains in the fluid is at rest at the point when the top cube is removed. Since the upthrust at that instant is larger than the weight of the cube, the net force is upwards so the velocity starts to increase in the upward direction.
- As the cube moves upwards, the upthrust decreases till it is the same magnitude as the weight of the cube at equilibrium position where the magnitude of the velocity is maximum.
- The upthrust decreases further resulting in the net force being downwards as it moves further up. This results in the velocity decreasing as it reaches its highest position where the velocity comes to zero.
- This shows that the cube that remains in the fluid is in oscillating motion.

(c) **(i)** Height starts from lowest point (1.30 cm) to highest point (2.00 cm) with equilibrium position at 1.65 cm. Height at t=0 is 1.30 cm and increasing. Reaches 2.00 cm after half a period.
Sinusoidal
Label period and starts from lowest point

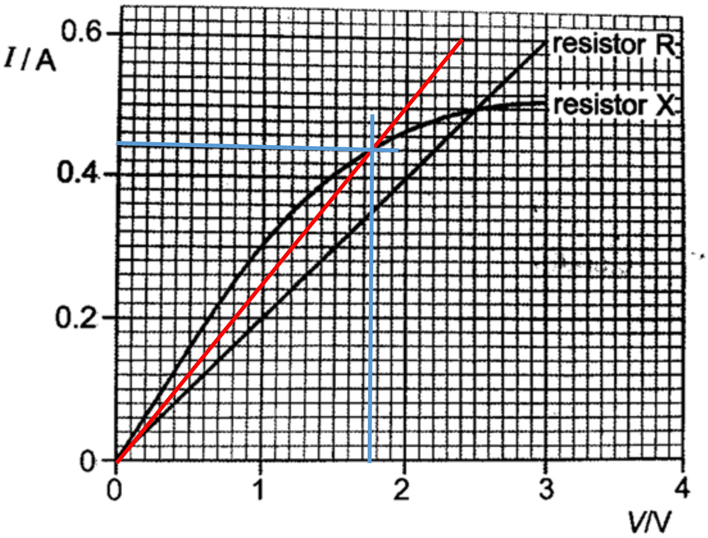
(ii) Kinetic energy graph is sinusoidal. 2 cycles shown within a period.KE is 0 at 0, T/2 and T. KE is max at T/4 and 3T/4.
Sinusoidal
2 maxima within one period and starts from zero

4(a)(i)



At I = 0.22 A, pd across X = 0.7 V while pd across R = 1.1 V.
Emf = 2*(1.1) + 0.7 = 2.9 V

4(a)(ii)
Resistance of R = 3/0.6 = 5 Ω
Resistance of X = 0.8(5) = 4 Ω



From graph, V_x = 1.75 V and I_x = 0.44A
Method 1:
Since parallel circuit, $I_R = V_x/10$ = 0.175 A
Effective resistance = 1.75/ (0.44 + 0.175) = 2.846 Ω

OR
Method 2
Effective resistance = 1/(1/4+1/10) = 2.857Ω

Applying potential divider rule, Vx/VT = Reff/RT
RT = Reff*VT/Vx = 2.857 *(2.9/1.75) = 4.734Ω
Variable resistance = RT – Reff = 4.734 – 2.857 = 1.9 Ω
(Range of 1.75-1.95 was allowed. Also ECF from previous part)

4(a)(iii)
Assuming voltmeter and ammeter are ideal, voltmeter has infinite resistance so no current will pass through resistor X. Hence, voltmeter will give a reading of the potential difference across 2 resistors R while the ammeter will show the reading of the current through R. Hence the graph for resistor X cannot be obtained.
However not the entire graph for resistor R as shown in Fig. 4.1 can be obtained since the potential difference across R can never be zero by potential divider rule.
Also since the voltmeter is placed across two identical resistors R, when the variable resistor is zero the maximum value for the potential difference across one resistor R can only be half of the value of the emf source which is 1.45 V. Hence the graph for resistor R from 1.45 V to 3V cannot be obtained.

4(b)
The drift velocity is an average not a maximum.
Since the derivation I = nevA is based on average current = total charge/total time. (Any indication that the electrons have a range of speeds/velocities

5ai Random means it is impossible to state exactly which nucleus or when a particular nucleus will disintegrate, but only the probability of decay in unit time interval for a particular radioactive isotope. [B1]

aii $\Delta N = -\lambda N \Delta t = 4.8 \times 10^{-11} \times 6.9 \times 10^{14} \times (5 \times 3.2 \times 10^{7})$
$= 5.2 \times 10^{12}$

aiii As the half life of americium is 458 years, N will not change much(remain constant) over 5 year period. N/t will remains constant over 5 years, thus this equation can be used.

OR

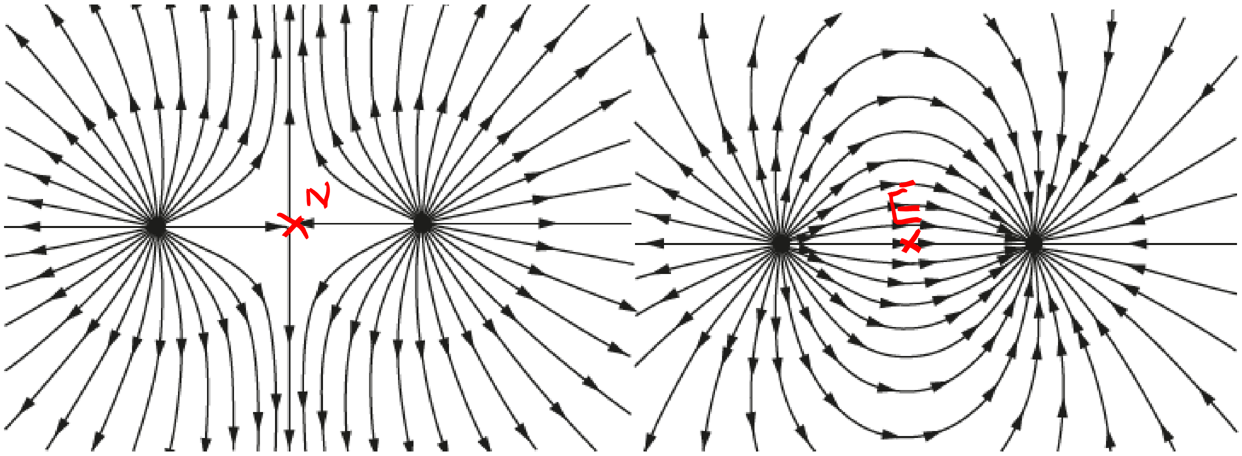
As the half life of americium is 458 years, over a few hundred years, N will decreases significant. Since activity depends on number of nuclei present, N/t will also change significantly over a few hundred years. Thus this equation cant be used.

aiv
Over the five years, dust and other particles might have build up on the surface of the detector. This will affect the detector's ability to detect the incoming alpha particles which will trigger a false alarm. Thus a replacement must be done.
OR
Alpha particles has strong ionising power. Over the 5 years, the electronic component in the detector will be affected by this high ionising power, leading to electronic failure inside the detector. Thus a replacement must be done.

b
Beta particles have lower penetration (have a shorter range or less likely to escape from the body)/ are more highly ionising than gamma photons.
The body or cells will have a larger (absorbed) dose of beta particles which will increase the risk of Cancer (or higher of mutation of cells)
ACCEPT reverse argument for gamma photons

6(a)(i) Force = qE = $1.4 \times 10^{-15} (3.0 \times 10^{3}) = 4.2 \times 10^{-12}$ N
(ii)
A couple acts on the particle since two parallel forces of equal magnitude but in opposite directions acts on the particle, i.e positive charge experience a force to the left and the negative charge experience a force to the right.
The torque of the couple causes the particle to <u>rotates</u> anti-<u>clockwise</u> to align with the field.OR
The torque of the couple causes the particle <u>oscillates about a position</u> with the <u>positive charge in the direction of electric field.</u>

(b)(i)



(ii)

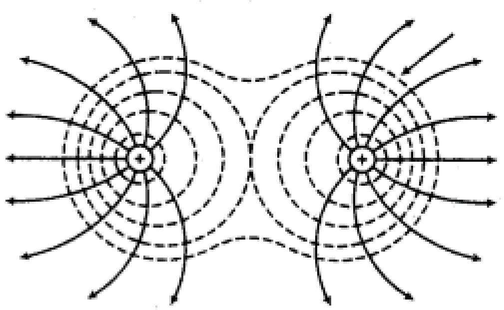
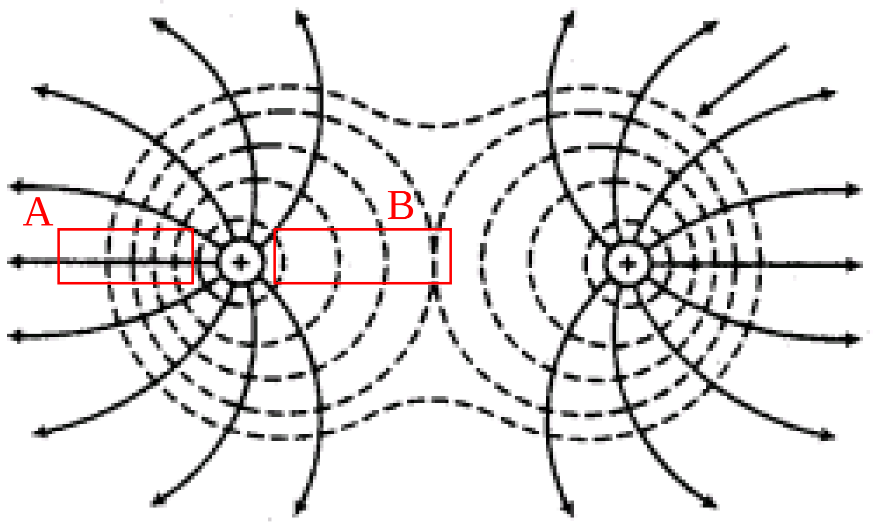


Fig 6.2: Dotted lines represent the equipotential lines.

- 3 equipotential(labelled) of roughly correct shape (lines must be perpendicularly to the field lines)
- Spacing between each line is difference.

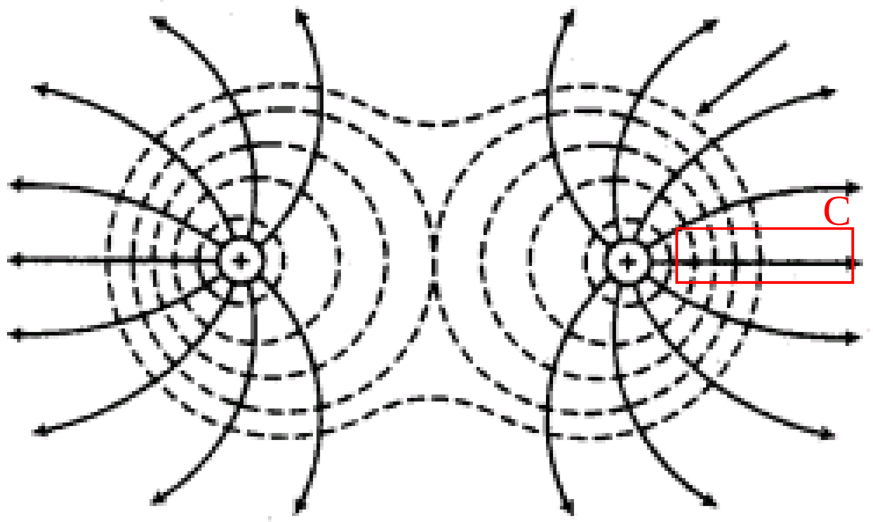
Case 1: 3 circles drawn on the same charge

See red rectangles A and B to check for spacing between each line. In rectangle A, spacing between each lines < spacing between each lines in rectangle B.



Case 2: 1 circle drawn on the same charge with 2 complete lines drawn surrounding both charges. Or
Case 3: 2 circles drawn on the same charge and 1 complete line drawn surrounding both charges. Or

See red rectangle C to check for spacing between each line. In rectangle C, spacing between each lines get wider.



6(c) Student's answer must include the following 4 points:

1) Area under E(R) electric field strength graph

- Area under E(R) field graph between 2 points gives the change in potential between the 2 points.

From E(R) graph, change in potential can be calculated using = 1 x 15sq (4 x 10^6 J per square)

= 60 MJ

From V-R graph, change in potential is from -90 MV to -30 MV.

2) Gradient of V(R) potential graph

- Electric field strength E is the negative potential gradient (OR negative gradient of V(R)) i.e $E = -dV/dR$ (MUST write in words)
- From the V-R graph, draw 1 tangent at R = 100 m. gradient (MUST show working).

Gradient = magnitude of the E-field strength = 100×10^{-4} Vm^{-1}

From E-R, ar R = 100m, the magnitude E-field strength is 100×10^{-4} Vm^{-1}

7

ai Energy of higher level – Energy of lower level = energy of photon emitted (or product of planck's constant and frequency of photon) .

aii The energy level (or orbit) of hydrogen are discrete. The energy of photon emitted is the energy difference between the two energy level which is distinct. (or a unique value). Hence, the emission line spectrum comprise of discrete lines.

7a iii 1 Electrostatic force provides the centripetal force

$$F_E = F_C$$
$$\frac{e^2}{4\pi\varepsilon_o r^2} = \frac{mv^2}{r}$$
$$\frac{me^2}{4\pi\varepsilon_o r} = m^2v^2$$
$$p = \sqrt{\frac{me^2}{4\pi\varepsilon_o r}}$$

2 P = 1.99 x 10^{-24} kg m s^{-1}, wavelength = 33 x 10^{-11} m

iv If momentum of electron in radial direction is fixed, then its uncertainty is zero. Using $\Delta\times\Delta p \geq \frac{h}{4\pi}$, $\Delta\times$ would be infinite. However the above model has a fixed radius.

bi)

$$\Delta E = E_1 - E_2$$
$$= \frac{-(13.60)(Z-1)^2}{1^2} - \frac{-(13.60)(Z-1)^2}{2^2}$$
$$= -(10.2)(Z-1)^2 \, eV$$
$$f = \frac{E_2 - E_1}{h}$$
$$= \frac{(10.2\times1.6\times10^{-19})(Z-1)^2}{(6.63\times10^{-34})}$$
$$= (2.46\times10^{15})(Z-1)^2$$

(b)(ii) 7.72

(ii)1. Plot point at coordinates (28, 7.72) to half smallest square

2. Points evenly scattered on both sides of line

(iii) Knowing *A* = gradient

Correct value of *A* (= 0.286 x 10^4)

-AB = vertical intercept = -0.281 x 10^4

Correct value of *B* (= 0.98)

(c) Calculate

$\sqrt{\frac{1}{\lambda_\times}}$ To get the impurity as Zinc.

2018 H2 Physics Prelim P3 Suggested Solution

1(a) Gravitational potential energy of an object is the energy it possesses by virtue of its position in a gravitational field while elastic potential energy is the energy that is stored when a spring is stretched or compressed.

(b)(i) Taking the child and the pogo stick as a system.

At **A**, the gravitational potential energy is at a minimum while the elastic potential energy is at a maximum, since it is at rest, kinetic energy is zero.
From **A** to **B**, the gravitational potential energy has increased while the elastic potential energy is now zero since the spring is relaxed. Kinetic energy is non-zero at this point.
From **B** to **C**, the gravitational potential energy reaches its maximum, elastic potential energy is still zero while the kinetic energy is zero since it comes to rest.

(b)(ii) By conservation of energy,

Total energy at point A = Total energy at point C

$\frac{1}{2}k{x_A}^2 = mg(x_A + x_C)$

$x_A + x_C = 1.22\ m$

$x_C = 1.02\ m$

(b)(iii) Point of maximum speed is where the system is in equilibrium, net force = 0.

Mg – kx = 0
x = 0.01635 m

By conservation of energy,
Loss in EPE = Gain in KE + Gain in GPE

$\frac{1}{2}k{x_A}^2 - \frac{1}{2}k(0.01635)^2 = Gain\ in\ KE + \ mg(x_A - 0.01635)$

Gain in KE = 252.95 J

Maximum speed = 4.50 ms^{-1}

(b)(iv) Just below B, since x = 0.01635m. At B there is only weight OR at maximum speed elastic force upwards is equal to the weight downwards.

2.

(a)

By conservation of energy, the first sphere will accelerate as it loses gravitational potential energy and gains kinetic energy achieving maximum velocity, v, at the lowest position just before it with the second sphere.

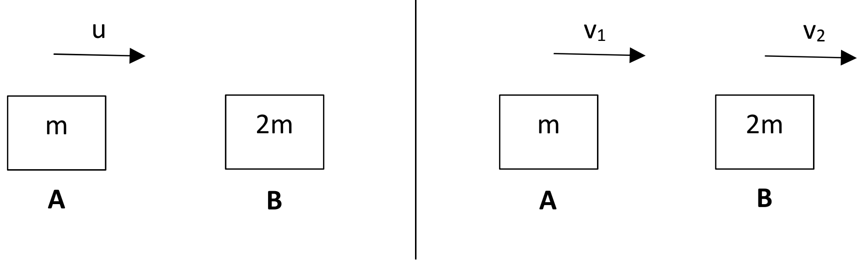
Since the spheres are identical, they have the same mass. By conservation of linear momentum, the first sphere with a velocity of v will collide with the next sphere which is at rest. After collision, the second sphere will move off with a velocity v, while the first sphere comes to rest. This continues on till the last sphere moves off with a velocity v.

Since the last sphere has the same velocity as the first sphere, it will rise to the same height as the first sphere where it was released by conservation of energy as the last sphere loses kinetic energy and gains gravitational potential energy.

The last sphere then reaches the same maximum height and comes to rest momentarily. Due to the tension of the string and weight of the sphere, the net force causes the last sphere to accelerate in the opposite direction before colliding with the neighbouring sphere. This motion then repeats itself in an oscillatory manner.

2(b)(i)

Before: After:



By PCLM,

$mu = mv_1 + 2mv_2$ --- (1)

Since collision is elastic, applying relative speed relation,

$u - 0 = v_2 - v_1$ --- (2)

Sub (2) into (1)

$m(v_2 - v_1) = mv_1 + 2mv_2$

$(v_2 - v_1) = v_1 + 2v_2$

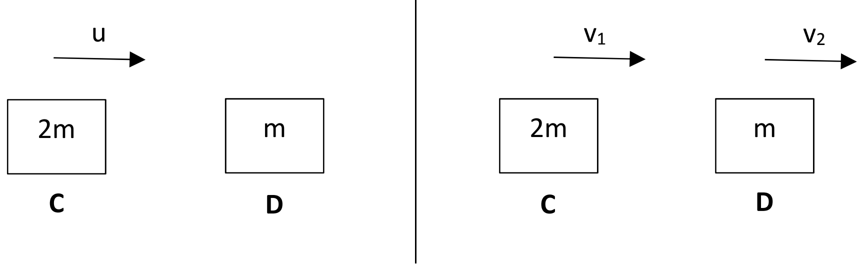
$v_2 = -2v_1$

Hence $v_1 = -\frac{u}{3}$ and $v_2 = \frac{2u}{3}$

$Ratio = \frac{2}{3}$ = 0.67

2(b)(ii)

Before: After:



By PCLM,

$2mu = 2mv_1 + mv_2$ --- (1)

Since collision is elastic, applying relative speed relation,

$u - 0 = v_2 - v_1$ --- (2)

Sub (2) into (1)

$2m(v_2 - v_1) = 2mv_1 + mv_2$

$(2v_2 - 2v_1) = 2v_1 + v_2$

$v_2 = 4v_1$

Hence $v_1 = \frac{u}{3}$ and $v_2 = \frac{4u}{3}$

$Ratio = \frac{4}{3}$ = 1.3

2(b)(iii)

Collision (i) occurs twice.

Collision (ii) occurs twice.

$$\frac{Max\ vert\ displacement\ of\ first\ sphere}{Max\ vert\ displacement\ of\ last\ sphere} = \frac{Change\ in\ GPE\ of\ first\ sphere}{Change\ in\ GPE\ of\ last\ sphere}$$

By CoE, since the ball comes to rest at max GPE,

$$\frac{Change\ in\ GPE\ of\ first\ sphere}{Change\ in\ GPE\ of\ last\ sphere} = \frac{Max\ KE\ of\ first\ sphere}{Max\ KE\ of\ last\ sphere} = \frac{0.5\ mv_i^2}{0.5\ mv_f^2}$$

Hence

$$\frac{Max\ vert\ displacement\ of\ first\ sphere}{Max\ vert\ displacement\ of\ last\ sphere} = \frac{v_i^2}{v_f^2} = \frac{u^2}{(\left(\frac{2}{3}\right)\left(\frac{4}{3}\right)\left(\frac{2}{3}\right)\left(\frac{4}{3}\right)u)^2}$$

Ratio = 1.60

2(c)

The tension of the spring for all the spheres except for the first sphere is equal to the weight of the sphere since net force = 0. The first sphere will have a greater tension since it undergoes centripetal acceleration, T = mg + mv^2/r. Hence extension for the first sphere is greater than that of the rest.

The first sphere and the second sphere no longer collide head-on.

3

(a)(i) Faulty Lamp: Lamp C
Nature of fault: Lamp is shorted(or short circuit).

(ii) Using a power supply might short Lamp A, high current pass through the circuit and would damage the power supply/lamps/blow fuse in supply.

(iii) 15 Ω

(b)(i) Potential difference across wire is V= IR where R is $\rho\frac{L}{A}$ where I is current in wire, R is resistance of wire, ρ is resistivity of wire, L is length of wire and A is cross-sectional area of wire. Since I, ρ and A are constant, therefore V is directly proportional to length of wire.

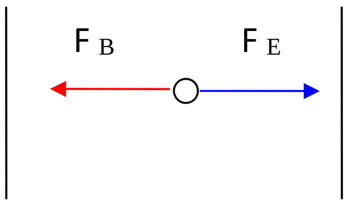
(ii) Potential across thermistor = pd across QM
= 1800/3000 (4.5) = 2.7 V

$\frac{L}{100} = \frac{2.7}{4.5}$

L = 60.0 cm

3(b)(ii) As temperature rises, thermistor resistance decreases. Pd across QM will be smaller, thus QM is shorter.

4.(a) (i)



(ii) The alpha particle would be deflected to the **right** along a **parabolic path.**

As the speed of the particle is less than v, the **magnetic force experienced is less than the electric force.** Hence the particles experience **a constant acceleration to the right.**

(b) Stage 2

By Newton's 2nd law, the magnetic force provides the centripetal force for electron to undergo circular motion

$Bqv = mv^2/r$

➔ $r = mv/Bq$ ------ (1)

$= (4 \times 1.67 \times 10^{-27} \times 1.00 \times 10^5) / (0.050 \times 2 \times 1.6 \times 10^{-19})$

$= 4.175 \times 10^{-2}$ m

Point of impact = $2r = 2 \times 4.175 \times 10^{-2}$ m $= 8.35 \times 10^{-2}$ m

(c) Stage 1:

As the Beta particle velocity is 100 times faster, The magnetic force is now 100 times stronger than the electric force. Hence, an electric field strength 100 times the original one must be applied for it to remain undeflected.

For alpha particle,

$F_E = F_B$

$qE = Bqv$

$v = E/B$

Since beta particles travels 100 times faster,

$F_B' = B(2q)(100v)$

$F_E' = (2q) E'$

For Beta particle to remainl undeflected,

$F_B' = F_E'$

E' = 100Bv = 100 E

Stage 2:

- While the speed of beta particles is 100 times faster, its mass is more than 1000 times smaller than alpha particle. Hence the position of photographic plate needs to be placed much closer to the entrance since the point of impact is much smaller now.
- Beta particle is negatively charge, the point of impact is on the right side of the entrance. Thus the position of the plate must be placed at the right side of the entrance instead of the left side.

From (1),

Radius of He particle, r = *mv/Bq*

Radius for Beta particles, r' = $m_e v_e / B2q$

$$= \frac{\frac{1}{1833} m\,(100v)}{2} B$$

$$= 0.0266 \frac{mv}{Bq} = 0.0266\ r$$

5

(a)(i) It means direction of force on a (small test) mass/ direction of acceleration of a (small test) mass.

(ii) It is because field lines are radial. The lines near the surface are (approximately) parallel. With parallel lines, the field strength is constant, thus constant acceleration of free fall.

(b)(i) GPE at infinity is maximum at 0J and KE is minimum at 0J.
By conservation of energy,

Gain in GPE from surface to infinity = Lost in KE from surface to infinity

$\frac{GMm}{r}$ =1/2 mv^2 where mass is the mass of one gas molecule

$v = \sqrt{\frac{2GM}{r}}$ (shown)

(ii) The escape velocity, $v = (2 \times 6.67 \times 10^{-11} \times 0.131 \times 10^{23} / (1.19 \times 10^{6}))^{1/2}$

$= 1212 = 1200\ ms^{-1}$

(iii) Mercury has a higher escape velocity than Pluto which is 4248 ms^{-1}.

Mercury is closer to sun and Mercury is hotter.

Molecules on Mercury have speed higher than the escape speed, thus they are fast enough to escape from Mercury. Mercury has no atmosphere.

6

(a) By conservation of energy,

Thermal Energy gained by ice = Thermal energy lost by water

$0.024(2.1 \times 10^3)(15) + 0.024(330 \times 10^3) = 0.20(4.2 \times 10^3)(28-T)$

T = 17.7 ◦C

(b)(i) PV/T = constant

$T = (6.5\text{x}10^6\text{x}30\text{x}300)/(1.1\text{x}10^5\text{x}540)$

= 985 K

(ii) $\Delta U = Q + W$

Since Q =0, gas compress, W is positive. Thus ΔU must increases.
ΔU increases, kinetic energy of the atoms also increases.
KE of atoms is proportional to thermodynamic temperature, i.e KE =3/2kT
KE increase, thus temperature must increase.

6(c)

	U	*q*	*w*
the compression of an ideal gas at constant temperature	0	-	+
the heating of a solid with no expansion	+	+	0
The melting ice at 0 ◦C to give water at 0 ◦C. (Note: ice is less dense than water)	+	+	+

7(a)(i) When the wavelength of the wave is comparable to slit width, diffraction is most significant.

(ii) Low-pitched notes have longer wavelengths that's more comparable to the width of door gap and undergo more diffraction through the door.

(b)(i) Distance *D* must be much longer than distance two adjacent slits of the grating

(ii) Slit separation, $d = 1/p$

path difference $x = d \sin\theta = 1/p \sin\theta$

(iii) Hence Constructive interference occurs when

$$1/p \ \sin\theta = n\ \lambda \text{ where } n = 0,\ 1,\ 2, \ldots\ldots$$

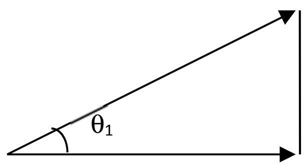
Where n is the order of the spectrum and θ is the angle of diffraction between the diffracted ray and the direction of incident light.

c (i) angular speed of grating, $\omega = 2\pi / T = 2\pi / 3 = 2.09 = 2.1\ \text{rad.s}^{-1}$

(ii) Peak C corresponds to the zeroth order of the interference pattern whereas peaks B and D the first order and Peaks A and E the second order.
The height of each peak is due to diffraction effect.

(iii)

Hence, time to shift from zeroth order to the first order through 1.7 cm on the screen is 1.7 x 0.1 = 0.17s



θ_1 = (2 π / 3) 0.17 rad = 0,355 rad = 0.36 rad

Similarly time from the zeroth order to 2nd order = 3.7 x 0.1 = 0.37 s

θ = (2 π / 3) 0.37 rad = 0.773 rad = 0.77 rad.

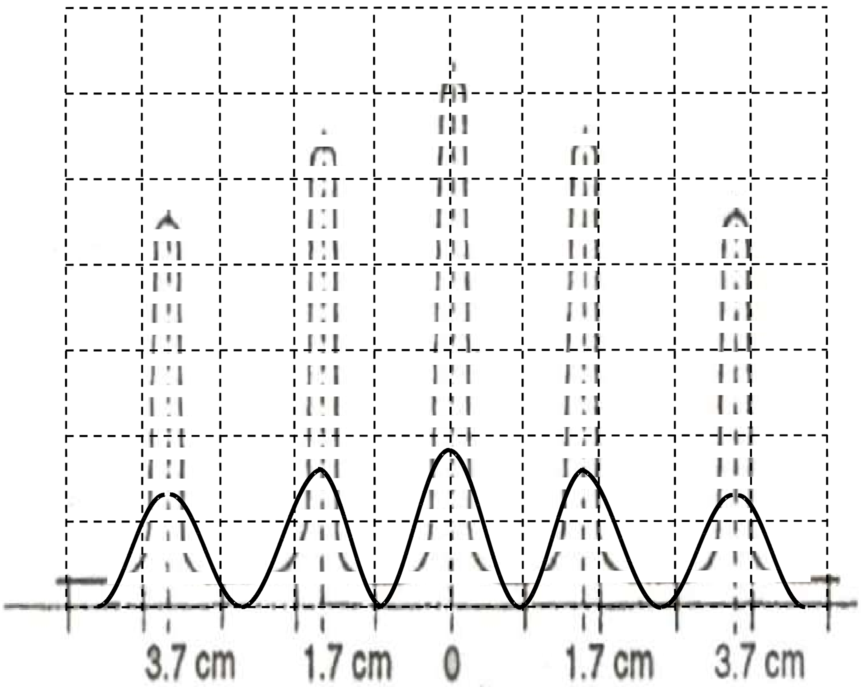
(iv) Using the grating equation

$\sin \theta_2 = 2 \times 5.5 \times 10^5 \times \lambda$

λ = 636 nm

(v) Peak E is preferred as the angle θ is larger and the percentage error for calculating the wavelength is smaller.

(vi) Since the slit separation remain the same, the fringe separation remains the same. However, the peaks are less intense (poorer contrast) and less sharp (broader and less defined).



8 (a) (i) most alphas have small deflection
so nucleus is small target
(ii) deflection too large to be gravitational
so must be electrostatic i.e. charged

(b) (i) 1. from the graph, Q = 1.2 MeV

2. $v = \sqrt{(E/(\frac{1}{2} m_e)}$
$= 6.5 \times 10^8\ ms^{-1}$

3. The calculated value of v is more than c, the speed of light.
(This suggests that the classical formula for kinetic energy ½ mv^2, is not valid in calculating the speed of the beta particle.)

(ii) $m(Po) = m(Bi) – m_e – Q/c^2$
$= [(209.939u) – (9.11 \times 10^{-31}/1.66 \times 10^{-27}) – (1.2x10^6x1.60x10^{-19}/c^2)]/(1.66 \times 10^{-27}\ kg)$
$= 209.937$ u

(iii) Range of values accepted : 0.16 - 0.18 MeV

(iv) Since ^{210}Bi undergoes spontaneous beta decay, a process in which it increases its proton number by one
while decreasing its neutron number by one, it suggests that ^{210}Bi must have an excess of neutrons as compared to the optimal ratio.

(v) For a stationary nucleus decaying into the beta particle and daughter nucleus, the conservation of linear momentum requires that $\underline{p_1} = -\underline{p_2}$.
The sum of kinetic energies will thus be $(p_1)^2/2m_1 + (p_2)^2/2m_2 = E$, which ought to equal the energy released in the reaction, which, if equal to the increase in the total binding energy/decrease in total mass, ought to be constant.

The range of beta particle energies and thus the supposed energy released E, seem to suggest that the energy released was not constant, in contradiction to the principle of conservation of energy.

(vi)
- Energy was not conserved in a beta decay**.** (proven false)
- **The existence of another undetected particle.**
- (The actual reason. The undetected particle was the neutrino, and a 3 body interaction allowed for the beta particle to carry away a varying amount of KE whilst still ensuring COE)

(b) (i) random nature of emissions
(ii) e.g. self-absorption, detector not 100% efficient,
detector not surrounding source

ci
$R = R_o e^{-\lambda t}$ so $8.3 \times 10^3 = 7.6x10^8 xe^{-4.6x10-3t}$ t = 2480 s

ii Using inverse square law, answer is 26 counts per minute.

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

PHYSICS 9749/01

Paper 1 Multiple Choice **25 September 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and tutor's name on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **13** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1} $(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + ½at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm / r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{\left(x_o^{\ 2} - x^2\right)}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \dots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \dots$
electric potential	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\mu_o I / 2\pi d$
magnetic flux density due to a flat circular coil	B	=	$\mu_o NI / 2r$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

1 Which of the following statements is not always true?

A The total mass of two 1 kg masses is 2 kg.

B The total charge of a +1 C charge and a –1 C charge is zero.

C The resultant of two 1 N forces is 2 N.

D The total energy of 1 J of kinetic energy and 1 J of potential energy is 2 J.

2 The following are the results obtained by two students P and Q in the determination of the mass of an object.

Student P	1.05 kg	0.96 kg	1.01 kg	0.97 kg
Student Q	1.08 kg	1.07 kg	1.08 kg	1.06 kg

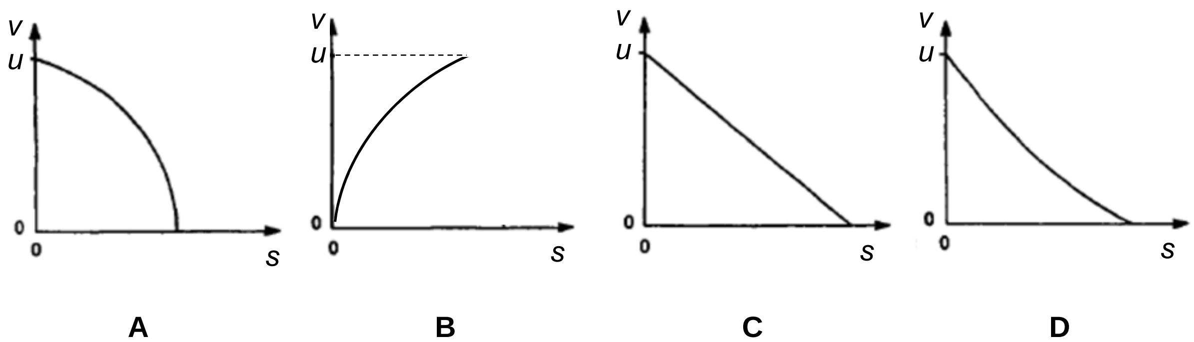
Which of the following most appropriately describes the results obtained by students P and Q?

	more accurate	more precise
A	Q	*cannot be determined*
B	P	Q
C	Q	P
D	*cannot be determined*	Q

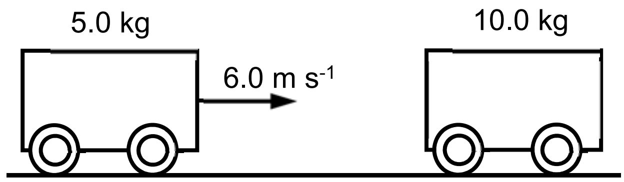
3 A train initially at rest accelerates at a constant rate of 1.4 m s^{-2} for 10 s and then slows down at a constant rate of 0.20 m s^{-2} until it comes to a rest. The total distance travelled by the train is

A 80 m **B** 220 m **C** 560 m **D** 1120 m

4 A falling stone strikes some soft ground at speed u and suffers a constant deceleration until it stops. Which one of the following graphs best represents the variation of the stone's speed, v, with distance, s, measured downwards, from the surface of the ground?



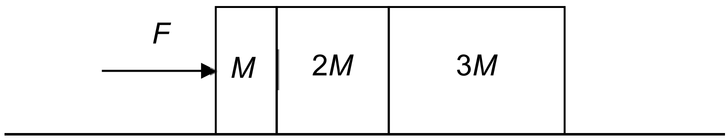
5 A trolley of mass 5.0 kg travelling at a speed of 6.0 m s^{-1} collides head-on and locks together with another trolley of mass 10.0 kg which is initially at rest. The collision lasts for 0.20 s.



What is the total kinetic energy of the two trolleys after the collision and the average force acting on each trolley during this collision?

	Total kinetic energy after the collision / J	Average force on each trolley / N
A	30	150
B	75	150
C	30	100
D	75	100

6 Three blocks with masses *M,* 2*M* and 3*M* are pushed along a rough surface by a horizontal force *F* as shown.



The frictional force between a block and the rough surface is directly proportional to the weight of the block. Given that the frictional force between the block with mass *M* and the rough surface is *f,* what is the magnitude of the force mass 3*M* exerts on mass 2*M*?

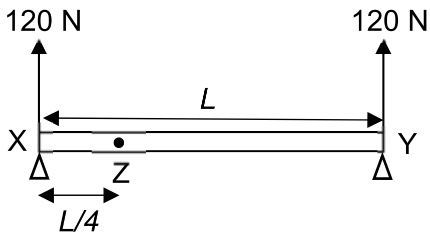
A $\frac{F}{2}$

B $\frac{F}{2} + 3f$

C $\frac{F}{3} + f$

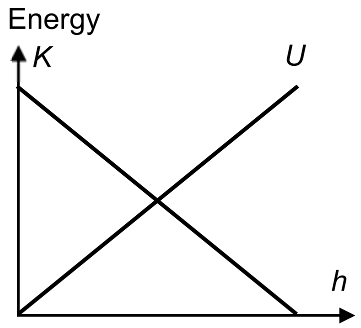
D $\frac{F}{3} + 3f$

7 A uniform plank of length L is supported by initially equal forces of 120 N at X and Y. If the force at X is now moved to Z such that the plank is kept horizontal, what is the magnitude of the force at Y?

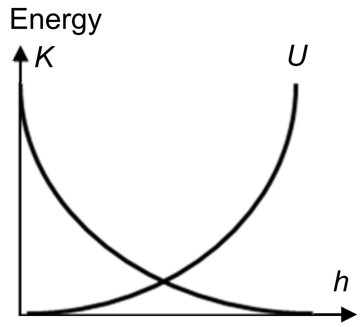


A 60 N **B** 80 N **C** 120 N **D** 160 N

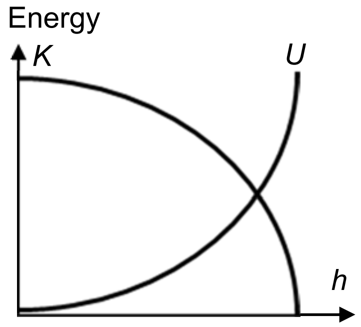
8 A ball is projected vertically upwards. At a height h, the kinetic energy of the ball is K and its potential energy is U. Taking air resistance to be negligible, which graph correctly shows the variations of K and U with h?



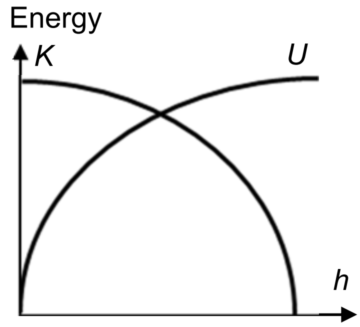
A



B



C

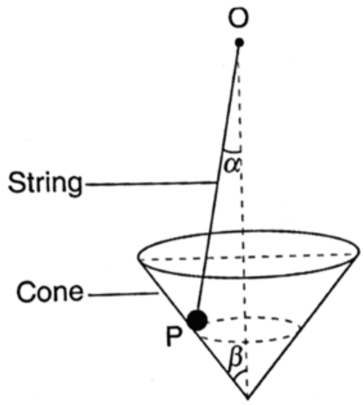


D

9 The engine of a car has maximum output power of 54 kW. The air resistance acting on the car when it is moving with speed v is cv^2, where c is 2.0 kg m^{-1}. What is the maximum speed that can be achieved by the car on level road?

A 3.0 m s^{-1} **B** 5.0 m s^{-1} **C** 30 m s^{-1} **D** 160 m s^{-1}

10 A pendulum bob at the end of the string which is fixed at O moves in a horizontal circle on the inside of a cone as shown.



If the tension in the string is T and the normal contact force by the cone is R, which of the following gives the centripetal force on the bob?

A $T \sin \alpha + R \cos \beta$

B $T \sin \alpha - R \cos \beta$

C $T \cos \alpha + R \sin \beta$

D $T \cos \alpha - R \sin \beta$

11 Two satellites X and Y are orbiting at heights of $5R$ and $9R$ above the surface of the Earth respectively, where R is the radius of the Earth.

What is the ratio of their orbital speeds v_X/v_Y ?

A 1.29 **B** 1.34 **C** 1.67 **D** 1.80

12 The gravitational potentials on the surface of a planet P and on the surface of its moon Q are –120 MJ kg^{-1} and –20 MJ kg^{-1} respectively.

The minimum amount of energy required to project a 1 kg mass from the surface of Q to the surface of P is E.

Which of the following correctly describes the value of E?

A E < 20 MJ

B E = 20 MJ

C 20 MJ < E < 100 MJ

D 100 MJ < E < 120 MJ

13 Which of the statements about damped oscillations is not true?

A The period of the oscillation increases with time.

B The amplitude of the oscillation decreases with time.

C The energy of the oscillation decreases with time.

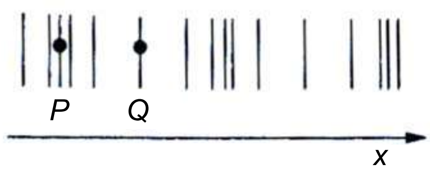
D The frequency of the oscillation is lower compared to that of an undamped oscillation.

14 In a heating experiment, energy is supplied at a constant rate to a liquid in a beaker of negligible heat capacity. The temperature of the liquid rises by 4.0 K per minute just before it begins to boil. After 40 minutes, all the liquid has boiled away.

For this liquid, what is the ratio $\dfrac{\text{specific heat capacity}}{\text{specific latent heat of vapourisation}}$?

A $\dfrac{1}{10}\ \text{K}^{-1}$ **B** $\dfrac{1}{40}\ \text{K}^{-1}$ **C** $\dfrac{1}{160}\ \text{K}^{-1}$ **D** $\dfrac{1}{640}\ \text{K}^{-1}$

15 The compressions and rarefactions of a sound wave travelling in air in the positive *x*-direction are shown below.



Which statement is true about the diagram?

A At *P*, the air pressure is minimum.

B At *Q*, it is a position of antinode.

C At *Q*, the air molecule is momentarily at rest.

D At *P*, the air molecule is moving in the positive *x*-direction.

16 The two lowest frequencies at which an open narrow tube resonates are 256 Hz and 512 Hz. If one of the ends is closed, what are the two lowest frequencies at which it would now resonate?

A 128 Hz and 256 Hz

B 128 Hz and 384 Hz

C 384 Hz and 640 Hz

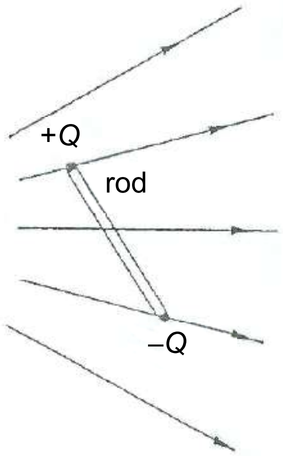
D 768 Hz and 1536 Hz

17 A beam of light that consists of all wavelengths between 480 nm and 600 nm is projected on a diffraction grating that contains 500 lines per millimeter.

What is the maximum number of complete continuous spectra that can be observed emerging from the grating?

A 6 **B** 7 **C** 8 **D** 9

18 An insulated rod with equal and opposite charges at its ends is placed in a non-uniform electric field with field lines as shown below.



The rod experiences

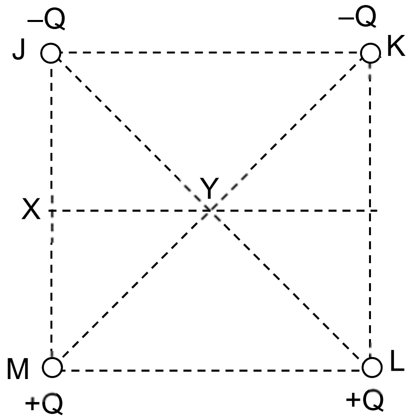
A a resultant force in the plane of the paper and a torque.

B a resultant force in the plane of the paper but no torque.

C a resultant force normal to the plane of the paper and a torque.

D a resultant force normal to the plane of the paper but no torque.

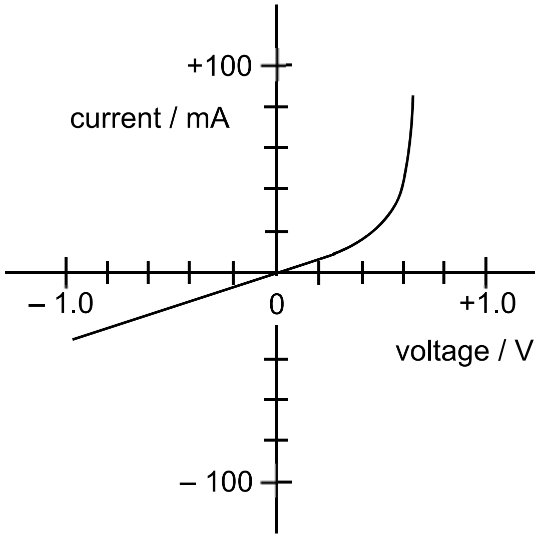
19 Four point charges are at the corners of a square JKLM. The point charges at J and K have a charge of $-Q$ and the point charges at L and M have a charge of $+Q$.



An electron is brought from point X to point Y in a straight line by an external force without any change in its speed. Which of the following is correct about the change in electric potential energy of the system and work done by the external force?

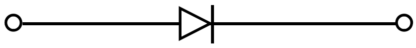
	change in electric potential energy	work done by the external force
A	positive	positive
B	negative	negative
C	negative	positive
D	zero	zero

20 A student is given a sealed box containing a concealed electrical circuit. The student plots the current-voltage characteristics below.

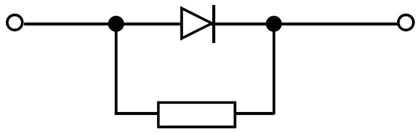


Which circuit is most likely to be enclosed within the box?

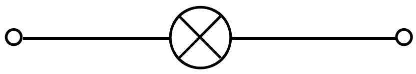
A



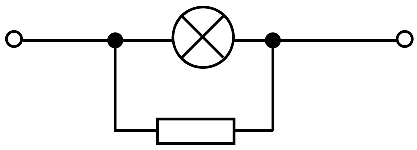
B



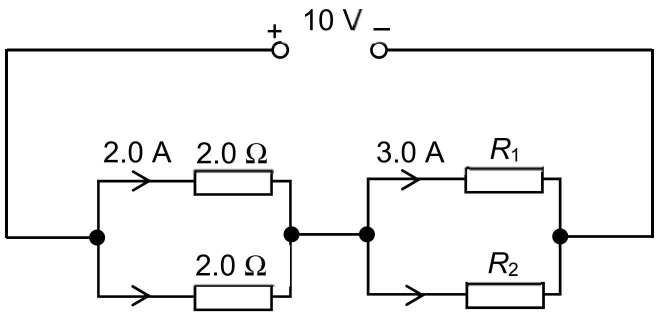
C



D



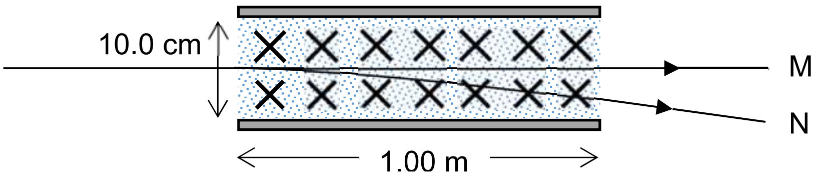
21 Four resistors are connected across a 10 V supply as shown in the circuit below.



What are the resistances R_1 and R_2?

	R_1	R_2
A	1.0 Ω	3.0 Ω
B	2.0 Ω	2.0 Ω
C	2.0 Ω	6.0 Ω
D	3.0 Ω	3.0 Ω

22 In the region of dimensions 10.0 cm by 1.00 m between two charged plates with a p.d. of 100 V, there is a uniform magnetic field of strength 100 mT directed into the page.



M and N are the paths made by electrons of different speeds.

Which of the following correctly describes the speed of the electron that made N?

A slightly smaller than 1.00×10^4 m s^{-1}

B slightly greater than 1.00×10^4 m s^{-1}

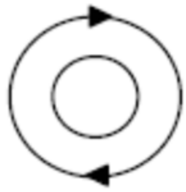
C slightly smaller than 1.00×10^5 m s^{-1}

D slightly greater than 1.00×10^5 m s^{-1}

23 A circular loop of wire with radius of 0.20 m is placed in a uniform magnetic field of 1.2 T that is normal to the plane of the loop. The loop is rotated about an axis along a diameter at a rate of 50 revolutions per minute. What is the maximum instantaneous e.m.f. induced?

A 0.13 V **B** 0.15 V **C** 0.79 V **D** 47 V

24 A small circular coil lies inside a large coil. The two coils are horizontal and concentric. The large coil carries a constant clockwise current.



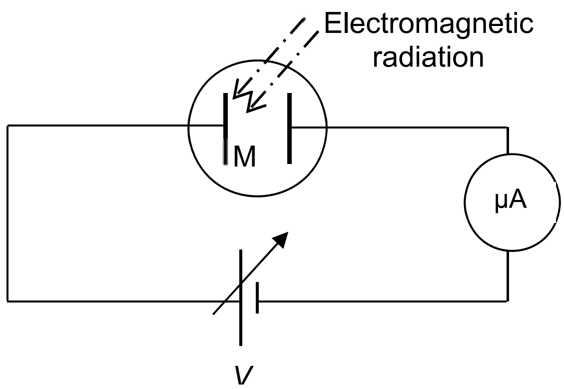
The smaller coil is pulled perpendicular out of the plane of the paper. Which of the following describes the direction of the induced current in the smaller coil and the resultant force between the coils?

	Induced current	Force between coils
A	Clockwise	Attraction
B	Clockwise	Repulsion
C	Anticlockwise	Attraction
D	Anticlockwise	Repulsion

25 An alternating voltage of 230 kV is supplied to a transformer, which steps the voltage down to a number of streetlamps with a rating of 230 V 150 W. If the maximum allowable current through the primary coil is 10 A, what is the maximum number of streetlamps that can be connected in parallel?

A 1500 **B** 6500 **C** 10000 **D** 15000

26 A 0.31 mW beam of photons with energy 3.11 eV each is incident on a clean metal plate M. The potential difference *V* is varied until the microammeter gives a maximum reading of 2.0 μA.



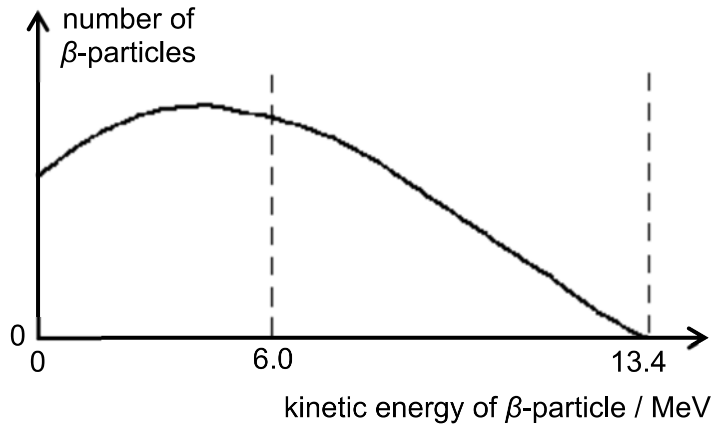
What is the ratio $\dfrac{\text{electrons emitted per unit time}}{\text{photons incident per unit time}}$?

A 3.2×10^{-21} **B** 2.0×10^{-2} **C** 1.0 **D** 1.3×10^{17}

27 What is the de Broglie wavelength of an alpha particle of kinetic energy E, given that u is the unified atomic mass unit?

A $\dfrac{h}{2\sqrt{uE}}$ **B** $\dfrac{2\sqrt{uE}}{h}$ **C** $\dfrac{h}{2\sqrt{2uE}}$ **D** $\dfrac{2\sqrt{2uE}}{h}$

28 The beta spectrum for ^{12}B decay is as shown below.



The kinetic energy of an emitted β-particle is 6.0 MeV. What is the approximate energy of the associated neutrino?

A 4.0 MeV **B** 6.0 MeV **C** 7.4 MeV **D** 13.4 MeV

29 Two radioactive isotopes P and Q have half-lives of 10 minutes and 15 minutes respectively. A sample initially contains the same number of atoms of each isotope. After 30 minutes, the ratio of the number of atoms of P to the number of atoms of Q will be

A 0.25 **B** 0.50 **C** 1.0 **D** 2.0

30 At time t, a sample of a radioactive substance contains N atoms of a particular nuclide.

At time $(t + \Delta t)$, where Δt is a short period of time, the number of atoms of the nuclide is $(N - \Delta N)$.

Which of the following expressions gives the decay constant of the nuclide?

A $\dfrac{\Delta N}{N}$ **B** $\dfrac{N - \Delta N}{t + \Delta t}$ **C** $\dfrac{\Delta N}{N\Delta t}$ **D** $\dfrac{N\Delta N}{\Delta t}$

End of Paper

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

CENTRE NUMBER S

INDEX NUMBER

PHYSICS 9749/02

Structured Questions

12 September 2018

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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1	/ 8
2	/ 6
3	/ 8
4	/ 6
5	/ 9
6	/ 8
7	/ 8
8	/ 8
9	/ 19
Total	/ 80

This document consists of **19** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm / r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o^{\ 2} - x^2)}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\mu_o I / 2\pi d$
magnetic flux density due to a flat circular coil	B	=	$\mu_o NI / 2r$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

For Examiner's Use

1 In 2018, the Singapore government announced that personal mobility devices (PMDs) such as e-scooters used on public paths must not have a device speed exceeding 25 km h^{-1} or weigh more than 20 kg.

(a) Suggest why there is a need to set a speed limit and weight limit on PMDs.

…………………………………………………………………………………………………...

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……...…………………………………………………………………………………….. [2]

(b) Given that a typical e-scooter with rider has a total mass of 100 kg and that the time of impact is 0.20 s, determine the average force this scooter could cause. Assume that the e-scooter comes to rest after impact.

average force = ……………………. N [2]

(c) Other than the speed and weight of PMDs, state and explain one other factor that can contribute to the magnitude of the force of impact caused in an accident involving PMDs.

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……...…………………………………………………………………………………….. [2]

(d) It is suggested that an infra-red sensor can be fixed at the front end of a PMD such that once an obstacle is detected within 30 cm, the PMD will decelerate to a stop. By reference to the maximum allowable speed of 25 km h^{-1}, explain whether this is feasible.

…………………………………………………………………………………………………...

……...…………………………………………………………………………………….. [2]

For Examiner's Use

2 A grenade is launched at ground level with velocity of 75 m s^{-1} and angle 20^0 from the horizontal to hit a sniper on top of a 30 m tall building at a position 245 m from the foot of the building. The sniper is standing at a distance *x* from the edge of the building.

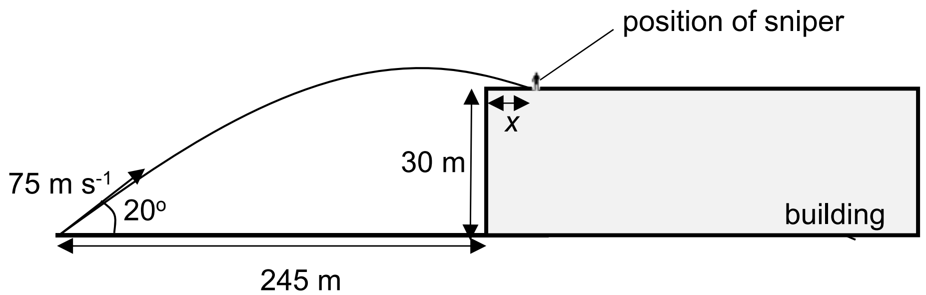


Fig. 2.1

(a) Show that the time for the grenade to reach the sniper is 3.5 s.

[1]

(b) Calculate the speed of the grenade just before impact.

speed = …………………… m s^{-1} [2]

(c) Determine the distance, *x*, of the sniper from the edge of the building.

x = …………………… m [2]

(d) The sniper runs away immediately from the edge of the building when the grenade is launched. Given that the grenade has a 'kill radius' of 10 m, calculate the minimum constant acceleration at which the sniper should run in order to escape.

minimum acceleration = …………………… m s^{-2} [1]

For Examiner's Use

3 A peg is fixed to the rim of a vertical turntable of radius r, rotating with a constant angular speed ω, as shown below.

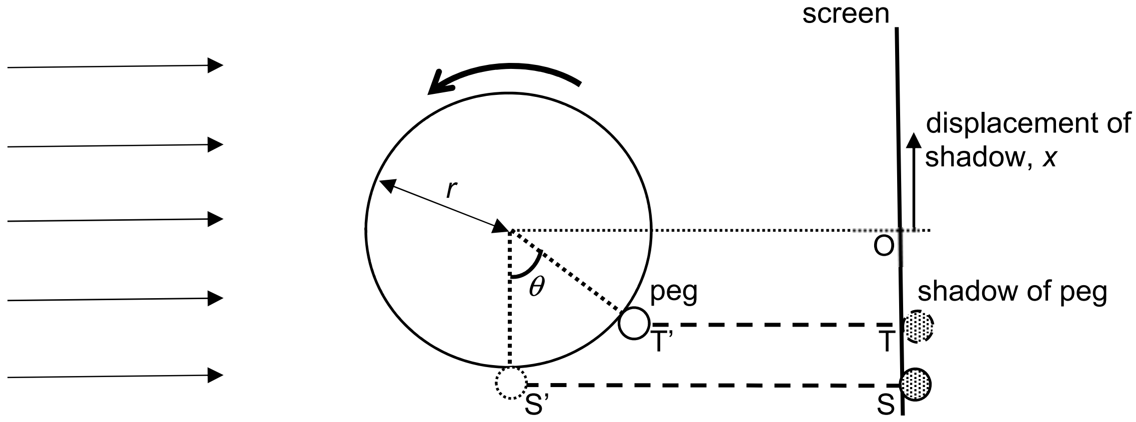


Fig. 3.1

A parallel beam of light is incident on the turntable such that the shadow of the peg is observed on the screen. Initially, the peg is at position S' and its shadow is at S. After time t, the peg moves through an angle of θ and it is positioned at T' while its shadow is at T. The displacement of the shadow, x, from O is shown in Fig. 3.1 where the upward direction is taken to be positive.

(a) **(i)** Express the angular displacement of the peg, θ, in terms of ω and t.

[1]

(ii) Write down an expression for the displacement, x, of the shadow on the screen in terms of ω, t and r .

[1]

(iii) Hence, prove that the shadow of the peg is moving in simple harmonic motion. Explain your working.

[2]

(b) The turntable has a radius of 20.0 cm and angular speed of 3.5 rad s^{-1}. For the motion of the shadow on the screen,

(i) calculate the acceleration of the shadow when the shadow is instantaneously at rest,

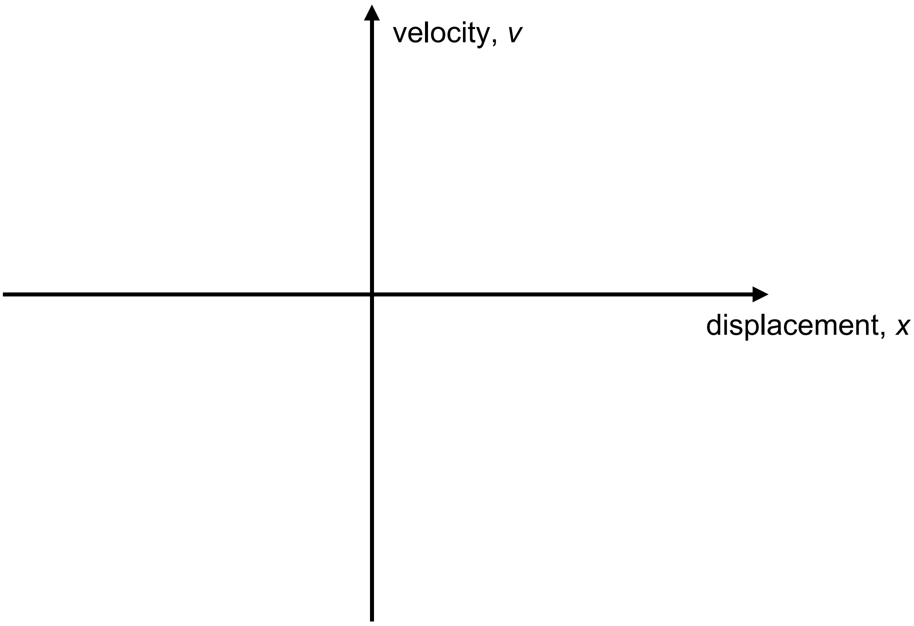
acceleration = …………………… m s^{-2} [1]

For Examiner's Use

(ii) determine the velocity of the shadow as it passes through S,

velocity = …………………… m s^{-1} [1]

(iii) sketch the variation of the velocity, *v*, of the shadow with its displacement, *x*.



[2]

4 **(a)** Explain what is meant by *polarised* light.

……………………………………………………………………………………………………..

……...……………………………………………………………………………………. [1]

(b) Explain why two coherent sources of light that are polarised in planes perpendicular to each other will not produce interference fringes.

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……...……………………………………………………………………………………. [1]

(c) Fig. 4.1 shows the setup for a Young's double slit experiment. The polarisers are initially aligned such that the light from the slits are polarised in parallel planes. The slit separation of the double slit is 0.10 mm, the distance between the double slit and the screen is 1.50 m and the separation of the fringes produced is 0.90 cm.

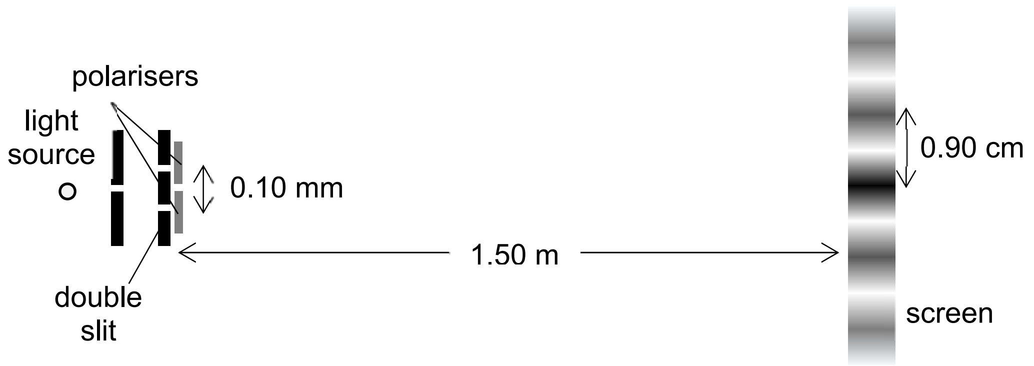

Fig. 4.1

(i) Calculate the wavelength of the light source.

wavelength = …………………… m [2]

(ii) One of the polarisers is rotated by an angle of 45° about an axis parallel to the incident light. Describe the appearance of the fringes with reference to its original appearance.

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…...…………………………………………………………………………………….. [2]

For Examiner's Use

5 A stationary copper-64 nucleus undergoes a nuclear reaction to form a zinc-64 nucleus and a beta-particle. After the reaction, the zinc-64 nucleus moves off with negligible speed, while the beta-particle moves off with high speed.

(a) Explain qualitatively why the beta-particle moves off with a much higher speed than the zinc-64 nucleus.

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....

.... [2]

(b) The kinetic energy E_K and the distance r of the beta-particle from the centre of nucleus of zinc-64 nucleus' centre are monitored. Fig. 5.2 shows how the values of E_K varies with $\frac{1}{r}$.

Assume that the beta-particle and zinc-64 nucleus form an isolated system.

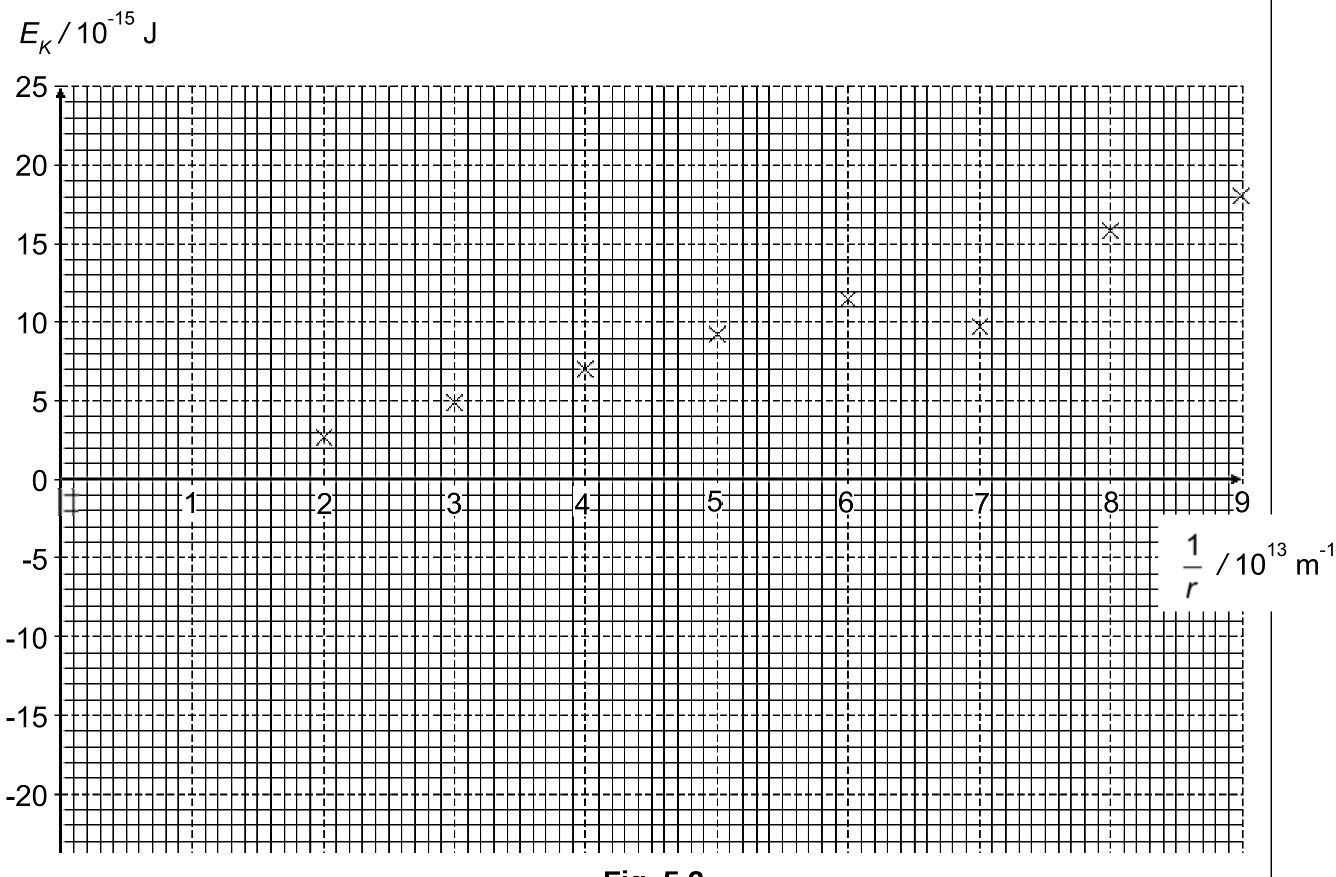


Fig. 5.2

(i) By drawing an appropriate line on Fig. 5.2, determine the y-intercept, E_o, of the graph.

vertical intercept, E_o = ... J [2]

For Examiner's Use

(ii) Explain the physical significance of the value of E_o found in **(b)(i)**.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

…...…………………………………………………………………………………….. [2]

(iii) Assuming that total energy of the beta-particle remains constant during its motion, sketch labelled graphs on the axes in Fig. 5.2 to represent

1. the variation of the total energy E_T .

2. the variation of the electric potential energy E_P. [3]

6 Fig. 6.1 shows a circuit consisting of two resistors connected in series to a d.c. supply.

For Examiner's Use

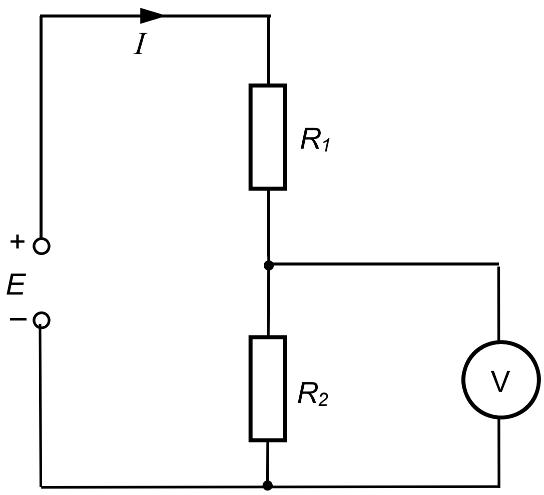


Fig. 6.1

The resistors have resistances R_1 and R_2. The supply has e.m.f. E and negligible internal resistance. The current from the supply is I. The voltmeter has an infinite resistance.

(a) By reference to Ohm's Law, show that the voltmeter reading V is given by the relation

$$V = \left(\frac{R_2}{R_1 + R_2}\right)E.$$

[2]

(b) Fig. 6.2 shows a circuit that includes a thermistor.

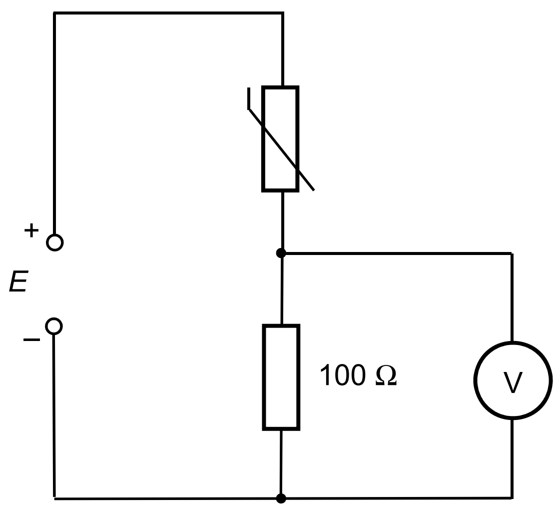


Fig. 6.2

For Examiner's Use

Describe and explain how the voltmeter reading changes as the temperature of the thermistor is increased.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

……...……………………………………………………………………………………….. [2]

(c) Fig. 6.3 shows a circuit that includes a potentiometer wire. It is used to test E_T, the e.m.f. of the test cell and the balance length is found to be *b*.

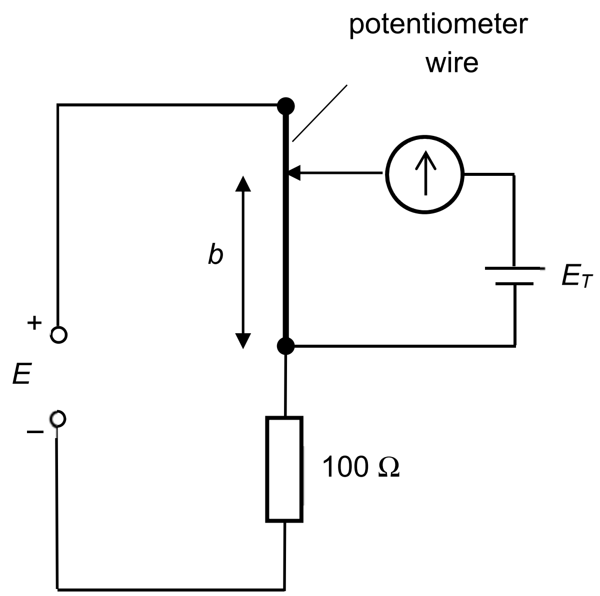


Fig. 6.3

(i) The potentiometer wire, of 1.00 m long, is made of nichrome wire of resistivity 1.57×10^{-6} Ω m and has a uniform radius of 0.10 mm. Determine the resistance of the potentiometer wire.

resistance = ……………………… Ω [2]

(ii) Given that the ratio of $\frac{E_T}{E} = 0.20$, determine the balance length *b*.

b = ……………………… m [2]

7 **(a)** Define *magnetic flux density*.

………………………………………………………………………………………………………

……..………………………………………………………………………………………….. [1]

(b) A 1.0 m long wire carrying a current of 2.0 A is placed in a magnetic field. When it is aligned with XX' as shown in Fig. 7.1A, it experiences a force of 0.50 N that is directed into the page. When it is aligned with YY' as shown in Fig. 7.1B, it experiences a force of 0.80 N that is directed out of the page.

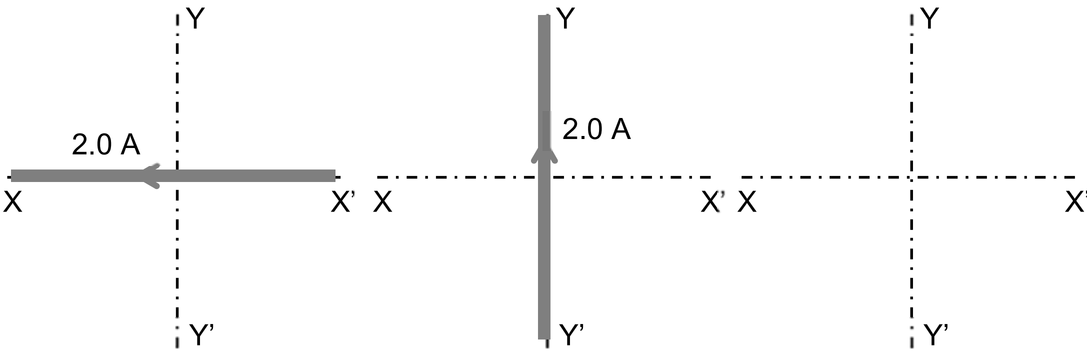


Fig. 7.1A **Fig. 7.1B** **Fig. 7.1C**

(i) Calculate the magnetic flux density of the field present.

magnetic flux density = …………………… T [3]

(ii) Determine the position of the wire such that it experiences a force of the maximum magnitude. Draw <u>accurately</u> the position of the wire in Fig. 7.1C.

[2]

(c) The current-carrying wire in **(b)** has a magnetic field of its own. Show, by calculation, that it is impossible to find a point near the wire such that its magnetic flux density at that point has the same magnitude as the field present.

[2]

For Examiner's Use

8 In Singapore, the power stations are situated near the coast because sea water is used to condense steam into water. The transmission of electric power over long distances from the power stations to homes would not be feasible without transformers.

A step-up transformer near the power station boosts the station's output root-mean-square (r.m.s.) voltage from 12.0 kV to 240 kV and a series of step-down transformers near the homes reduces the r.m.s. voltage to a final value of 240 V at the homes. The transmission voltage has a frequency of 50 Hz.

(a) For the transformer located near the power station, determine the ratio

$$\frac{N_p}{N_s} = \frac{\text{number of turns of primary coil}}{\text{number of turns of secondary coil}}.$$

ratio = ... [1]

(b) Explain why

(i) the voltage is stepped up near the power plant,

....

....

....

.... [2]

(ii) an alternating voltage is used instead of direct voltage to transmit electrical energy.

....

....

.... [1]

(c) **(i)** Determine the r.m.s. current delivered to an electric kettle rated at 700 W when it is connected to a power socket in the house.

r.m.s. current = ... A [1]

(ii) Calculate the peak output voltage to the electric kettle.

V_o = ... V [1]

For Examiner's Use

(d) On Fig. 8.1 below, sketch a labelled graph for the variation with time t of the thermal power P dissipated by the electric kettle.

Fig. 8.1

[2]

For Examiner's Use

9 The use of satellites for communication using microwaves is relatively commonplace, for example in telephone links. The most useful sort of satellite orbit is a geostationary or geosynchronous one. It orbits the Earth which has a radius of 6.4×10^3 km. The microwave transmitting and receiving dishes do not have to constantly change their orientation, but can constantly point in the same direction.

One disadvantage, however, in the use of the geostationary satellite is that there will be regions on Earth where the satellite will appear to be below the horizon and cannot be seen at all. As shown in Fig. 9.1, there will be an angle, θ, above the equator, beyond which an observer on Earth cannot see the geostationary satellite.

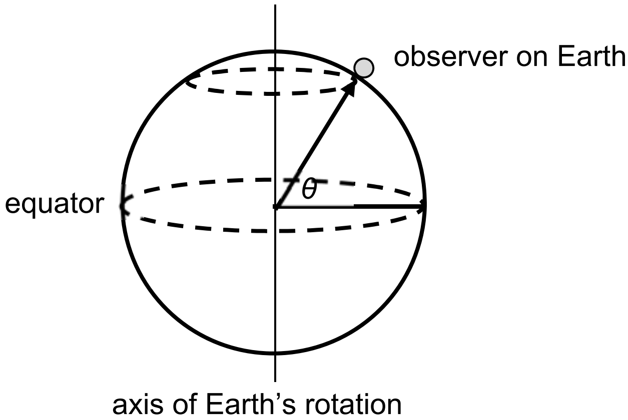


Fig. 9.1

Communication to and from moving ships and aircraft over long distances is obviously more difficult, even with geostationary satellites. Large ships move relatively slowly, and can carry a transmitting dish and the tracking equipment to keep it pointing in the right direction (assuming they know where they are on the Earth's surface accurately enough). However, small boats and aircraft have a weight and size problem; aircraft have the added complication of high speeds.

A type of microwave transmitter (and receiver) has been developed which can transmit in almost any carefully controlled direction without any moving parts, making it lighter and less vulnerable to mechanical damage than a conventional dish. The working principle is shown in Fig. 9.2.

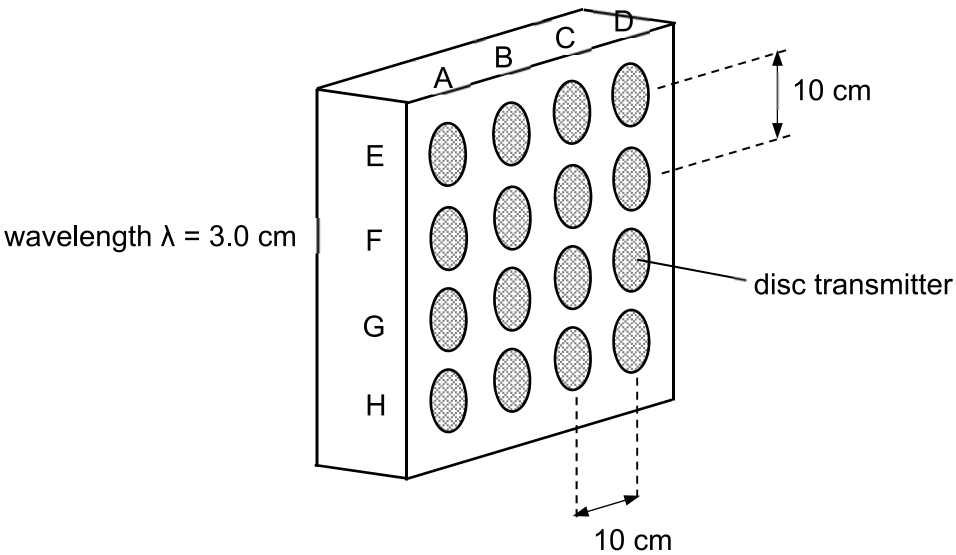


Fig. 9.2

For Examiner's Use

Fig. 9.2 shows a microwave transmitter which consists of 4 columns of discs, column A, B, C and D, and four rows of discs, row E, F, G and H. Each disc can have a different phase difference introduced into the signal before it is transmitted. For instance, if all the signals are in phase, there will be a strong signal sent directly in front of the array, but if row G is 1 cycle behind row H, row F 2 cycles behind row H and row E 3 cycles behind row H, a strong signal is sent upwards at an angle of about 17°. This is very similar to the way in which a diffraction grating works for light. Care has to be taken in choosing the spacing in the array, otherwise there could be very little signal in some directions.

(a) Calculate the time it takes a geostationary satellite to orbit the Earth once.

time = ... s [1]

(b) A geostationary satellite must be positioned directly above the Equator. Explain why this is so.

....

....

....

....

.... [3]

(c) Using the data provided and your answer in **(a)**, show that the radius of a geostationary orbit is 4.2×10^4 km. Explain your working.

[3]

For Examiner's Use

(d) Estimate, by scale drawing or otherwise, the angle θ above the Equator at which a receiving dish can be and still "see" the satellite.

angle = ... ° [3]

For Examiner's Use

(e) Show that the angle of 17° given in the passage is correct.

[1]

(f) A strong signal can be sent out if the phase relationships were as follows; vertical column A all in phase, column B all 1/3 of a cycle later, column C all 2/3 of a cycle later and column D all 1 cycle later.

(i) Calculate the path difference of the waves between adjacent column.

path difference = ... m [1]

(ii) Hence, determine the angle and direction, of this strong signal.

angle = ... °

direction = ... [2]

(g) Suggest, in principle, and without technical details, how a ship's communication with satellites could be used as a navigation aid, so that it can know accurately where its position is.

....

....

....

.... [3]

For Examiner's Use

(h) "Care has to be taken in choosing the spacing in the array". In this "phased array" setup, it is essential that each disc is only a few wavelengths apart from its neighbouring discs. Suggest why the discs cannot be positioned too close together or too far apart.

....

....

.... [2]

End of Paper

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
CLASS		TUTOR'S NAME	
CENTRE NUMBER	S	INDEX NUMBER	

PHYSICS 9749/03

Paper 3 Longer Structured Questions **20 September 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

You are advised to spend about one and a half hours on Section A, and about thirty minutes on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	**/ 7**
2	**/ 6**
3	**/ 8**
4	**/ 10**
5	**/ 10**
6	**/ 7**
7	**/ 12**
Section B	
8	**/ 20**
9	**/ 20**
Total	**/ 80**

This document consists of **21** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1} $(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm / r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o^{2} - x^2)}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\mu_o I / 2\pi d$
magnetic flux density due to a flat circular coil	B	=	$\mu_o NI / 2r$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

For Examiner's Use

Section A

Answer **all** the questions in the spaces provided.

1 Capacitance measures the ability of an electrical component to store charge and is defined as the ratio of charge stored in a capacitor to the potential difference across it.

(a) The S.I. unit for capacitance is the farad (F). Express F in S.I. base units.

F = ………………………… [3]

(b) A capacitor of capacitance 50 μF is charged using a cell in the circuit shown in Fig. 1.1.

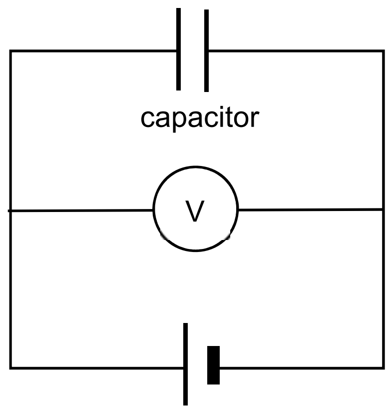


Fig. 1.1

(i) The voltmeter reads 2.20 V. By applying the given definition of capacitance, calculate the charge stored in the capacitor to 3 significant figures.

charge = ………………………… C [1]

(ii) The uncertainty of the voltmeter reading is ±0.05 V, and the capacitance of the capacitor has a tolerance of ±10%.

Express the charge stored in the capacitor in the form of ($Q \pm \Delta Q$).

($Q \pm \Delta Q$) = ………………………… C [3]

2 A person supports a load of 20 N in his hand as shown in Fig. 2.1. The system consisting of the arm and load is equivalent to the system shown in Fig. 2.2. The rod represents the forearm, and *T* represents the tension exerted in the biceps. The forearm weighs 65 N.

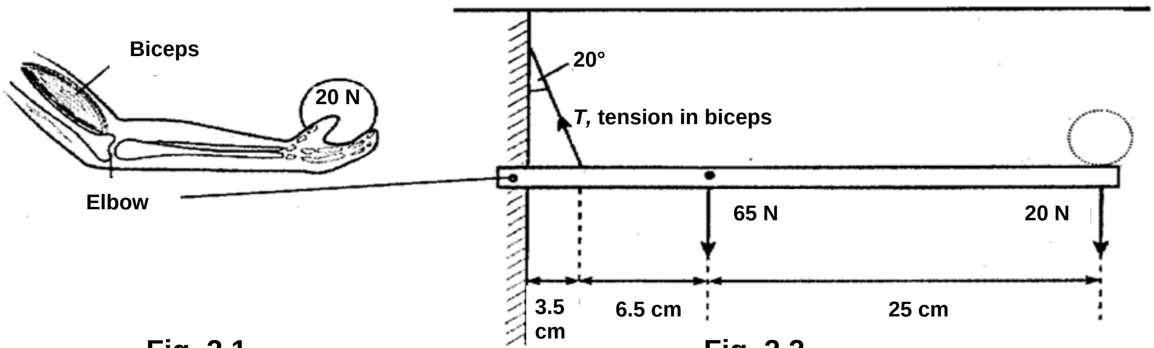


Fig. 2.1 **Fig. 2.2**

(i) Show that the tension *T* in the biceps is 410 N.

[2]

For Examiner's Use

(ii) Hence, determine the magnitude and direction of the force acting at the elbow.

force = ………………………… N [3]

direction = ………………………… [1]

3 At Luna Amusement Park in Sydney, Australia, the Rotor and Big Dipper Rollercoaster are the most exciting rides.

(a) The popular Rotor ride consists of a large vertical cylinder, which spins about its axis so quickly that any person standing inside is held against the wall when the floor drops away. The passengers maintain horizontal circular motion at constant speed within the cylinder. The normal contact force N acting on each passenger is related to the frictional force f on the passenger by a constant μ as given by the expression $f = \mu N$.

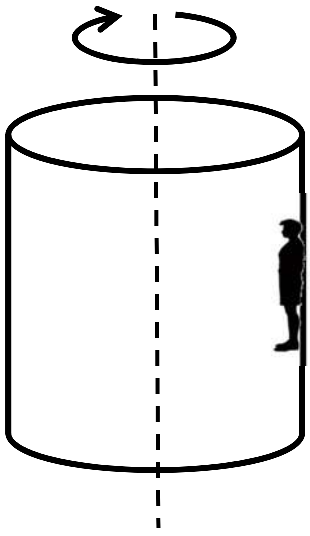


Fig. 3.1

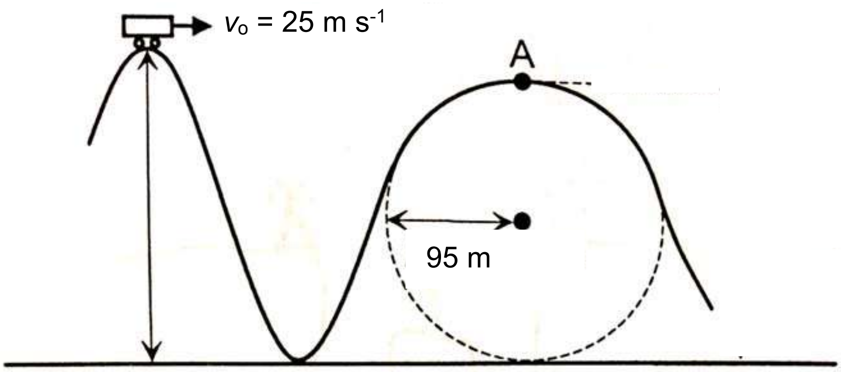
(i) Draw and label, on Fig. 3.1, the forces acting on the passenger. [1]

For Examiner's Use

(ii) Show that the linear velocity v at which the cylinder of radius R must rotate is independent of the mass of the passenger, m.

[3]

(b) The cart on the exhilarating Big Dipper Rollercoaster moves with negligible friction along the track as shown. The cart travels with an initial speed v_o of 25 m s^{-1} at the top of one hill, of height h, before reaching the top of a second hill, which forms a circular arc of radius 95 m.



(i) Calculate the maximum speed at which the cart can travel without leaving the track at the top of the second hill at point A.

maximum speed = ………………………… m s^{-1} [2]

(ii) Hence, determine the maximum height, h, of the first hill for the condition in **(b)(i)** to hold.

h = ………………………… m [2]

4 **(a)** "The magnitude of *gravitational field strength* at a point is proportional to the *gravitational potential gradient* at that point."

Explain the terms in italics.

gravitational field strength: ....

....

gravitational potential gradient: ....

.... [2]

(b) Fig. 4.1 shows four equipotential lines at 1000-km intervals in a non-uniform gravitational field.

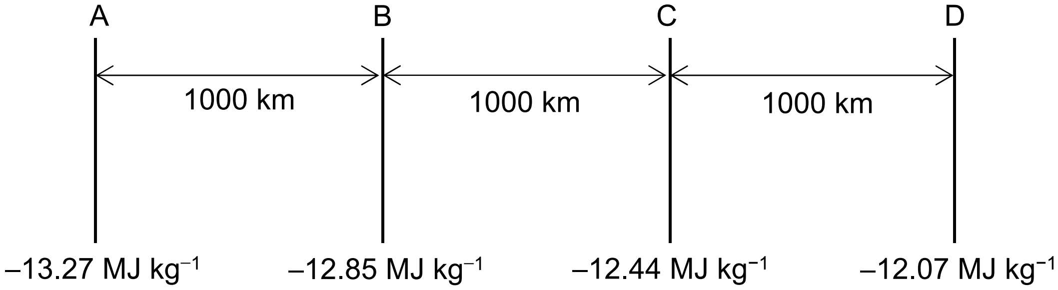


Fig. 4.1

(i) Draw an arrow on Fig. 4.1 to indicate the direction of the gravitational field. [1]

(ii) Calculate the ratio of

$$\frac{\text{field strength at B}}{\text{field strength at C}}.$$

ratio = ... [3]

(c) A theoretical long open tube is placed in the gravitational field as shown in Fig. 4.2. An object is released from rest at B.

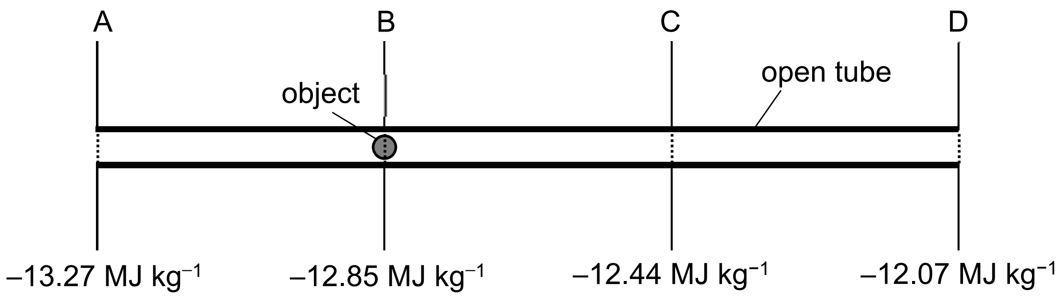


Fig. 4.2

Determine the speed with which the object leaves the tube.

speed = ... m s^{-1} [4]

5 **(a)** State what is meant by the term *internal energy of an ideal gas*.

....

.... [1]

(b) The pressure p exerted by an ideal gas is given by the equation

$$p = \tfrac{1}{3}\rho < c^2 >$$

State what the symbols ρ and $<c^2>$ represent.

ρ: ....

$<c^2>$: .... [2]

For Examiner's Use

(c) Use the equation given in **(b)** to show that the total kinetic energy of the molecules of an ideal gas of volume V and pressure p is given by $\frac{3}{2}pV$.

[2]

(d) **(i)** Calculate the internal energy of an ideal gas of volume 3.4×10^{-4} m^3 when its pressure is 100 kPa.

internal energy = ………………………… J [1]

(ii) Calculate the increase in internal energy when the gas expands at constant pressure to a volume of 8.8×10^{-4} m^3.

increase in internal energy = ………………………… J [2]

(iii) Determine the heat supplied to the gas so as to enable the expansion at constant pressure to take place.

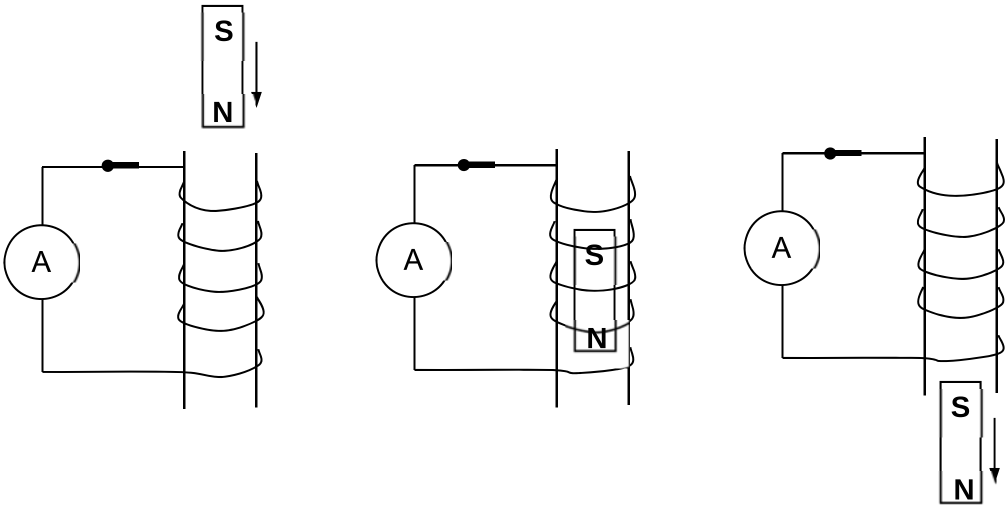
energy supplied = ………………………… J [2]

6 **(a)** State Lenz's Law.

....

.... [1]

A strong magnet is allowed to drop through a solenoid which is wound around a cardboard tube. The solenoid is connected to a switch and an ammeter.



Magnet approaching solenoid
Fig. 6.1A

Magnet in the middle of solenoid
Fig. 6.1B

Magnet leaving solenoid
Fig. 6.1C

(b) Indicate, with arrows on the winding of the solenoid in Fig. 6.1A, Fig. 6.1B and Fig. 6.1C, the direction of any induced current. [2]

(c) Hence, sketch on Fig. 6.2 a labelled graph showing the variation with time of the current induced in the solenoid as the magnet falls through it. [2]

Fig. 6.2

For Examiner's Use

(d) The switch connected to the solenoid is now opened, and the same magnet is allowed to drop through the solenoid again.

State and explain any change in the speed of the magnet as it leaves the solenoid.

....

....

....

.... [2]

7 **(a)** Tungsten, a transition metal, is commonly used as a target metal for the production of X-rays. The energy levels of the K- to M-shells for tungsten are shown in Fig. 7.1 below.

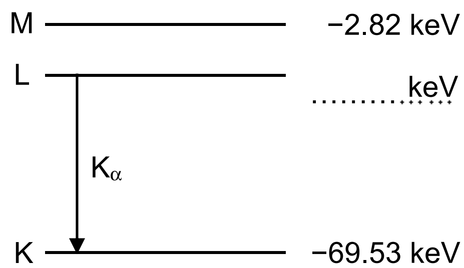


Fig. 7.1

The wavelength of the photon produced by the K_α transition is 21.65 pm.

(i) Complete Fig. 7.1 by filling in the energy level of the L-shell for tungsten.

[2]

(ii) Determine the wavelength of the photon produced by L_α transition.

wavelength = ... pm [1]

For Examiner's Use

The intensity of various photon wavelengths from electron bombardment of a tungsten target metal is shown in Fig. 7.2 below.

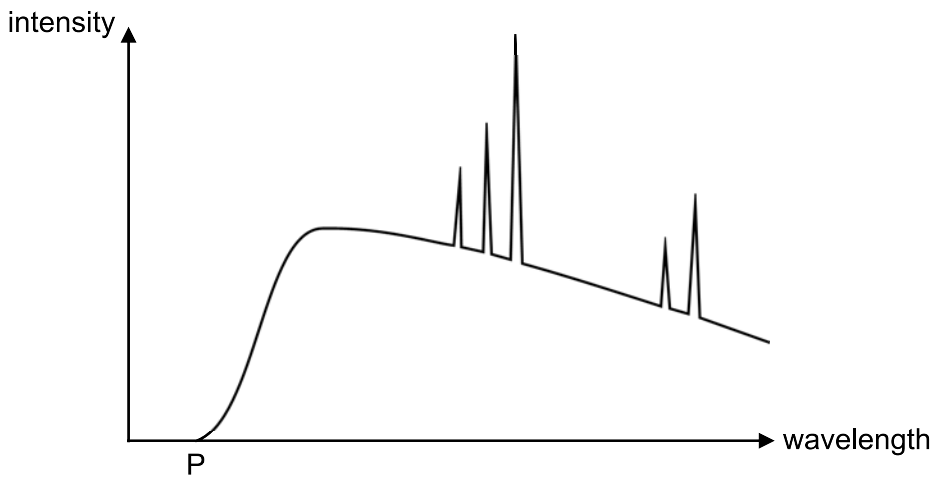


Fig. 7.2

(iii) On Fig. 7.2, label the peaks for K_α and L_α transitions. [2]

(iv) State the significance of the value of P.

....

.... [1]

(v) With reference to Fig. 7.1, explain why the electrons bombarding the target metal must have a minimum energy of 69.53 keV to produce the spectrum shown in Fig. 7.2.

....

....

....

....

.... [3]

(b) Fig. 7.3 below shows a typical setup for producing such X-ray beams.

For Examiner's Use

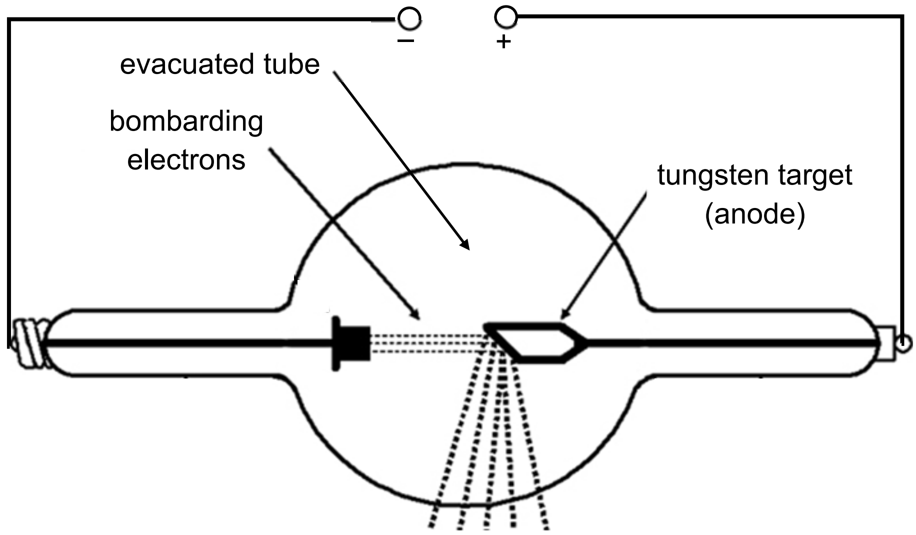


Fig. 7.3

For safety reasons, the wavelength of radiation used for medical X-rays is no shorter than 50 pm. Explain, with calculation, how the setup in Fig. 7.3 can be adjusted to ensure that the wavelength of the X-rays produced does not fall below 50 pm.

....

....

....

.... [3]

For Examiner's Use

Section B

Answer **one** question from this section in the spaces provided.

8 **(a)** Point source P, consisting of light with wavelength 630 nm, passes through a narrow slit and is incident on a screen at a distance of 2.4 m from the slit. Fig. 8.1 below shows the variation of intensity I of the light on the screen with distance *x* along the screen.

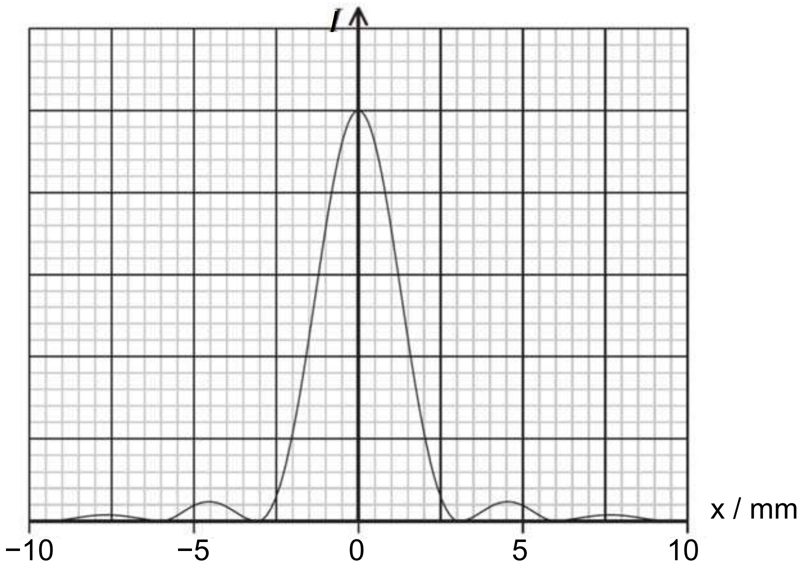


Fig. 8.1

(i) Use Fig. 8.1 to determine the width of the slit.

width = ………………………… mm [2]

(ii) State the effect on the pattern on the screen if each of the following changes is made separately:

1. the width of the single slit is reduced,

....

....

.... [2]

For Examiner's Use

2. the red source is replaced with another source of violet light.

....

....

.... [2]

(b) Another point source Q, emitting light of the same wavelength as P, is placed 5.0 mm from P, and the two sources are arranged as shown in Fig. 8.2. The slit is now replaced with another slit of width *b*.

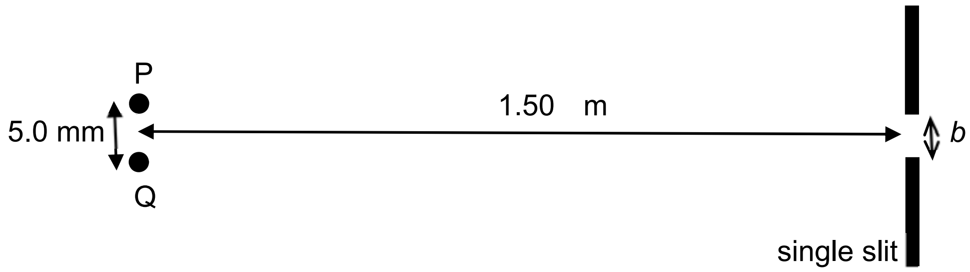


Fig. 8.2

(i) State the condition for the image of P and the image of Q formed on the screen to be just resolved.

....

.... [1]

(ii) Sketch, on Fig. 8.1, the graph for point source Q when the condition in **(b)(i)** is met. [1]

(iii) Calculate the minimum width *b* of the slit for the two images to be just resolved.

b = ... mm [3]

For Examiner's Use

(c) Two microwave transmitters, A and B, are separated by a distance of 0.80 m. They each transmit a microwave of frequency 3.00 GHz.

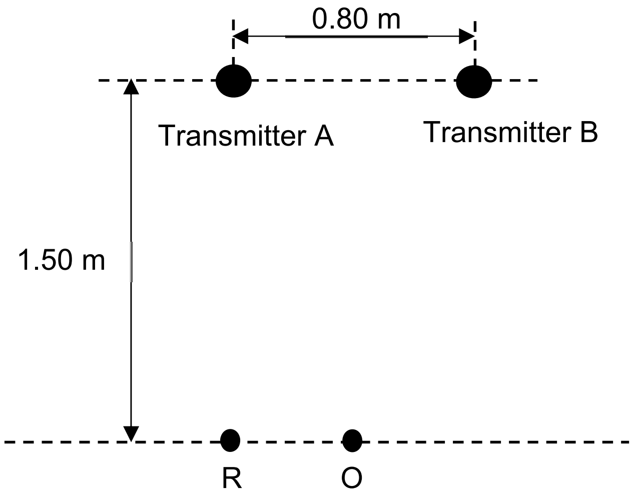


Fig. 8.3

A microwave receiver is moved along a line parallel to, and 1.50 m from, the line joining the two transmitters, as shown in Fig. 8.3. Point O lies on the line where it is equidistant from both transmitters, while point R is at a distance 1.50 m from transmitter A. As the receiver moves from O to R, a minimum signal is detected at R.

(i) Determine the path difference between the two waves arriving at R.

path difference = ………………………… m [2]

(ii) Show that the two waves are emitted in antiphase at the transmitters.

[4]

Fig. 8.4 below shows the displacement-time graph of the waves arriving at R when only transmitter A is switched on and when both transmitters A and B are switched on.

For Examiner's Use

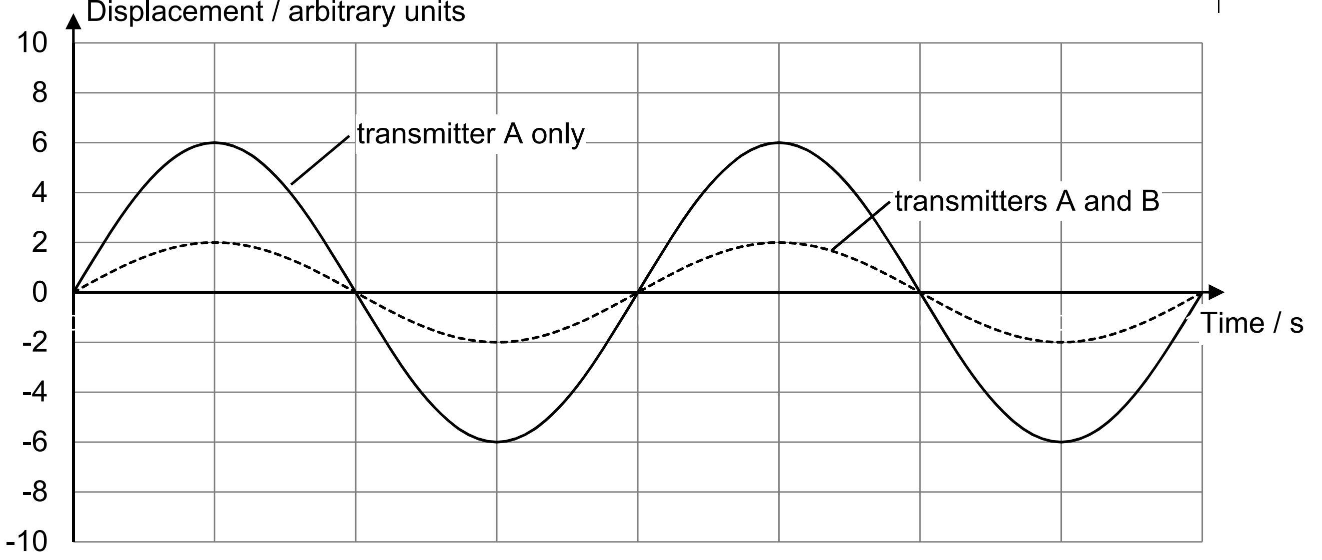


Fig. 8.4

(iii) Sketch, on Fig. 8.4, the displacement-time graph of the waves arriving at R when only transmitter B is switched on. [1]

(iv) Determine the ratio, at point R, of $\dfrac{\text{intensity of microwave due to transmitter A}}{\text{intensity of microwave due to transmitter B}}$.

ratio = ………………………… [2]

For Examiner's Use

9 **(a)** Fig. 9.1 below shows a Rutherford scattering experiment in which α-particles are directed at a gold foil. The detector is shown in two positions in the evacuated chamber.

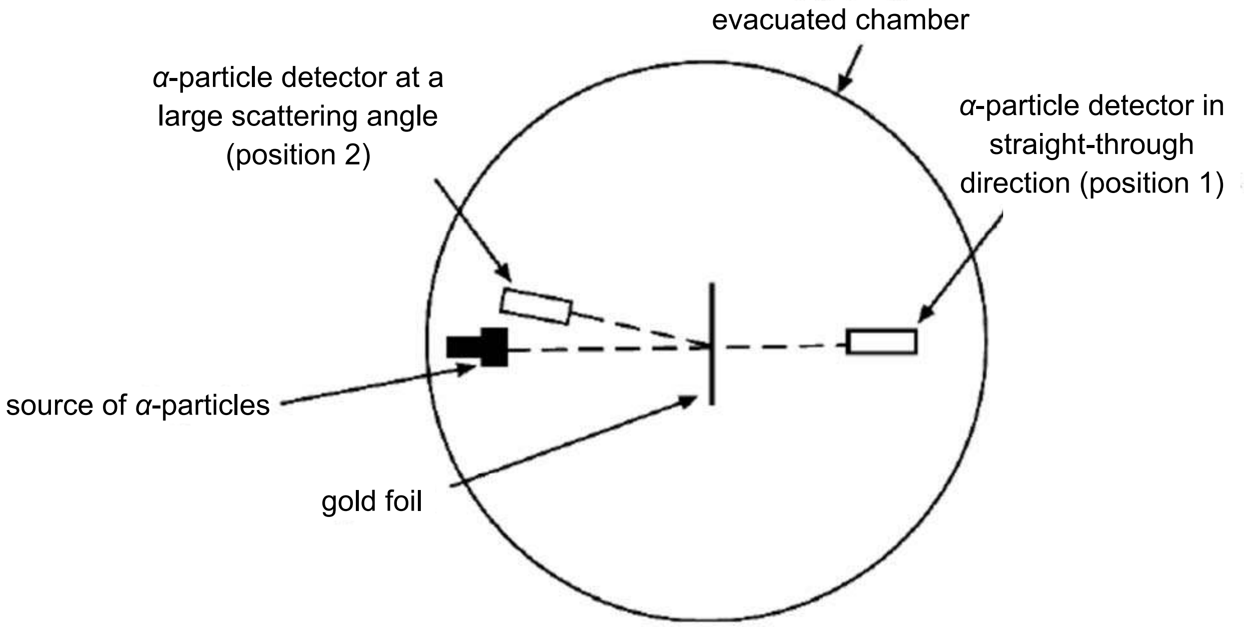


Fig. 9.1

(i) Explain why air needs to be removed from the apparatus.

....

.... [1]

(ii) Explain why the gold foil should be very thin.

....

.... [1]

(iii) State what can be deduced, from the following observations, about the structure of the atom and the properties of the gold nucleus:

1. A high count rate is detected by the α-particle detector in position 1.

....

.... [1]

2. A low count rate is detected by the α-particle detector in position 2.

....

....

.... [2]

(b) Fig. 9.2 illustrates the variation with nucleon number of the binding energy per nucleon of nuclei.

For Examiner's Use

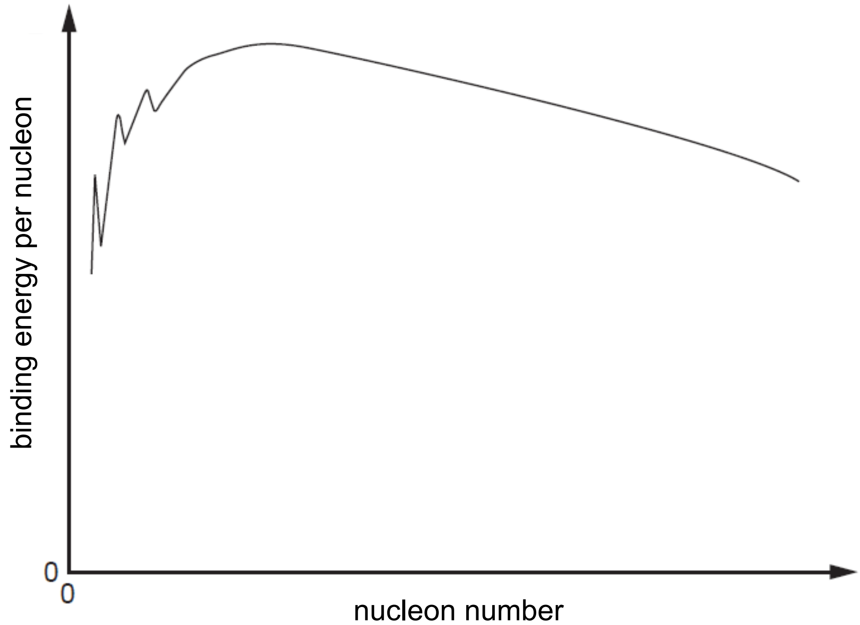


Fig. 9.2

(i) Explain what is meant by the *binding energy* of a nucleus.

....

....

.... [2]

(ii) With the aid of Fig. 9.2, explain why more energy per nucleon is released in fusion than in fission.

....

....

....

....

.... [3]

(iii) On Fig. 9.2, mark with the letter **S** the region of the graph representing nuclei having the greatest stability. [1]

(iv) On Fig. 9.2, complete the graph for elements of low nucleon numbers. [1]

For Examiner's Use

(c) Uranium-235 may undergo fission when bombarded by a slow-moving neutron to produce xenon-142 and strontium-90 as shown below.

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{142}_{54}\text{Xe} + {}^{90}_{39}\text{Sr} + \text{neutrons} + {}^{0}_{-1}e$$

(i) Determine the number of neutrons produced in this fission reaction.

number = ... [1]

(ii) State the role of these neutrons in the fission reaction.

....

.... [1]

(iii) Data on binding energy per nucleon for some nuclides is given in Fig. 9.3.

isotope	binding energy per nucleon / MeV
Uranium-235	7.59
Xenon-142	8.23
Strontium-90	8.70

Fig. 9.3

Calculate

1. the energy released in this fission reaction,

energy = ... J [2]

2. the mass equivalent of this energy.

mass = ... kg [1]

For Examiner's Use

(iv) A nuclear power station supplies 100 MW of electrical power to a town for one year at an efficiency of 35%.

Calculate the mass of uranium needed to operate the power station for one year.

mass = ... kg [3]

End of Paper

2018 JC2 H2 PHYSICS PRELIMINARY EXAM PAPER 4

APPARATUS LIST

Question 1

1 One digital multimeter.

2 One electrical component labelled C (with values 15μF).

3 One resistor labelled Y (with values 10.0 kΩ).

4 Three resistors with values 1.0 kΩ.

5 One resistor with values 3.9 kΩ.

6 6 V d.c. power supply.

7 Switch

8 One stopwatch reading to 0.1 s or better.

9 Twelve connecting leads.

Question 2

1 Two 50 g slotted masses taped to a wire.

2 One protractor.

3 One 30 cm ruler.

4 One spring.

5 One mass hanger and masses with a total mass of 200 g, securely taped together.

6 One retort stand (with boss and clamp).

7 One hook.

8 One stopwatch reading to 0.1 s or better.

9 Micrometer screw gauge (shared basis – Teacher's bench).

Question 3

1 One table-tennis ball attached to a 75 cm thread.

2 One retort stand (with boss and clamp).

3 One half-metre rule.

4 One metre rule.

5 One set square.

6 One wooden block, 22 cm by 6 cm by 6 cm.

7 Two flat wooden planks, each 5 cm by 5 cm by 5 mm.

8 One protractor.

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS **9749/04**

Paper 4 Practical Paper **20 August 2018**

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

You are expected to record all your observations as soon as they are made and to plan the presentation of the records so that it is not necessary to make a fair copy of them.
The working of the answers is to be handed in.
Marks are mainly given for a clear record of the observations actually made, their suitability and accuracy, and for the use made of them.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift Timing	
Laboratory	
For Examiner's Use	
Total	/ 55

For Examiner's Use

1 In this experiment, you will investigate the time for the voltage across an electrical component to decrease after a switch is opened.

(a) You are provided with a power supply, a component C, an unknown resistor Y, four resistors labelled with their resistance values in kΩ, a voltmeter and a switch.

Assemble the circuit as shown in Fig. 1.1.

Ensure that the positive terminal of the power supply is connected to the positive terminal of component C.

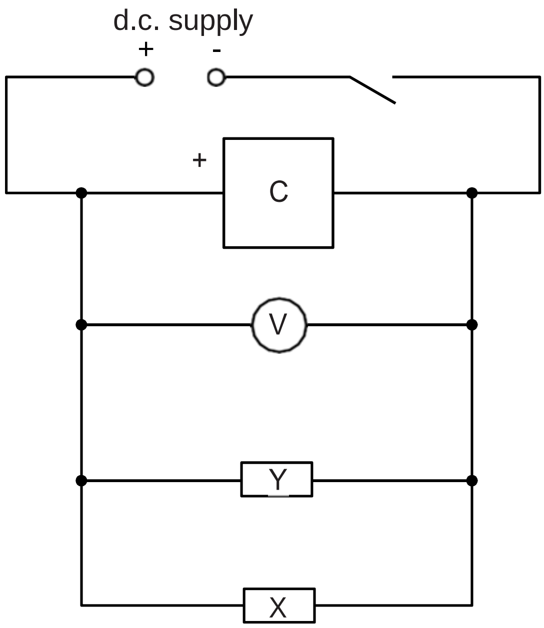


Fig. 1.1

X has a value of resistance *S*. Connect the resistors provided such that *S* has a value of 4 kΩ.

(b) **(i)** Close the switch and check that the voltmeter reading is about 6 V.

(ii) When the switch is opened, the voltmeter reading will gradually decrease. Take measurements to find the time *t* for the voltmeter reading to fall from 5.0 V to 2.0 V after the switch is opened.

Record *t*.

t = ...
[1]

(c) Estimate the percentage uncertainty in your value of t.

percentage uncertainty = ... [1]

For Examiner's Use

For Examiner's Use

(d) Repeat **(b)** for different values of S. The effective value of S should **not exceed 4 kΩ**.

[6]

(e) It is suggested that t and S are related by the expression

$$\frac{1}{t} = \frac{a}{S} + b$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b.

a = ...

b = ...

[5]

For Examiner's Use

[3]

For Examiner's Use

(f) Comment on any anomalous data or results that you have obtained.
Explain your answer.

....

.

....

.

....

[1]

(g) Calculate the value of *S* for which *t* is equal to 6.5 s.

S = ... kΩ [1]

(h) Theory suggests that the resistance of Y is given by

$$\text{resistance of Y} = \frac{a}{b}$$

t depends on the resistance of the combination of resistor X and resistor Y.

By referring to the relationship between *t* and resistance *S* in your results table in **(d)**, sketch, on the graph grid on page 5, a second graph to represent the results when the resistance of resistor Y is doubled.

Label this second graph Z. Explain your answer.

....

.

....

.

....

[1]

[Total: 19 marks]

For Examiner's Use

2 In this experiment, you will investigate the motion of a system of masses as its shape is changed.

(a) You are provided with a length of wire, bent into two arms, with a mass attached at the end of each arm as shown in Fig. 2.1.

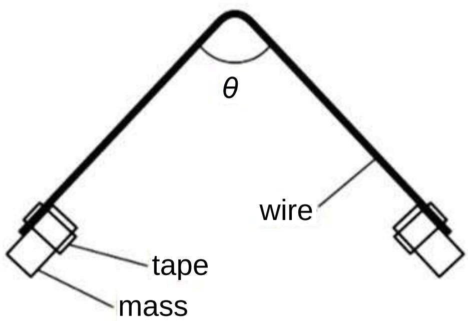


Fig. 2.1

(i) Using a micrometer screw gauge, measure and record the thickness of the wire *d*.

d = ... [1]

(ii) Measure and record the angle *θ* between the two arms.

θ = ... [1]

(iii) Calculate $\sin^2\left(\dfrac{\theta}{2}\right)$, where

For Examiner's Use

$$\sin^2\left(\frac{\theta}{2}\right) = \sin\left(\frac{\theta}{2}\right) \times \sin\left(\frac{\theta}{2}\right).$$

$\sin^2\left(\frac{\theta}{2}\right)$ = ...

(b) You are provided with a spring suspended from a stand. A hook is suspended from the bottom of the spring.

Hang the wire from the upper part of the hook and hang the mass hanger from the lower part of the hook as shown in Fig. 2.2.

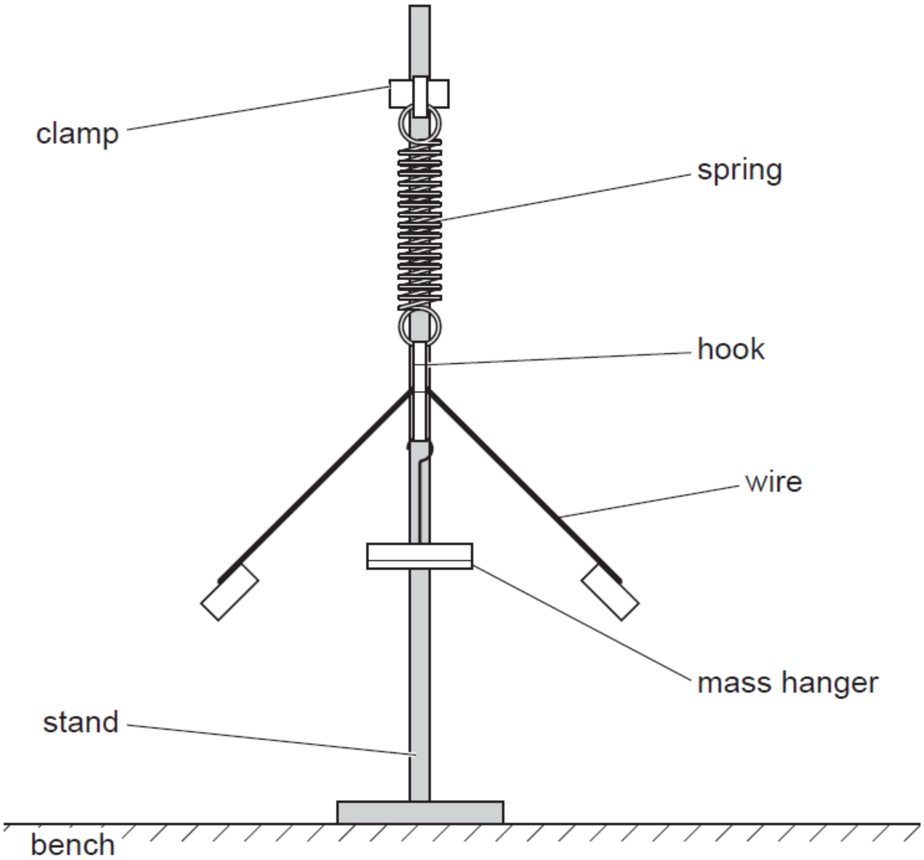
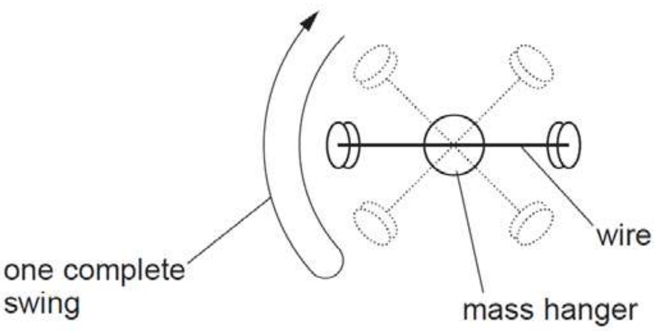


Fig. 2.2

(i) Twist the mass hanger through about 45° and release it so that the mass hanger and wire rotate back and forth as shown in Fig. 2.3.



For Examiner's Use

Fig. 2.3 (Top view)

(ii) Measure and record the time *t* for the mass hanger and wire to make 5 complete swings.

t = ... [2]

For Examiner's Use

(c) Remove the wire from its hook. Bend the wire to change the angle θ. The arms of the wire must remain straight.

Repeat **(a)** and **(b)**.

θ = ...

$\sin^2\left(\frac{\theta}{2}\right)$ = ...

t = ... [2]

(d) The quantities t and θ are related by the equation

$$t^2 = p + q\sin^2\left(\frac{\theta}{2}\right)$$

where p and q are constants.

It is suggested that the mass of the masses attached to the wire affects the values of p and q.

(i) Suggest one other factor that may affect the values of p and q.

....

....

[1]

For Examiner's Use

(ii) Plan an investigation to determine whether the mass of the masses attached to the wire affects the values of *p* and/or *q*.

Your account should include:

- your experimental procedure
- how your results can be analysed to reach the conclusion.

....

....

....

....

....

....

....

....

....

....

....

....

[4]

[Total: 11 marks]

For Examiner's Use

3 In this experiment you are provided with a ball attached to a thread and a solid vertical surface. You will investigate how the rebound distance of the ball is related to the release distance when it swings against the solid surface.

(a) Assemble the apparatus as shown in Fig. 3.1, with the thread clamped between the two wooden planks so that *L* is about 50 cm, and with the wooden block positioned so that it is just touching the stationary ball.

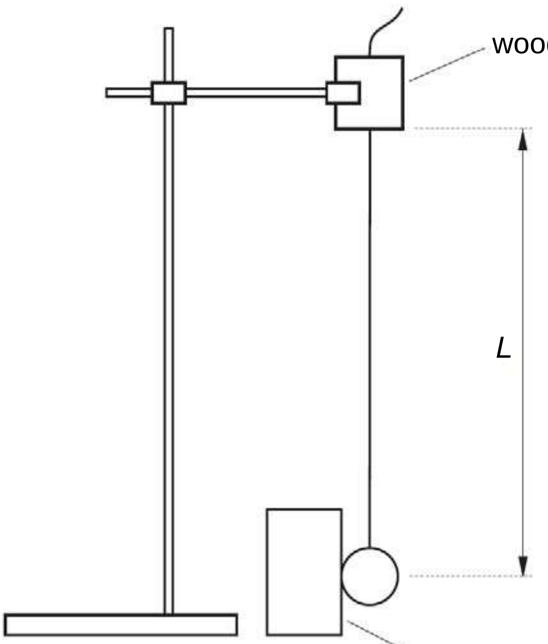


Fig 3.1

Measure *L*.

L = ...

(b) **(i)** Pull back the ball and measure the distance *a* shown in Fig. 3.2. Do not exceed *a* = 25 cm.

a = ... [1]

For Examiner's Use

(ii) Release the ball and make measurements to determine the rebound distance *b* shown in Fig. 3.2.

b = ... [1]

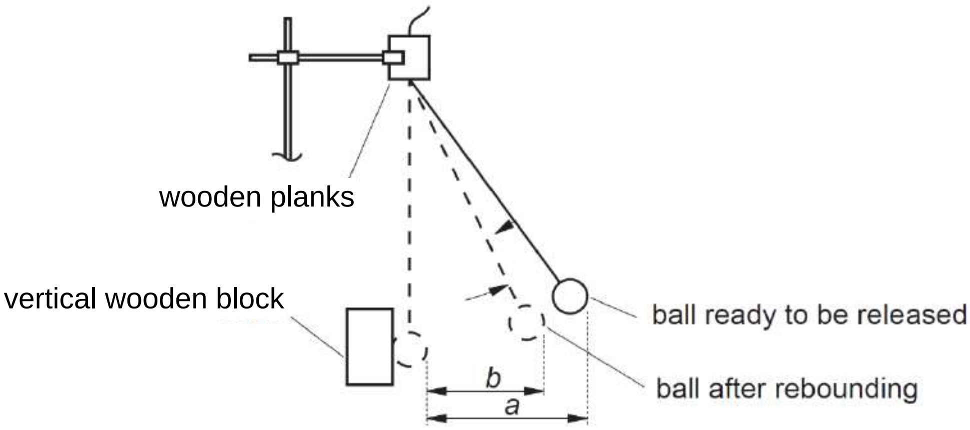


Fig. 3.2

(c) **(i)** Explain how you used the apparatus to ensure that the rebound distance *b* was measured as accurately as possible.

....

....

....

....

....

[1]

(ii) Estimate the percentage uncertainty in *b*.

percentage uncertainty in *b* = ... [1]

For Examiner's Use

(d) For values of *a* less than 25 cm, theory predicts that

$$k = \frac{L - \sqrt{L^2 - b^2}}{L - \sqrt{L^2 - a^2}}$$

where *k* is a constant. Calculate a value for *k*.

k = ... [1]

(e) Repeat **(b)(i)**, **(b)(ii)** and **(d)** using a different value of *a*.

a = ……………………………………

b = ……………………………………

k = ……………………………… [2]

(f) Explain whether your results indicate that *k* is a constant.

....
.

....
.

....
.

....

[1]

For Examiner's Use

(g) **(i)** State two sources of error or limitations of the procedure in this experiment.

1. ....
.

....
.

....
.

2. ....
.

....
.

....[2
]

(ii) Suggest two improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1. ....
.

....
.

....
.

2. ....
.

....
.

....[2
]

[Total: 12 marks]

For Examiner's Use

4 A student is investigating the motion of a small block on a turntable connected to an electric motor as shown in Fig. 4.1.

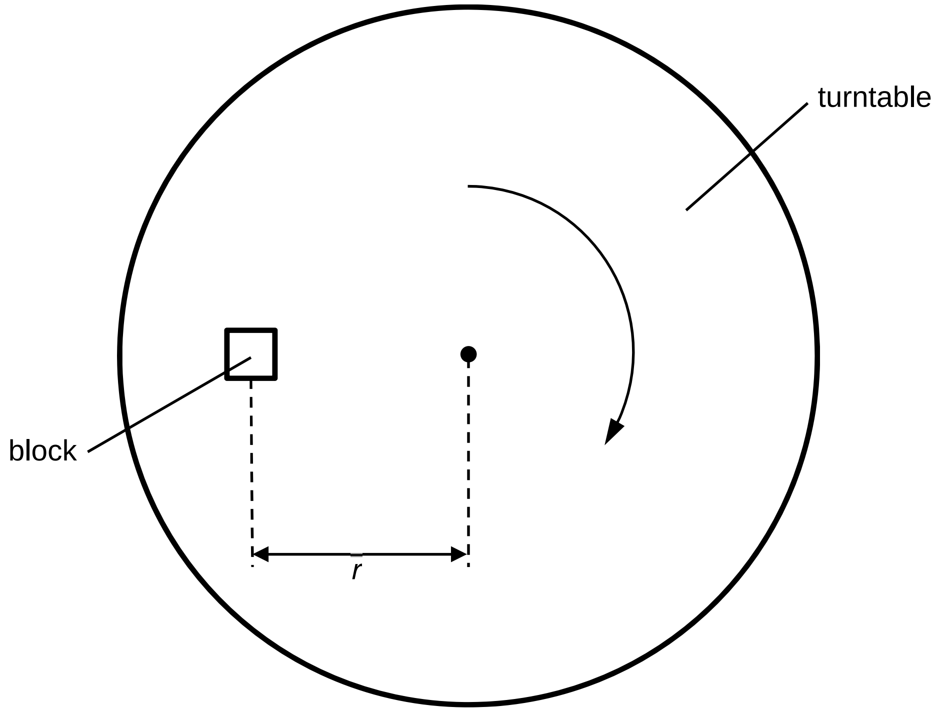


Fig. 4.1

The block has a mass *m* and is placed at a distance *r* from the centre of the turntable. It is suggested that the relationship between *m*, *r* and the maximum frequency *f* of the turntable for which the block does not move relative to the turntable is

$$\frac{1}{f} = 4\pi^2 \mathrm{k} m r^{x}$$

where *k* and *x* are constants.

Design an experiment to test the relationship between *f*, *m* and *r*, and determine the value of *x*. You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

a) the equipment you would use,

b) the procedure to be followed,

c) how the value of *x* is determined from your readings,

d) the control of variables,

e) the measurements to be taken,

f) any precautions that should be taken to improve the accuracy and safety of the experiment.

For Examiner's Use

Diagram

For Examiner's Use

For Examiner's Use

For Examiner's Use

[13]

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

PHYSICS — 9749/01

Paper 1 Multiple Choice

25 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Solution

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and tutor's name on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **16** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1} $(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm / r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm\omega\sqrt{\left(x_o^{\,2} - x^2\right)}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\mu_o I / 2\pi d$
magnetic flux density due to a flat circular coil	B	=	$\mu_o NI / 2r$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

1 Which of the following statements is not always true?

A The total mass of two 1 kg masses is 2 kg.

B The total charge of a +1 C charge and a –1 C charge is zero.

C The resultant of two 1 N forces is 2 N.

D The total energy of 1 J of kinetic energy and 1 J of potential energy is 2 J.

Vector addition takes into consideration direction.

2 The following are the results obtained by two students P and Q in the determination of the mass of an object.

Student P	1.05 kg	0.96 kg	1.01 kg	0.97 kg
Student Q	1.08 kg	1.07 kg	1.08 kg	1.06 kg

Which of the following most appropriately describes the results obtained by students P and Q?

	more accurate	more precise
A	Q	*cannot be determined*
B	P	Q
C	Q	P
D	*cannot be determined*	Q

True value is not known.

3 A train initially at rest accelerates at a constant rate of 1.4 m s^{-2} for 10 s and then slows down at a constant rate of 0.20 m s^{-2} until it comes to a rest. The total distance travelled by the train is

A 80 m **B** 220 m **C** 560 m **D** 1120 m

$$s_1 = u_1 t_1 + \frac{1}{2} a_1 t_1^2 = \frac{1}{2} x 1.4 x 10^2 = 70 m$$

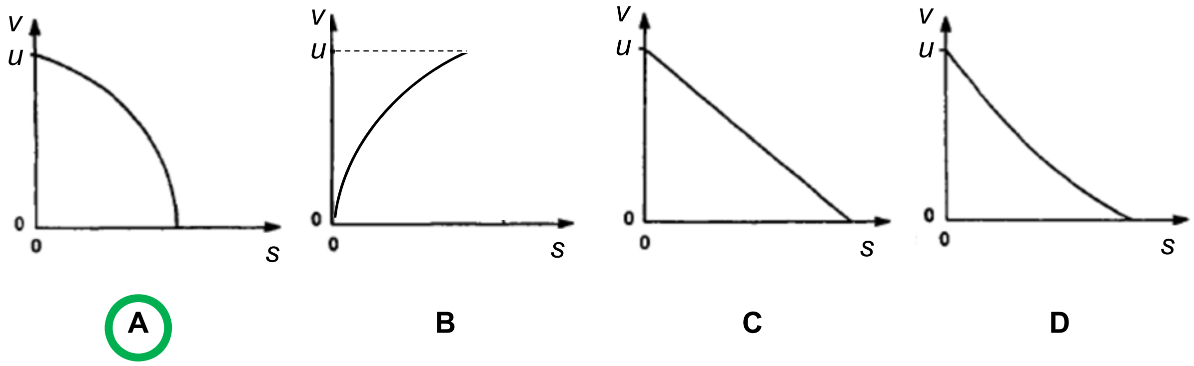
$$v_1 = u_1 + a_1 t_1 = 1.4 x 10 = 14 = u_2$$

$$v_2^2 = u_2^2 + 2 a_2 s_2$$

$$s_2 = \frac{u_2^2}{2a_2} = \frac{14^2}{2 x 0.2} = 490 m$$

$$s = s_1 + s_2 = 70 + 490 = 560 m$$

4 A falling stone strikes some soft ground at speed u and suffers a constant deceleration until it stops. Which one of the following graphs best represents the variation of the stone's speed, v, with distance, s, measured downwards, from the surface of the ground?

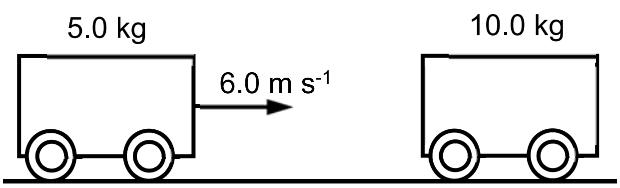


$v^2 = u^2 + 2as$ where a is negative.

$$\frac{dv}{ds} = \frac{dv}{dt} \times \frac{dt}{ds} = \frac{a}{v}$$

As v decrease, gradient of v-s graph becomes increasingly negative.

5 A trolley of mass 5.0 kg travelling at a speed of 6.0 m s^{-1} collides head-on and locks together with another trolley of mass 10.0 kg which is initially at rest. The collision lasts for 0.20 s.



What is the total kinetic energy of the two trolleys after the collision and the average force acting on each trolley during this collision?

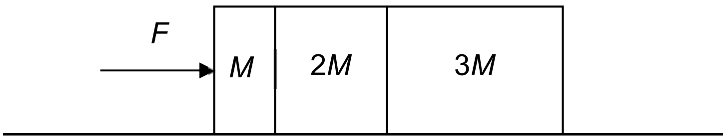
	Total kinetic energy after the collision / J	Average force on each trolley / N
A	30	150
B	75	150
C	30	100
D	75	100

Applying conservation of linear momentum, the speed after the collision is 2.0 m s^{-1}.

Hence, the total kinetic energy after the collision is $\frac{1}{2} m_{total} v^2 = \frac{1}{2} \times 15 \times 2.0^2 = 30$ J.

The force on either trolley is $\Delta p/\Delta t = 20/0.20 = 100$ N.

6 Three blocks with masses *M*, 2*M* and 3*M* are pushed along a rough surface by a horizontal force *F* as shown.



The frictional force between a block and the rough surface is directly proportional to the weight of the block. Given that the frictional force between the block with mass *M* and the rough surface is *f*, what is the magnitude of the force mass 3*M* exerts on mass 2*M*?

A $\frac{F}{2}$

B $\frac{F}{2}+3f$

C $\frac{F}{3}+f$

D $\frac{F}{3}+3f$

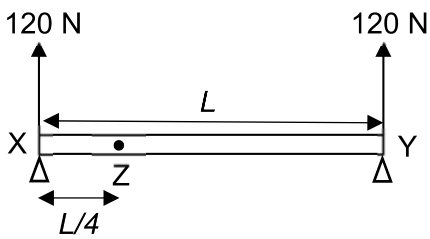
Consider the whole system,
$F - 6f = 6Ma$

$$a = \frac{F-6f}{6M}$$

Let the force that 3M acts on 2M be F_1.
Consider Newton's 2nd law on 3M,
$F_1 - 3f = 3Ma$

$$F_1 = 3M\left(\frac{F-6f}{6M}\right) + 3f = \frac{F}{2}$$

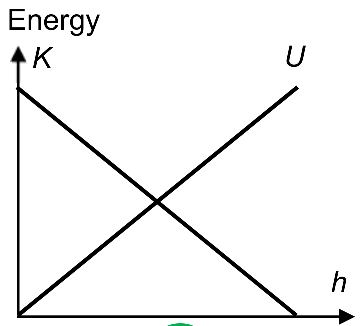
7 A uniform plank of length *L* is supported by initially equal forces of 120 N at X and Y. If the force at X is now moved to Z such that the plank is kept horizontal, what is the magnitude of the force at Y?



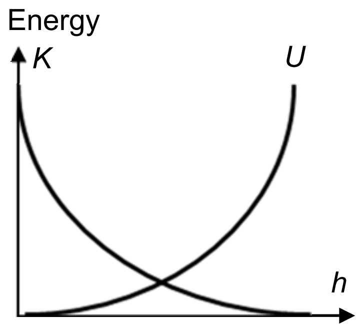
A 60 N **B** 80 N **C** 120 N **D** 160 N

Weight of plank is 240 N acting through the centre.
When force is moved to point Z, taking moment about point Z,
240 x L/4 = Force at Y x 3L/4
Force at Y = 80 N

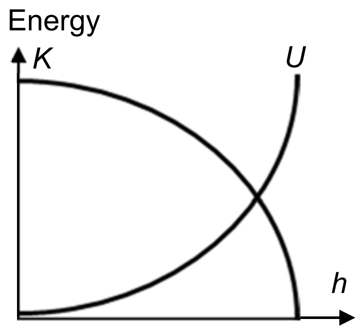
8 A ball is projected vertically upwards. At a height *h*, the kinetic energy of the ball is *K* and its potential energy is *U*. Taking air resistance to be negligible, which graph correctly shows the variations of *K* and *U* with *h*?



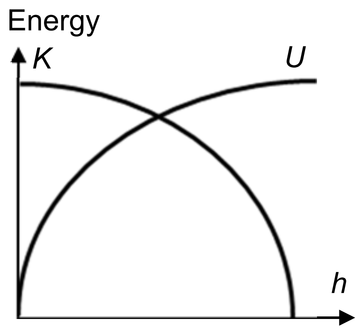
A (circled)



B



C



D

U = m g h → U varies linearly with h.

K + U = Total energy (constant)

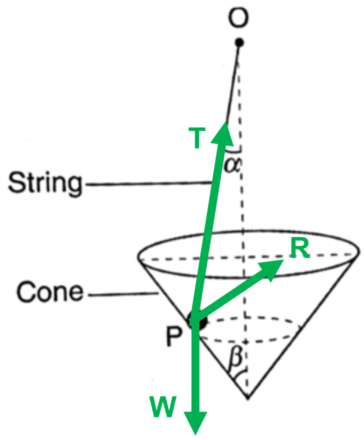
9 The engine of a car has maximum output power of 54 kW. The air resistance acting on the car when it is moving with speed *v* is cv^2, where *c* is 2.0 kg m^{-1}. What is the maximum speed that can be achieved by the car on level road?

A 3.0 m s^{-1} **B** 5.0 m s^{-1} **C** (circled) 30 m s^{-1} **D** 160 m s^{-1}

At max speed, rate of work done against air resistance = 54×10^3 W

F v = $cv^2 \times v = 54 \times 10^3$ → v = 30 m s^{-1}

10 A pendulum bob at the end of the string which is fixed at O moves in a horizontal circle on the inside of a cone as shown.



If the tension in the string is T and the normal contact force by the cone is R, which of the following gives the centripetal force on the bob?

A $T \sin \alpha + R \cos \beta$

B $T \sin \alpha - R \cos \beta$

C $T \cos \alpha + R \sin \beta$

D $T \cos \alpha - R \sin \beta$

11 Two satellites X and Y are orbiting at heights of 5R and 9R above the surface of the Earth respectively, where R is the radius of the Earth.

What is the ratio of their orbital speeds v_X/v_Y ?

A 1.29 **B** 1.34 **C** 1.67 **D** 1.80

$G M m / r^2 = m v^2 / r \rightarrow G M / r = v^2$

$\rightarrow v_X / v_Y = (r_Y / r_X)^{1/2} = (10R / 6R)^{1/2} = 1.29$

12 The gravitational potentials on the surface of a planet P and on the surface of its moon Q are –120 MJ kg^{-1} and –20 MJ kg^{-1} respectively.

The minimum amount of energy required to project a 1 kg mass from the surface of Q to the surface of P is E.

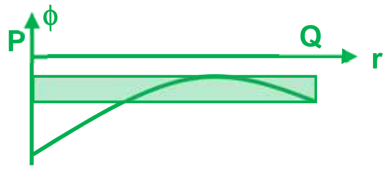
Which of the following correctly describes the value of E?

A E < 20 MJ

B E = 20 MJ

C 20 MJ < E < 100 MJ

D 100 MJ < E < 120 MJ



The highest potential between P and Q is greater than –20 MJ kg^{-1} and less than 0.

13 Which of the statements about damped oscillations is not true?

A The period of the oscillation increases with time. (circled)

B The amplitude of the oscillation decreases with time.

C The energy of the oscillation decreases with time.

D The frequency of the oscillation is lower compared to that of an undamped oscillation.

14 In a heating experiment, energy is supplied at a constant rate to a liquid in a beaker of negligible heat capacity. The temperature of the liquid rises by 4.0 K per minute just before it begins to boil. After 40 minutes, all the liquid has boiled away.

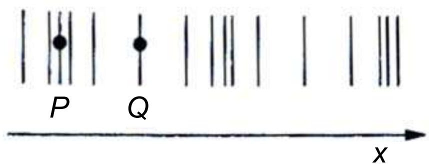
For this liquid, what is the ratio $\dfrac{\text{specific heat capacity}}{\text{specific latent heat of vapourisation}}$?

A $\dfrac{1}{10}$ K^{-1} **B** $\dfrac{1}{40}$ K^{-1} **C** $\dfrac{1}{160}$ K^{-1} (circled) **D** $\dfrac{1}{640}$ K^{-1}

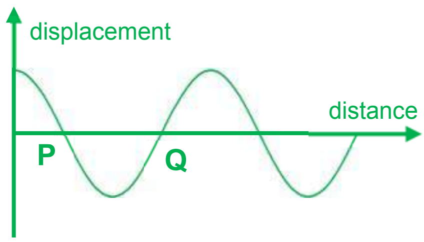
P = m c dθ/dt = dm/dt L

c / L = (m/40) / (m × 4.0) = 1/160

15 The compressions and rarefactions of a sound wave travelling in air in the positive *x*-direction are shown below.



Which statement is true about the diagram?



A At *P*, the air pressure is minimum.

B At *Q*, it is a position of antinode.

C At *Q*, the air molecule is momentarily at rest.

D At *P*, the air molecule is moving in the positive *x*-direction. (circled)

16 The two lowest frequencies at which an open narrow tube resonates are 256 Hz and 512 Hz. If one of the ends is closed, what are the two lowest frequencies at which it would now resonate?

A 128 Hz and 256 Hz

B 128 Hz and 384 Hz (circled)

C 384 Hz and 640 Hz

D 768 Hz and 1536 Hz

Length of tube L = ½ × v / 256 = v / 512

Closed tube: f_0 = v / (4L) = 512 / 4 = 128 Hz

f_1 = v / (4L/3) = ¾ × 512 = 384 Hz

17 A beam of light that consists of all wavelengths between 480 nm and 600 nm is projected on a diffraction grating that contains 500 lines per millimeter.

What is the maximum number of complete continuous spectra that can be observed emerging from the grating?

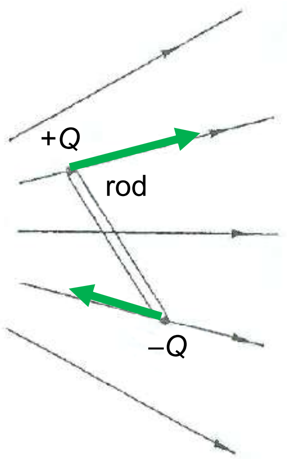
A 6 **B** 7 **C** 8 **D** 9

For longest wavelength: $n \lambda / d \leq 1 \rightarrow n \leq (1.0\times10^{-3} / 500) / 600\times10^{-9} = 3.3$

max n = 3

Thus there will be 6 spectra observed. (Zeroth order maximum is not a spectrum.)

18 An insulated rod with equal and opposite charges at its ends is placed in a non-uniform electric field with field lines as shown below.



The rod experiences

A a resultant force in the plane of the paper and a torque.

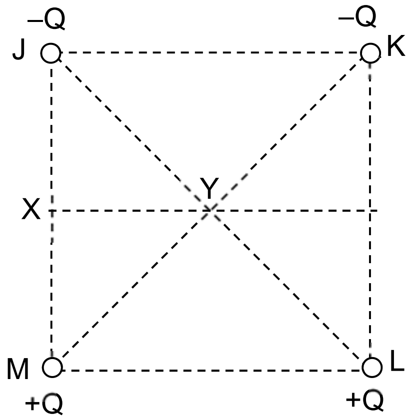
B a resultant force in the plane of the paper but no torque.

C a resultant force normal to the plane of the paper and a torque.

D a resultant force normal to the plane of the paper but no torque.

The resultant force can be seen from the diagram that it lies in the plane of the paper. The forces will produce a clockwise torque and cause the rod to rotate.

19 Four point charges are at the corners of a square JKLM. The point charges at J and K have a charge of –Q and the point charges at L and M have a charge of +Q.



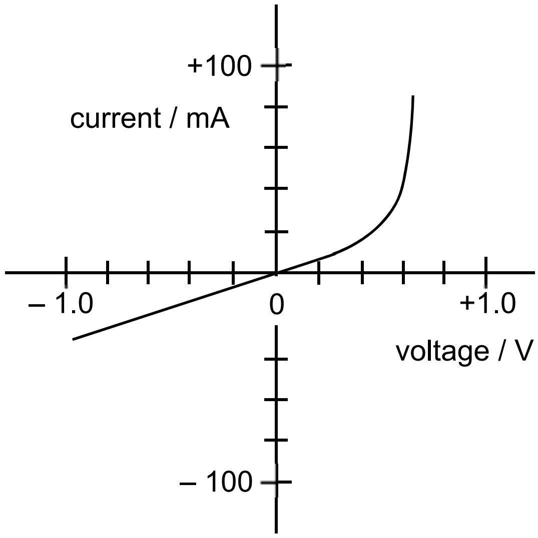
An electron is brought from point X to point Y in a straight line by an external force without any change in its speed. Which of the following is correct about the change in electric potential energy of the system and work done by the external force?

	change in electric potential energy	work done by the external force
A	positive	positive
B	negative	negative
C	negative	positive
D	zero	zero

The potentials at points X and Y are both zero, because they are each equidistant from the charges at J and M, and also equidistant from the charges at K and L.

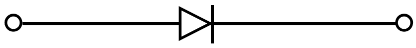
Since there is no change in the electrical potential energy from X to Y, no work is done by the external force.

20 A student is given a sealed box containing a concealed electrical circuit. The student plots the current-voltage characteristics below.

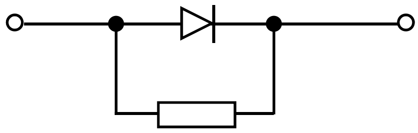


Which circuit is most likely to be enclosed within the box?

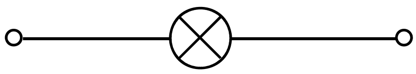
A



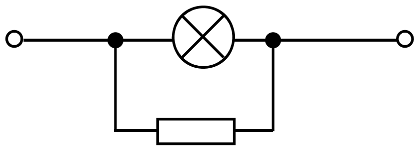
B



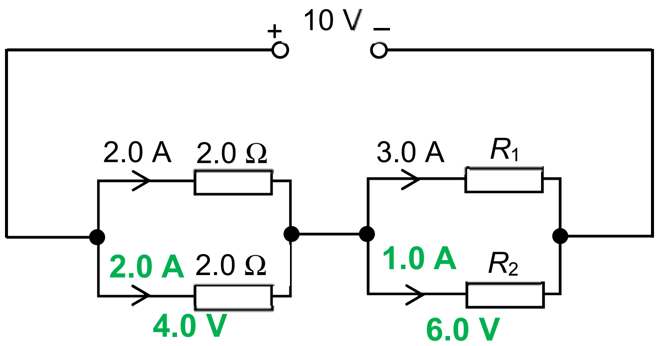
C



D



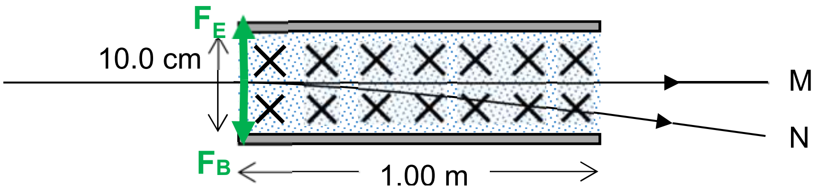
21 Four resistors are connected across a 10 V supply as shown in the circuit below.



What are the resistances R_1 and R_2?

	R_1	R_2
A	1.0 Ω	3.0 Ω
B	2.0 Ω	2.0 Ω
C	2.0 Ω	6.0 Ω
D	3.0 Ω	3.0 Ω

22 In the region of dimensions 10.0 cm by 1.00 m between two charged plates with a p.d. of 100 V, there is a uniform magnetic field of strength 100 mT directed into the page.



M and N are the paths made by electrons of different speeds.

Which of the following correctly describes the speed of the electron that made N?

A slightly smaller than 1.00×10^4 m s^{-1}

B slightly greater than 1.00×10^4 m s^{-1}

C slightly smaller than 1.00×10^5 m s^{-1}

D slightly greater than 1.00×10^5 m s^{-1}

M: $F_B = F_E$ → $B q v = q E$

$v = E / B = V / d B = 1.00\times10^4$ m s^{-1}

N: $F_B > F_E$

$v > 1.00\times10^4$ m s^{-1}

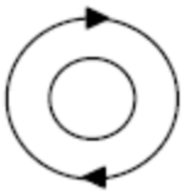
23 A circular loop of wire with radius of 0.20 m is placed in a uniform magnetic field of 1.2 T that is normal to the plane of the loop. The loop is rotated about an axis along a diameter at a rate of 50 revolutions per minute. What is the maximum instantaneous e.m.f. induced?

A 0.13 V **B** 0.15 V **C** 0.79 V **D** 47 V

$$\varepsilon = -\frac{d\phi}{dt} = -\frac{d(BA\cos\omega t)}{dt} = \omega BA\sin\omega t$$

$$\varepsilon_{\max} = \omega BA = \frac{50x2\pi}{60}x1.2x\pi x0.20^2 = 0.79V$$

24 A small circular coil lies inside a large coil. The two coils are horizontal and concentric. The large coil carries a constant clockwise current.



The smaller coil is pulled perpendicular out of the plane of the paper. Which of the following describes the direction of the induced current in the smaller coil and the resultant force between the coils?

	Induced current	Force between coils
A	Clockwise	Attraction
B	Clockwise	Repulsion
C	Anticlockwise	Attraction
D	Anticlockwise	Repulsion

25 An alternating voltage of 230 kV is supplied to a transformer, which steps the voltage down to a number of streetlamps with a rating of 230 V 150 W. If the maximum allowable current through the primary coil is 10 A, what is the maximum number of streetlamps that can be connected in parallel?

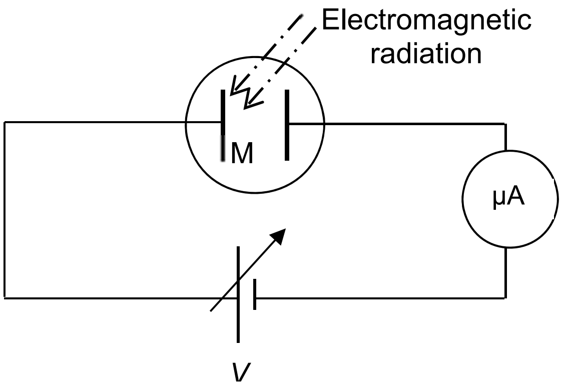
A 1500 **B** 6500 **C** 10000 **D** 15000

$N_P/N_S = V_P/V_S = 1000 = I_S/I_P$ → $I_S = 1000 \times 10 = 1\times10^4$ A

Current in each lamp = P / V = 150 / 230 = 0.65 A

No of lamps = 1×10^4 / 0.65 = 1.5×10^4

26 A 0.31 mW beam of photons with energy 3.11 eV each is incident on a clean metal plate M. The potential difference *V* is varied until the microammeter gives a maximum reading of 2.0 μA.



What is the ratio $\dfrac{\text{electrons emitted per unit time}}{\text{photons incident per unit time}}$?

A 3.2×10^{-21} **B** 2.0×10^{-2} **C** 1.0 **D** 1.3×10^{17}

Electrons: $dN_e/dt = I / e = 2.0\times10^{-6} / 1.6\times10^{-19}$

Photons: $dN_p/dt = P / E = 0.31\times10^{-3} / 3.11\times1.6\times10^{-19}$

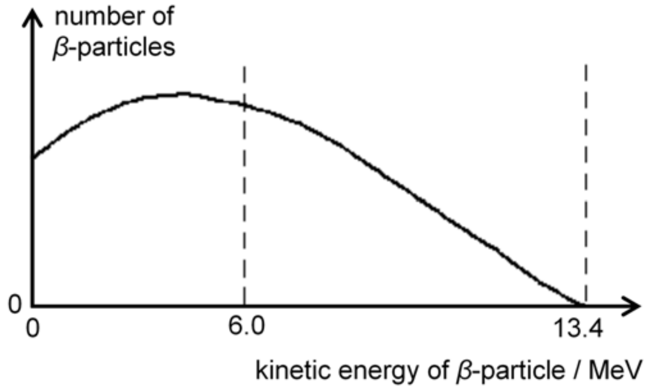
27 What is the de Broglie wavelength of an alpha particle of kinetic energy *E*, given that *u* is the unified atomic mass unit?

A $\dfrac{h}{2\sqrt{uE}}$ **B** $\dfrac{2\sqrt{uE}}{h}$ **C** $\dfrac{h}{2\sqrt{2uE}}$ **D** $\dfrac{2\sqrt{2uE}}{h}$

$E = \frac{1}{2} m v^2 = p^2/ 2m \rightarrow p = (2mE)^{1/2} = (8uE)^{1/2}$

$\lambda = h / p = h / (8uE)^{1/2}$

28 The beta spectrum for ^{12}B decay is as shown below.



The kinetic energy of an emitted β-particle is 6.0 MeV. What is the approximate energy of the associated neutrino?

A 4.0 MeV **B** 6.0 MeV **C** 7.4 MeV **D** 13.4 MeV

Based on COE and COM, the kinetic energy of the daughter nuclei is negligible hence the total energy released is shared between β particle and neutrino. Since the highest possible KE of β particle is 13.4 MeV, i.e. when neutrino has zero KE, hence the total energy released by the reaction is also 13.4 MeV, and this value is fixed for this particular reaction. Thus, when an emitted β particle has KE of 6.0 MeV, the associated neutrino must have 13.4 – 6.0 = 7.4 MeV of energy.

29 Two radioactive isotopes P and Q have half-lives of 10 minutes and 15 minutes respectively. A sample initially contains the same number of atoms of each isotope. After 30 minutes, the ratio of the number of atoms of P to the number of atoms of Q will be

A 0.25 **B** 0.50 **C** 1.0 **D** 2.0

$$\frac{\text{the number of atoms of P}}{\text{the number of atoms of Q}} = \frac{\left(\frac{1}{2}\right)^{30/10}}{\left(\frac{1}{2}\right)^{30/15}} = \frac{\left(\frac{1}{2}\right)^{3}}{\left(\frac{1}{2}\right)^{2}} = \frac{1}{2} = 0.5$$

30 At time *t*, a sample of a radioactive substance contains *N* atoms of a particular nuclide.

At time ($t + \Delta t$), where Δt is a short period of time, the number of atoms of the nuclide is ($N - \Delta N$).

Which of the following expressions gives the decay constant of the nuclide?

A $\frac{\Delta N}{N}$ **B** $\frac{N - \Delta N}{t + \Delta t}$ **(C)** $\frac{\Delta N}{N \Delta t}$ **D** $\frac{N \Delta N}{\Delta t}$

Decay constant is the fraction of the total number of undecayed nuclei present which decays per unit time. Suppose *N* is the size of a population of radioactive atoms at a given time *t*, and *dN* is the amount by which the population decreases in time *dt*; then the rate of change is given by the equation $\frac{dN}{dt} = -\lambda N$, where λ is the decay constant.

$$\frac{dN}{dt} = -\lambda N \rightarrow \lambda = -\frac{1}{N}\frac{dN}{dt} = \frac{\Delta N}{N \Delta t}$$

End of Paper

1	2	3	4	5	6	7	8	9	10
C	**D**	**C**	**A**	**C**	**A**	**B**	**A**	**C**	**B**
11	12	13	14	15	16	17	18	19	20
A	**A**	**A**	**C**	**D**	**B**	**A**	**A**	**D**	**B**
21	22	23	24	25	26	27	28	29	30
C	**B**	**C**	**A**	**D**	**C**	**C**	**C**	**B**	**C**

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

CENTRE NUMBER S

INDEX NUMBER

PHYSICS 9749/02

Structured Questions

12 September 2018

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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1	**/ 8**
2	**/ 6**
3	**/ 8**
4	**/ 6**
5	**/ 9**
6	**/ 8**
7	**/ 8**
8	**/ 8**
9	**/ 19**
Total	**/ 80**

This document consists of **19** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm / r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o^{\ 2} - x^2)}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\mu_o I / 2\pi d$
magnetic flux density due to a flat circular coil	B	=	$\mu_o NI / 2r$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

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1 In 2018, the Singapore government announced that personal mobility devices (PMDs) such as e-scooters used on public paths must not have a device speed exceeding 25 km h^{-1} or weigh more than 20 kg.

(a) Suggest why there is a need to set a speed limit and weight limit on PMDs. [2]

Momentum is the product of mass and velocity, which are related to weight and speed of PMD. [1] As force is proportional to rate of change of momentum, the amount of force a PMD can inflict is controlled. [1]
Note: award one mark only answer only state 'Setting speed limit so that rider will not be thrown outward due to sudden stop/deceleration' [1]

(b) Given that a typical e-scooter with rider has a total mass of 100 kg and that the time of impact is 0.20 s, determine the average force this scooter could cause. Assume that the e-scooter comes to rest after impact. [2]

$$F = \frac{\Delta P}{t} = \frac{(100)(0 - \frac{25\times10^3}{60\times60})}{0.20} = 3472 = 3500 \text{ N}$$

(c) Other than the speed and weight of PMDs, state and explain one other factor that can contribute to the magnitude of the force of impact caused in an accident involving PMDs. [2]

- mass of the load on the PMD. A greater load increases the momentum of the PMD/load system, contributing to a large force.

Or

- material of PMD (Hardness of material): Harder material causes shorter time of impact and by N2L, larger force.

(Area of contact is not accepted as it affects the pressure, but not the force)

(d) It is suggested that an infra-red sensor can be fixed at the front end of a PMD such that once an obstacle is detected within 30 cm, the PMD will decelerate to a stop. By reference to the maximum allowable speed of 25 km h^{-1}, explain whether this is feasible. [2]

$v^2 = u^2 + 2as$

$0 = (\frac{25\times10^3}{60\times60})^2 + 2a(0.30)$

$a = -80 \text{ m s}^{-2} \approx -8g$ [1]

Not feasible as the deceleration is several times that of *g*/deceleration is too large. [1]

2 A grenade is launched at ground level with velocity of 75 m s^{-1} and angle 20^0 from the horizontal to hit a sniper on top of a 30 m tall building at a position 245 m from the foot of the building. The sniper is standing at a distance *x* from the edge of the building.

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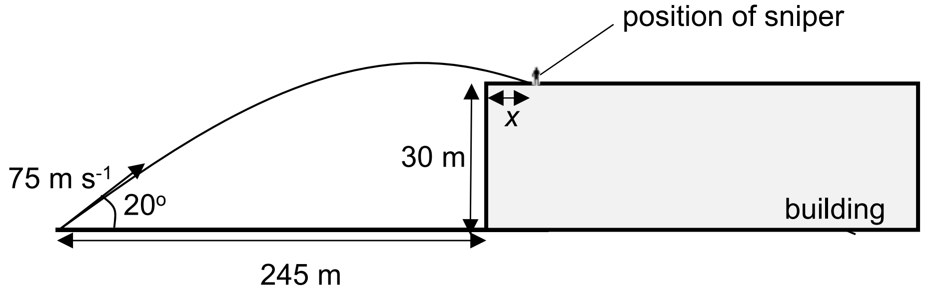

Fig. 2.1

(a) Show that the time for the grenade to reach the sniper is 3.5 s. [1]

$$s_y = u_y t + \frac{1}{2}gt^2$$

$$30 = 75\sin 20^o t - \frac{1}{2}x9.81t^2$$

$$t = 3.5\ s$$

(b) Calculate the speed of the grenade just before impact. [2]

$$v_y = u_y + at$$

$$= 75\sin 20^o - \frac{1}{2}x9.81x3.5$$

$$= 8.5\ ms^{-1}$$

$$v_x = 75\cos 20^o = 70.5\ ms^{-1}$$

$$v = \sqrt{8.5^2 + 70.5^2} = 71\ ms^{-1}$$

(c) Determine the distance, *x*, of the sniper from the edge of the building. [2]

$$u_x t = 245 + x$$

$$75\cos 20^o x3.5 = 245 + x$$

$$x = 1.7\ m$$

(d) The sniper runs away immediately from the edge of the building when the grenade is launched. Given that the grenade has a 'kill radius' of 10 m, calculate the minimum constant acceleration at which the sniper should run in order to escape. [1]

$$s = u\ t + \frac{1}{2}at^2$$

$$10 = \frac{1}{2}a.(3.5)^2$$

$$a = 1.6\ ms^{-2}$$

3 A peg is fixed to the rim of a vertical turntable of radius *r*, rotating with a constant angular speed ω, as shown below.

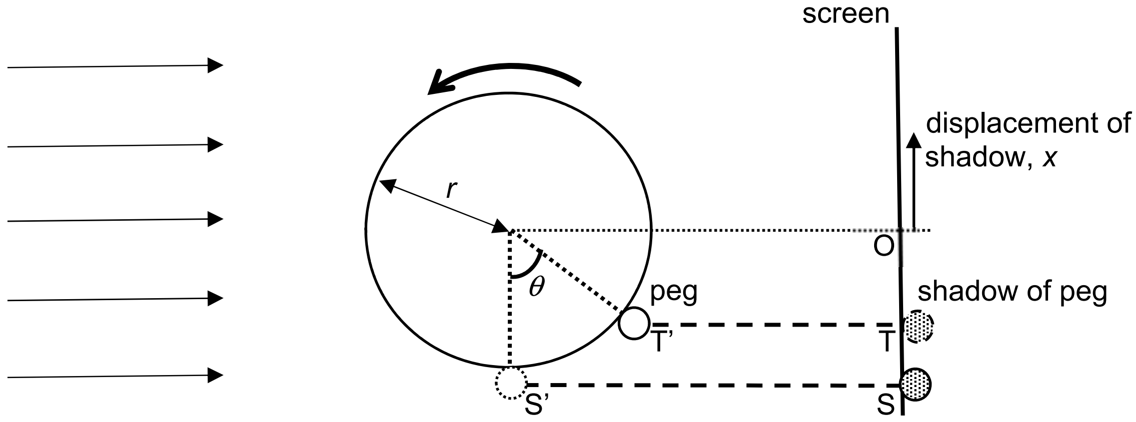

Fig. 3.1

A parallel beam of light is incident on the turntable such that the shadow of the peg is observed on the screen. Initially, the peg is at position S' and its shadow is at S. After time *t*, the peg moves through an angle of θ and it is positioned at T' while its shadow is at T. The displacement of the shadow, *x*, from O is shown in Fig. 3.1 where the upward direction is taken to be positive.

(a) **(i)** Express the angular displacement of the peg, θ, in terms of ω and *t*. [1]

$\theta = \omega t$

(ii) Write down an expression for the displacement, *x*, of the shadow on the screen in terms of ω, *t* and *r* . [1]

$x = -r\cos\omega t$

(iii) Hence, prove that the shadow of the peg is moving in simple harmonic motion. Explain your working. [2]

Since velocity is the rate of change of displacement,

$$v = \frac{dx}{dt} = -\omega(-r\sin\omega t) = \omega r\sin\omega t$$

Since acceleration is the rate of change of velocity,

$$a = \frac{dv}{dt} = \omega(r\omega\cos\omega t) = \omega^2(r\cos\omega t) = -\omega^2(-r\cos\omega t) = -\omega^2 x$$

Since acceleration of the shadow *a* is directly proportional to its displacement *x*, and is in the opposite direction to displacement, $a = -\omega^2 x$ is the defining equation of a simple harmonic equation.

(b) The turntable has a radius of 20.0 cm and angular speed of 3.5 rad s^{-1}. For the motion of the shadow on the screen,

(i) calculate the acceleration of the shadow when the shadow is instantaneously at rest, [1]

$$a = -\omega^2 x$$
$$= -(3.5)^2(0.200)$$
$$= -2.45\, m\, s^{-2}$$

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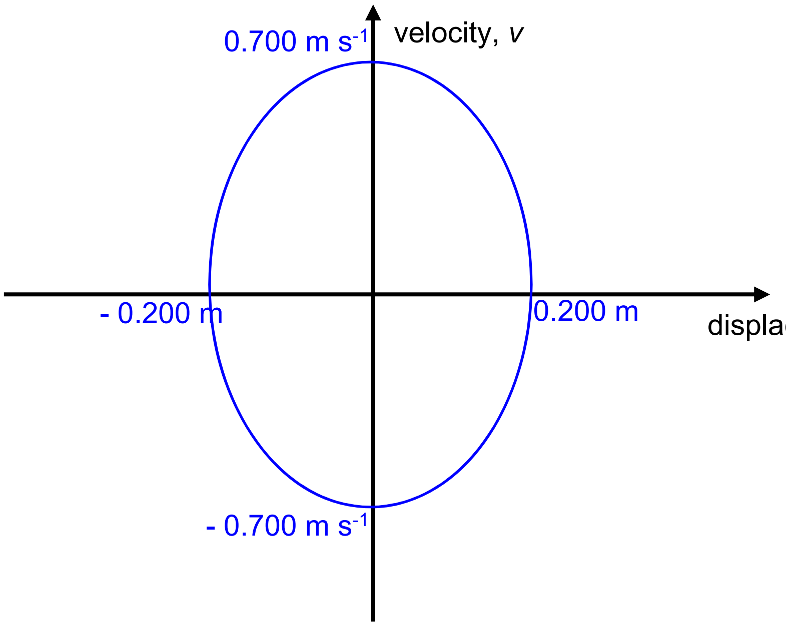
(ii) determine the velocity of the shadow as it passes through S, [1]

As the shadow passes through S, its amplitude position, it is instantaneously at rest.

$$v = \pm\omega\sqrt{x^2 - x_o{}^2}$$
$$= \pm\omega\sqrt{0.200^2 - 0.200^2}$$
$$= 0.00\, m\, s^{-1}$$

(iii) sketch the variation of the velocity, *v*, of the shadow with its displacement, *x*.



[2]

$$v_{max} = \pm\omega\sqrt{x^2 - x_o{}^2}$$
$$= \pm 3.5\sqrt{0.200^2 - 0^2}$$
$$= \pm 0.700\, m\, s^{-1}$$

Elliptical shape with max *v* (y-intercept) = 0.700 m s^{-1};
max *x* (x-intercept) = 0.200 m

4 (a) Explain what is meant by *polarised* light. [1]

Light in which the oscillations of the electromagnetic fields are all in a single plane

(b) Explain why two coherent sources of light that are polarised in planes perpendicular to each other will not produce interference fringes. [1]

The displacements due to the two waves are in perpendicular axes, thus their vector sum will not be able to produce maxima and minima, since they can never be in the same or in opposite directions.

(c) Fig. 4.1 shows the setup for a Young's double slit experiment. The polarisers are initially aligned such that the light from the slits are polarised in parallel planes. The slit separation of the double slit is 0.10 mm, the distance between the double slit and the screen is 1.50 m and the separation of the fringes produced is 0.90 cm.

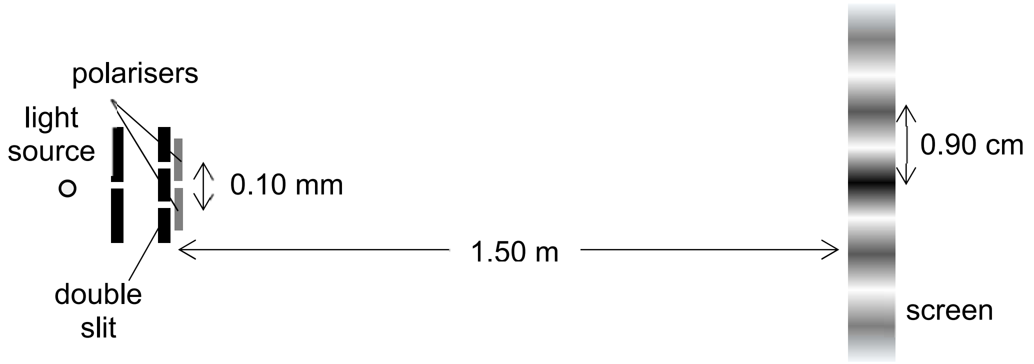


Fig. 4.1

(i) Calculate the wavelength of the light source. [2]

$\lambda = a\,x / D = 0.10\times10^{-3} \times 0.90\times10^{-2} / 1.50 = 6.00\times10^{-7}$ m

(ii) One of the polarisers is rotated by an angle of 45□ about an axis parallel to the incident light. Describe the appearance of the fringes with reference to its original appearance. [2]

Only the components of the light waves that are oscillating in parallel planes will interfere to form maxima and minima. The components that are oscillating in perpendicular planes will not be affected by each other. Thus the maxima will be less bright and the minima will be brighter.

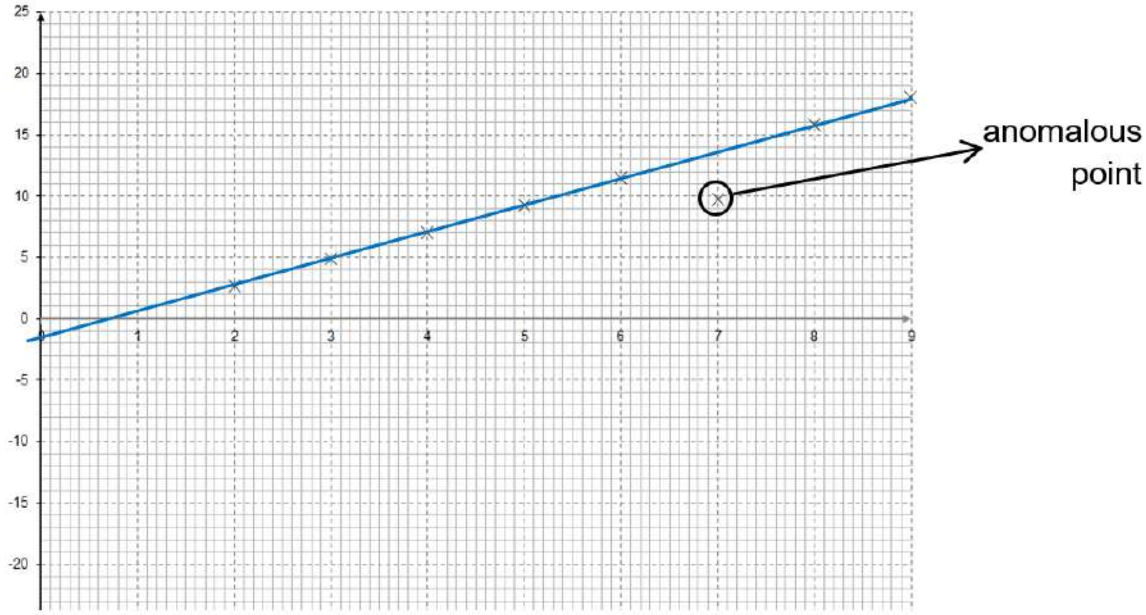
5 A stationary copper-64 nucleus undergoes a nuclear reaction to form a zinc-64 nucleus and a beta-particle. After the reaction, the zinc-64 nucleus moves off with negligible speed, while the beta-particle moves off with high speed.

(a) Explain qualitatively why the beta-particle moves off with a much higher speed than the zinc-64 nucleus. [2]

By Conservation of Momentum, the **final total momentum of Zinc-64 nucleus and beta-particle must be equal to the initial momentum of Copper-64 which is zero**. [1] As the **beta-particle is much light** than Zinc-64 nucleus, the beta-particle will have much **larger speed** in order to have a momentum equal in **magnitude** but **opposite** in direction to that of Zinc-64 nucleus. [1]

(b) The kinetic energy E_K and the distance r of the beta-particle from the centre of nucleus of zinc-64 nucleus' centre are monitored. Fig. 5.2 shows how the values of E_K varies with $\frac{1}{r}$.

Assume that the beta-particle and zinc-64 nucleus form an isolated system.



Identifying the anomalous point (circled and labelled) **and** sketching an appropriate BFL
Or
A BFL without anomalous point.

(i) By drawing an appropriate line on Fig. 5.2, determine the *y*-intercept, E_o, of the graph. [2]

Reading correctly the *y*-intercept: E_o = -2.0 x 10^{15} J

(ii) Explain the physical significance of the value of E_o found in **(b)(i)**. [2]

At $\frac{1}{r} = 0 \Rightarrow r \to \infty$. The vertical intercept represents the kinetic energy of the beta-particle when it is at an infinite distance from the Zinc-64 nucleus.

Since E_o is negative, it means that the beta-particle cannot escape from the Zinc nucleus' electric field / it requires additional k.e. to escape from the Zinc nucleus' electric field.

(iii) Assuming that total energy of the beta-particle remains constant during its motion, sketch labelled graphs on the axes in Fig. 5.2 to represent

1. the variation of the total energy E_T .

2. the variation of the electric potential energy E_P. [3]

1. Total Energy : E_T – a horizontal straight line passing through E_o.
2. EPE:

Treating the beta-particle and the Zinc-64 nucleus as an isolated system, the electric potential energy of the system $E_p = -\frac{1}{4\pi\varepsilon_0}\frac{Q_{Zn}q_\beta}{r} \propto -\frac{1}{r}$

When $r \to \infty \Rightarrow \frac{1}{r} = 0$, $E_p = 0$.

When $\frac{1}{r} = 9 \times 10^{13}$ m^{-1}, $E_K = 18.0 \times 10^{-15}$ J,

$\Rightarrow$ Therefore $E_P = E_T - E_K = (-2-18) \times 10^{-15}$ J $= -20.0 \times 10^{-15}$ J

Hence, E_p graph is a straight line graph with negative gradient, passing through (0,0) and (9, -20).

[1]: a negative gradient straight line graph passing through (0,0)

[1]: The line passes through (9, -20.5) – note that shape of line must be correct first for the second mark to be awarded.

6 Fig. 6.1 shows a circuit consisting of two resistors connected in series to a d.c. supply.

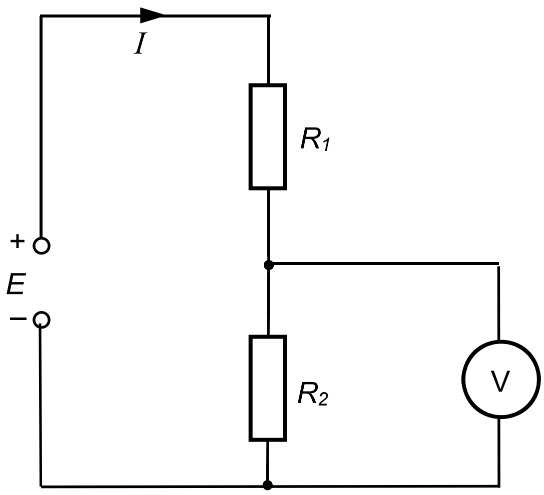


Fig. 6.1

The resistors have resistances R_1 and R_2. The supply has e.m.f. E and negligible internal resistance. The current from the supply is I. The voltmeter has an infinite resistance.

(a) By reference to Ohm's Law, show that the voltmeter reading V is given by the relation

$$V = \left(\frac{R_2}{R_1 + R_2}\right)E.$$

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[2]

By Ohm's Law, $E = IR_{tot}$

$$I = \frac{E}{R_{tot}} = \frac{E}{R_1 + R_2}$$

Potential difference across R_2, $V = IR_2$

$$= \left(\frac{E}{R_1 + R_2}\right)R_2 = \left(\frac{R_2}{R_1 + R_2}\right)E \quad \text{[shown]}$$

(b) Fig. 6.2 shows a circuit that includes a thermistor.

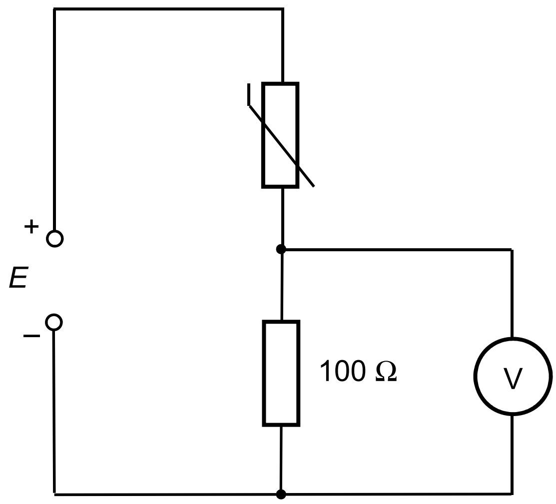

Fig. 6.2

Describe and explain how the voltmeter reading changes as the temperature of the thermistor is increased. [2]

As the temperature of the thermistor is increased, the resistance of the thermistor will decrease (R_1 decreases). As the resistance of the 100 Ω resistor remains constant, the ratio of its resistance to the total resistance will increase, i.e. $R_2/(R_1$

+ R_2) will increase. As such the potential difference across the 100 Ω resistor increases and the voltmeter will register a higher reading.

(c) Fig. 6.3 shows a circuit that includes a potentiometer wire. It is used to test E_T, the e.m.f. of the test cell and the balance length is found to be *b*.

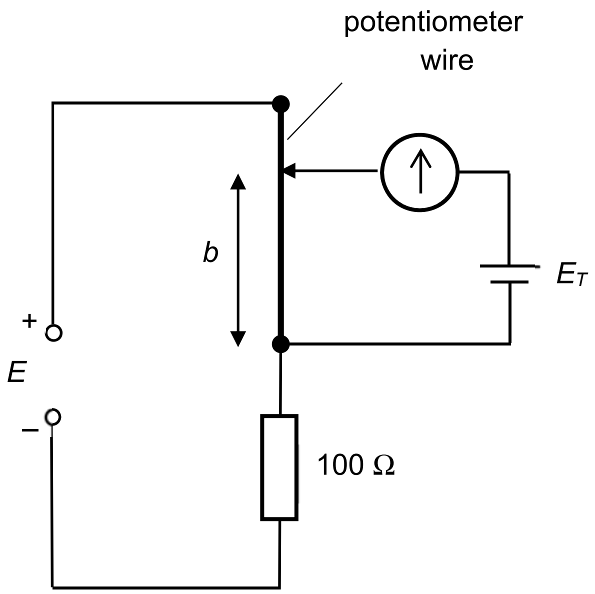

Fig. 6.3

(i) The potentiometer wire, of 1.00 m long, is made of nichrome wire of resistivity 1.57×10^{-6} Ω m and has a uniform radius of 0.10 mm. Determine the resistance of the potentiometer wire. [2]

$$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2} = \frac{1.57 \times 10^{-6}(1.00)}{\pi(0.10 \times 10^{-3})^2} = 50\ \Omega$$

(ii) Given that the ratio of $\frac{E_T}{E} = 0.20$, determine the balance length *b*. [2]

Potential across potentiometer wire $= \frac{50}{50+100} \times E = 0.333\ E$

balance length $b = \frac{0.20}{0.333} \times 1.00 = 0.60$ m

7 (a) Define *magnetic flux density*. [1]

Magnetic flux density is defined as the force acting per unit length per unit current on a conductor carrying current placed at right angles to the magnetic field.

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(b) A 1.0 m long wire carrying a current of 2.0 A is placed in a magnetic field. When it is aligned with XX' as shown in Fig. 7.1A, it experiences a force of 0.50 N that is directed into the page. When it is aligned with YY' as shown in Fig. 7.1B, it experiences a force of 0.80 N that is directed out of the page.

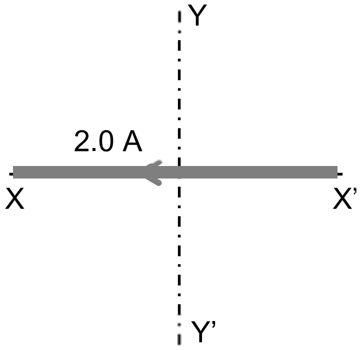

Fig. 7.1A

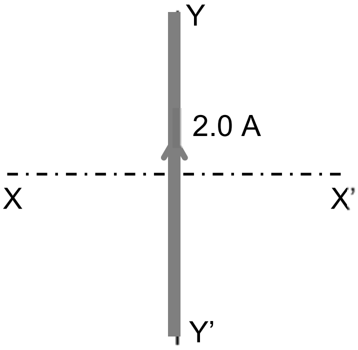

Fig. 7.1B

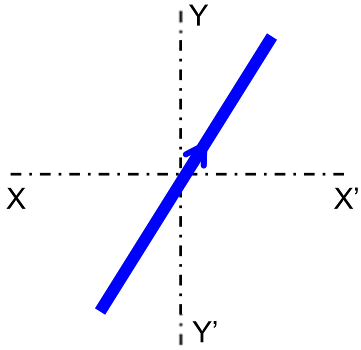

Fig. 7.1C

(i) Calculate the magnetic flux density of the field present. [3]

$(F/L)_x = B_y I$ → $B_y = 0.50 / 2.0 = 0.25$ T ↑
$(F/L)_y = B_x I$ → $B_x = 0.80 / 2.0 = 0.40$ T ←
$B = \sqrt{(0.25^2 + 0.40^2)} = 0.47$ T

(ii) Determine the position of the wire such that it experiences a force of the maximum magnitude. Draw <u>accurately</u> the position of the wire in Fig. 7.1C. [2]

$\theta = \tan^{-1}(0.25 / 0.40) = 32^o$
Direction of B is $\perp$ 32^{o} → Alignment of wire for maximum force is $\underline{\angle}$ 58^o

(c) The current-carrying wire in **(b)** has a magnetic field of its own. Show, by calculation, that it is impossible to find a point near the wire such that its magnetic flux density at that point has the same magnitude as the field present. [2]

$B = \mu_0 I / 2\pi d$ → $0.47 = 2\times10^{-7} \times 2.0 / d$
$d = 8.5\times10^{-7}$ m
distance is much smaller than thickness of wire → not possible

8 In Singapore, the power stations are situated near the coast because sea water is used to condense steam into water. The transmission of electric power over long distances from the power stations to homes would not be feasible without transformers.

A step-up transformer near the power station boosts the station's output root-mean-square (r.m.s.) voltage from 12.0 kV to 240 kV and a series of step-down transformers near the homes reduces the r.m.s. voltage to a final value of 240 V at the homes. The transmission voltage has a frequency of 50 Hz.

(a) For the transformer located near the power station, determine the ratio

$$\frac{N_p}{N_s} = \frac{\text{number of turns of primary coil}}{\text{number of turns of secondary coil}}.$$

[1]

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$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$
$$= \frac{12000}{240000}$$
$$= 0.05$$

(b) Explain why

(i) the voltage is stepped up near the power plant, [2]

The same power delivered at **higher transmission voltage** would result in a **lower transmission current**.
Lower current results in **lower power loss/dissipated in the power cables**.

(ii) an alternating voltage is used instead of direct voltage to transmit electrical energy. [1]

Alternating voltage can set up a **changing magnetic flux linkage** in a transformer which can be used to step the transmission voltage up or down.

(c) **(i)** Determine the r.m.s. current delivered to an electric kettle rated at 700 W when it is connected to a power socket in the house. [1]

Kettle power rating = P_{avg}
$P_{avg} = V_{rms}I_{rms}$
I_{rms} = 700/240 = 2.92 A

(ii) Calculate the peak output voltage to the electric kettle. [1]

$V_0 = \sqrt{2} \times V_{rms} = \sqrt{2} \times 240$
= 339 V

(d) On Fig. 8.1 below, sketch a labelled graph for the variation with time *t* of the thermal power *P* dissipated by the electric kettle.

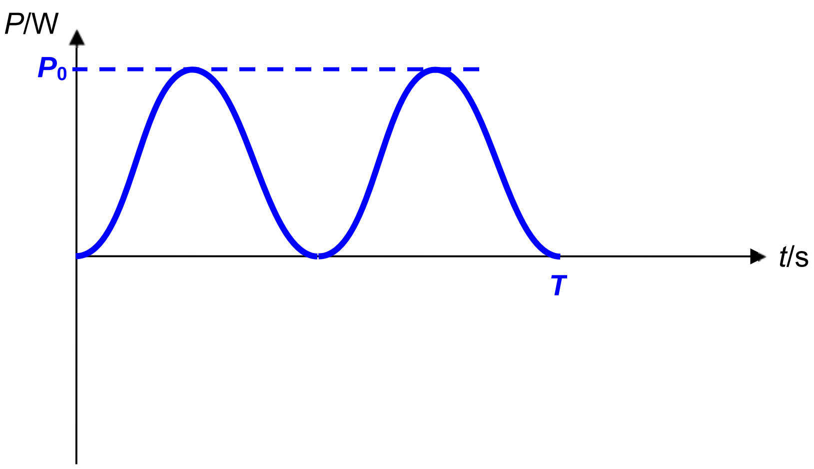

Fig. 8.1

[2]

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9 The use of satellites for communication using microwaves is relatively commonplace, for example in telephone links. The most useful sort of satellite orbit is a geostationary or geosynchronous one. It orbits the Earth which has a radius of 6.4×10^3 km. The microwave transmitting and receiving dishes do not have to constantly change their orientation, but can constantly point in the same direction.

One disadvantage, however, in the use of the geostationary satellite is that there will be regions on Earth where the satellite will appear to be below the horizon and cannot be seen at all. As shown in Fig. 9.1, there will be an angle, θ, above the equator, beyond which an observer on Earth cannot see the geostationary satellite.

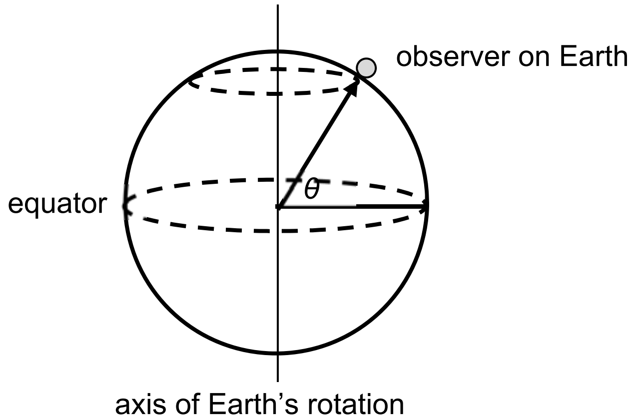

Fig. 9.1

Communication to and from moving ships and aircraft over long distances is obviously more difficult, even with geostationary satellites. Large ships move relatively slowly, and can carry a transmitting dish and the tracking equipment to keep it pointing in the right direction (assuming they know where they are on the Earth's surface accurately enough). However, small boats and aircraft have a weight and size problem; aircraft have the added complication of high speeds.

A type of microwave transmitter (and receiver) has been developed which can transmit in almost any carefully controlled direction without any moving parts, making it lighter and less vulnerable to mechanical damage than a conventional dish. The working principle is shown in Fig. 9.2.

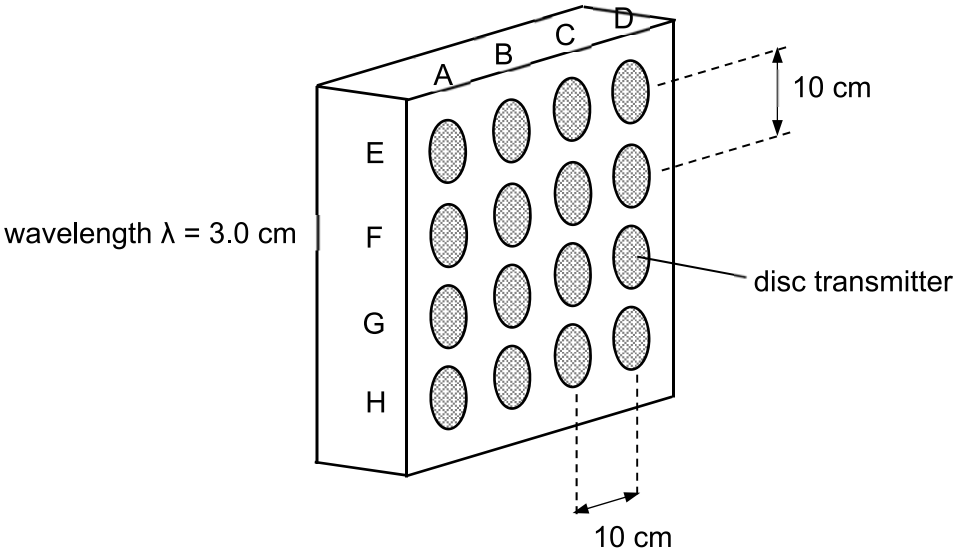

Fig. 9.2

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Fig. 9.2 shows a microwave transmitter which consists of 4 columns of discs, column A, B, C and D, and four rows of discs, row E, F, G and H. Each disc can have a different phase difference introduced into the signal before it is transmitted. For instance, if all the signals are in phase, there will be a strong signal sent directly in front of the array, but if row G is 1 cycle behind row H, row F 2 cycles behind row H and row E 3 cycles behind row H, a strong signal is sent upwards at an angle of about 17°. This is very similar to the way in which a diffraction grating works for light. Care has to be taken in choosing the spacing in the array, otherwise there could be very little signal in some directions.

(a) Calculate the time it takes a geostationary satellite to orbit the Earth once. [1]

time = 24.0 × 3600 = 8.64 × 10^4 s

(b) A geostationary satellite must be positioned directly above the Equator. Explain why this is so. [3]

This is to ensure that the satellite rotates about the same axis as the Earth. The line joining the object and the centre of Earth (which the gravitational force acts along) has to pass through the Equator and rests along the plane perpendicular to the Earth's axis of rotation.
If the object lies above other latitudes besides the equator, its axis of rotation will not coincide with that of the Earth's. As such it will be above different latitudes as it rotates and will not be geostationary.

(c) Using the data provided and your answer in **(a)**, show that the radius of a geostationary orbit is 4.2 × 10^4 km. Explain your working. [3]

The gravitational force on the satellite by Earth provides the centripetal force for it to orbit the Earth.
By Newton's 2nd Law of motion,

$$\Sigma F = ma$$

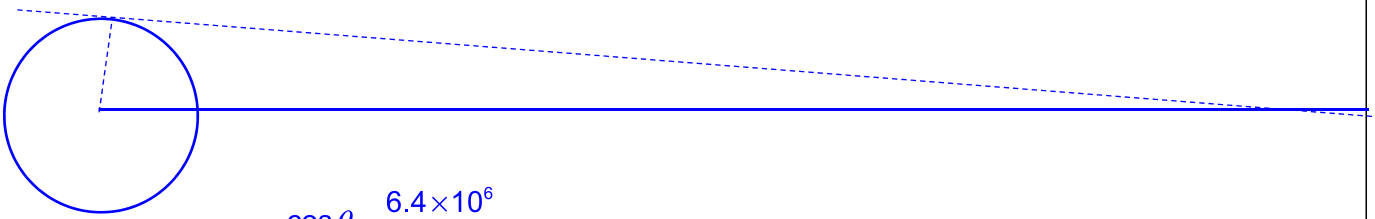
$$\frac{GM_E m}{r^2} = mr\omega^2$$

$$\frac{GM_E m}{r^2} = mr\left(\frac{4\pi^2}{T^2}\right)$$

$$r = \sqrt[3]{\frac{GM_E T^2}{4\pi^2}} = \sqrt[3]{\frac{gR_E{}^2 T^2}{4\pi^2}} = \sqrt[3]{\frac{(9.81)(6.4\times10^6)^2(86400)^2}{4\pi^2}} = 4.2\times10^7 \text{ m}$$

(Near the Earth's surface, $g = \frac{GM_E}{R_E{}^2} \Rightarrow GM_E = gR_E{}^2$)

(d) Estimate, by scale drawing or otherwise, the angle θ above the Equator at which a receiving dish can be and still "see" the satellite. [3]



$$\cos\theta = \frac{6.4\times10^6}{4.2\times10^7}$$

$$\theta = 81°$$

accept 75° to 85° for scale drawing; 81° for exact calculation

For Examiner's Use

(e) Show that the angle of 17° given in the passage is correct. [1]

$d\sin\theta = n\lambda$

$$\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right)$$

$$= \sin^{-1}\left(\frac{1\times 0.030}{0.10}\right)$$

$$= 17°$$

(f) A strong signal can be sent out if the phase relationships were as follows; vertical column A all in phase, column B all 1/3 of a cycle later, column C all 2/3 of a cycle later and column D all 1 cycle later.

(i) Calculate the path difference of the waves between adjacent column. [1]

Path difference = 1/3 × 0.03. = 0.010 m

(ii) Hence, determine the angle and direction, of this strong signal. [2]

$d\sin\theta = n\lambda$

$$\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right)$$

$$= \sin^{-1}\left(\frac{\frac{1}{3}\times 0.030}{0.10}\right)$$

$$= 5.7°$$

Direction to towards column D.

(g) Suggest, in principle, and without technical details, how a ship's communication with satellites could be used as a navigation aid, so that it can know accurately where its position is. [3]

The ship can transmit signals in all directions by varying the phase difference between the columns as well as the rows of transmitters. When the signal is received by a satellite in a known position, the satellite can transmit a signal back to notify the ship. The ship can then use its own orientation on Earth (using a compass) and the phase differences between the columns and rows to calculate the exact location it is on the Earth's surface.

(h) "Care has to be taken in choosing the spacing in the array". In this "phased array" setup, it is essential that each disc is only a few wavelengths apart from its neighbouring discs. Suggest why the discs cannot be positioned too close together or too far apart. [2]

If the discs are positioned too close together (much less than 1 wavelength), signals can only be detected at certain angles.
If the discs are positioned too far apart, a small phase difference between the discs will not change the angle of the signal significantly.

End of Paper

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS 9749/03

Paper 3 Longer Structured Questions

20 September 2018

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

You are advised to spend about one and a half hours on Section A, and about thirty minutes on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	**/ 7**
2	**/ 6**
3	**/ 8**
4	**/ 10**
5	**/ 10**
6	**/ 7**
7	**/ 12**
Section B	
8	**/ 20**
9	**/ 20**
Total	

This document consists of **21** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1} $(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm / r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o^2 - x^2)}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\mu_o I / 2\pi d$
magnetic flux density due to a flat circular coil	B	=	$\mu_o NI / 2r$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_o \exp(-\lambda t)$
decay constant	λ	=	$\ln 2 / t_{1/2}$

Section A

Answer **all** the questions in the spaces provided.

1 Capacitance measures the ability of an electrical component to store charge and is defined as the ratio of charge stored in a capacitor to the potential difference across it.

(a) The S.I. unit for capacitance is the farad (F). Express F in S.I. base units.

$F = C\ V^{-1}$

$C = A\ s$ and $V = [W/q] = kg\ m^2\ s^{-2}\ A^{-1}\ s^{-1} = kg\ m^2\ s^{-3}\ A^{-1}$

$F = kg^{-1}\ m^{-2}\ s^4\ A^2$

F = ... [3]

(b) A capacitor of capacitance 50 μF is charged using a cell in the circuit shown in Fig. 1.1.

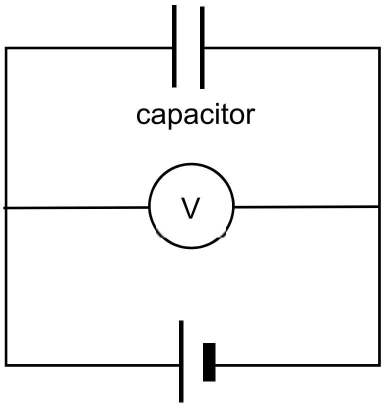


Fig. 1.1

(i) The voltmeter reads 2.20 V. By applying the given definition of capacitance, calculate the charge stored in the capacitor to 3 significant figures.

$C = Q / V \rightarrow Q = 50\times10^{-6} \times 2.20 = 1.10 \times10^{-4}$ C

(ii) The uncertainty of the voltmeter reading is ±0.05 V, and the capacitance of the capacitor has a tolerance of ±10%.

Express the charge stored in the capacitor in the form of ($Q \pm \Delta Q$).

$Q = C\ V$

$\Delta Q/Q = \Delta C/C + \Delta V/V = 0.10 + 0.05/2.20 = 0.12$

$\Delta Q = 0.1\times10^{-4}$ C

$Q \pm \Delta Q = (1.1 \pm 0.1) \times10^{-4}$ C

2 A person supports a load of 20 N in his hand as shown in Fig. 2.1. The system consisting of the arm and load is equivalent to the system shown in Fig. 2.2. The rod represents the forearm, and *T* represents the tension exerted in the biceps. The forearm weighs 65 N.

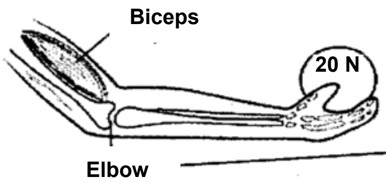


Fig. 2.1

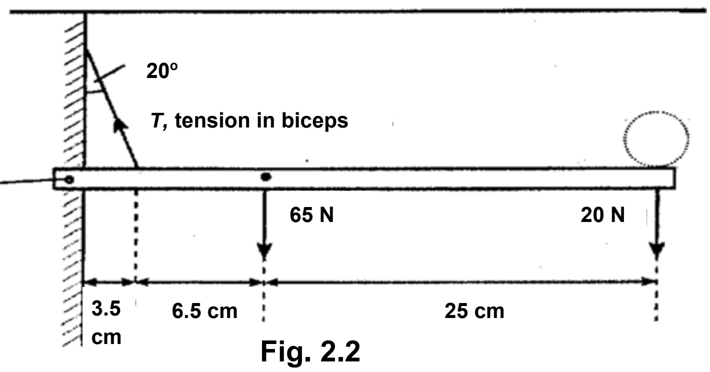


Fig. 2.2

(i) Show that the tension T in the biceps is 410 N. [2]

Taking moments about elbow

$T\cos 20^{o} \times 0.035 = [20 \times (0.250+0.065+ 0.035)] + [65 \times (0.065+ 0.035)]$

$T = 410$ N

(ii) Hence, determine the magnitude and direction of the force acting at the elbow.

Let the force acting on the elbow be F.

Horizontal component of $F = 410 \times \sin 20^{o} = 140.2$ N right

Vertical component of $F = (410 \times \cos 20^{o}) – 65 – 20 = 300.3$ N downwards

$F = \sqrt{(300.3^2 + 140.2^2)} = 331$ N

$\theta = \tan^{-1}(300.3/140.2) = 65^{o}$ below forearm

3 At Luna Amusement Park in Sydney, Australia, the Rotor and Big Dipper Rollercoaster are the most exciting rides.

(a) The popular Rotor ride consists of a large vertical cylinder, which spins about its axis so quickly that any person standing inside is held against the wall when the floor drops away. The passengers maintain horizontal circular motion at constant speed within the cylinder. The normal contact force *N* acting on each passenger is related to the frictional force *f* on the passenger by a constant μ as given by the expression $f = \mu N$.

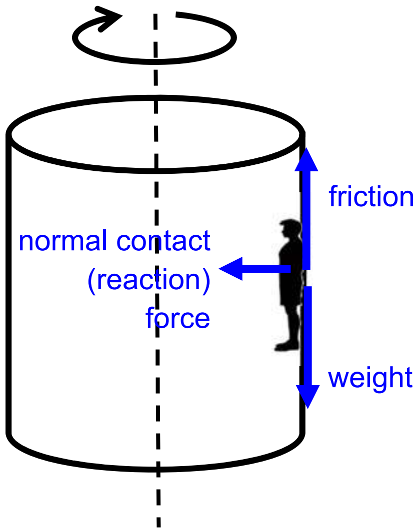


Fig. 3.1

(i) Draw and label, on Fig. 3.1, the forces acting on the passenger. [1]

All forces spelled out in full and in the correct direction

(ii) Show that the linear velocity *v* at which the cylinder of radius *R* must rotate is independent of the mass of the passenger, m.

By Newton's First Law,

$$\sum F_y = ma = 0$$
$$f - W = 0$$
$$f = mg \ldots (1)$$

Normal contact force provides the centripetal force for the passenger to be in circular motion.

$$\sum F_c = ma_c$$
$$N = \frac{mv^2}{R} \quad where\ f = \mu N$$
$$\frac{f}{\mu} = \frac{mv^2}{R} \ldots (2)$$

Taking (2) / (1):

$$\frac{\frac{f}{\mu}}{f} = \frac{\frac{mv^2}{R}}{mg}$$

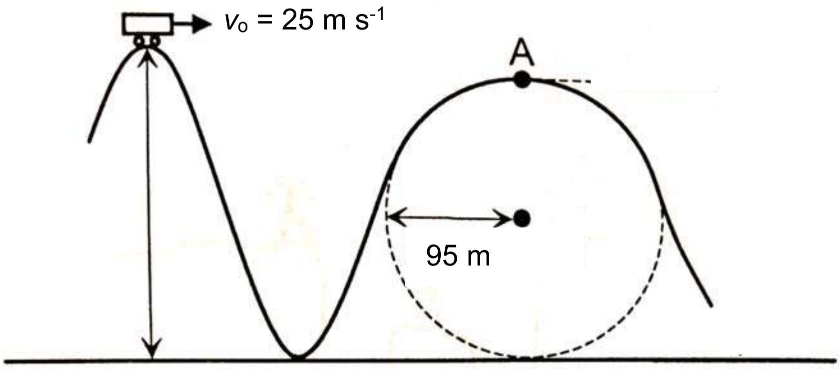
$$\frac{1}{\mu} = \frac{v^2}{Rg}$$

$$v = \sqrt{\frac{Rg}{\mu}}$$

where velocity v is independent of mass m.

[3]

(b) The cart on the exhilarating Big Dipper Rollercoaster moves with negligible friction along the track as shown. The cart travels with an initial speed v_o of 25 m s^{-1} at the top of one hill, of height h, before reaching the top of a second hill, which forms a circular arc of radius 95 m.



(i) Calculate the maximum speed at which the cart can travel without leaving the track at the top of the second hill at point A.

$$\sum F_c = ma_c$$

$$W - N = \frac{mv^2}{r}$$

Upon losing contact, $N = 0$

$$W = \frac{mv^2}{r}$$

$$mg = \frac{mv^2}{r}$$

$$v = \sqrt{rg}$$

$$= \sqrt{95 \times 9.81}$$

$$= 30.528$$

$$= 30.5\, m\, s^{-1}$$

maximum speed = ... m s^{-1} [2]

(ii) Hence, determine the maximum height, *h*, of the first hill for the condition in **(b)(i)** to hold. [2]

By Principle of Conservation of Energy,

$$GPE_{top\ of\ hill} + KE_{top\ of\ hill} = GPE_{At\ A} + KE_{At\ A}$$

$$mgh + \frac{1}{2}m(25)^2 = mg(95\times2) + \frac{1}{2}m(30.528)^2$$

$$h = 206\,m$$

h = ... m [2]

4 **(a)** "The magnitude of *gravitational field strength* at a point is proportional to the *gravitational potential gradient* at that point."

Explain the terms in italics.

gravitational field strength: gravitational force per unit mass

gravitational potential gradient: change in gravitational potential energy per unit mass per unit distance, *or* work done per unit mass against gravitational force per unit distance

(b) Fig. 4.1 shows four equipotential lines at 1000-km intervals in a non-uniform gravitational field.

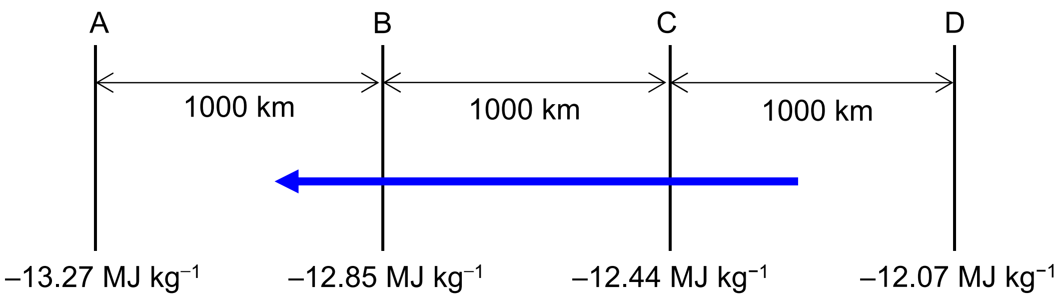


Fig. 4.1

(i) Draw an arrow on Fig 4.1 to indicate the direction of the gravitational field. [1]

(ii) Calculate the ratio of

$$\frac{\text{field strength at B}}{\text{field strength at C}}$$

Field strength at B = $(13.27 – 12.44)\times10^6 / 2000\times10^3 = 0.415$ N kg^{-1}

Field strength at C = $(12.85 – 12.07)\times10^6 / 2000\times10^3 = 0.390$ N kg^{-1}

Ratio = 0.415 / 0.390 = 1.06

ratio = ... [3]

(c) A theoretical long open tube is placed in the gravitational field as shown in Fig. 4.2. An object is released from rest at B.

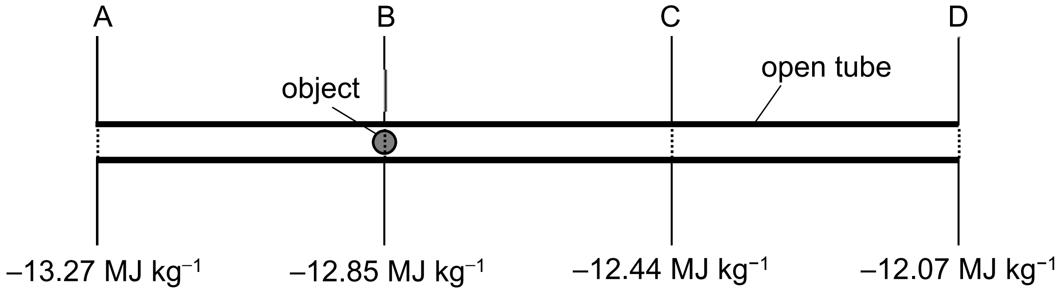


Fig. 4.2

Determine the speed with which the object leaves the tube.

object will accelerate to the left

Loss in GPE = m (13.27 – 12.85)$\times 10^6$ = 0.42$\times 10^6$ m

Gain in KE = ½ m v^2 – 0 = 0.42$\times 10^6$ m

v = 917 m s^{-1}

speed = ………………………… m s^{-1} [4]

5 **(a)** State what is meant by the term *internal energy of an ideal gas*.

The internal energy of an ideal gas is the sum of the microscopic kinetic energy due to random motion of all the atoms/molecules of the gas.

(b) The pressure *p* exerted by an ideal gas is given by the equation

$$p = \tfrac{1}{3}\rho < c^2 >$$

State what the symbols ρ and $<c^2>$ represent.

ρ: density of the gas

$<c^2>$: mean-square speed of the atoms/molecules in the gas

(c) Use the equation given in **(b)** to show that the total kinetic energy of the molecules of an ideal gas of volume *V* and pressure *p* is given by $\frac{3}{2}pV$.

$$p = \tfrac{1}{3}\rho < c^2 > = \tfrac{1}{3}\frac{Nm}{V} < c^2 >$$

where *N* is the number of molecules in the gas; *m* the mass of each molecule and *V* the volume of the gas. Therefore,

$$pV = \tfrac{1}{3}Nm < c^2 >$$

$$\tfrac{1}{2}Nm < c^2 > = \frac{3}{2}pV$$

(d) **(i)** Calculate the internal energy of an ideal gas of volume 3.4 × 10^{-4} m^3 when its pressure is 100 kPa.

$$\text{Internal Energy} = \frac{3}{2}pV$$
$$= \frac{3}{2}(100\times10^{3})(3.4\times10^{-4})$$
$$= 51\text{ J}$$

(ii) Calculate the increase in internal energy when the gas expands at constant pressure to a volume of 8.8 × 10^{-4} m^3.

$$\text{Increase in internal Energy} = \frac{3}{2}p\Delta V$$
$$= \frac{3}{2}(100\times10^{3})(8.8\times10^{-4} - 3.4\times10^{-4})$$
$$= 81\text{ J}$$

(iii) Determine the heat supplied to the gas so as to enable the expansion at constant pressure to take place.

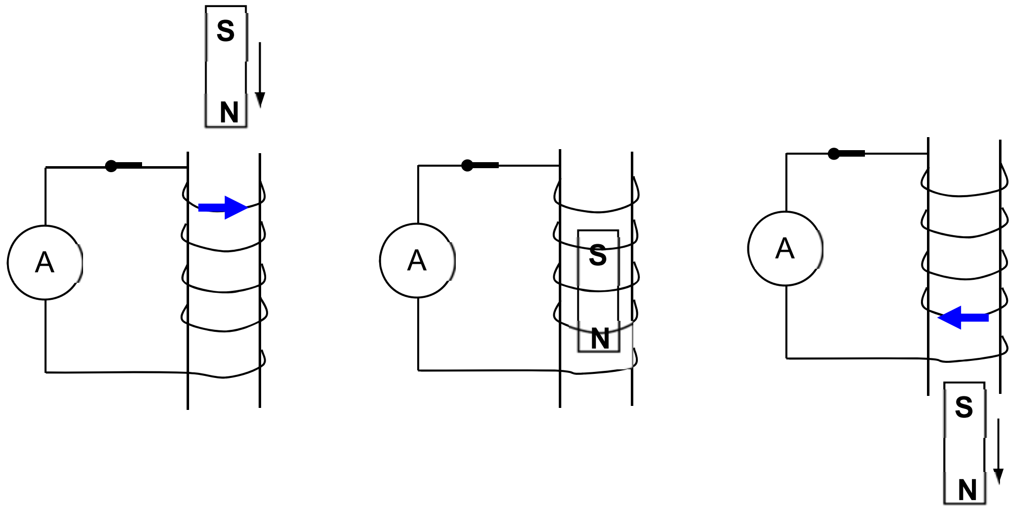
$$\text{Work done by gas} = p\Delta V$$
$$= (100\times10^{3})(8.8\times10^{-4} - 3.4\times10^{-4})$$
$$= 54\text{ J}$$

$$\Delta U = Q + W$$
$$81 = Q - 54$$
$$Q = 135\text{ J}$$

6 **(a)** State Lenz's Law.

Lenz's law states that the e.m.f. is induced in the direction such that its effects oppose the change in the magnetic flux linkage that is inducing it. [1]

A strong magnet is allowed to drop through a solenoid which is wound around a cardboard tube. The solenoid is connected to a switch and an ammeter.



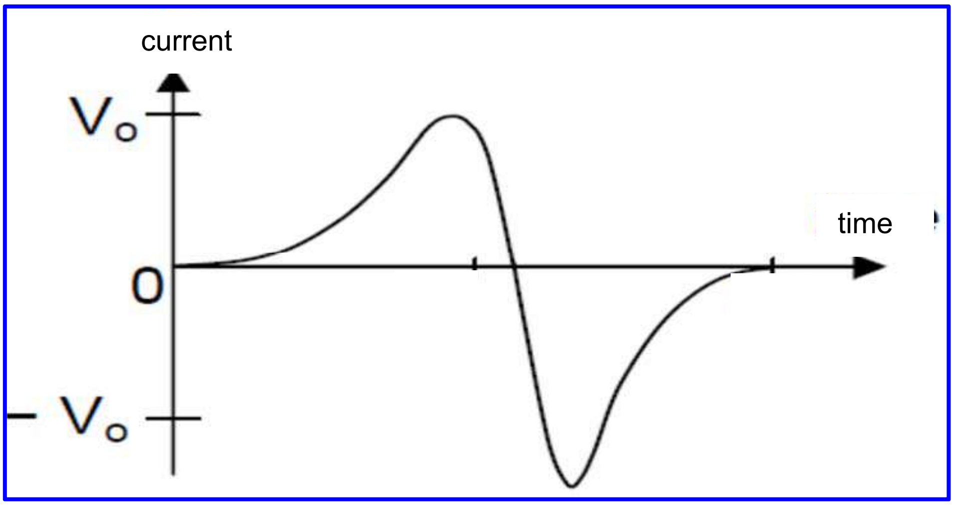
Magnet approaching solenoid
Fig. 6.1A

Magnet in the middle of solenoid
Fig. 6.1B

Magnet leaving solenoid
Fig. 6.1C

(b) Indicate, with arrows on the winding of the solenoid in Fig. 6.1A, Fig. 6.1B and Fig. 6.1C, the direction of any induced current. [2]

(c) Hence, sketch on Fig. 6.2 a labelled graph showing the variation with time of the current induced in the solenoid as the magnet falls through it. [2]



Correct shape/positive & negative current. [1]

Peak of current for retreating magnet is greater. [1]

(d) The switch connected to the solenoid is now opened, and the same magnet is allowed to drop through the solenoid again.

State and explain any change in the speed of the magnet as it leaves the solenoid.

The speed of the magnet increases. [1]

Since the switch is opened; there is no induced current in the solenoid to produce an opposing induced magnetic field to oppose the motion of the magnet. [1]

7 **(a)** Tungsten, a transition metal, is commonly used as a target metal for the production of X-rays. The energy levels of the K- and M-shells for tungsten are shown in Fig. 7.1 below.

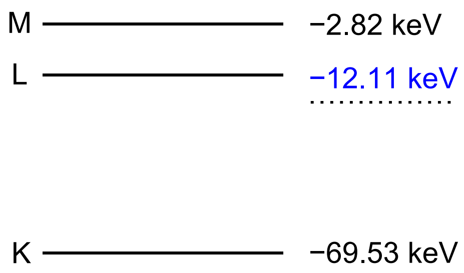


Fig. 7.1

The wavelength of the photon produced by the K_α transition is 21.65 pm.

(i) Complete Fig. 7.1 by filling in the energy level of the L-shell for tungsten.

$$E = \frac{h\,c}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{21.65 \times 10^{-12}}$$

$= 9.187 \times 10^{-15}$ J = 57.42 keV

E_2 = –69.53 + 57.42 = –12.11 keV

Examiner's comments:
A number of students rounded values prematurely, resulting in inaccurate final values.

[2]

(ii) Determine the wavelength of the photon produced by L_α transition.

−2.82−(−12.11) = 9.29 keV

$$\lambda = \frac{h\,c}{E} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{9.29 \times 10^{3} \times 1.6 \times 10^{-19}}$$

= 134 pm

wavelength = ... pm [1]

The intensity of various photon wavelengths from electron bombardment of a tungsten target metal is shown in Fig. 7.2 below.

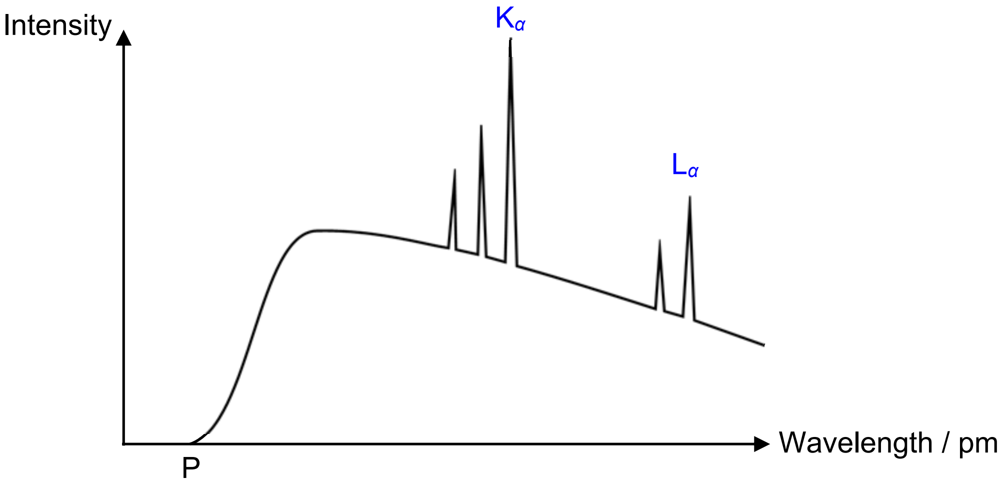


Fig. 7.2

(iii) On Fig. 7.2, label the peaks for K_α and L_α transitions. [2]

(iv) State the significance of the value of P.

indicates highest energy photons / KE of electrons [1]

no marks for "minimum wavelength" only

.... [1]

Examiner's comments

An alarming number of students used phrasing that indicates a concept error. Photons do not have KE, nor is KE "transferred" from electrons to photons.

(v) With reference to Fig. 7.1, explain why the electrons bombarding the target metal must have a minimum energy of 69.53 keV to produce the spectrum shown in Fig. 7.2.

To produce the characteristic lines in the spectrum, [1]

electrons must have sufficient energy to knock out / remove K-shell electrons.[1]...

The amount of energy required to bring the electron from K-shell to ionized state is 69.53 keV / the energy level of the K-shell is −69.53 eV. [1]

Examiner's comments:

Some students are still labouring under the misconception that electrons can deexcite from "infinity energy level" to ground state and produce a photon. E_∞ indicates the electron has escaped the atom (free electron) and has a minimum energy of 0 eV [3]

(b) Fig. 7.3 below shows a typical setup for producing such X-ray beams.

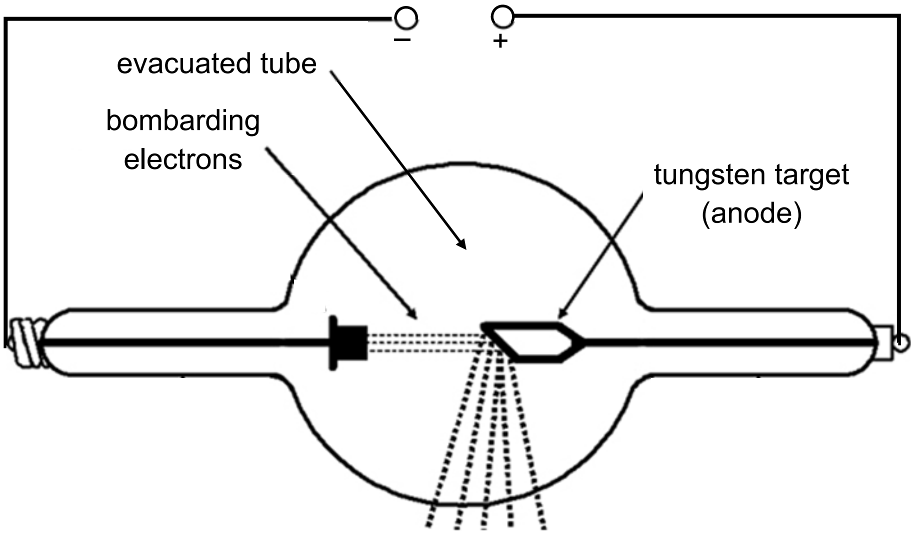


Fig. 7.3

For safety reasons, the wavelength of radiation used for medical X-rays is no shorter than 50 pm. Explain, with calculation, how the setup in Fig. 7.3 can be adjusted to ensure that the wavelength of the X-rays produced does not fall below 50 pm.

Minimum wavelength of X-rays produced is determined by KE of electrons which is, in turn, determined by the accelerating p.d. [1]

$$eV = \frac{hc}{\lambda}$$

$$= \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{50 \times 10^{-12}}$$

V = 2.5×10^4 V = 25 kV [1] for working to show value of V

The accelerating p.d. is to be kept under 25 kV. [1]

[3]

Section B

Answer **one** question from this section in the spaces provided.

8 **(a)** Point source P, consisting of light with wavelength 630 nm, passes through a narrow slit and is incident on a screen at a distance of 2.4 m from the slit. Fig. 8.1 below shows the variation of intensity I of the light on the screen with distance x along the screen.

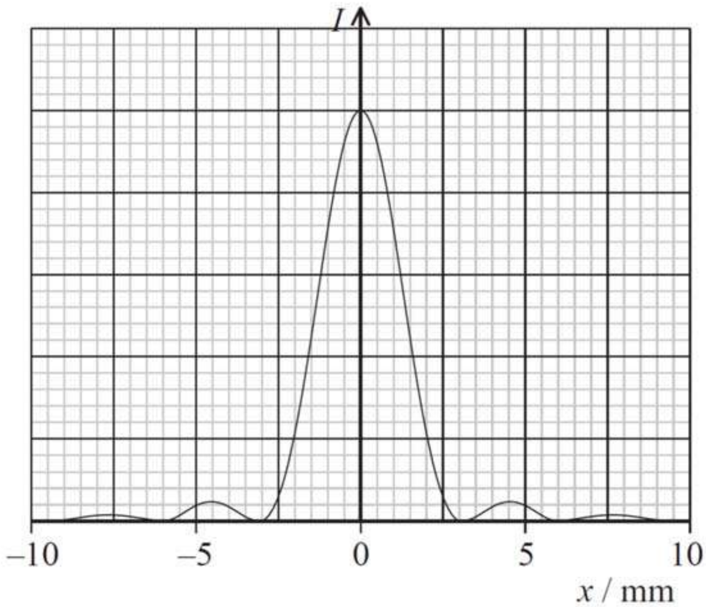


Fig. 8.1

(i) Use Fig. 8.1 to determine the width of the slit.

sin $\theta = \lambda/b$

$sin\theta = \frac{0.003}{2.4} = \frac{\lambda}{b}$

$b = 5.04 \times 10^{-4}\ m$

(ii) State the effect on the pattern on the screen if each of the following changes is made separately:

1. the width of the single slit is reduced,

b↓ , sinθ↑, θ↑ → increase in width of central maximum, maxima are further

lower intensity

2. the red source is replaced with another source of violet light.

λ↓, sinθ↓, θ↓ → reduced width of central maximum, maxima are closer

green and dark regions

(b) Another point source Q emitting light of the same wavelength as P is placed 5.0 mm from P, and the two sources are arranged as shown in Fig. 8.2. The slit is now replaced with another slit of width *b*.

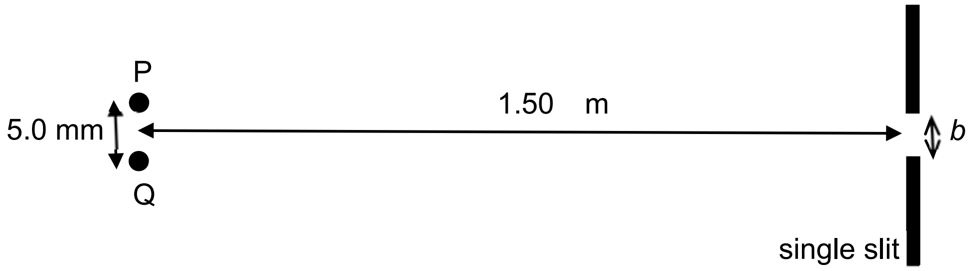


Fig. 8.2

(i) State the condition for the image of P and the image of Q formed on the screen to be just resolved.

Rayleigh's criterion states that two images are just distinguishable if the central maximum of one diffraction pattern falls on the first minimum of the diffraction pattern of the other.

(ii) Sketch, on Fig. 8.1, the graph for point source Q when the condition in **(b)(i)** is met. [1]

(iii) Calculate the minimum width *b* of the slit for the two images to be just resolved. **[3]**

$$tan\theta = \frac{0.0025}{1.50} = 1.6667 \times 10^{-3}$$

$$By\ small\ angle\ approximation, \theta res = 2tan\theta$$

$$\theta res = \frac{\lambda}{b}$$

$$b = \frac{630 \times 10^{-9}}{2 \times 1.6667 \times 10^{-3}} = 1.89 \times 10^{-4}\ m$$

b = ... mm [2]

(c) Two microwave transmitters, A and B, are separated by a distance of 0.80 m. They each transmit a microwave of frequency 3.00 GHz.

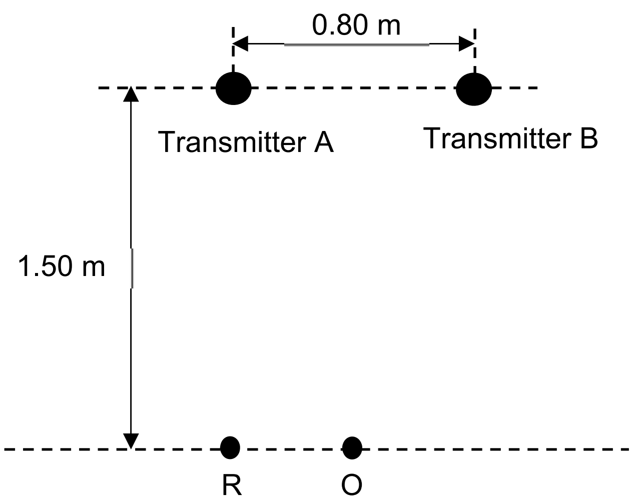


Fig. 8.3

A microwave receiver is moved along a line parallel to, and 1.50 m from, the line joining the two transmitters, as shown in Fig. 8.3. Point O lies on the line where it is equidistant from both transmitters, while point R is at a distance 1.50 m from transmitter A. As the receiver moves from O to R, a minimum signal is detected at R.

(i) Determine the path difference between the two waves arriving at R.

$S_2R = (0.80^2 + 1.50^2)^{½} = 1.70$ m

Path difference = 1.70 – 1.50 = 0.20 m

(ii) Show that the two waves are emitted in antiphase at the transmitters. [4]

Wavelength of microwave = c / f = $(3.00 \times 10^8) / (3.00 \times 10^9)$ = 0.100 m

Path difference = 0.20 m = 2 x wavelengths

Phase difference due to path difference = $(2\lambda / \lambda) \times 2\pi = 4\pi$

Total phase difference = 3π or 5π

Since the signal received at R is a minimum, destructive interference must have occurred where the waves met in antiphase. Therefore, a phase difference of π must have been introduced at the sources.

i.e. Phase difference due sources = π

Fig. 8.4 below shows the displacement-time graph of the waves arriving at R when only transmitter A is switched on and when both transmitters A and B are switched on.

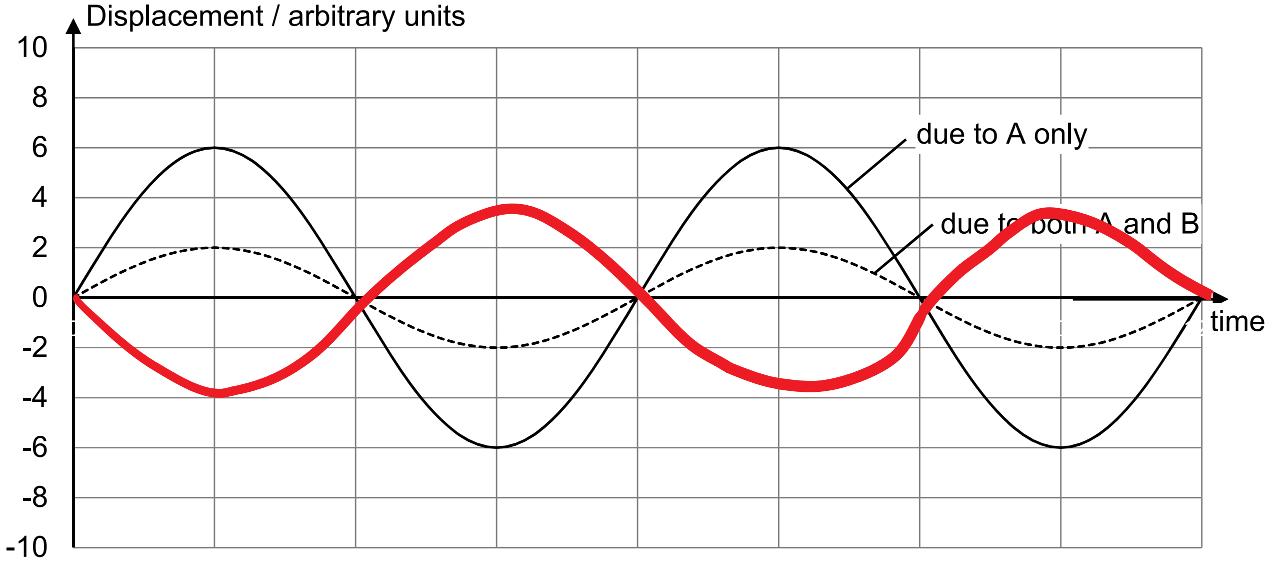


Fig. 8.4

(iii) Sketch, on Fig. 8.4, the displacement-time graph of the waves arriving at R when only transmitter B is switched on. [1]

(iv) Determine the ratio, at point R, $\dfrac{\text{intensity of microwave due to transmitter A}}{\text{intensity of microwave due to transmitter B}}$.

$$\frac{Amplitude\ due\ to\ A}{Amplitude\ due\ to\ A\ and\ B} = \frac{9}{3}$$

$$\frac{Amplitude\ due\ to\ A}{Amplitude\ due\ to\ B} = \frac{9}{6}$$

$$\frac{Intensity\ due\ to\ A}{Intensity\ due\ to\ A\ and\ B} = \left(\frac{9}{6}\right)^2 = 2.25$$

9 **(a)** Fig. 9.1 below shows a Rutherford scattering experiment in which *α*-particles are directed at a gold foil. The detector is shown in two positions in the evacuated chamber.

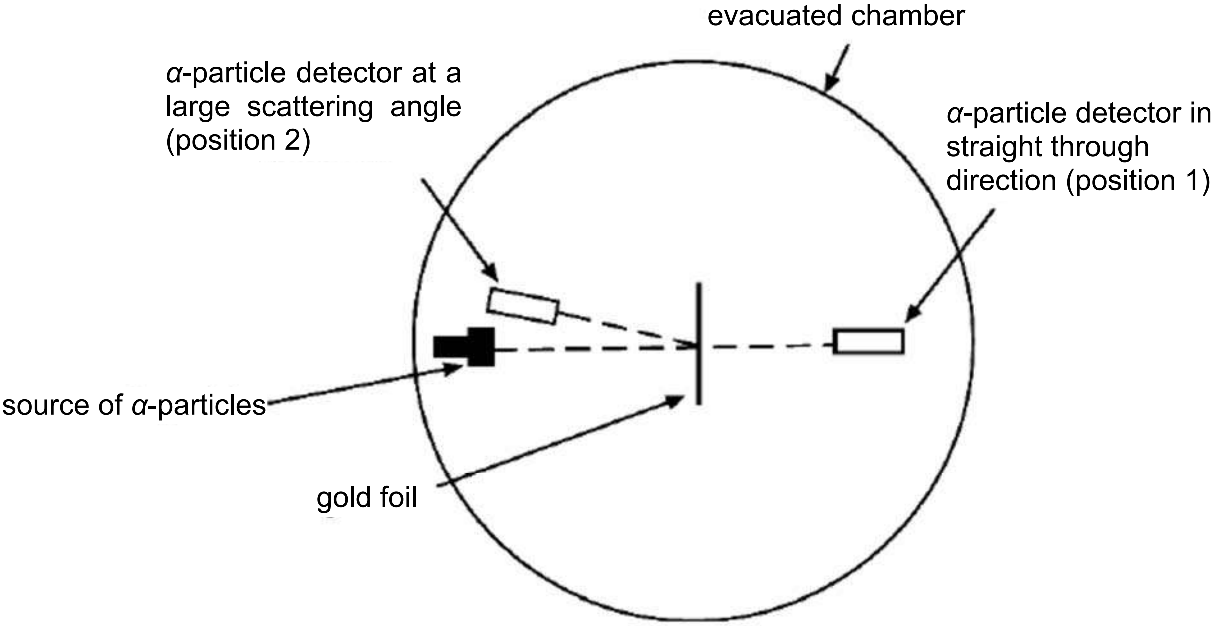


Fig. 9.1

(i) Explain why air needs to be removed from the apparatus.

to minimise collisions between α particles and air molecules) ………………… **B1**
Or
α particles have a short range in air (3–5 cm) ………………… **B1**
(or any answer to the same effect)

(ii) Explain why the gold foil should be very thin.

the α particles must only be scattered at most once ………………… **B1**
Or
- the α particles must not be absorbed/stopped/blocked by the foil ………… **B1**
("to allow the alpha particle to emerge from the gold foil" is not accepted)

(iii) **1.** Explain why a high count rate is detected by the *α*-particle detector in position 1.

Most of the **α** particles pass straight through as the atom consists mainly of open space ……………….. **B1**
(do not accept small nucleus)

2. A low count rate is detected by the *α*-particle detector in position 2. State what can be deduced from this observation about the structure of the atom and the properties of the gold nucleus.

- the nucleus is positively charged
- the nucleus is **very** small **in comparison to the size of an atom**
- the nucleus is very massive
(any two answers)

(b) Fig. 9.2 illustrates the variation with nucleon number A of the binding energy per nucleon *E* of nuclei.

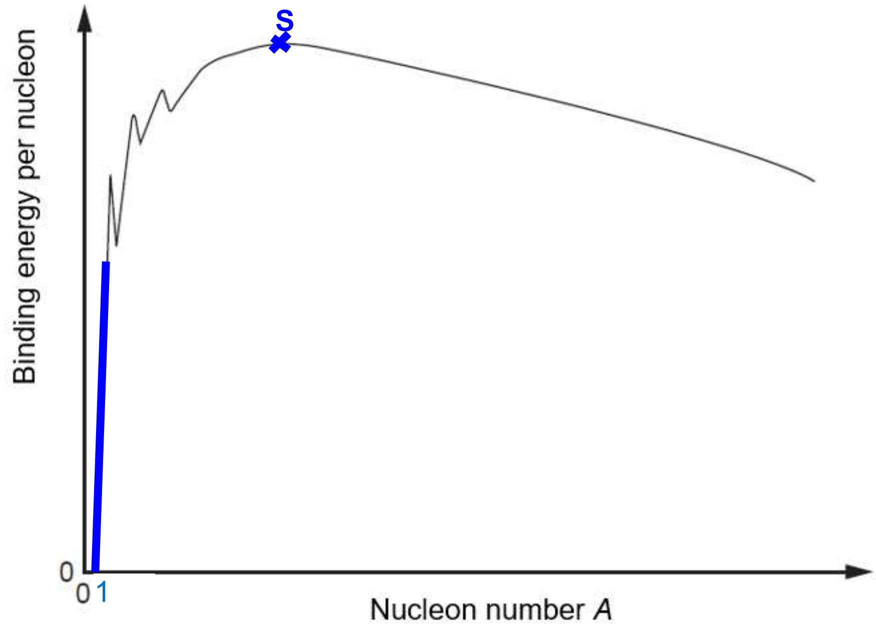


Fig. 9.2

(i) Explain what is meant by the *binding energy* of a nucleus.

Binding energy of a nucleus refers to the amount of energy required to break it apart into its separate constituents of protons and neutrons. **B1**

nucleons separated to infinity / completely …………………….. **B1**

(ii) With the aid of Fig. 9.2, explain why more energy per nucleon is released in fusion than in fission.

- Energy released in a nuclear reaction is equal to the difference in binding energies between the products and the original reactants. ……………….. **B1**

- Fusion occurs for reactants and products that have nucleon numbers less than 56 while fission occurs for reactants and products that have nucleon numbers greater than 56. ………………… **B1**

Or

- Fusion reaction is one in which two light nuclei combine to form a heavier nucleus, while in fission a heavy nucleus splits into two lighter nuclei. ……………….. **B1**

- From graph, the steeper slope of the binding energy curve for lighter nuclei indicates that the change in binding energy in fusion is larger, compared to that for fission reactions. ……………….. **B1**

- Hence, more energy is released in a fusion reaction.

(iii) On Fig. 9.2, mark with the letter **S** the region of the graph representing nuclei having the greatest stability. [1]

(iv) On Fig. 9.2, complete the graph for elements of low nucleon numbers. [1]

(c) Uranium-235 may undergo fission when bombarded by a slow moving neutron to produce Xenon-142 and Strontium-90 as shown below.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{54}Xe + ^{90}_{39}Sr + \text{neutrons} + ^{0}_{-1}\beta$$

(i) Determine the number of neutrons produced in this fission reaction.

No of neutrons = 4 …………………….. **A1**

(ii) State the role of these neutrons in the fission reaction.

The role of neutrons is to initiate more nuclear fission reactions by bombarding other $^{236}_{92}U$ nuclei such that a chain reaction results.

(iii) Data on binding energy per nucleon for some nuclides are given in Fig. 9.3.

isotope	binding energy per nucleon / MeV
Uranium-235	7.59
Xenon-142	8.23
Strontium-90	8.70

Fig. 9.3

Calculate

1. the energy released in this fission reaction,

energy released = (8.23 × 142 **+** 8.70 × 90) **–** 235 × 7.59 ……………….. **C1**

= 168 MeV

= 2.69×10^{-11} J …………………….. **A1**

2. the mass equivalent of this energy.

mass equivalent = $(2.69 \times 10^{-11}) / (3.0 \times 10^{8})^2$

= 2.99×10^{-28} kg …………………….. **A1**

(iv) A nuclear power station supplies 100 MW of electrical power to a town for one year at an efficiency of 35%.

Calculate the mass of uranium needed to operate the power station for one year.

Useful output Power = 100×10^6 W at 35% efficiency

In a year, total energy required = $100 \times 10^6 \times 365 \times 24 \times 60 \times 60/0.35$

= 9.01×10^{15} J …………………….. **C1**

Energy released in 1 reaction = 2.69×10^{-11} J

No of reactions required = $9.01 \times 10^{15} / 2.69 \times 10^{-11}$

= 3.35×10^{26} …………………….. **C1**

= N, number of uranium atoms required.

Mass required = $3.35 \times 10^{26} \times 235 \times 1.66 \times 10^{-27}$

= 1.3×10^{2} kg …………………….. **A1**

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME Solution

PHYSICS 9749/04

Paper 4 Practical Paper

20 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

You are expected to record all your observations as soon as they are made and to plan the presentation of the records so that it is not necessary to make a fair copy of them.
The working of the answers is to be handed in.
Marks are mainly given for a clear record of the observations actually made, their suitability and accuracy, and for the use made of them.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift Timing	
Laboratory	
For Examiner's Use	
Total	/ 55

1 In this experiment, you will investigate the time for the voltage across an electrical component to decrease after a switch is opened.

(a) You are provided with a power supply, a component C, an unknown resistor Y, four resistors labelled with their resistance values in kΩ, a voltmeter and a switch.

Assemble the circuit as shown in Fig. 1.1.

Ensure that the positive terminal of the power supply is connected to the positive terminal of component C.

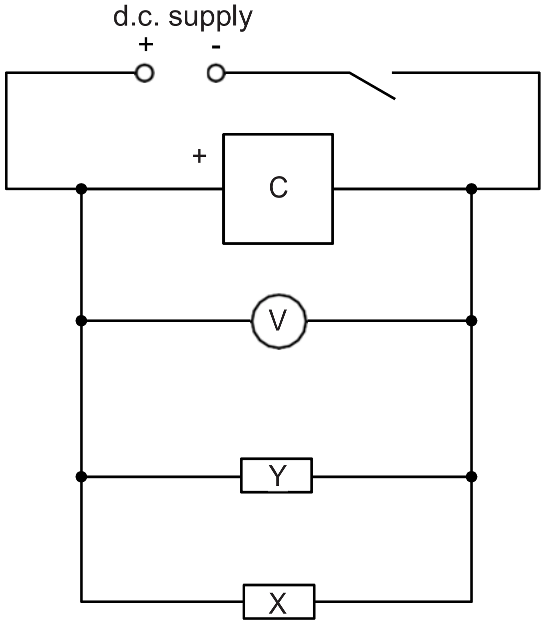


Fig. 1.1

X has a value of resistance *S*. Connect the resistors provided such that *S* has a value of 4 kΩ.

(b) **(i)** Close the switch and check that the voltmeter reading is about 6 V.

(ii) When the switch is opened, the voltmeter reading will gradually decrease. Take measurements to find the time *t* for the voltmeter reading to fall from 5.0 V to 2.0 V after the switch is opened.

Record *t*.

$$t = \frac{38.6 + 38.9}{t} = 38.8 \text{ s}$$

[Repeat measurement, range 38 to 45 s, correct unit]

t = ...38.8 s..................... [1]

For Examiner's Use

(c) Estimate the percentage uncertainty in your value of *t*.

$$\frac{\Delta t}{t} = \frac{0.2}{38.8} \times 100\% = 0.52\%$$

[$\Delta t \geq 0.2$ s or $\Delta t \geq \frac{|t_1 - t_2|}{2}$, whichever is larger, but less than 1 s]

percentage uncertainty = ...0.52%..................... [1]

(d) Repeat **(b)** for different values of S. The effective value of S should **not exceed 4 kΩ**.

S / kΩ (1 dp)	t_1/s (1 dp)	t_2/s (1 dp)	t_{ave}/s (1 dp)	$1/t_{ave}$/ s^{-1} (follow sf)	$1/S$ / $k\Omega^{-1}$ (follow sf)
4.0	38.6	38.9	38.8	0.0258	0.25
3.0	31.6	31.7	31.7	0.0316	0.33
2.0	22.9	22.9	22.9	0.0437	0.50
1.8	20.9	20.9	20.9	0.0478	0.56
1.5	17.9	17.8	17.9	0.0560	0.67
1.0	12.1	12.2	12.2	0.0823	1.0

[2] to have 6 sets of data without assistance and to have correct trend,
[1] for correct headings and units,
[1] for correct number of d.p. for raw values,
[1] for correct number of s.f. for calculated values,
[1] for correct calculation

[6]

(e) It is suggested that t and S are related by the expression

$$\frac{1}{t} = \frac{a}{S} + b$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b.

Plot a graph of $1/t$ against $1/S$ where gradient is a and y-intercept is b.
Using the coordinates (0.900, 0.0735) and (0.200, 0.0250),

$$Gradient = \frac{0.0735 - 0.0250}{0.900 - 0.200} = \frac{0.0485}{0.700} = 0.0693$$

Using the coordinates (0.900, 0.0735),
0.0735 = 0.0693(0.900) + vertical intercept
0.0735 = 0.0624 + vertical intercept
Vertical-intercept = 0.0111

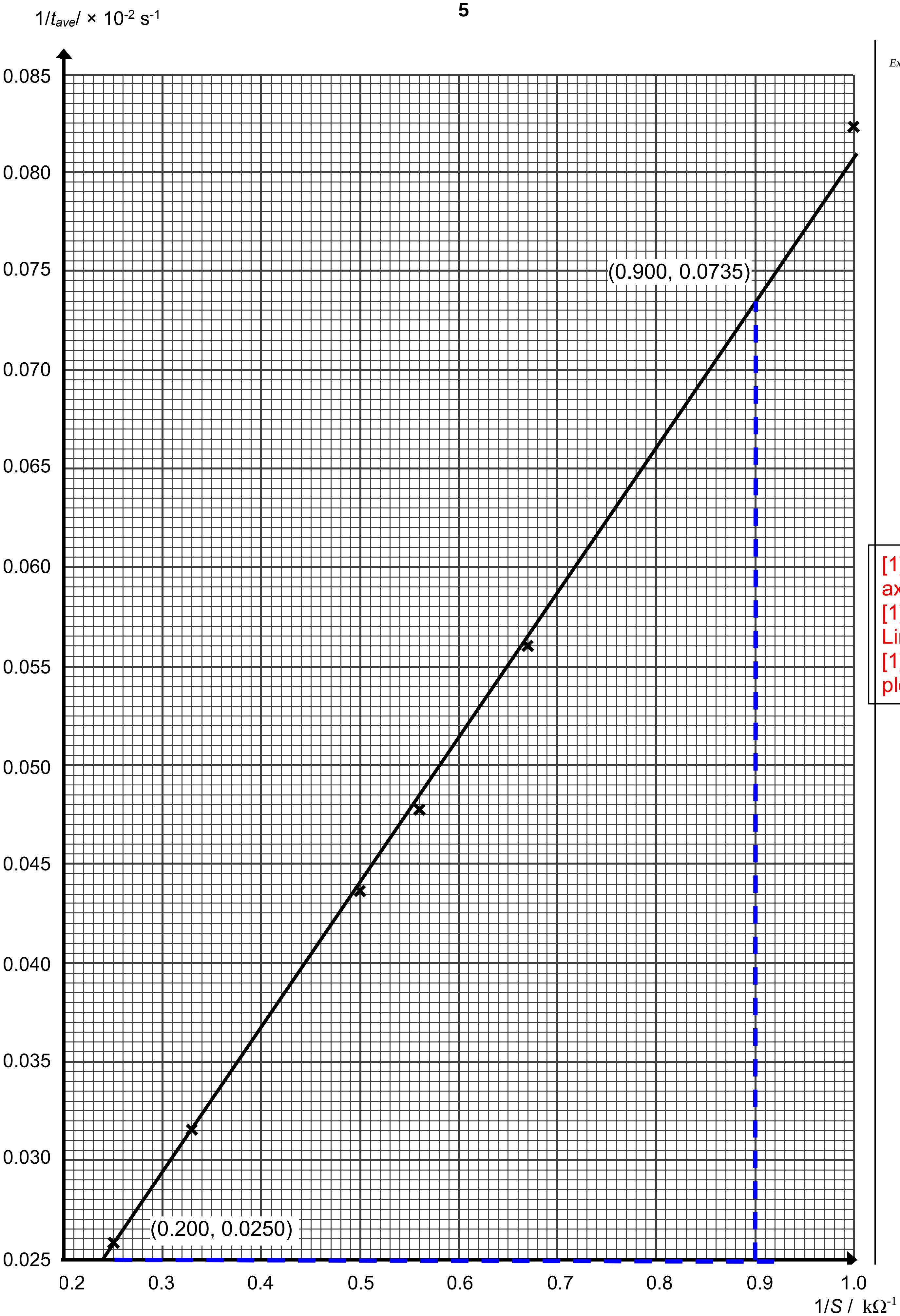
b = 0.0111 s^{-1}
a = gradient = 0.0693 kΩ s^{-1}

[1]: Linearise the equation
[1]: Correct calculation of gradient (read half the smallest square)
[1]: Correct calculation/reading of y-intercept
[1]: State a = gradient, with correct s.f. and unit
[1]: State b = y-intercept, with correct s.f./d.p. and unit

a = 0.0693 kΩ s^{-1}

b = 0.0111 s^{-1}

[5]



[1] Scale & axes;
[1] Best Fit Line;
[1] Correct plots

For Examiner's Use

(f) Comment on any anomalous data or results that you have obtained. Explain your answer.

- There is no anomalous point. All data points are close to the best fit line.
- There is one anomalous point as it is far from the best fit line. The anomalous point is circled as shown in the graph. All other data points are close to the best fit line.
- There is no anomalous point. However, the results show an appreciable scatter about the best fit line.

[1]

(g) Calculate the value of *S* for which *t* is equal to 6.5 s.

$$\frac{1}{t} = \frac{a}{S} + b$$

$$\frac{1}{6.5} = \frac{0.0693}{S} + 0.0111$$

$$S = 0.49\ \text{k}\Omega$$

[correct calculation, unit, s.f.]

S = ...0.49 kΩ......................... kΩ [1]

(h) Theory suggests that the resistance of Y is given by

$$\text{resistance of Y} = \frac{a}{b}$$

t depends on the resistance of the combination of resistor X and resistor Y.

By referring to the relationship between *t* and resistance *S* in your results table in **(d)**, sketch, on the graph grid on page 5, a second graph to represent the results when the resistance of resistor Y is doubled.

Label this second graph Z. Explain your answer.

- When Y is doubled, one of the following will happen
  1. *a* doubles but *b* remains unchanged
  2. *b* halves but *a* remains unchanged
  3. *a* increases less than double, while *b* decreases less than half

[1]

Z can fall under one of the categories mentioned above.

[Total: 19 marks]

For Examiner's Use

2 In this experiment, you will investigate the motion of a system of masses as its shape is changed.

(a) You are provided with a length of wire, bent into two arms, with a mass attached at the end of each arm as shown in Fig. 2.1.

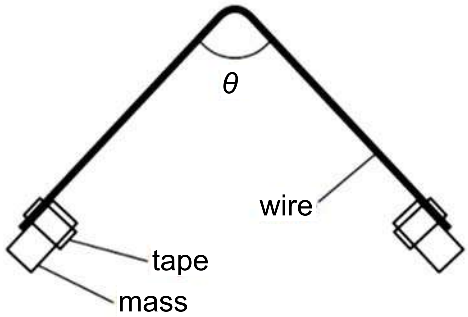


Fig. 2.1

(i) Using a micrometer screw gauge, measure and record the thickness of the wire *d*.

(2.10 + 2.12) / 2 = 2.11 mm

[Repeat measurement, 2 d.p., range 2.0 to 2.2 mm, correct unit]

d = ...2.11 mm...... [1]

(ii) Measure and record the angle θ between the two arms.

[nearest 1 deg, range 100 to 120 deg, correct unit]

θ = ...110°...... [1]

(iii) Calculate $\sin^2\left(\frac{\theta}{2}\right)$, where

$$\sin^2\left(\frac{\theta}{2}\right)=\sin\left(\frac{\theta}{2}\right)\times\sin\left(\frac{\theta}{2}\right).$$

$\sin^2(110°/2) = 0.671$

$\sin^2\left(\frac{\theta}{2}\right)$ = ...0.671......

For Examiner's Use

(b) You are provided with a spring suspended from a stand. A hook is suspended from the bottom of the spring.

Hang the wire from the upper part of the hook and hang the mass hanger from the lower part of the hook as shown in Fig. 2.2.

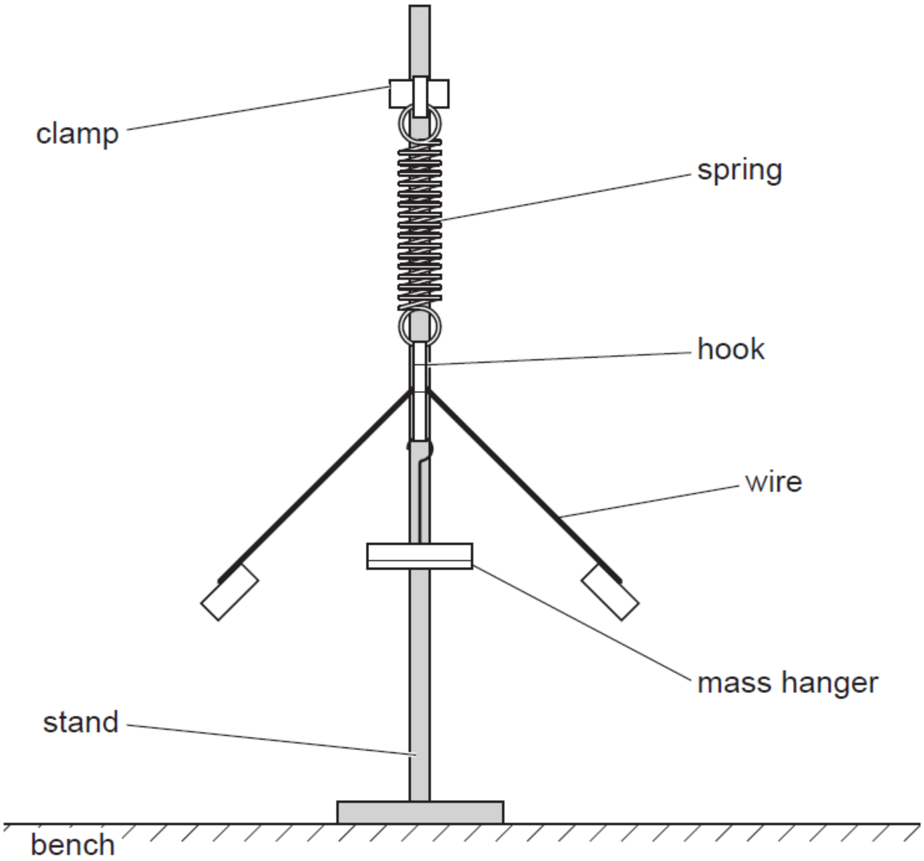


Fig. 2.2

(i) Twist the mass hanger through about 45° and release it so that the mass hanger and wire rotate back and forth as shown in Fig. 2.3.

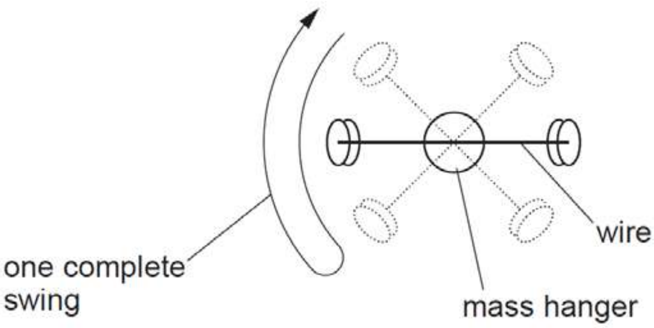


Fig. 2.3 (Top view)

(ii) Measure and record the time t for the mass hanger and wire to make 5 complete swings.

(27.1 + 26.9) / 2 = 27.0 s

[1] for repeat measurement,
[1] for 1 or 2 d.p. of second (to be consistent with repeat measurement, correct unit]

t = 27.0 s [2]

For Examiner's Use

(c) Remove the wire from its hook. Bend the wire to change the angle θ. The arms of the wire must remain straight.

Repeat **(a)** and **(b)**.

θ = 70° ....

$\sin^2(70°/2) = 0.574$

[1] Both $\sin^2(\theta/2)$ calculated correctly with correct s.f.

$\sin^2\left(\frac{\theta}{2}\right)$ = 0.574 ....

(18.6 + 18.5)/2 = 18.6 s

[1] *t* is shorter for smaller θ, correct d.p. and unit

t = 18.6 s .... [2]

(d) The quantities *t* and θ are related by the equation

$$t^2 = p + q\sin^2\left(\frac{\theta}{2}\right)$$

where *p* and *q* are constants.

It is suggested that the mass of the masses attached to the wire affects the values of *p* and *q*.

(i) Suggest one other factor that may affect the values of *p* and *q*.

Mass of mass hanger or spring constant of spring or

length of wire. ....[1]

For Examiner's Use

(ii) Plan an investigation to determine whether the mass of the masses attached to the wire affects the values of *p* and/or *q*.

Your account should include:

- your experimental procedure
- how your results can be analysed to reach the conclusion.

Perform experiment using different values of θ to obtain at least 6 sets of t and θ values. [1]

Repeat the experiment using a pair of different attached masses without changing <*the independent variable identified in (i)*>. [1]

Plot a graph of t^2 vs $\sin^2(\theta/2)$ for each pair of attached masses. [1]

If the gradient of the two graphs are different, the attached masses affect the value of q.

If the y-intercept of the two graphs are different, the attached masses affect the value of p. [1]

Examiners' comments:

Some students attempted to determine p and q without a graph (i.e. by substitution). This will result in in accurate values of p and q.

[4]

Students should note that determining p and q by graphical methods will require multiple sets of readings of *t* and *θ*.

[Total: 11 marks]

For Examiner's Use

3 In this experiment you are provided with a ball attached to a thread and a solid vertical surface. You will investigate how the rebound distance of the ball is related to the release distance when it swings against the solid surface.

(a) Assemble the apparatus as shown in Fig. 3.1, with the thread clamped between the two wooden planks so that *L* is about 50 cm, and with the wooden block positioned so that it is just touching the stationary ball.

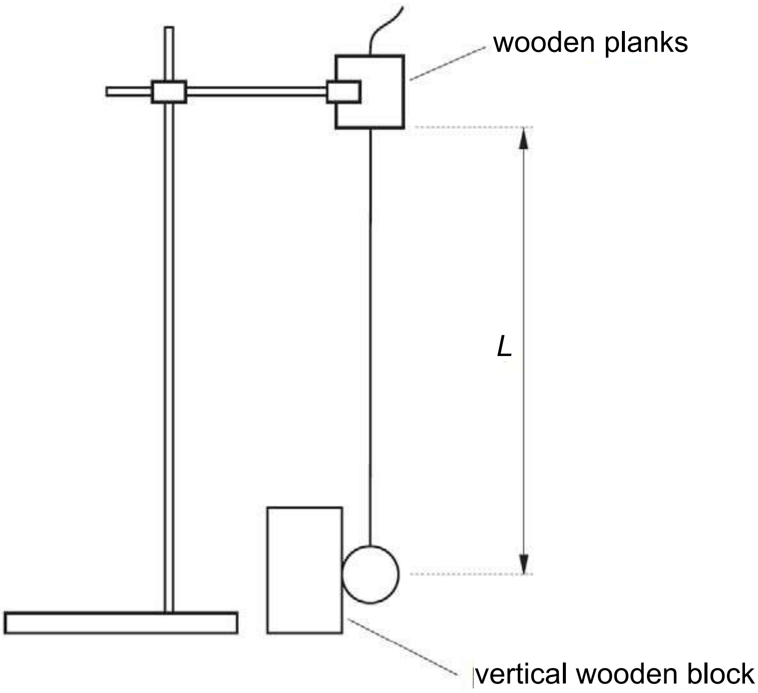


Fig 3.1

Measure *L*.

L = 50.0 cm ....

(b) **(i)** Pull back the ball and measure the distance *a* shown in Fig. 3.2. Do not exceed *a* = 25 cm.

a=25.0 cm

L and *a* recorded to 1dp of cm / units
Repeat measurement is not required

a = 25.0 cm .... [1]

For Examiner's Use

(ii) Release the ball and make measurements to determine the rebound distance *b* shown in Fig. 3.2.

b= (21.2+20.2)/2 = 20.7 cm

b recorded to 1dp of cm / units

b between 70% and 90% of a. (17.5 – 22.5 cm)

Repeat measurement is required

b = 20.7 cm .... [1]

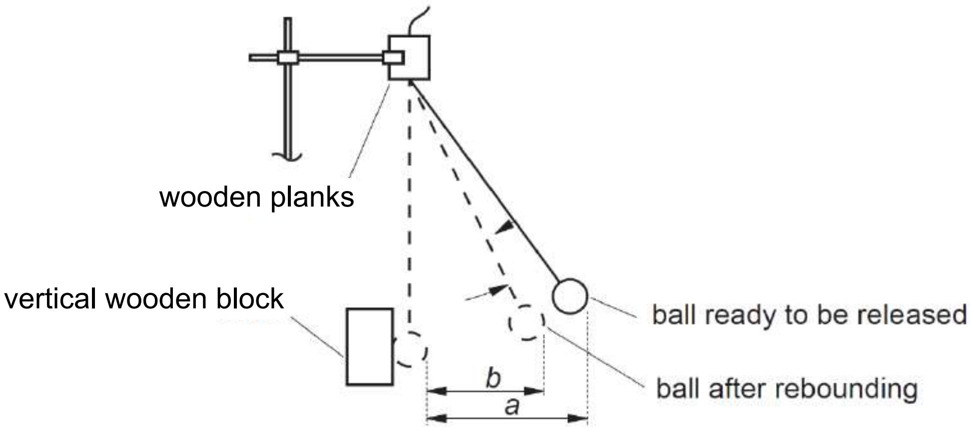


Fig. 3.2

(c) (i) Explain how you used the apparatus to ensure that the rebound distance *b* was measured as accurately as possible.

Use of fiducial marker

Repeated observations to refine position.

or anything that is reasonable. [1]

....[1]

(ii) Estimate the percentage uncertainty in *b*.

0.5 / 20.7 × 100% = 2.4%

0.2 cm < Δb < 1 cm / % calculated correctly, in 1 or 2 s.f.

If repeat measurement of *b* is used, % uncertainty must be at least half of the range of the two *b* values [1]

percentage uncertainty in *b* = 2.4 % .... [1]

For Examiner's Use

(d) For values of a less than 25 cm, theory predicts that

$$k = \frac{L - \sqrt{L^2 - b^2}}{L - \sqrt{L^2 - a^2}}$$

where k is a constant. Calculate a value for k.

$k = (50.0 - (50.0^2 - 20.7^2)^{1/2}) / (50.0 - (50.0^2 - 25.0^2)^{1/2})$

$= 0.670$

calculated correctly to 3sf [1]

k = 0.670 .... [1]

(e) Repeat **(b)(i)**, **(b)(ii)** and **(d)** using a different value of a.

$b = (16.9+16.3)/2 = 16.6$ cm

a = 20.0 cm ....

a is smaller than 25 cm /

b is between 70% and 90% of a [1]

Repeat measurement for b required

b = 16.6 cm ....

$k = (50.0 - (50.0^2 - 16.6)^{1/2}) / (50.0 - (50.0^2 - 20.0^2)^{1/2})$

$= 0.679$

k calculated correctly [1]

k = 0.679 .... [2]

(f) Explain whether your results indicate that k is a constant.

$\Delta k / \langle k \rangle = 0.009 / 0.675 = 1.3\%$

Since the % difference in k values is less than the % uncertainty in the experiment which is at least 2.4% (the % uncertainty in b), my results show that k is a constant.

.... [1]

calculated difference / comparison with $\Delta b/b$ / reasonable conclusion [1]

For Examiner's Use

(g) **(i)** State two sources of error or limitations of the procedure in this experiment.

1. -Parallax error when measuring a and b due to gap between ball and ruler.

-Ball is only instantaneously at rest, causing measurement of b to be inaccurate.

2. -Ball doesn't rebound along the same path; rebound at an angle away from the normal of wooden block

-Source of error identified and related to value affected. [1 each]

[2]

(ii) Suggest two improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1. Use of video recording *(with elaboration).*

-Use of motion sensor *(with elaboration).*

-Use two pieces of transparent plastic perpendicular to the wooden block to guide the ball along the same curve path.

2. -Improvement involves equipment not provided. [1 each]

[2]

[Total: 12 marks]

Accept for source of error

Ball released at different heights and/or speeds.

but do not accept *use clamp / cut string* to release for improvement.

Use of electromagnet is not acceptable in this experiment because ball is not ferromagnetic and cannot be substituted. (unless you change the ball to something ferromagnetic. That being said, a metal ball may not necessary be ferromagnetic.)

For Examiner's Use

4 A student is investigating the motion of a small block on a turntable connected to an electric motor as shown in Fig. 4.1.

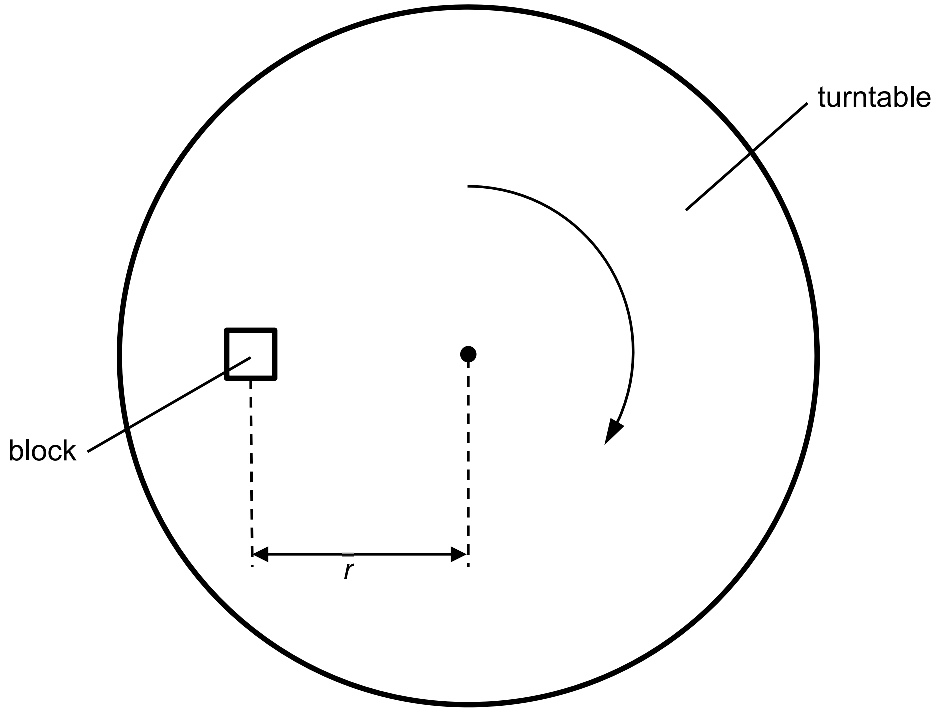


Fig. 4.1

The block has a mass *m* and is placed at a distance *r* from the centre of the turntable. It is suggested that the relationship between *m*, *r* and the maximum frequency *f* of the turntable for which the block does not move relative to the turntable is

$$\frac{1}{f} = 4\pi^2 \text{k} m r^{\text{x}}$$

where *k* and *x* are constants.

Design an experiment to test the relationship between *f*, *m* and *r*, and determine the value of *x*. You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

a) the equipment you would use,

b) the procedure to be followed,

c) how the value of *x* is determined from your readings,

d) the control of variables,

e) the measurements to be taken,

f) any precautions that should be taken to improve the accuracy and safety of the experiment.

For Examiner's Use

Sample MS

Methods of data collection [5]

M1 labelled diagram showing power supply connected to <u>motor</u> (two leads) within turntable; circuit must be workable

M2 Carry out two sets of experiments:
method to test relationship between *f* and *m*: keep *r* constant, *m* is the independent variable, while *f* is the dependent variable

M3 method to test relationship between *f* and *r*: keep *m* constant, *r* is the independent variable, while *f* is the dependent variable

M4 method to change frequency of rotation of turntable: variable power supply / variable resistor / potentiometer (shown in diagram)

M5 method to determine frequency of rotation: $f = 1/T$, period determined by stopwatch using fiducial marker (only if rotation is stated to be slow enough for observation) / stroboscope / photogate connected to datalogger (positioned correctly in diagram)

Methods of analysis [3]

A1 plot a graph of *f* vs 1/*m* or plot a graph of lg *f* vs lg *m* (or relevant alternative)

A2 plot a graph of lg *f* vs lg *r* (or relevant alternative)

A3 value of x is negative gradient (or relevant alternative)

Safety consideration [1]

S1 use safety screen / safety goggles

Additional detail [4]

(any 4)

D1 *m* measured with an electronic balance / other appropriate apparatus <u>and</u> *r* measured with metre rule

D2 wait for turntable to rotate steadily before adjusting frequency
/ gradually increase frequency (to prevent jerking motion or sudden sliding)

D3 increase frequency until block moves, describing method to determine precisely if block has moved

D4 time at least 10 rotations of turntable (stopwatch) (only if rotation is stated to be slow enough for observation) / detailed use of stroboscope
/ detailed method for analysing datalogger data (middle of duration of light blockage)

D5 repeat experiment for each *r* & *m*, take average *f*

D6 use spirit level to check that turntable is horizontal
/ ensure surface of turntable and block are clean

D7 method to ensure *r* is measured to centre of block: put a mark on edge of block
/ align front/back of block by a set distance from the rim, etc.

D8 method to determine centre of turntable: measure two or more diameters, etc.

D9 relationship valid if straight line graph passing through origin is obtained (for 1/*f* vs *m*) / gradient of graph is −1 (for lg(1/*f*) vs lg*r*)

D10 carry out preliminary experiments to determine range of V needed
/ maximum frequency required (for largest *m* to slide at smallest *r*)
/ maximum *m* that can be used for a certain limit of *f*.

For Examiner's Use

For Examiner's Use

[13]

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/01**
Higher 2

Paper 1 Multiple Choice

21 September 2018

1 hour

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **17** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$= (1/(36\pi)) \times 10^{-9}\ \text{F m}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\varphi = -\frac{GM}{r}$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{x_0^{\ 2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 A resistor is marked as having a resistance value R of 4.7 Ω ± 2%. The current in the resistor is measured as (2.50 ± 0.05) mA.

Given that the power P dissipated in the resistor is $P = I^2R$, what is the percentage uncertainty in the calculated value of P?

A 2%

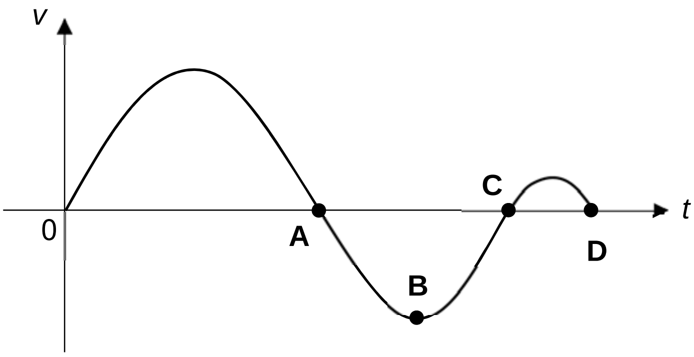
B 4%

C 6%

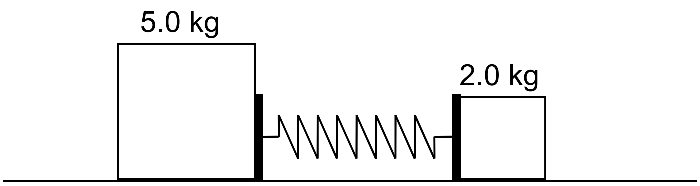
D 8%

2 A graph showing the variation of the velocity v of a body with time t is as shown.

At which point is the body furthest away from its starting position?



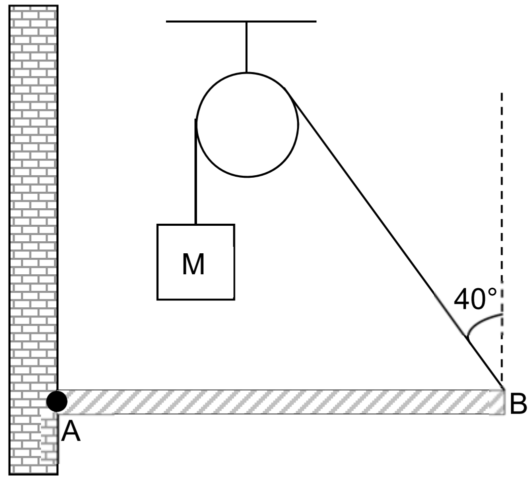
3 A light spring is connected between two blocks of wood of masses 5.0 kg and 2.0 kg, on a frictionless horizontal surface. The spring is compressed and the blocks are released simultaneously from rest.



When the acceleration of the heavier block is 10 m s^{-2}, what is the acceleration of the lighter block?

A 5.0 m s^{-2} **B** 10 m s^{-2} **C** 20 m s^{-2} **D** 25 m s^{-2}

4 A uniform rod AB of mass 4.0 kg is suspended by a string attached at B. The string is connected to a block M and passed over a smooth pulley. The other end of the rod is hinged at A. When the rod is horizontal, the string makes an angle of 40° with the vertical.



What is the weight of M required to maintain equilibrium?

A 20 N

B 26 N

C 31 N

D 39 N

5 The forward thrust provided by the engine of a car moving horizontally with constant velocity of 12 m s^{-1} on a straight road is 500 N.

Which of the following statements is correct?

A The net force on the car is 500 N.

B The average power of the engine is 3.0 kW.

C The rate of work done by the engine is 6.0 kW.

D The power of the engine is zero as the car is moving at constant velocity.

6 A circular disc is rotating about a vertical axis through its centre. Two objects of mass 3.0 kg and 6.0 kg are placed on the rough surface of the rotating disc at 2.0 m and 5.0 m from its centre respectively.

What is the ratio of the centripetal force on the 3.0 kg mass to the 6.0 kg mass?

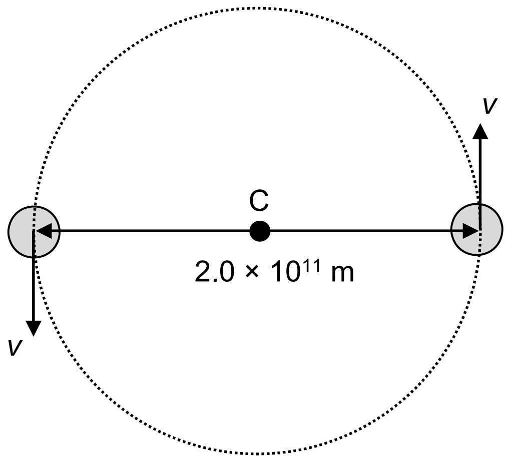
A 0.20

B 0.80

C 5.0

D 1.3

7 A binary star system consists of two identical stars each of mass 4.0×10^{30} kg orbiting about their common centre of mass C. The stars are moving with a constant speed *v* and their centres are separated by a distance of 2.0×10^{11} m**.**



What is the speed *v* of each star?

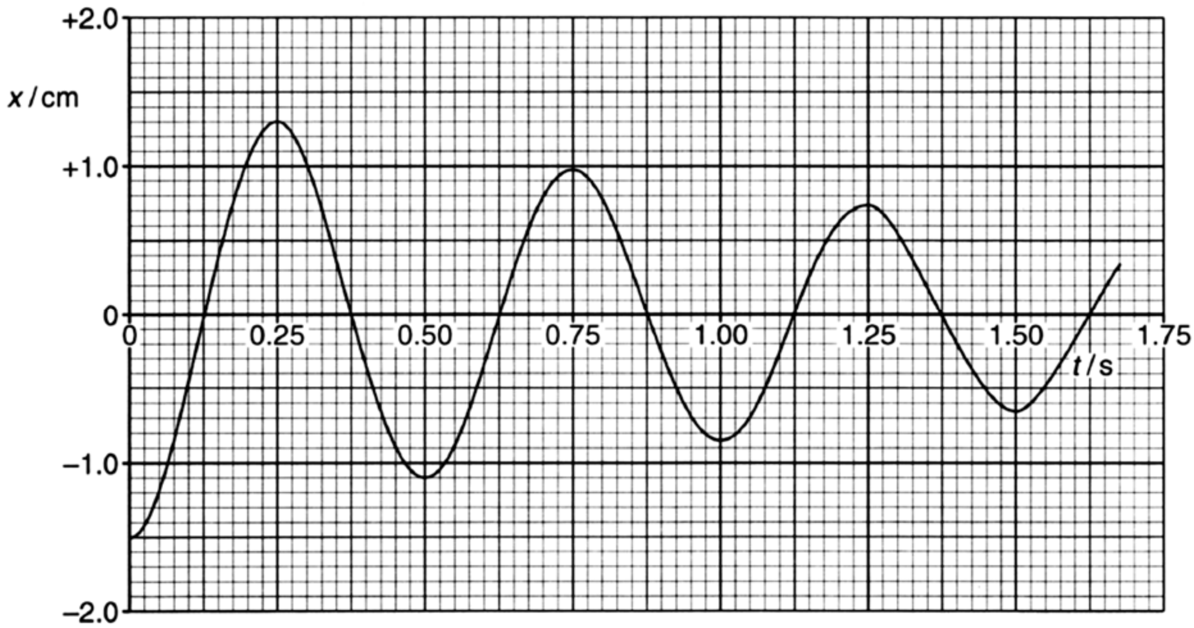
A 1.8×10^{4} m s^{-1}

B 2.6×10^{4} m s^{-1}

C 3.7×10^{4} m s^{-1}

D 5.2×10^{4} m s^{-1}

8 A wooden block of mass 200 g floats on water and oscillates vertically. Its vertical displacement *x* varies with time *t* as shown.



What is the decrease in maximum gravitational potential energy of the oscillations during the first 1.5 s?

A 0.7×10^{-3} J **B** 2.9×10^{-3} J **C** 3.6×10^{-3} J **D** 1.7×10^{-2} J

9 To cool down the electrical generator of a nuclear power plant, cold water enters the heat exchanger of the generator at 3 °C and leaves at 11 °C. The rate of heat removed by the water is 4.0×10^{11} J per hour. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

What is the rate of water flow?

A $\dfrac{4.0\times10^{11}}{4200\times8\times60\times60}$ kg s^{-1}

B $\dfrac{4.0\times10^{11}\times60\times60}{4200\times8}$ kg s^{-1}

C $\dfrac{4.0\times10^{11}}{4200\times8\times60}$ kg s^{-1}

D $\dfrac{4.0\times10^{11}\times60}{4200\times8}$ kg s^{-1}

10 A gas cylinder has volume of 4.0×10^{-4} m^3. It contains gas at a temperature of 300 K and a pressure of 500 kPa. A worker fills the cylinder to a pressure of 620 kPa without changing the temperature.

What is the amount of gas in number of moles that must be pumped into the cylinder?

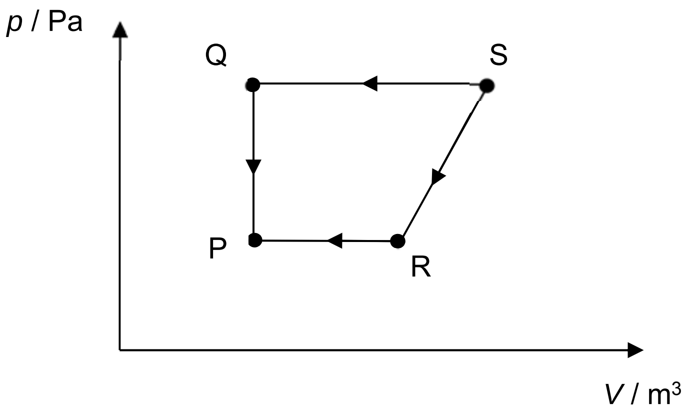
A 0.019 mol

B 0.080 mol

C 0.10 mol

D 0.18 mol

11 A fixed mass of ideal gas undergoes changes in pressure and volume as shown below.



For changes from S → Q → P, work done is 3 J and 8 J of heat is released by the gas. For the change of states from S → R → P, work done is 2 J.

Which statement about the heat exchange for the change S → R → P is correct?

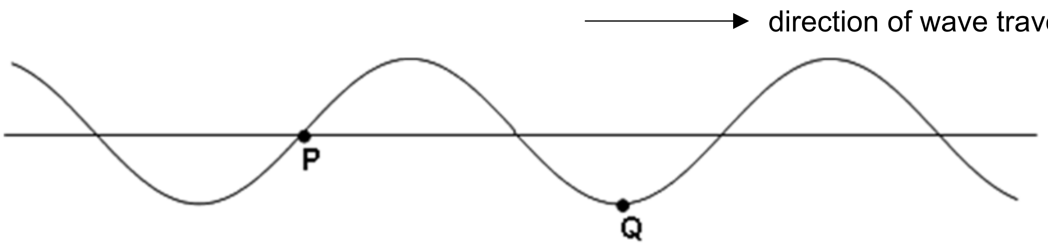
A 3 J of heat is released

B 7 J of heat is released

C 9 J of heat is released

D 13 J of heat is released

12 The diagram shows a transverse wave on a rope. The wave is travelling from left to right. At the instant shown, the points P and Q on the rope have zero displacement and maximum displacement respectively.



Which of the following describes the direction of motion, if any, of the points P and Q at this instant?

	P	Q
A	upwards	stationary
B	stationary	downwards
C	stationary	upwards
D	downwards	stationary

13 The diagram represents a longitudinal wave travelling from left to right at a frequency of 200 Hz. Two particles in the wave labelled X and Y are separated by a distance of 50 m.

What is the velocity of the wave?

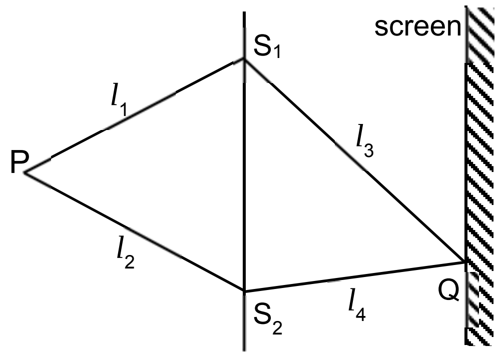
A 2000 m s^{-1}

B 4000 m s^{-1}

C 6700 m s^{-1}

D 8000 m s^{-1}

14 Two identical narrow slits S_1 and S_2 are illuminated by light of wavelength λ from a point source P. The light is then allowed to fall on a screen.



Given that m is a positive integer, what is the condition for destructive interference to occur at point Q?

A $(l_3 - l_4) = m\lambda$

B $(l_3 - l_4) = (2m + 1)\dfrac{\lambda}{2}$

C $(l_1 + l_3) - (l_2 + l_4) = m\lambda$

D $(l_1 + l_3) - (l_2 + l_4) = (2m + 1)\dfrac{\lambda}{2}$

15 A wire is stretched between two fixed points 1.2 m apart. It is set into vibration while the mid-point of the wire is held in place.

Which are the possible wavelengths of the waves in the wire?

A 0.2 m, 0.6 m, 2.4 m

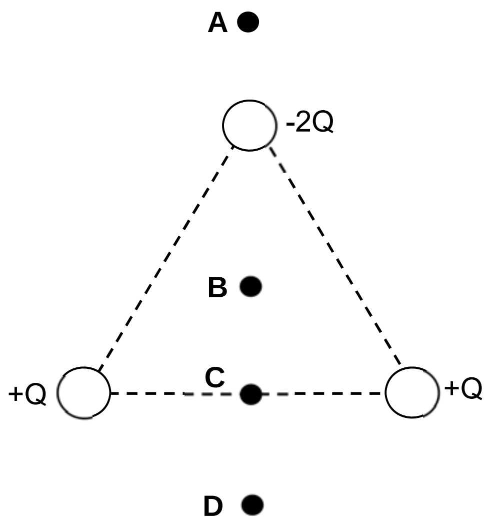
B 0.4 m, 0.8 m, 1.2 m

C 0.24 m, 0.3 m, 0.6 m

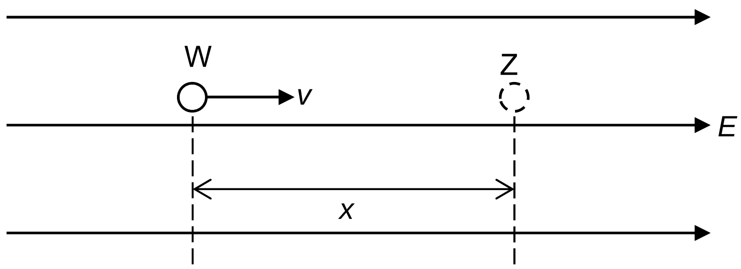
D 0.6 m, 1.2 m, 2.4 m

16 Three charges of charge +Q, +Q, and -2Q rest at the corners of an equilateral triangle as shown. A small test charge +q is brought near the three charges.

At which of the following positions would it be possible for the small test charge to experience zero net force?



17 A beta particle with charge *e* and mass *m* travels from point W to point Z within a uniform electric field of strength *E*. At point W, the particle has a velocity of *v*. It comes to a stop at point Z.

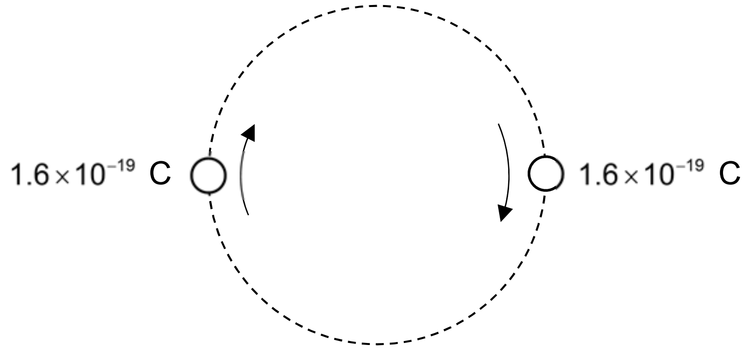


The distance between point W and Z is *x*.

Which expression gives the value of *x*?

A $\dfrac{mv}{E}$ **B** $\dfrac{mv}{Ee}$ **C** $\dfrac{mv^2}{2E}$ **D** $\dfrac{mv^2}{2Ee}$

18 Two charged particles, each of charge 1.6×10^{-19} C, are moving in a circular path due to an external magnetic field as shown. The period of the motion for each particle is 2.0×10^{-10} s.



What is the current caused by the motion of the two particles?

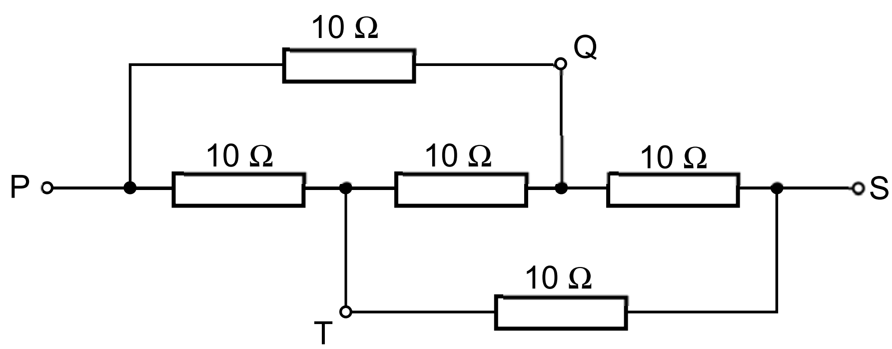
A 1.6×10^{-29} A

B 3.2×10^{-29} A

C 8.0×10^{-10} A

D 1.6×10^{-9} A

19 A network of resistors each of resistance 10 Ω are shown.



What is the effective resistance between Q and T?

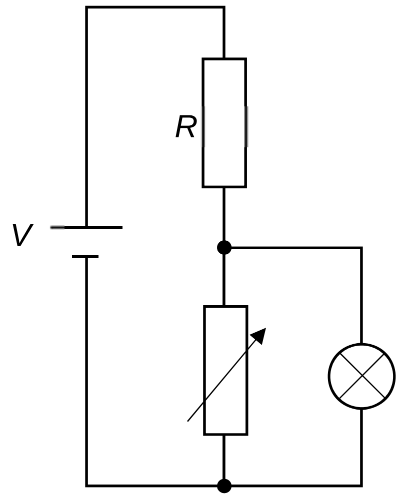
A 2.0 Ω

B 5.0 Ω

C 10 Ω

D 12 Ω

20 A battery of e.m.f. V and negligible internal resistance is connected to a resistor of resistance R, a variable resistor and a lamp as shown.



What happens to the brightness of the lamp as the resistance of the variable resistor is increased?

A The bulb becomes dimmer.

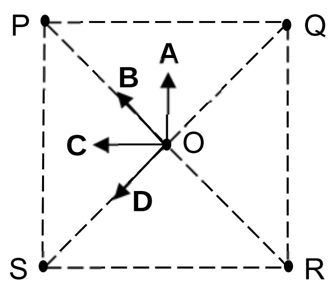
B The bulb becomes brighter.

C The brightness remains the same.

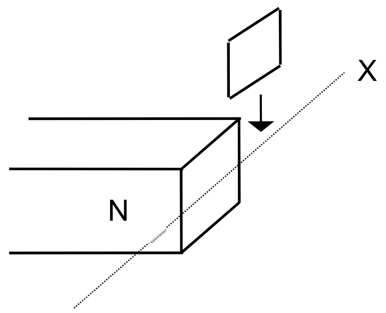
D The bulb becomes brighter initially, and then becomes dimmer.

21 The figure below shows four long, straight current-carrying wires P, Q, R and S which are perpendicular to the plane of the paper. They pass through the corners of a square. Point O is the point of intersection of the diagonals of the square. The currents in all four wires have the same magnitude. The currents in wires P, Q and R flow into the plane of the paper while that in S flows out of the plane of the paper.

Which arrow shows the direction of the resultant magnetic field at O?



22 A square loop of copper is held above and near to one pole of a strong magnet as shown below.



Which statement about the acceleration of the loop is correct if the loop is released?

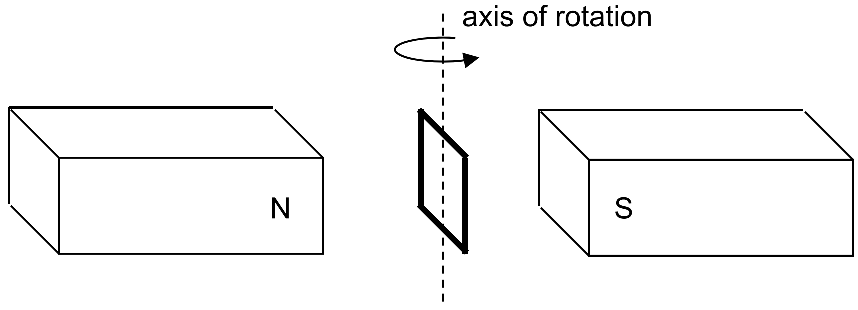
A The acceleration is greater than g just above X and less than g just below X

B The acceleration is less than g just above X and greater than g just below X.

C The acceleration is greater than g both just above and below X.

D The acceleration is less than g both just above and below X.

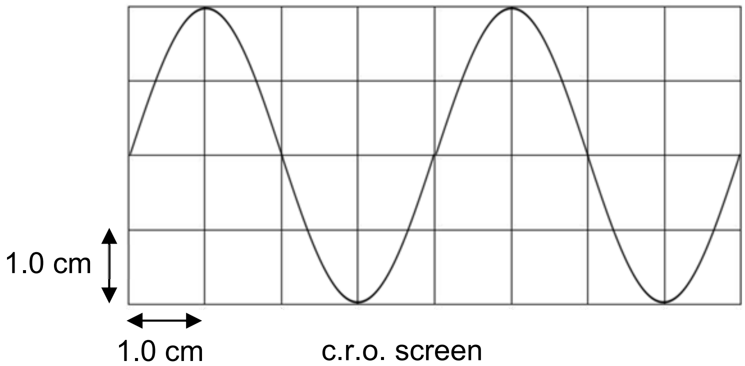
23 A rectangular coil of wire is rotated with constant angular velocity in a magnetic field as shown below. An e.m.f. of peak value E_o is generated. The coil is now rotated at twice the original frequency in a magnetic field whose strength is one-third of the original.



What is the peak e.m.f. generated now?

A $6E_o$ **B** $5E_o$ **C** $\frac{3}{2}E_o$ **D** $\frac{2}{3}E_o$

24 A cathode-ray oscilloscope (c.r.o) screen with a grid of 1 cm squares displays an alternating voltage waveform. The settings of the oscilloscope are: gain = 5.00 V cm^{-1}, time base = 1.0 s cm^{-1}.



Which expression gives the e.m.f. of this waveform?

A 2.0 sin 2.0 *t*

B 5.0 sin 2.0 *t*

C 7.1 sin 1.6 *t*

D 10 sin 1.6 *t*

25 Two light bulbs glow at the same brightness. One is supplied with alternating current and the other with direct current. Each bulb has a constant resistance of 4 Ω. The light bulb with direct current draws 3 A at 12 V.

What is the estimated peak value of the alternating current?

A 2 A

B 3 A

C 4 A

D 6 A

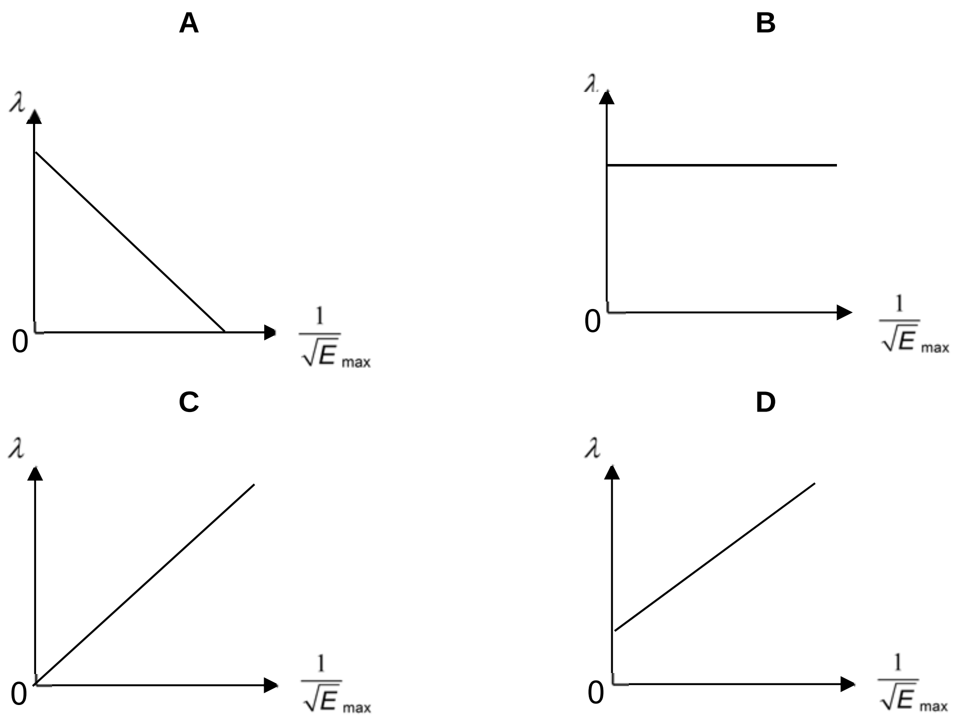
26 The photoelectric effect equation can be written as $hf = hf_0 + \frac{1}{2}mv^2_{max}$.

What is the meaning of each term in this equation?

	hf	hf_0	$\frac{1}{2}mv^2_{max}$
A	the energy of an incoming photon	the least energy required to release a photoelectron	the maximum kinetic energy of the photoelectron
B	the energy of an incoming photon	the threshold frequency which represents least energy required to release a photoelectron	the maximum kinetic energy of the photoelectron
C	the energy of an incoming photoelectron	the least energy required to release a photon	the maximum kinetic energy of a photon
D	the energy of an incoming photon	the work done by the incoming photon	the maximum kinetic energy of the outgoing photon

27 An electron with kinetic energy E_{max} has a de Broglie wavelength of λ.

Which of the following graphs correctly represents the relationship between λ and E_{max}?



28 White light from a filament lamp is passed through cooled hydrogen gas and viewed through a prism.

Which of the following best describes the spectrum?

A dark lines on a coloured background

B dark lines on a white background

C coloured lines on a black background

D coloured lines on a white background

29 A radioactive nuclide X disintegrates by emitting gamma radiation and a single α-particle, forming a daughter nuclide Y.

Which of the following statements is correct?

A X has more protons in its nucleus than Y.

B X and Y are isotopes of the same element.

C The atomic number of X is less than that of Y.

D The mass number of X is one less than that of Y.

30 A Geiger-Muller tube recorded an average count-rate of 20 min^{-1} in the absence of any radioactive source. When it is moved near a radioactive source of half-life 48 hours, the average count-rate rises to 100 min^{-1}.

What is average count rate recorded of the source 12 hours later?

A 67 min^{-1} **B** 84 min^{-1} **C** 87 min^{-1} **D** 94 min^{-1}

End of paper

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/02**
Higher 2

Paper 2 Structured Questions

14 September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 7
2	/ 8
3	/ 9
4	/ 9
5	/ 7
6	/ 8
7	/ 13
8	/ 19
Total	/ 80

This document consists of **22** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\varphi = -\frac{GM}{r}$
temperature	$T / \text{K} = T / °\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 **(a)** Define *work done*.

....

.... [1]

(b) A trolley of mass 400 g is moving at a constant speed of 2.5 m s^{-1} to the right as shown in Fig. 1.1.

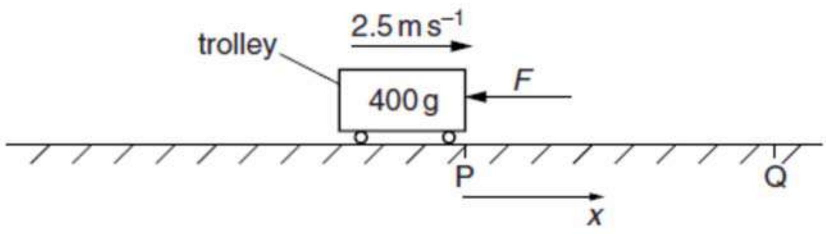


Fig. 1.1

A variable force F acts to the left on the trolley as it moves between points P and Q. The variation of F with displacement x from P is shown in Fig. 1.2.

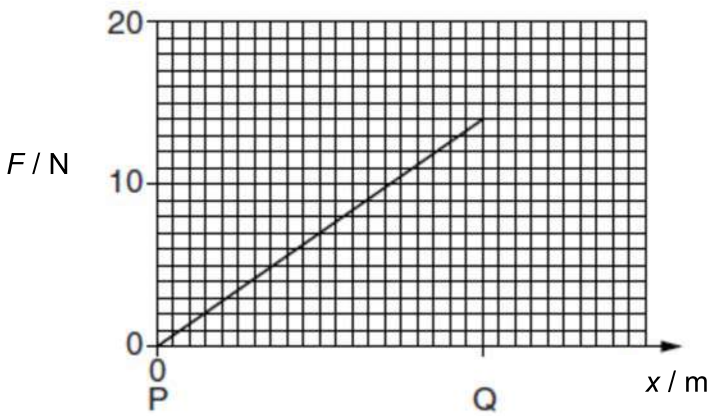


Fig. 1.2

The trolley comes to rest at point Q.

(i) Calculate the distance PQ.

distance = ... m [2]

(ii) On Fig. 1.3, sketch, with appropriate values, the variation with *x* of work done on trolley by *F*.

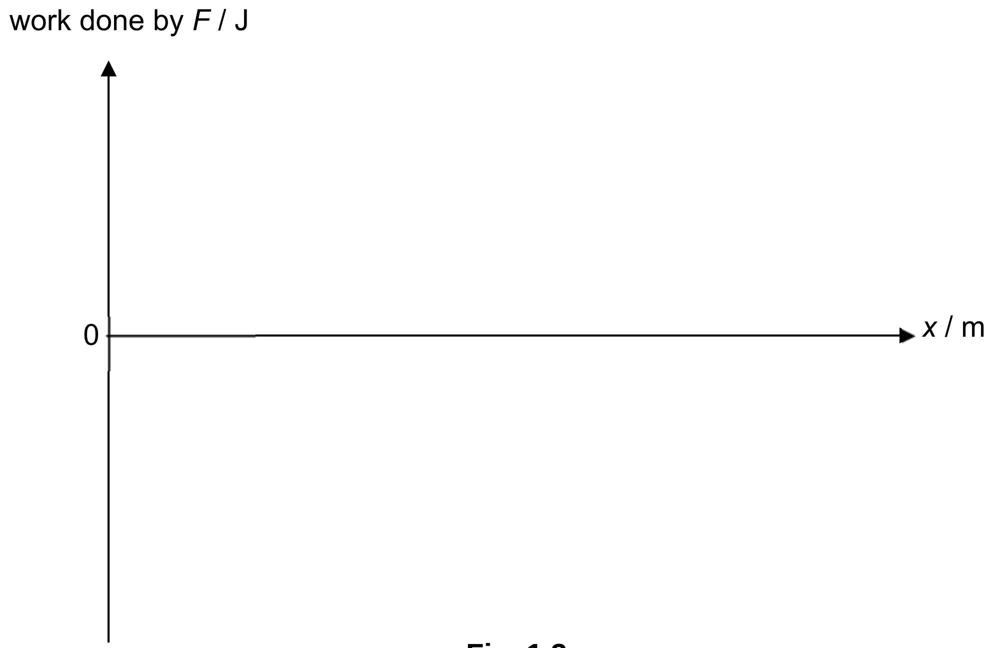


Fig. 1.3

[3]

(iii) In order to maintain a constant speed of 2.5 m s^{-1}, an electric motor attached to the trolley is switched on.

On Fig. 1.4, sketch the variation with *x* of the power supplied by motor while the trolley moves from point P to Q. No numerical value is required.

Fig. 1.4

[1]

2 **(a)** Explain how a body moving at constant speed can experience an acceleration.

………………………………………………………………………………………………………..

………………………………………………………………………………………………………..

……………………………………………………………………………………………………… [2]

(b) A ball at rest at O is slightly displaced so that it slides down a frictionless track towards the loop-the-loop of radius *R* as shown in Fig. 2.1.

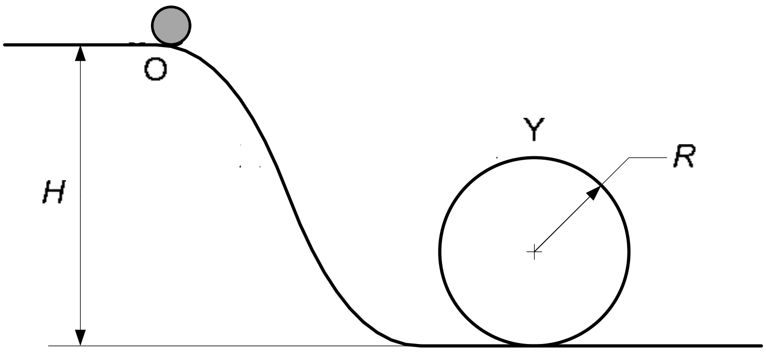


Fig. 2.1

(i) On Fig. 2.2, draw and label the forces acting on the ball when it is at the highest point Y of the loop-the-loop.

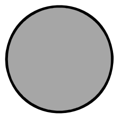


Fig. 2.2

[2]

(ii) Show that the minimum speed of the ball at point Y so that it remains in contact with the track is $\sqrt{gR}$.

[2]

(iii) Hence, determine an expression in terms of *R* for the minimum height *H* of point O with respect to the lowest point of the loop-the-loop.

[2]

3 A space rocket on Earth is fired for a few minutes to provide it with the necessary kinetic energy for it to travel directly to the Moon. Along the line joining the centres of the Earth and Moon, there is a point P where the rocket does not experience any gravitational force. P is 3.46×10^5 km from the centre of the Earth and 3.80×10^4 km from the centre of the Moon as shown in Fig. 3.1.

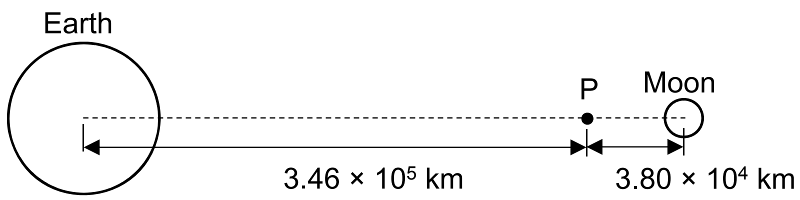


Fig. 3.1

(a) Explain why the rocket does not experience any gravitational force at P.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………… [2]

(b) Suggest two reasons why a return rocket from the Moon would need much less fuel than that required for the outward journey from the Earth.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………… [2]

(c) Given that the mass of the Earth is 5.97×10^{24} kg, calculate the mass of the Moon.

mass = ... kg [2]

(d) A meteorite of mass 7.5 kg moves towards P under the gravitational attraction of the Earth and Moon. It is initially at rest at a large distance away from P.

Calculate the kinetic energy of the meteorite when it reaches P.

kinetic energy = ... J [3]

4 **(a)** A point source of sound S emits a note of frequency 520 Hz at constant power. Two points along the wave X and Y, separated by a distance of 0.490 m, have a phase difference of $\frac{3}{2}\pi$ rad as shown in Fig. 4.1. Point X is 5.24 m away from S.

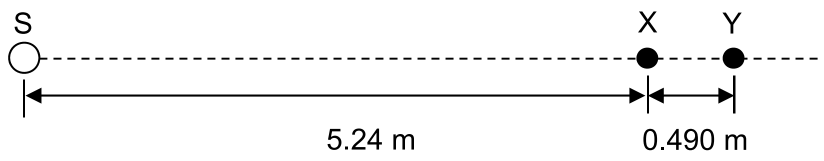


Fig. 4.1

(i) Determine the wavelength and speed of the sound wave.

wavelength = ... m

speed = …………………………. m s^{-1}

[3]

(ii) Given that the intensity at X is 2.6 × 10^{-3} W m^{-2}, calculate the intensity of the sound at Y.

intensity = ... W m^{-2} [2]

(b) A parallel beam of light is incident on two polarisers P and Q. When the polarising directions are parallel, the amplitude of the emergent beam is *A* as shown in Fig. 4.2.

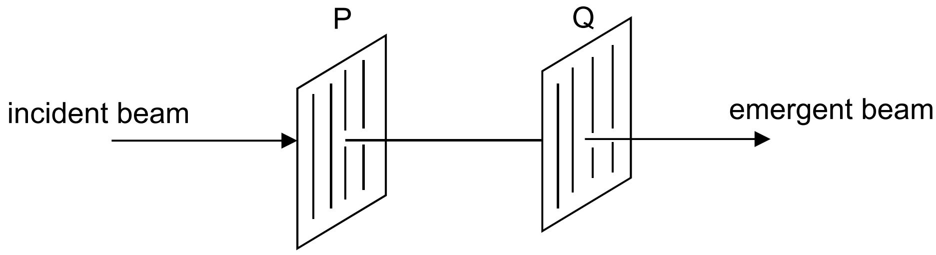


Fig. 4.2

(i) Determine the angle through which Q must be rotated so that the amplitude of the emergent beam is reduced to $\frac{A}{2}$.

angle = ... ° [2]

(ii) Determine the corresponding fractional change in the intensity of the emergent beam.

fractional change = ... [2]

5 A cell P, a fixed resistor R and a uniform resistance wire AB are connected in a circuit as shown in Fig. 5.1.

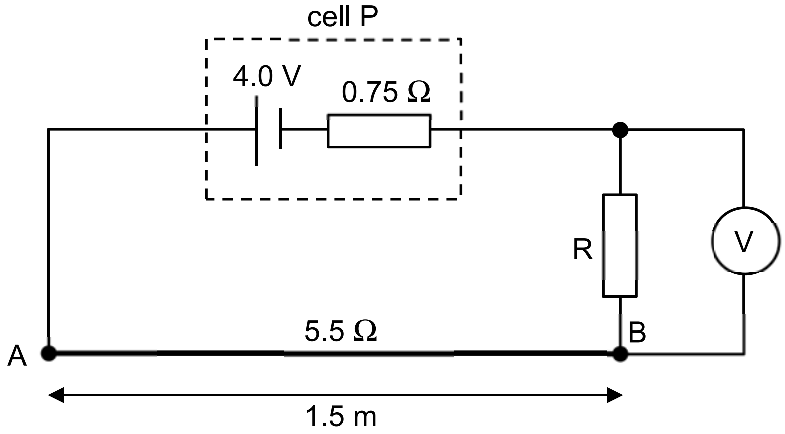


Fig. 5.1

Cell P has e.m.f. 4.0 V and internal resistance 0.75 Ω. Wire AB has length 1.5 m and resistance 5.5 Ω. The voltmeter reads 1.3 V.

(a) Show that the potential difference across AB is 2.4 V.

[3]

(b) A cell Q and a sensitive ammeter are connected to the circuit in Fig. 5.1, as shown in Fig. 5.2.

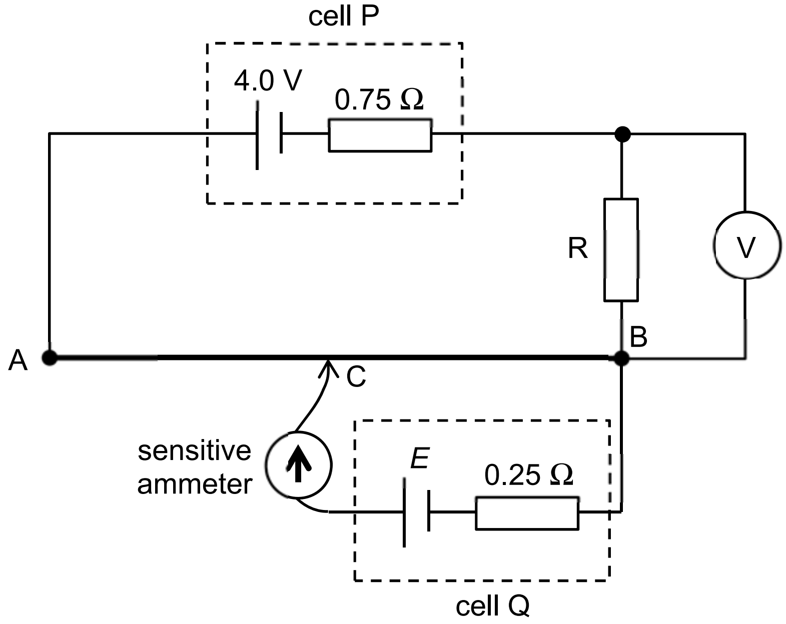


Fig. 5.2

Cell Q has e.m.f. *E* and internal resistance 0.25 Ω. The ammeter reads zero when the length of AC is 0.56 m.

(i) Determine *E*.

E = ... V [2]

(ii) There is a reading on the ammeter when the connection C is shifted closer to A.

State and explain the direction of the current across cell Q.

....

....

.... [2]

6 **(a)** **(i)** Write down the equation defining *magnetic flux density* in terms of F the force it produces on a long, straight conductor of length L carrying a current I at an angle θ to the field.

[1]

(ii) Draw a diagram to illustrate the direction of the force relative to the current and magnetic field.

[1]

(b) Fig. 6.1 shows a small square coil of N turns and sides of length L. It is mounted so that it can pivot freely through the centre of the coil, about a horizontal axis PQ parallel to one pair of sides of the coil.

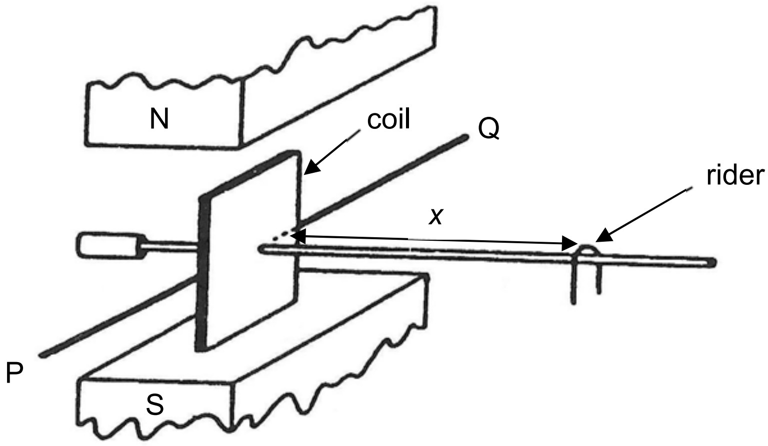


Fig. 6.1

The coil is situated between the poles of a magnet which produces a uniform vertical magnetic field of flux density B. The coil is maintained in a vertical plane by moving a rider of mass M along a horizontal beam attached to the coil. When a current I flow through the coil, equilibrium is restored by adjusting x, the distance of the rider from the coil.

(i) Starting from the definition of magnetic flux density, show that B is given by the expression

$$B = \frac{Mgx}{IL^2N}.$$

[3]

(ii) Current I is supplied by a battery of constant e.m.f. and negligible internal resistance. Discuss the effect on x if the coil is replaced by one wound with wire of same material and diameter, but forming a coil of N turns with sides of length $\frac{L}{2}$.

....

....

....

.... [3]

7 **(a)** Explain what is meant by *work function* of a metal by reference to the photoelectric effect.

....

....

.... [1]

(b) In a photoelectric emission experiment, light of wavelength 540 nm and intensity 150 $\mathrm{W m^{-2}}$ is incident on a metal surface of work function 1.9 eV in an evacuated tube, such that an area of 14 $\mathrm{mm^2}$ is illuminated.

(i) Calculate the energy of the incident photon.

energy = ... J [2]

(ii) Calculate the rate of photons incident on the metal surface.

rate = ... s^{-1} [2]

(iii) Determine the maximum kinetic energy of the electrons emitted from the surface.

maximum kinetic energy = ... J [2]

(c) An X-ray spectrum produced by copper is shown in Fig. 7.1 where I is the intensity and λ is the wavelength.

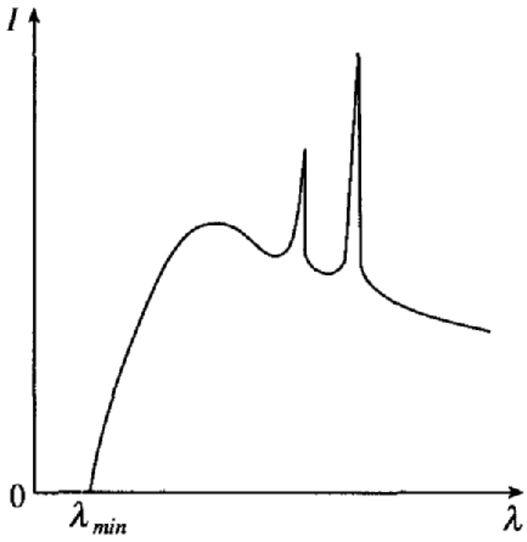


Fig. 7.1.

(i) Explain how a continuous spectrum is formed and why is there a minimum wavelength.

....

....

....

....

....

.... [3]

(ii) Sketch on Fig. 7.1 the new X-ray spectrum when a larger accelerating voltage is used instead. Explain your answer.

....

....

....

....

....

.... [3]

8 Fig. 8.1 shows a bubble chamber which consists of a sealed chamber filled with a liquefied gas. The coils around the chamber provide a magnetic field. The pressure inside the chamber can be reduced quickly by an adjustable piston. The liquid is originally at a temperature just below its boiling point. When the pressure is reduced, the boiling point of the liquid becomes lower, so that it is less than the original temperature of the liquid, leaving the liquid superheated.

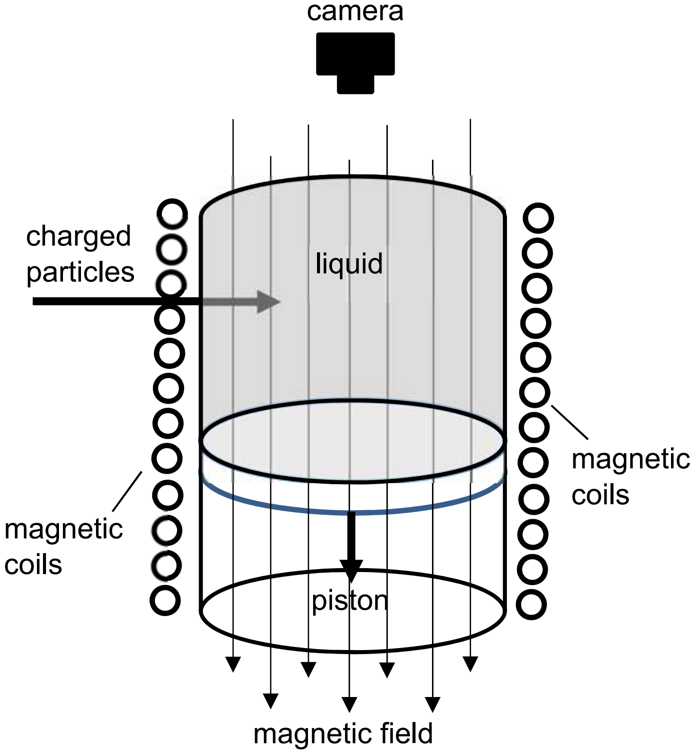


Fig. 8.1

As beams of charged particles pass through the liquid, they deposit energy by ionising the liquid atoms. This causes the liquid to boil and tiny gas bubbles are formed along the paths of the charged particles.

Some charged particles may also collide with an atomic nucleus of the liquid and form products which are charged too. These charged products will move on and ionise the liquid, causing more trails of bubbles to form.

The chamber is illuminated so that the tracks of the charged particles can be photographed. By analyzing the tracks, the charged particles can be identified and any complex events involving the particles can be studied.

In the presence of a magnetic field, the tracks of the charged particles will be curved. The degree of curvature depends on the mass, speed, and charge of each particle.

Neutral particles can be detected indirectly by applying various conservation laws to the events recorded in the bubble chamber or by observing their decay into pairs of oppositely charged particles.

Fig. 8.2 is a picture taken by the camera from a bubble chamber that is filled with liquid hydrogen. The lines show the path of the particles entering the chamber from one of the sides.

A parallel beam of K^- particles, each with an energy of 8.2 GeV and a charge of $-e$ enters from the bottom of Fig. 8.2.

The radius of any circular path made by a moving charged particle in the bubble chamber is proportional to the momentum and inversely proportional to the charge of the particle.

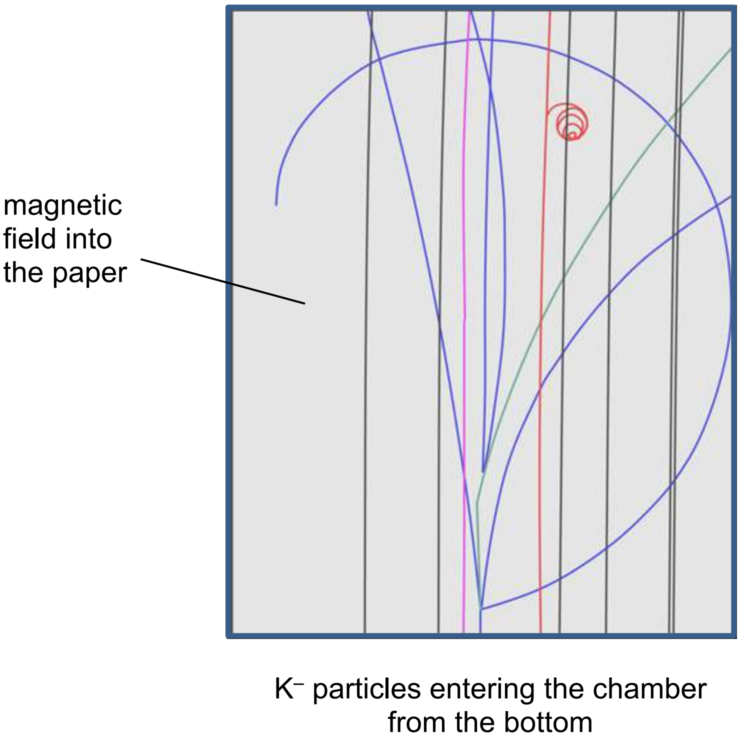


Fig. 8.2

(a) State the number of positively charged particles as shown in Fig. 8.2.

number = ... [1]

(b) Fig. 8.3 shows the enlarged picture of the little curly track at the top right quadrant of Fig. 8.2.

It has been proposed that this track is produced by an electron which is knocked out of the hydrogen atom by a passing K^- particle.

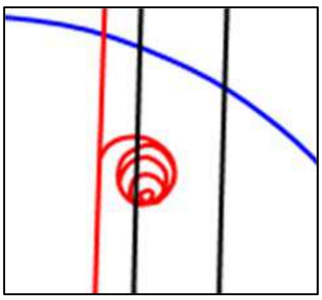


Fig. 8.3

(i) By comparing the curly path in Fig. 8.3 with paths made by other particles in Fig. 8.2, explain whether this proposal is possible.

....

....

.... [2]

(ii) Suggest why is this path a spiral.

....

....

.... [2]

(c) Fig. 8.4 shows a K^- particle colliding with the positively charged nucleus of a hydrogen atom at point A. The collision produced four charged particles as illustrated by the four outgoing tracks, numbered 1 to 4.

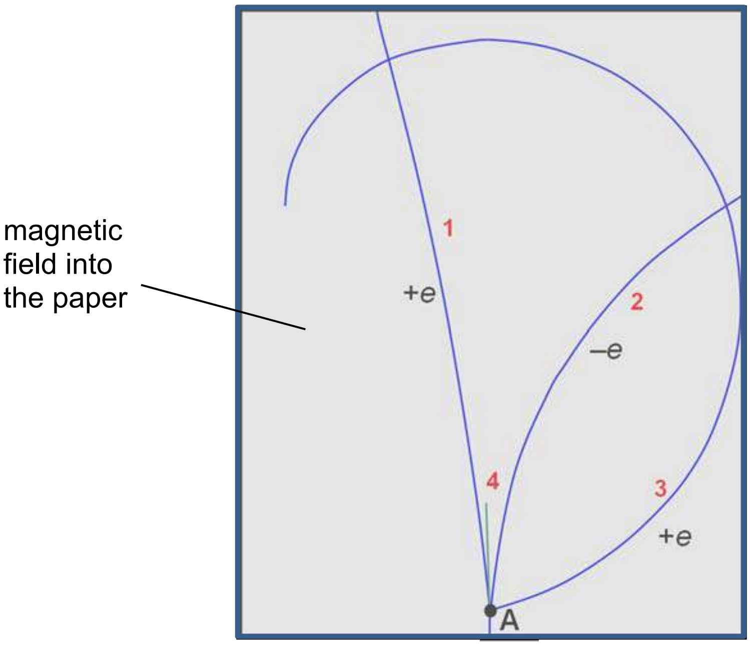


Fig. 8.4

The charges of three of the four outgoing particles after the collision are indicated beside their tracks.

(i) Deduce the charge of the fourth outgoing particle. Justify your answer.

....

.... [2]

(ii) State which of the outgoing particles 1 to 4 has the lowest momentum.

.... [1]

(d) There is a fifth outgoing particle from the collision at point A which is neutral and does not produce any visible track. This particle eventually decays into two smaller particles at point B as shown in Fig. 8.5.

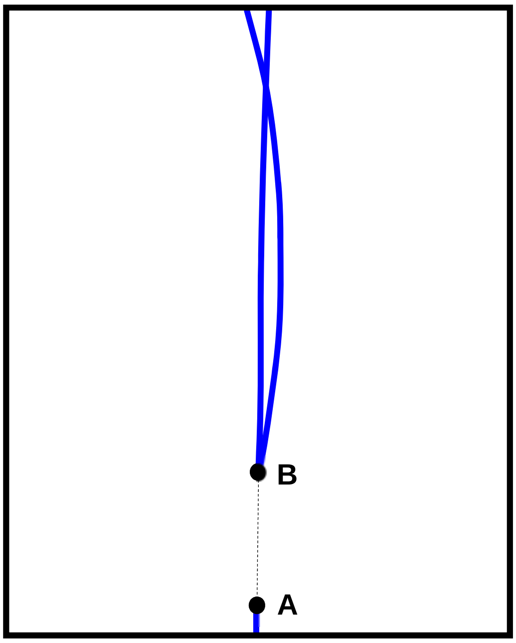


Fig. 8.5

(i) Explain why it leaves no track.

....

.... [1]

(ii) Deduce the charge of the two particles that are formed from the decay of the fifth particle. Explain your answer.

....

....

.... [2]

(e) The bubble chamber is used to study the collision between a K^- particle and a stationary proton p. The total energy E and momentum in three dimensions p_x, p_y, p_z of each particle produced in a collision is governed by the formula

$$E^2 = (p_x{}^2 + p_y{}^2 + p_z{}^2)c^2 + m^2c^4$$

where m is the mass of the particle and c is the speed of light.

In a particular collision, three additional particles Ω^-, Ω^+ and K^0 are formed and the data collected are shown in Fig. 8.6 below.

Before collision

particle	p_x / 10^{-20} N s	p_y / 10^{-20} N s	p_z / 10^{-20} N s	E / 10^{-12} J
K^-	438.05	-13.24	0.81	1317.12
p	0.00	0.00	0.00	150.13
sum				

After collision

particle	p_x / 10^{-20} N s	p_y / 10^{-20} N s	p_z / 10^{-20} N s	E / 10^{-12} J
K^-	79.03	1.48	11.95	252.50
Ω^-	7.98	-0.60	2.07	33.38
Ω^+	2.02	-6.52	-1.21	30.51
p	80.46	6.85	-3.76	285.22
K^0	189.10	-8.69	-13.07	574.78
sum				

Fig. 8.6

(i) Complete Fig. 8.6 to show

1. the sum of the momentum in all the dimensions for the particles before and after the collision, [1]

2. the sum of the energy for the particles before and after the collision. [1]

(ii) The sum of the total energies E before and after the collision are not equal, implying that more particles are formed but have gone undetected.

Assuming that there is only one undetected particle, determine

1. the components of its momentum p_x, p_y, p_z and its total energy E,

p_x = ... N s

p_y = ... N s

p_z = ... N s

E = ... J [4]

2. its mass m.

m = ... kg [2]

End of paper

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/03**
Higher 2

Paper 3 Longer Structured Questions

18 September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question only.

You are advised to spend about one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 6
2	/ 8
3	/ 9
4	/ 9
5	/ 7
6	/ 6
7	/ 7
8	/ 8
9	/ 20
10	/ 20
Total	/ 80

This document consists of **24** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{GM}{r}$
temperature	$T / \text{K} = T / {}^{\circ}\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{{x_0}^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** questions in this Section.

1 A ball is thrown from point O as shown in Fig. 1.1.

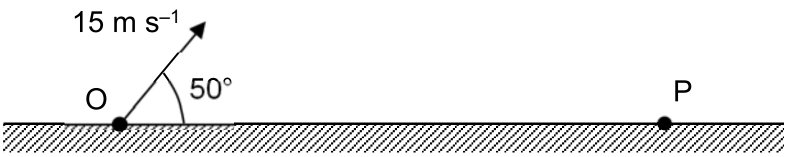


Fig. 1.1

The initial velocity of the ball is 15 m s^{-1} at an angle of 50° above the horizontal. The ball lands at point P. The points O and P are at the same horizontal level. Assume that air resistance is negligible.

(a) Determine the length of OP.

OP = ... m [3]

(b) On Fig. 1.1, sketch the paths of the ball for the same given initial velocity

(i) when there is no air resistance and label it A, [1]

(ii) when air resistance cannot be neglected and label it B. [2]

2 A rigid bar of mass 450 g is held horizontally by two supports A and B, as shown in Fig. 2.1.

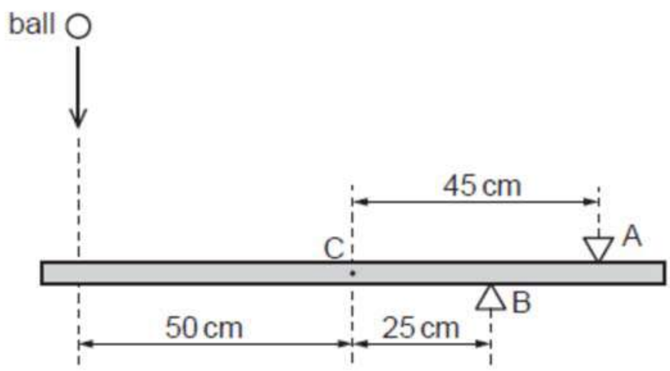


Fig. 2.1

The support A is 45 cm from the centre of gravity C of the bar and support B is 25 cm from C. A ball of mass 140 g falls vertically onto the bar such that it hits the bar at a distance of 50 cm from C, as shown in Fig. 2.1.

The variation with time t of the velocity v of the ball before, during and after hitting the bar is shown in Fig. 2.2.

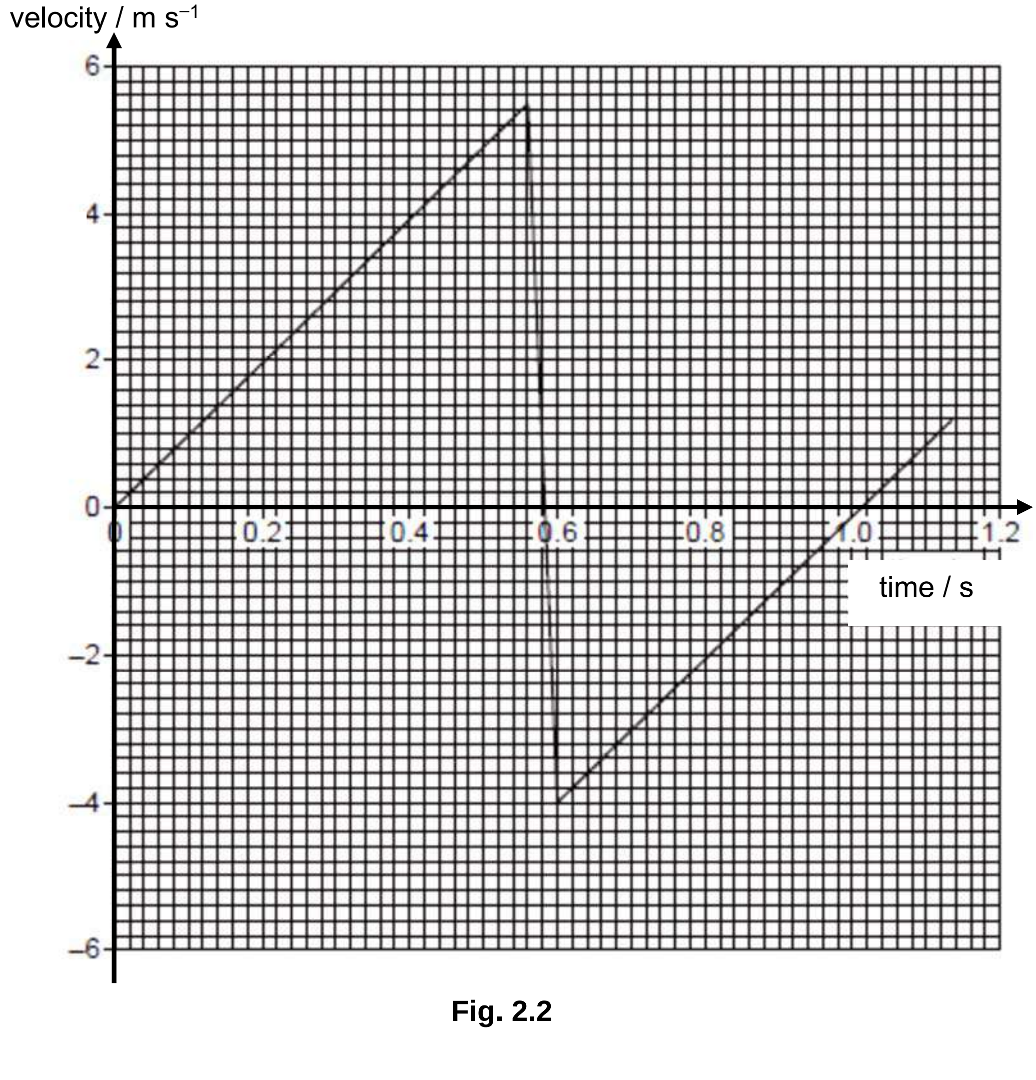


Fig. 2.2

[Turn over

(a) For the time that the ball is in contact with the bar, use Fig. 2.2 to determine

(i) the change in momentum of the ball,

change in momentum = ... N s [2]

(ii) the magnitude of the force exerted by the ball on the bar.

force = ... N [3]

(b) For the time that the ball is in contact with the bar, use data from Fig. 2.1 and **(a)(ii)** to calculate the magnitude of the force exerted on the bar by

(i) support A,

force = ... N [2]

(ii) support B.

force = ... N [1]

3 **(a)** State two basic assumptions of the kinetic theory of gases.

....

....

.... [2]

(b) A cylinder contains 2.5 moles of an ideal monatomic gas at a pressure of $1.8.\times 10^5$ Pa and temperature of 288 K. The gas has density of $2.7\ \text{kg m}^{-3}$.

(i) Determine the root-mean-square (r.m.s.) speed of the gas.

r.m.s. speed = ... m s^{-1} [1]

(ii) The gas is heated at constant pressure until its volume is doubled. Calculate

1. the increase in internal energy of the gas,

increase in internal energy = ... J [2]

2. the work done on the gas,

work done on gas = ... J [2]

3. the thermal energy supplied to the gas.

thermal energy = ... J [2]

4 **(a)** State the *principle of superposition*.

....

....

.... [2]

(b) Fig. 4.1 shows the variation with time t of the displacements x_A and x_B at a point P of two sound waves A and B.

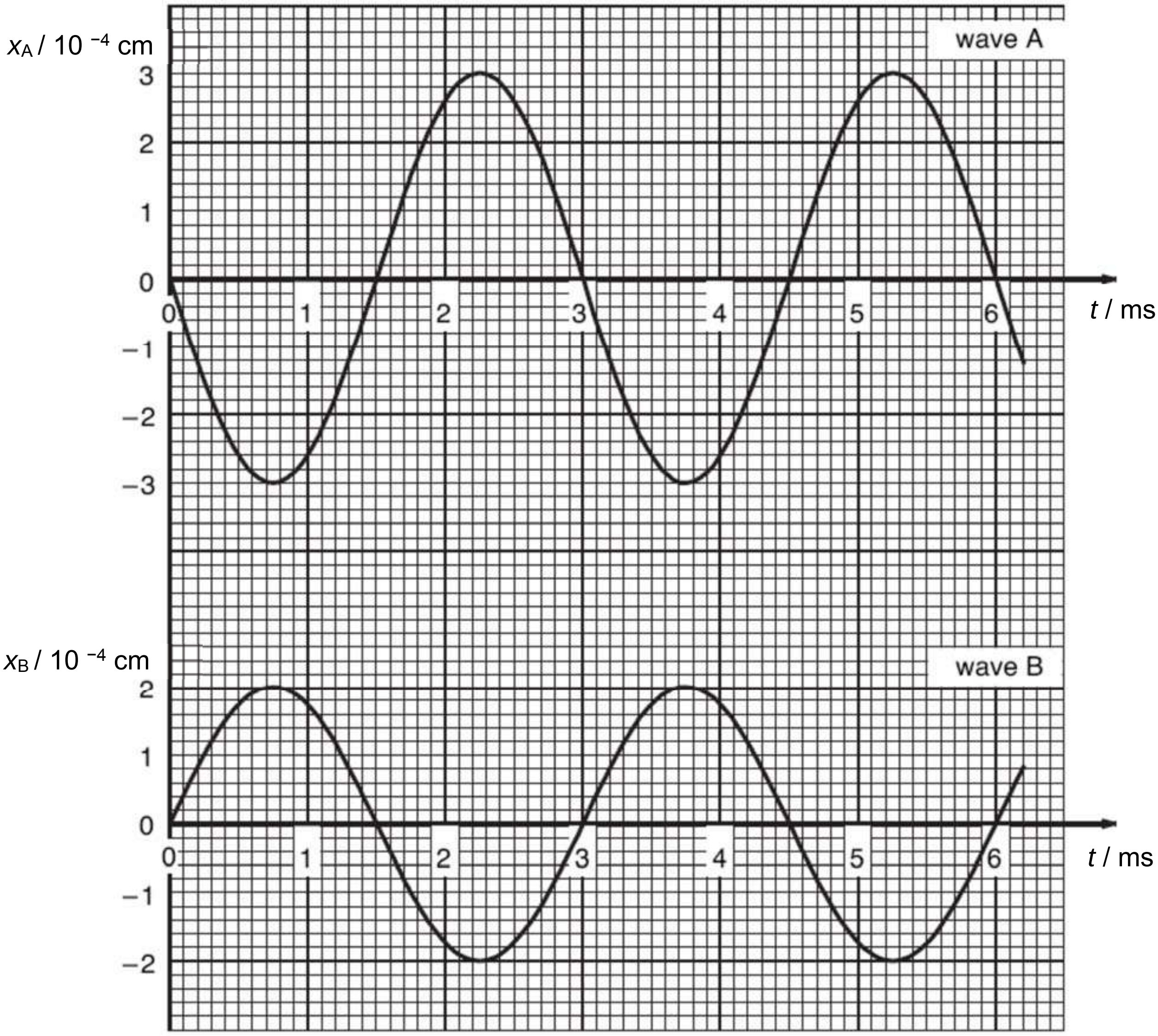


Fig. 4.1

(i) Determine the resultant displacement for the two waves at point P at time t = 4.0 ms,

resultant displacement = ...cm [1]

(ii) The intensity of wave A alone at point P is I. Calculate the resultant intensity, in terms of I, of the two waves at point P.

resultant intensity = ... [2]

(c) Fig. 4.2 shows the two loudspeakers that produced the two sound waves A and B as mentioned in **(b)**. Point O is equal distance from both loudspeakers.

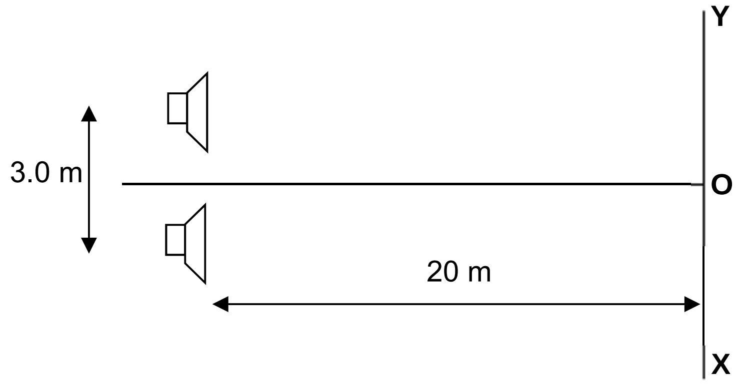


Fig. 4.2

(i) A detector is moved from point O towards Y along the line XY. After detecting three maxima including point O, a third minima is located at point P, which is 30.2 m from point O. Determine the speed of sound in air.

speed of sound = ... m s^{-1} [3]

(ii) Fig. 4.3 shows the two loudspeakers rotated to face each other but still kept 3.0 m apart. The sound emitted by the loudspeakers are in anti-phase.

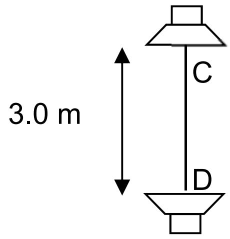


Fig. 4.3

If the detector is moved along the line CD, describe the variation of the sound intensity detected.

....

.... [1]

5 A step-up transformer near Tuas power plant increases the plant's output root-mean square (r.m.s) voltage from 12.0 kV to 240 kV. Step-down transformers near the consumers reduces the r.m.s voltage to 240 V.

The power station produces 20.0 MW of power. The total resistance of the transmission cables is $200\ \Omega$. The station loses $0.10 for every kWh of electrical energy lost.

(a) Explain what is meant by *root-mean-square voltage* when applied to a sinusoidal alternating voltage.

....

....

.... [2]

(b) (i) Determine the turns ratio of the transformer that is located near the power plant.

$\frac{N_s}{N_p}$ = ... [1]

(ii) Determine the power lost during transmission.

power lost = ...kW [2]

(iii) Hence, determine the amount of money lost by the station in one day.

amount lost = $ .... [2]

6 A filament lamp is connected in series to a cell of e.m.f. 4.0 V and negligible internal resistance and a variable resistor as shown in Fig. 6.1. The variation with the potential difference V across the filament lamp of the current I is as shown in Fig. 6.2.

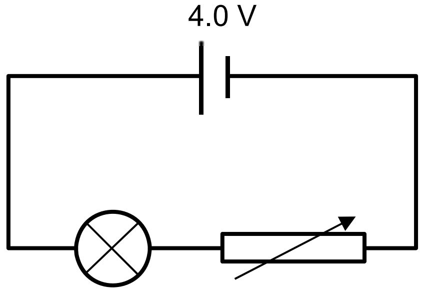


Fig. 6.1

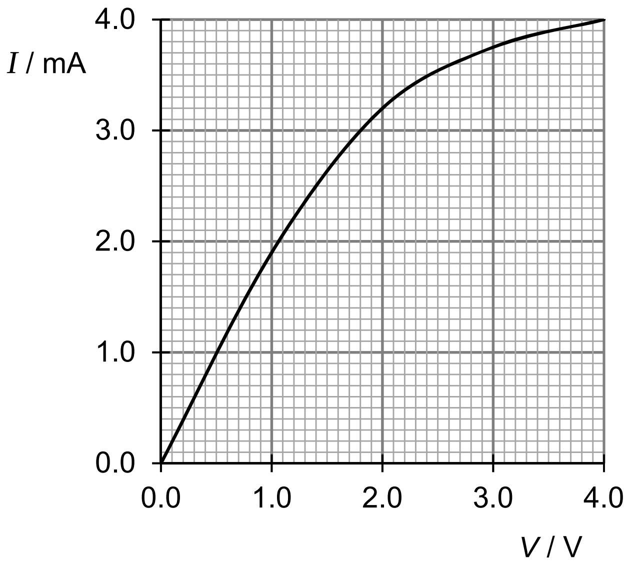


Fig. 6.2

(a) Determine the resistance of the variable resistor when V is 1.4 V.

resistance = ... Ω [2]

(b) On Fig. 6.3, sketch a labelled graph of the resistance R of the filament lamp against V between V = 1.0 V and 4.0 V.

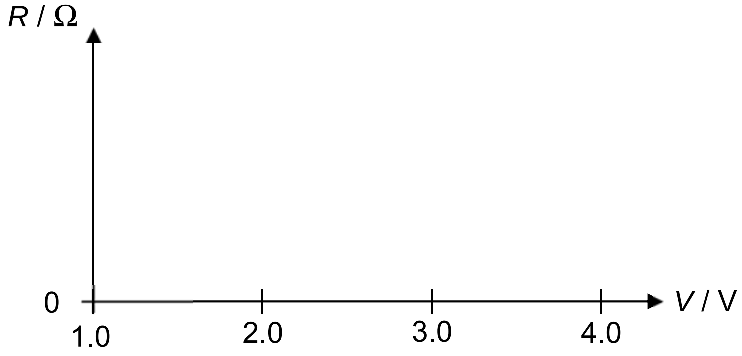


Fig. 6.3

[2]

(c) Discuss how the resistance of a filament lamp changes with temperature.

....

....

.... [2]

7 **(a)** Define *magnetic flux.*

....

.... [1]

(b) Fig. 7.1 shows two short coils connected in series by a switch S.

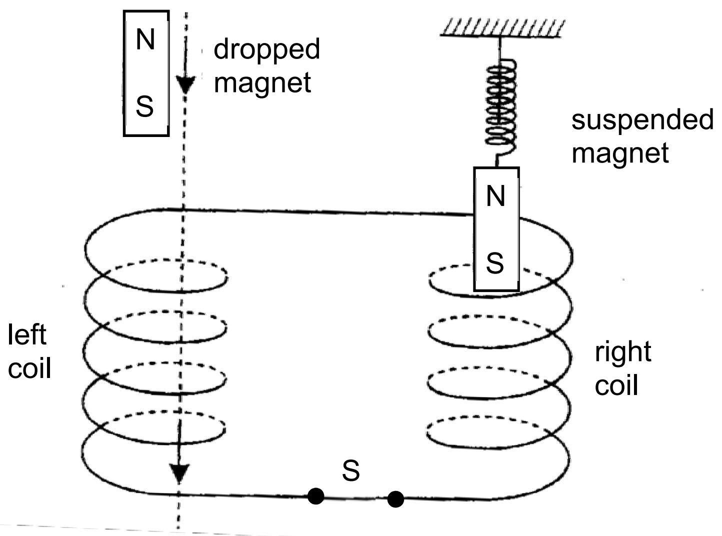


Fig. 7.1

Describe the behaviour of the suspended magnet above the right coil after a bar magnet is dropped through the left coil.

Explain your reasoning clearly.

....

....

....

....

....

....

.... [4]

(c) Switch S is now opened. State and explain any changes to your answer in **(b)**.

....

....

.... [2]

8 (a) Define *electric field strength* at a point.

....

....

.... [1]

(b) Fig. 8.1 shows two horizontal plates A and B whose electric potentials are 70.0 V and –20.0 V respectively. The plates are 90.0 cm apart. A conductor P is situated centrally between the two plates.

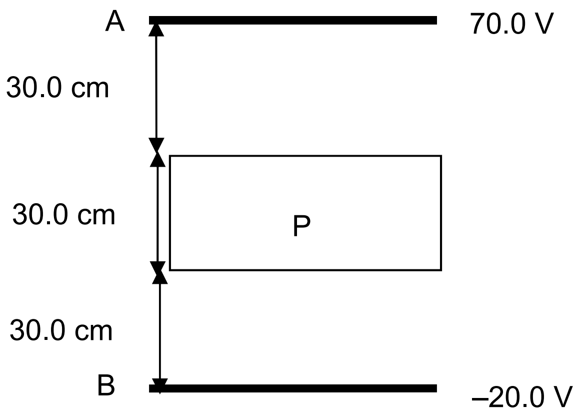


Fig. 8.1

(i) On Fig. 8.2, sketch the variation of electric potential V with distance x from A, between the two plates.

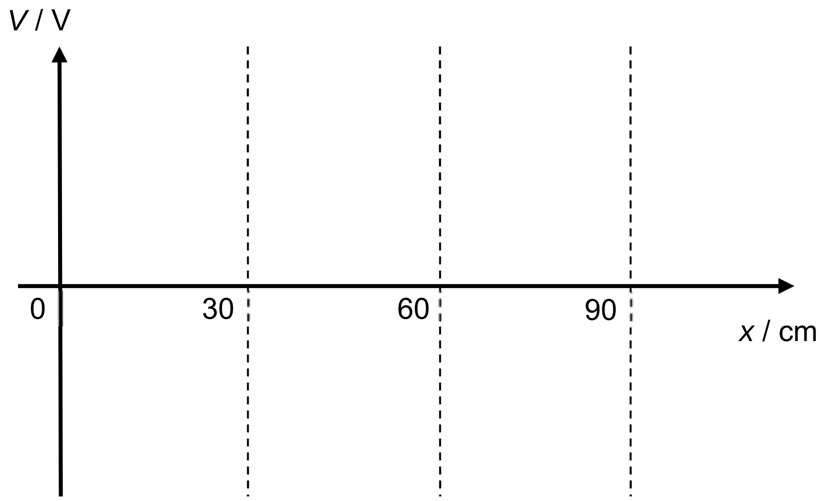


Fig. 8.2

[2]

(ii) On Fig. 8.3, sketch the variation of electric field strength *E* with distance *x* between the two plates.

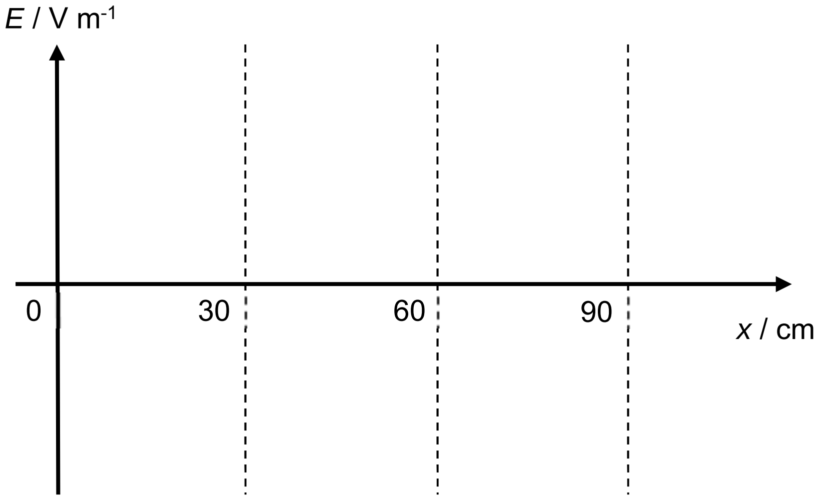


Fig. 8.3

[2]

(c) Fig. 8.4 shows an electron starting from rest between the two vertical plates A and B. The length of the plates is 20.0 cm and they are 90.0 cm apart.

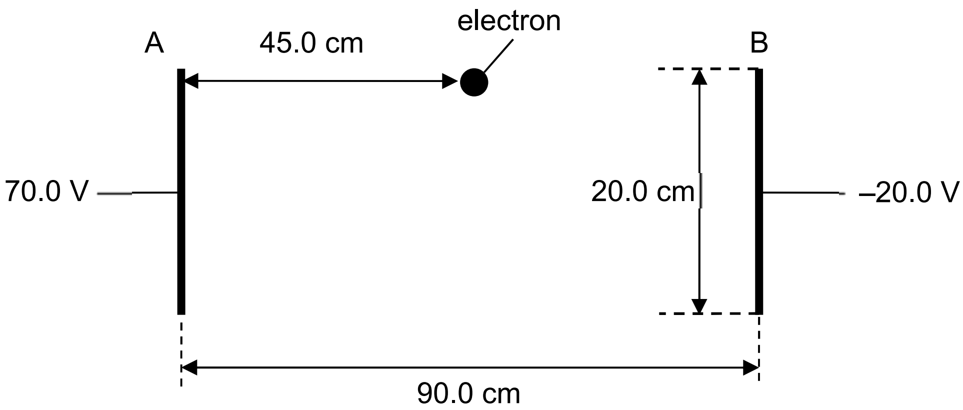


Fig. 8.4

(i) Describe the path travelled by the electron between the two plates A and B,

....

.... [1]

(ii) Determine the horizontal speed at which the electron would hit one of the plates.

speed = ... m s^{-1} [2]

Section B

Answer **one** question from this section.

9 **(a)** Distinguish between *velocity* and *angular velocity* for a body undergoing oscillations.

....

....

....

.... [2]

(b) A toy pendulum consists of a sphere of mass 0.800 kg, attached firmly to one end of a rod of negligible mass. The other end of the rod is pivoted freely at point O. The distance between the centre of gravity of the toy to O is 0.600 m. The structure is held in a position such that the rod is at an angle of 6.00° from the vertical, as shown in Fig. 9.1.

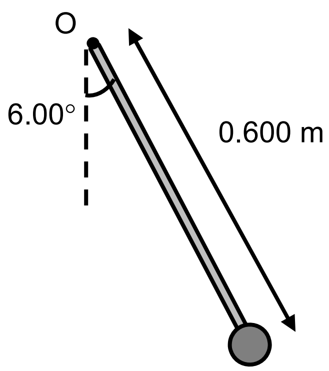


Fig. 9.1

The structure is then released from rest and oscillates in simple harmonic motion. At one instant during the oscillation, the toy is directly below O, as shown in Fig. 9.2.

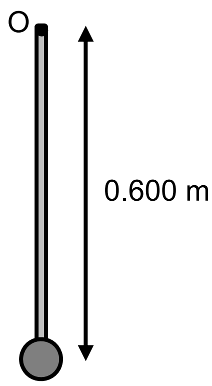


Fig. 9.2

(i) On Fig. 9.2, indicate the forces acting on the sphere. [2]

(ii) Show that the linear speed of the sphere at the instant in Fig. 9.2 is 0.254 m s^{-1}.

[2]

(iii) Determine the force *F* exerted on the pivot by the rod in Fig. 9.2.

F = ...N [2]

(iv) On Fig. 9.3, sketch the velocity-time graph of the sphere with correct labels assuming that the sphere is at maximum displacement at *t* = 0 s. Label the period as *T*.

Fig. 9.3

[2]

(c) (i) State what is meant by *resonance*.

....

....

.... [2]

(ii) A ship of mass 1020 kg undergoes simple harmonic motion in the vertical direction due to surface water waves that are incident on the ship. The water waves of amplitude of 0.18 m and frequency 0.56 Hz cause resonance in the vertical motion of the ship.

1. Write an expression for the vertical displacement *x* as a function of the time *t* associated with the motion of the ship.

[2]

2. Calculate the magnitude of acceleration of the sailing boat when its displacement from its equilibrium position is 0.080 m.

a = ... $m\ s^{-2}$ [2]

3. Calculate the maximum kinetic energy of the ship during the vertical oscillation.

maximum kinetic energy = ...J [2]

4. On Fig. 9.4, sketch a labelled graph showing the variation of kinetic energy of the ship with time.

Fig. 9.4

[2]

10 (a) Define *half-life*.

....

....

.... [1]

(b) The isotope ^{59}Fe is a $\beta-$emitter with a half-life of 45 days. In a medical investigation of blood disorders, a dose of ^{59}Fe with an initial activity of 8.5×10^{7} Bq is injected into the blood stream of a patient.

(i) Calculate

1. the probability per second of the decay of a ^{59}Fe nucleus,

probability = ... s^{-1} [2]

2. the initial number of ^{59}Fe nuclei injected into the body,

number = ... [2]

3. the time taken for the activity to be one-fifth of the initial value.

time = ... s [2]

(ii) Explain why in practice, the time taken for the activity in the patient to become one-fifth of the initial value is shorter than that calculated in **(i)3**.

....

.... [1]

(c) (i) On Fig. 10.1, sketch a graph to show the variation with nucleon number *A* of the binding energy per nucleon B_E. Label in the graph an approximate value, in MeV, of the maximum binding energy per nucleon.

Fig. 10.1

[2]

(ii) Using Fig. 10.1, explain why energy is released in a fusion reaction.

....

....

.... [2]

(iii) A possible nuclear reaction which has been suggested for the generation of energy is represented by the following equation:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + X$$

Data for the above reaction are given in Fig. 10.2.

nucleus	mass of nucleus / u
X	1.008665
$^{2}_{1}H$	2.014102
$^{3}_{1}H$	3.016050
$^{4}_{2}He$	4.002603

Fig. 10.2

1. Identify the nucleus represented by the symbol *X*.

.... [1]

2. Using the data in Fig. 10.2, determine the energy produced by 150 kg of an appropriate mixture of the hydrogen isotopes.

energy = ... J [4]

3. The average power needed by a nuclear submarine is 110 MW and the efficiency of the above process is 15%.

Determine the length of time, in years, that 150 kg of the mixture can supply sufficient energy to the submarine.

time = ... years [3]

End of paper

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Prelim Examination

PHYSICS **9749/04**
Higher 2

Paper 4 Practical

13 August 2018

2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

Shift
Laboratory

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 12
2	/ 9
3	/ 22
4	/ 12
Total	/ 55

This document consists of **19** printed pages.

[Turn over

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1 In this experiment, you will investigate the equilibrium position of a half-metre rule supported by a spring.

(a) Attach the spring tied to the string and the 20 cm length of string to the half-metre rule as shown in Fig. 1.1.

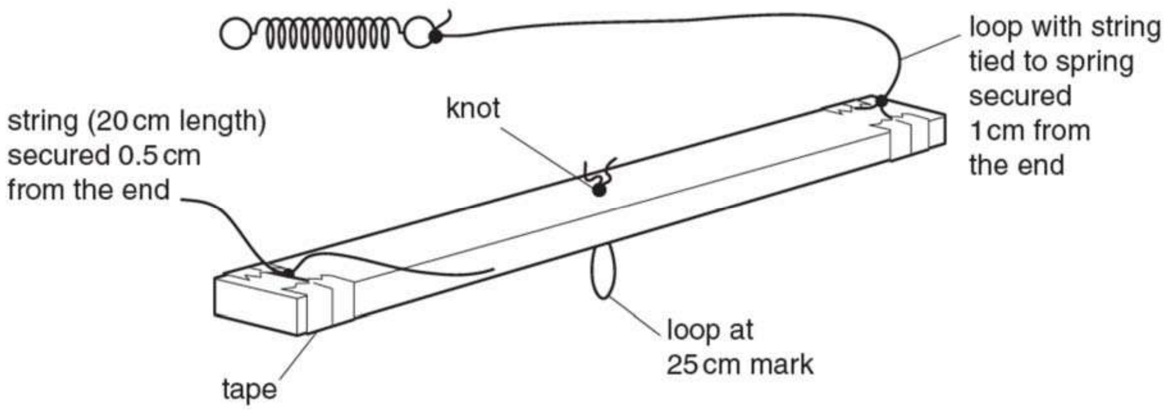

Fig. 1.1

(i) Measure and record the length d_o of the unstretched spring and the string.

d_o = ... [1]

Assemble the apparatus as shown in Fig. 1.2, using a total mass (mass hanger and masses) of 100 g. Ensure that the mass hanger and masses are not touching the bench. The upper string must be parallel to the bench.

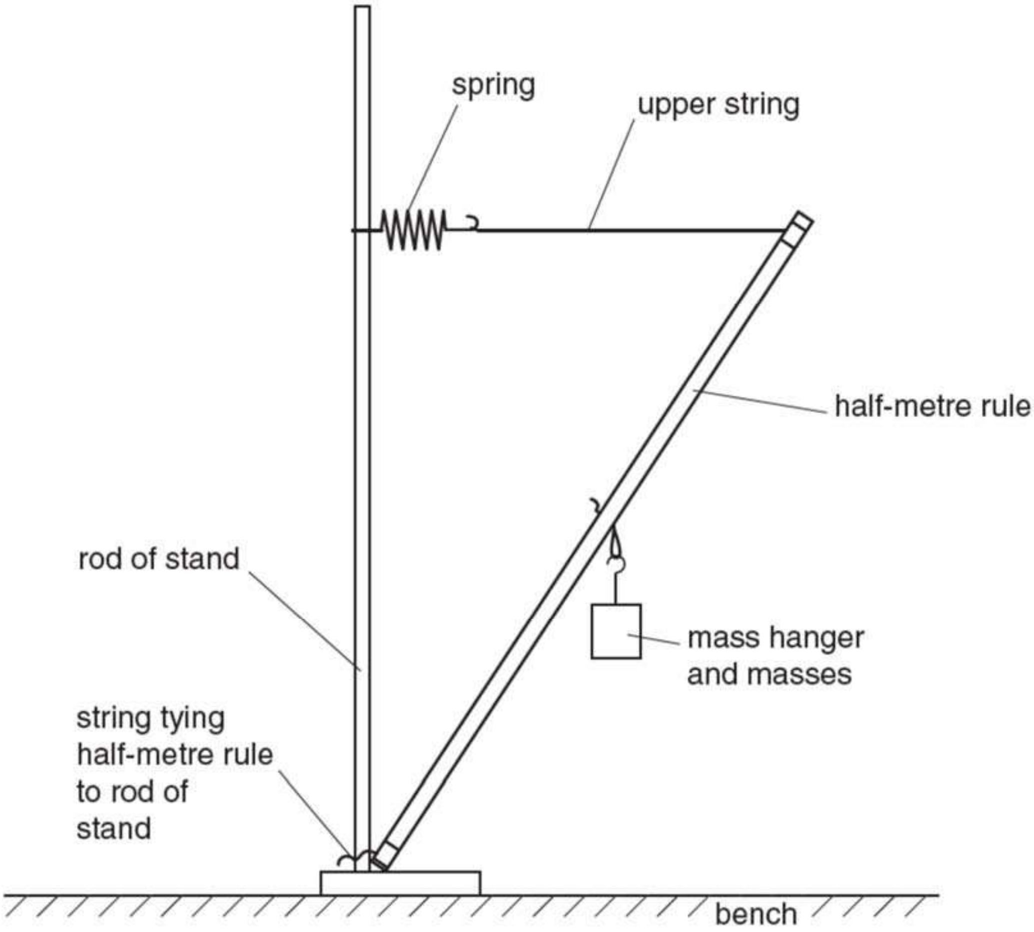

Fig. 1.2

(b) Fig. 1.3 shows the measurements you will take. Point A is where the line of the upper string meets the half-metre rule.

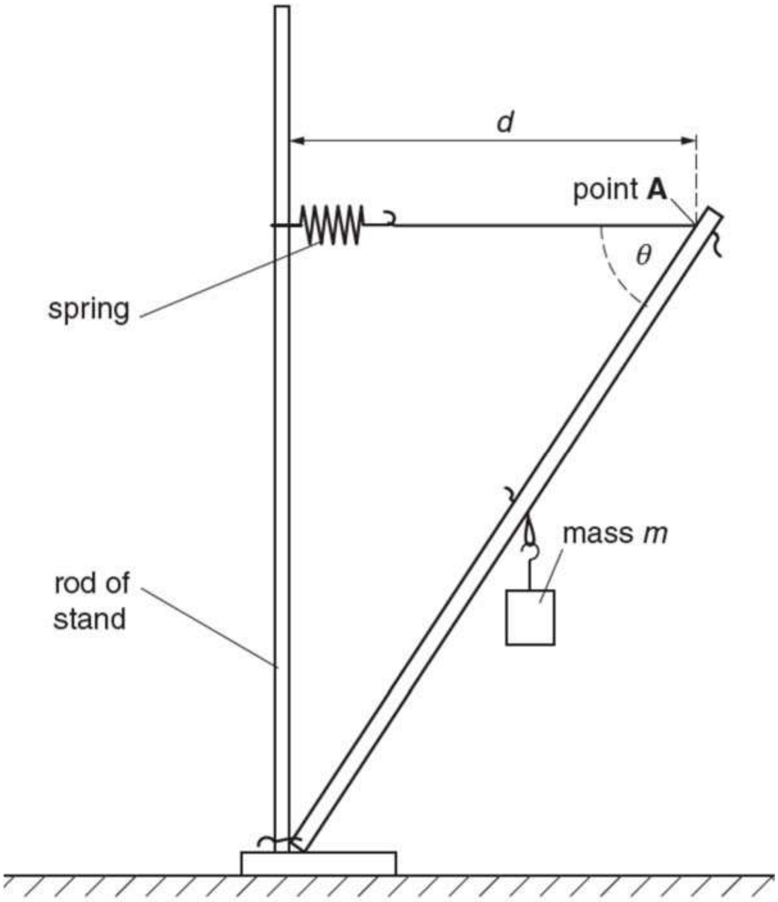

Fig. 1.3

(i) Measure and record the angle θ, as shown in Fig. 1.3.

θ = ... [1]

(ii) Estimate the percentage uncertainty in this value of θ.

percentage uncertainty = ... [1]

(iii) Measure and record the distance d between the rod of the stand and **A**, as shown in Fig. 1.3.

d = ... [1]

(c) Change the value of mass m to 200 g and repeat **(b)(i)** and **(b)(iii)** to obtain another set of values for θ and d.

θ = ... [1]

d = ... [1]

(d) Theory suggests that m, d and θ are related by the expression

$$\frac{(m+M)g}{\tan\theta} = P(d - d_0)$$

where P is a constant, M is the mass of the half metre rule and d_0 is the length of the upper string when the spring is unstretched.

(i) Using your data, and given that M is 50 g, calculate two values of P.

value of P for 100 g = ...

value of P for 200 g = ... [2]

(ii) Justify the number of significant figures that you have given for your values of P.

....

....

.... [1]

(iii) Explain whether your results support the suggested relationship.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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……………………………………………………………………………………………… [1]

(e) **(i)** State one significant source of error in the experiment. Give a reason.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(ii) Suggest one improvement that could be made to this experiment and explain how this addresses the error identified in **(i)**. You may suggest the use of other apparatus or a different procedure.

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……………………………………………………………………………………………… [1]

[Total: 12 marks]

2 In this experiment, you will investigate how the period *T* of the torsional oscillations of a suspended disc depends on the mass *m* which it carries.

(a) (i) Clamp disc B horizontally using two small blocks of wood. Suspend disc A vertically below B by threading the strings through the holes and using clips as shown in Fig. 2.1.

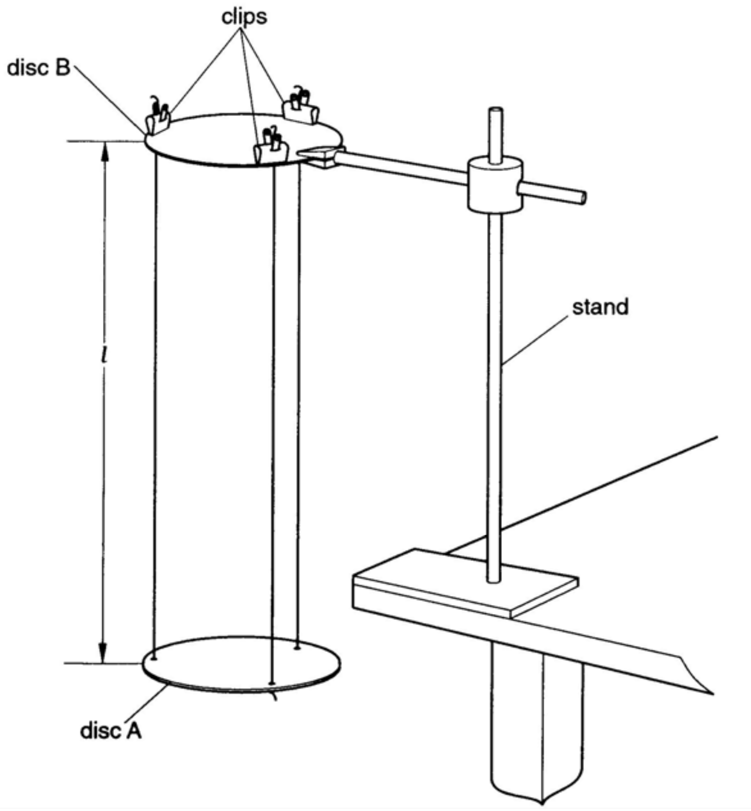


Fig. 2.1

(ii) Place a 50 g mass on disc A.

(iii) Use the clips to adjust the length l of each string until l is 1 m.

(iv) Gently rotate disc A through an angular displacement and release it so that the disc performs torsional oscillations in a horizontal plane as shown in Fig.2.2.

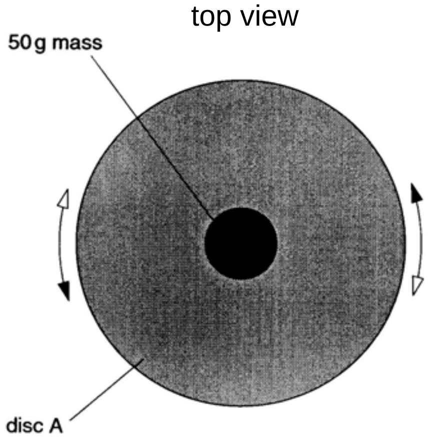


Fig. 2.2

(v) Determine the period *T* of these oscillations.

T = ... [2]

(b) (i) Suggest one significant source of error in this experiment.

....

....

....

.... [1]

(ii) Suggest an improvement that could be made to the experiment to address the error identified in **(b)(i).** You may suggest the use of other apparatus or a different procedure.

....

....

....

.... [1]

(c) It is suggested that $T=km^n$ where k and n are constants.

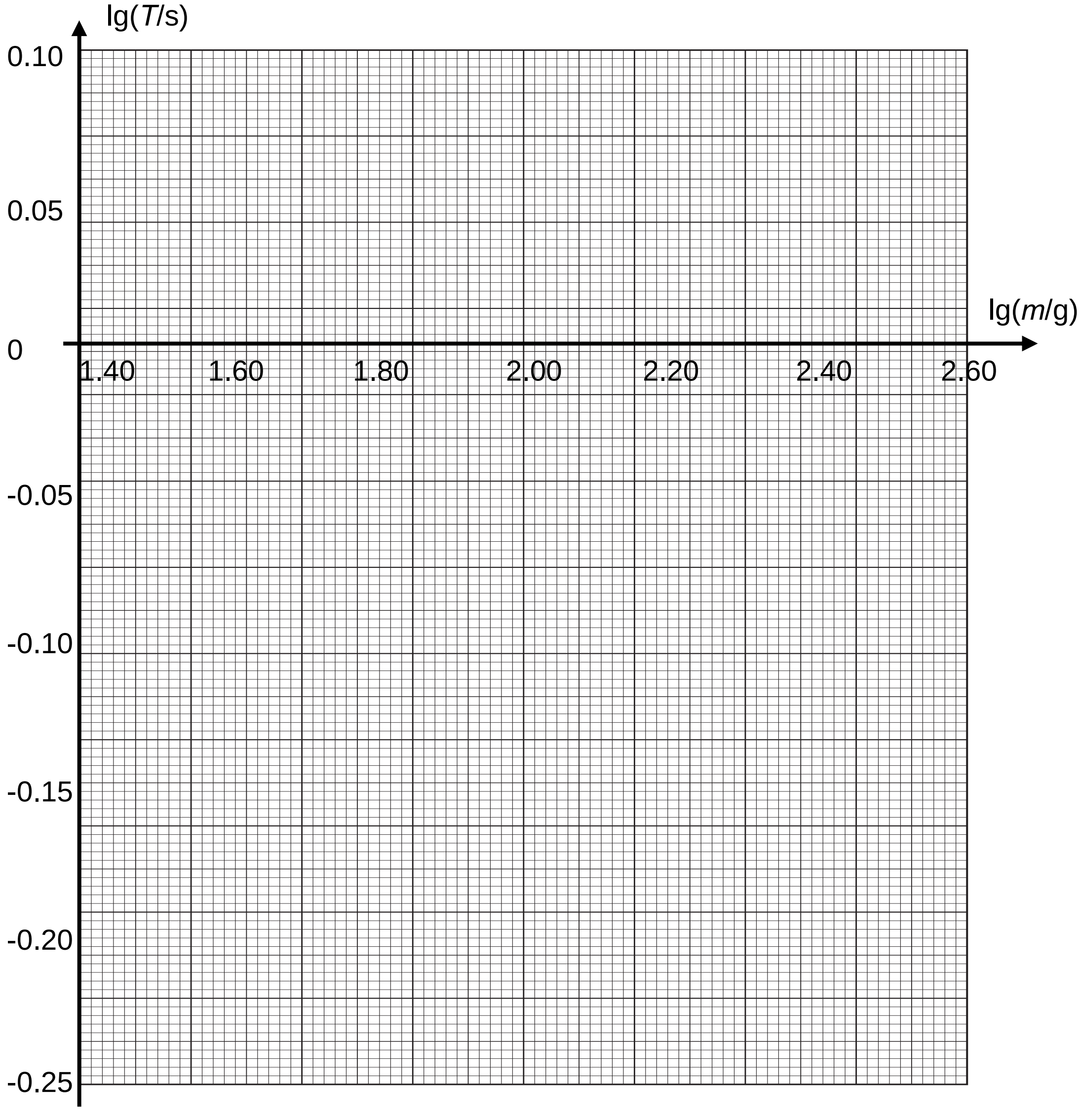
The experiment is repeated using different mass m. The results are shown in the table.

Values of lg(m/g) and lg(T/s) are included.

m / g	T / s	lg (m / g)	lg (T / s)
50			
100	0.864		
150	0.763	2.176	-0.117
200	0.701	2.301	-0.154
250	0.653	2.398	-0.185
300	0.619	2.477	-0.208

(i) Complete the table for the mass of 50g and 100g. [1]

(ii) Plot the points on the grid below and draw the line of best fit. [2]



(iii) The experiment is repeated using a piece of stone with an unknown mass *M*. The period is found to be 0.745 s.

Use your graph in **(c)(ii)** to determine *M*.

M = ... [2]

[Total: 9 marks]

3 In this experiment, you will investigate electrical properties of constantan wire.

(a) (i) You have been provided with two lengths of constantan wire attached to mountings labelled M and N, an unknown resistor Y, and six resistors labelled with their resistance values in ohms.

Connect the circuit as shown in Fig. 3.1.

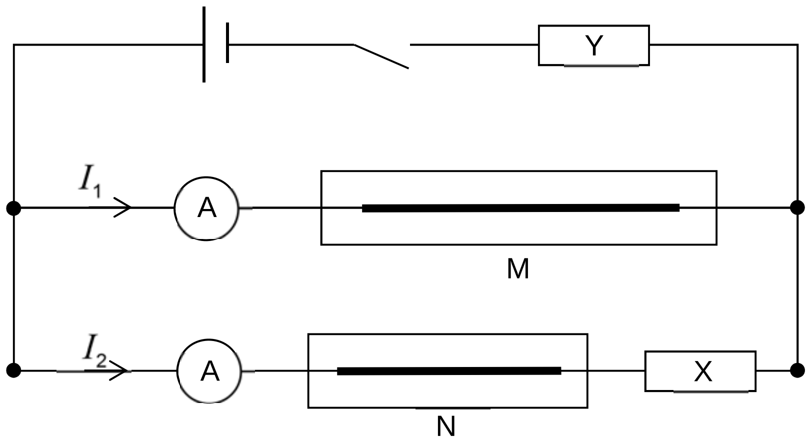


Fig. 3.1

The resistor X should be one of resistors provided which has its values given.

(ii) Record *R*, the resistance of X.

R = ...

(iii) When the switch is closed, the current through M is I_1 and the current through N is I_2.

Close the switch and record I_1 and I_2.

I_1 = ... [1]

I_2 = ... [1]

(iv) Open the switch.

(b) Change X and repeat **(a)(ii)**, **(a)(iii)** and **(a)(iv)** for further values of *R*.

[6]

(c) I_1, I_2 and *R* are related by the expression.

$$\frac{I_1}{I_2} = PR + Q$$

where *P* and *Q* are constants.

Plot a suitable graph to determine the values of *P* and *Q*.

P = ...

Q = ... [4]

[3]

(d) Standard wire gauge (*swg*) describes the diameter of a wire.

The data in the table shows the diameter *d* and the resistance per metre *R'* for constantan wire of different *swg*.

swg	*d*/mm	*R'*/ Ω m^{-1}
26	0.46	3.0
28	0.38	4.4
30	0.32	6.3
32	0.27	8.3
34	0.23	11.4
36	0.19	16.8
38	0.15	27.0
40	0.11	39.0
42	0.09	46.0

Theory suggests that the resistance of wire M = $\frac{1}{P}$.

Use the value from **(c)** and the data from the table to identify the *swg* of the wire used in this experiment.

swg = ... [1]

(e) Theory suggests that $Q = \frac{\text{length of wire N}}{\text{length of wire M}}$.

Explain whether your results support the theory.

....

....

....

.... [1]

(f) **(i)** The experiment is repeated with the length of wire M increased but the *swg* of the wire used for M and N kept the same.

On the graph grid on page 14, sketch a second graph to represent the new results. Label it Z. [1]

(ii) State a problem that might arise if both wires M and N are shortened and constantan wire of *swg* 26 is used.

....

....

....

.... [1]

(g) A student wishes to investigate how the *swg* and length of the wire used for N affects the potential difference across Y in the circuit in Fig. 3.1.

Suggest how the student should carry out the investigation.

....

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.... [3]

[Total: 22 marks]

4 When a weight is hung from a wire, the length of the wire does not seem to change initially. However, if left for a length of time, the wire is found to be gradually stretched by the weight. If the temperature is higher, the length increases more. This deformation at high temperature under constant load is called creep. The amount of creep depends on the wire's material and its temperature.

Creep is an important consideration in any application where a component made of metal is operating under a load at high temperature. A jet engine turbine as shown in Fig. 4.1 is one good example where a material operates at very high temperatures and load.

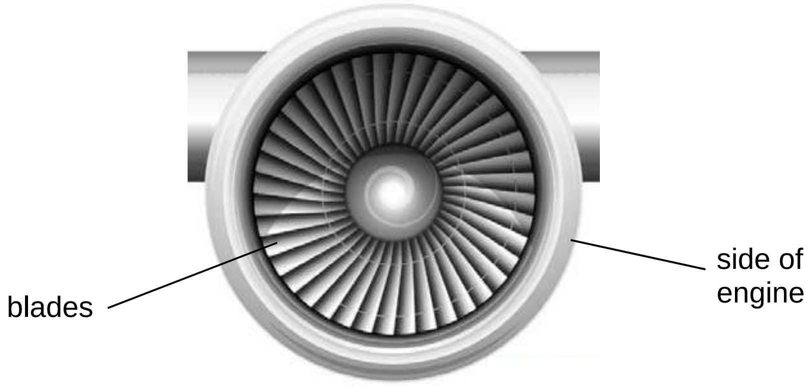

Fig. 4.1

The amount of creep experiences by the turbine blades will determine the safety life span of the blades as significant increase in length may cause the blades to hit the side of the engine. Thus engineers must have information of the amount of creep of the material used to make the blades.

You are provided with an electric heater, water bath, sand bath, signal generator, vernier scales, microscope with scale and an oscilloscope. You may also use any of the other equipment usually found in a physics laboratory.

Design an experiment to determine how the length of a wire changes with time as the temperature of the wire is changed.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the identification and control of variables,

(b) the equipment you would use,

(c) the procedure to be followed,

(d) how the increase in length is measured,

(e) how the temperature of the wire is measured,

(f) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

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……………………………………………………………………………………………… [12]

[Total: 12 marks]

End of paper

PJC Answers to JC2 Preliminary Examination Paper 1 (H2 Physics)

1	**C**	**6**	**A**	**11**	**B**	**16**	**D**	**21**	**B**	**26**	**A**
2	**A**	**7**	**B**	**12**	**D**	**17**	**D**	**22**	**D**	**27**	**C**
3	**D**	**8**	**B**	**13**	**B**	**18**	**D**	**23**	**D**	**28**	**A**
4	**B**	**9**	**A**	**14**	**D**	**19**	**B**	**24**	**D**	**29**	**A**
5	**C**	**10**	**A**	**15**	**C**	**20**	**B**	**25**	**C**	**30**	**C**

Suggested Solutions:

1 $P = I^2 R$

$$\frac{\Delta P}{P} = \frac{2\Delta I}{I} + \frac{\Delta R}{R} = \frac{2(0.05)}{2.50} + \frac{2}{100}$$
$$= 0.06$$

Therefore, percentage uncertainty is 6%.

Answer: C

2 The displacement is determined from the area underneath the graph. The point where the area underneath the graph is the largest is A.

This means that the body is moving towards the starting position from A to C, and then away from the starting position from C to D.

Answer: A

3 Let F on 5 kg = (5)(10) = 50 N

50 = 2a
a = 25 m s^{-2}

Answer: D

4 Taking moments about A,

$$4(9.81)\left(\frac{L}{2}\right) = L\left(T\cos 40^\circ\right)$$
$$T = 26 \text{ N}$$

Weight of M = 26 N (since pulley is smooth)

Answer: B

5 $P = Fv$

$$P = (500)(12)$$
$$= 6000 \text{ W}$$

Answer: C

6 Frictional force on the masses provides the centripetal force for their motion

$$F_c = f = mr\omega^2$$
$$f_{3kg} = (3.0)(2.0)\omega^2$$
$$f_{6kg} = (6.0)(5.0)\omega^2$$
$$\frac{f_{3kg}}{f_{6kg}} = \frac{6.0}{30} = 0.20$$

Answer: A

7

Gravitational force = centripetal force

$$\frac{GM^2}{r^2} = \frac{Mv^2}{\left(\frac{r}{2}\right)}$$
$$v = \sqrt{\frac{GM}{2r}}$$
$$= \sqrt{\frac{(6.67\times10^{-11})(4.0\times10^{30})}{2(2.0\times10^{11})}}$$
$$= 2.6\times10^{4}\ \text{m s}^{-1}$$

Answer: B

8 Max GPE = Total Energy = Max KE

$$KE_{\text{max initial}} = \frac{1}{2}m\omega^2x_0^2$$
$$= \frac{1}{2}(0.2)(\frac{2\pi}{0.5})^2(0.015)^2$$
$$= 3.6\times10^{-3}\ \text{J}$$
$$KE_{\text{max final}} = \frac{1}{2}m\omega^2x_0^2$$
$$= \frac{1}{2}(0.2)(\frac{2\pi}{0.5})^2(0.0065)^2$$
$$= 0.7\times10^{-3}\ \text{J}$$
$$KE_{\text{max initial}} - KE_{\text{max final}} = 2.9\times10^{-3}\ \text{J}$$

Answer: B

9 Using $Q = mc\Delta\theta$,

Rate of heat removed is $\frac{Q}{t} = \frac{m}{t}c\Delta\theta$

$$\Rightarrow \frac{m}{t} = \frac{\left(\frac{Q}{t}\right)}{c\Delta\theta} = \frac{\left(\frac{4.0\times10^{11}}{60\times60}\right)}{4200\times8} = \frac{4.0\times10^{11}}{4200\times8\times60\times60} \text{ kg s}^{-1}$$

Answer: A

10 Using $pV = nRT$

$500000\times4.0\times10^{-4} = n_1R(300)$

$n_1 = 0.0802$ moles

After filling the cylinder,

$620000\times4.0\times10^{-4} = n_2R(300)$

$n_2 = 0.0995$ moles

Amount pumped in = 0.019 moles

Answer: A

11 Using 1st law of thermodynamics,

$\Delta U = Q + W$

For change S → Q → P,

$\Delta U = -8 + 3 = -5$ J

For change S → R → P,

$-5 = Q + 2$

$Q = -7$ J

Answer: B

12 Q is at the amplitude position, hence it must be momentarily at rest. Since the wave is moving to the right, by considering the wave profile slightly later, P is moving downwards.

Answer: D

13

$2.5\lambda = 50$

$\lambda = 20$ m

$v = f\lambda$

$= (200)(20)$

$= 4000$ m s^{-1}

Answer: B

14 For destructive interference at Q,

difference of the 2 paths starting from point P to point Q = $(2m + 1)\frac{\lambda}{2}$

$$(l_1 + l_3) - (l_2 + l_4) = (2m + 1)\frac{\lambda}{2}$$

Answer : D

15 With a constraint at mid-point, $1.2 = n\frac{\lambda_n}{2}$ where n is even number.

Possible wavelengths are λ_2 = 1.2 m, λ_4 = 0.6 m, λ_6 = 0.4 m, λ_8 = 0.3 m, λ_{10} = 0.24 m, λ_{12} = 0.2 m.

Answer : C

16 Answer: D

17

$$\textit{Work done} \text{ by E field} = KE \text{ loss}$$

$$F \times D = \frac{1}{2}mv^2$$

$$qEx = \frac{1}{2}mv^2$$

$$x = \frac{mv^2}{2Ee}$$

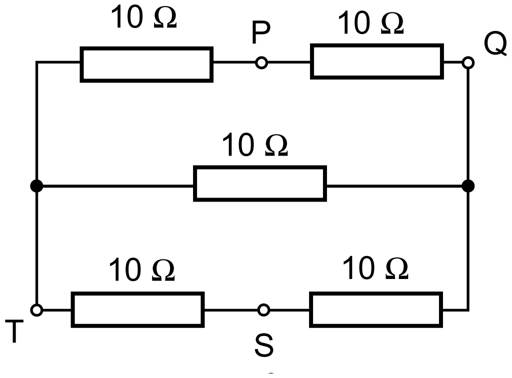
Answer: D

18 Since current is the rate of flow of charge at a point,

$$I = \frac{dQ}{dt} = \frac{1.6\times10^{-19}}{0.5(2.0\times10^{-10})} = 1.6\times10^{-9} \text{ A}$$

Answer: D

19 The given circuit is similar to the circuit below.



Thus, calculating the effective resistance across QT,

$$R_{QT} = \left(\frac{1}{10+10} + \frac{1}{10} + \frac{1}{10+10} \right)^{-1} = 5.0\ \Omega$$

Answer: B

20 When the resistance across the variable resistor increases, the effective resistance across the variable resistor and the lamp increases. By potential divider rule, this will increase the p.d. across the lamp and the variable resistor. Thus, the brightness of the lamp increases, assuming the resistance of the lamp is constant.

Answer: B

21 By right hand grip rule, magnetic flux density at O due to P and Q points in direction of C.
Magnetic flux density due to R and S points in direction of A.
Hence resultant magnetic flux density at point O is in direction of B.

Answer : B

22 According to Lenz's law, the induced e.m.f. and thus the induced current in the loop will be such as to oppose the change causing it. The change here is the copper loop falling. As such, the induced current will result in an opposing magnetic force on the loop causing its acceleration to be less than *g* throughout the fall.

Answer D

23 Initially, $E_o = NBA\omega = NBA(2\pi f)$

$$E_o^{'} = N\left(\frac{B}{3}\right)A\left(2\pi(2f)\right) = \frac{2}{3}E_o$$

Answer: D

24

$E_{peak} = 10 \text{ V}$

$\omega = \frac{2\pi}{4} = 1.6 \text{ rads}^{-1}$

Answer: D

25

$(I_{rms})^2 R = (I_{dc})^2 R$

$\frac{I_0}{\sqrt{2}} = 3$

$I_0 = 4.2 \text{ A}$

Answer: C

26 A and B seems to be the closest options. hf_o should be a form of energy rather than the threshold frequency.

Answer: A

27 $\lambda = \frac{h}{p}$

$\lambda = \frac{h}{\sqrt{2mE_{\max}}}$

Answer: C

28 Absorption spectrum.

Answer: A

29 ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + \gamma$

Answer: A

30 Actual count-rate of the source, $C_0 = 100 - 20 = 80 \text{ min}^{-1}$

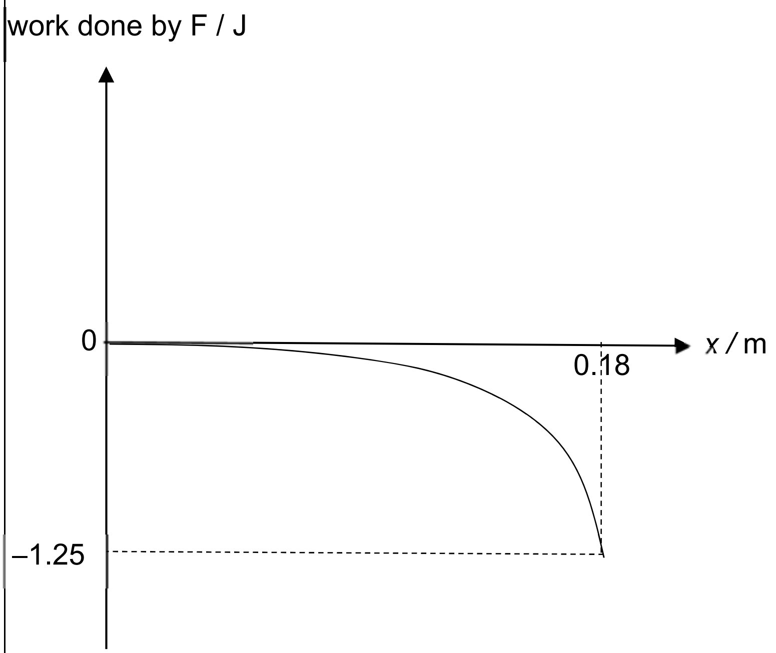
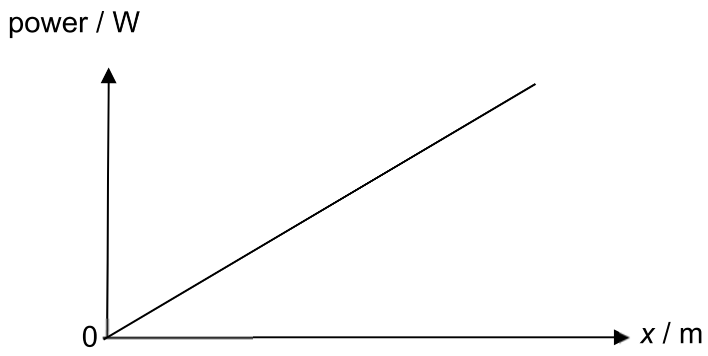
After 12 hours, actual count-rate, $C = C_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}} = 80\left(\frac{1}{2}\right)^{\frac{12}{48}} \approx 67 \text{ min}^{-1}$

Observed count-rate $= 67 + 20 = 87 \text{ min}^{-1}$ (Need to add background radiation)

Answer: C

Answers to 2018 JC2 Preliminary Examination Paper 2 (H2 Physics)

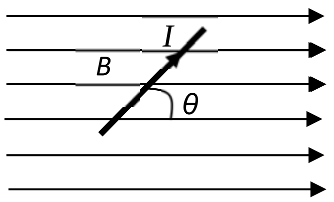
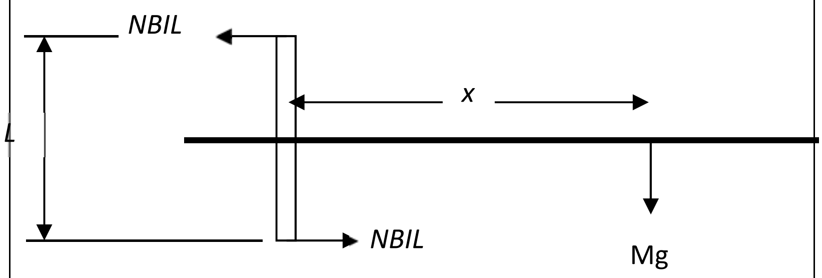
Suggested Solutions:

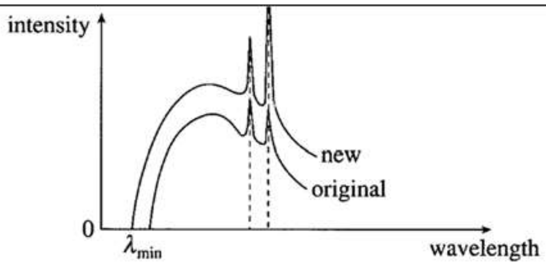
No.	**Solution**	**Remarks**
1(a)	The work done by a force on an object particle is defined as the product of the magnitude of the force and the component of the displacement in the direction of the force.	
(b)(i)	Change in KE = Net work done $0-\frac{1}{2}mu^2=-\frac{1}{2}F_{max}x$ $(0.400)(2.5)^2=(14)x$ $x=0.18\text{ m}$	
(ii)		
(iii)		

No.	Solution	Remarks
2(a)	Body is moving in a circle/circular arc. The velocity is changing therefore there is an acceleration towards the centre of the circle/circular arc.	
2(b)(i)	 	
2(b)(ii)	At Y, for the ball to be just in contact with the loop, let the normal contact force be zero. $N + W = \frac{mv^2}{R}$ $mg = \frac{mv^2}{R}$ $v = \sqrt{gR}$	
2(b)(iii)	By Conservation of Energy, $mgH = mg(2R) + \frac{1}{2}m\left(\sqrt{gR}\right)^2$ $H = 2.5R$	
3(a)	The rocket experiences equal and opposite gravitational forces exerted by Earth and Moon. Hence there is zero net force as the forces cancel out.	
3(b)	1. Moon does not have an atmosphere hence there is no need to supply energy to do work against air resistance. 2. The gain in gravitational potential energy from Moon to P is much lower than that from Earth to P hence less kinetic energy is required for the rocket to move from Moon to P.	
3(c)	At P, $F_E = F_M$ $\frac{GM_E m}{{d_E}^2} = \frac{GM_M m}{{d_M}^2}$ $M_M = \frac{\left(5.97\times10^{24}\right)\left(3.80\times10^{7}\right)^2}{\left(3.46\times10^{8}\right)^2}$ $= 7.20\times10^{22}$ kg	

No.	Solution	Remarks
3(d)	$\phi_P = -\frac{GM_E}{d_E} - \frac{GM_M}{d_M}$ $= -\left(6.67\times10^{-11}\right)\left(\frac{5.97\times10^{24}}{3.46\times10^{8}} + \frac{7.20\times10^{22}}{3.80\times10^{7}}\right)$ $= -1.277\times10^{6}\ \text{J kg}^{-1}$ $\text{KE} = \text{Loss in GPE}$ $= (7.5)\left[0-\left(-1.277\times10^{16}\right)\right]$ $= 9.58\times10^{6}\ \text{J}$	
4(a)(i)	$\Delta\phi = \frac{\Delta x}{\lambda}\times 2\pi$ $\frac{3}{2}\pi = \frac{0.490}{\lambda}\times 2\pi$ $\lambda = 0.653\ \text{m}$ $v = f\lambda$ $= (520)(0.653)$ $= 340\ \text{m s}^{-1}$	
4(a)(ii)	$I = \frac{P}{4\pi r^2}$ Since P is constant, $I \propto \frac{1}{r^2}$ $\frac{I_Y}{I_X} = \frac{{r_X}^2}{{r_Y}^2}$ $I_Y = \frac{(5.24)^2}{(5.73)^2}\left(2.6\times10^{-3}\right)$ $= 2.17\times10^{-3}\ \text{W m}^{-2}$	
4(b)(i)	$Amp = Amp_0 \cos\theta$ $\frac{A}{2} = A\cos\theta$ $\cos\theta = \frac{1}{2}$ $\theta = 60^\circ$	
4(b)(ii)	$I = kAmp^2$ $\text{fractional change} = \frac{I_0 - I}{I_0}$ $= \frac{kA^2 - k\left(\frac{A}{2}\right)^2}{kA^2}$ $= 1 - \frac{\left(\frac{A}{2}\right)^2}{A^2} = 0.75$	

5(a)	p.d. across R = 1.3 V Let R_R be the resistance across R. Using potential divider rule, $\frac{R_R}{0.75+R_R+5.5}\times 4.0=1.3$ $R_R=3.0\ \Omega$ Hence, p.d. across AB $=\frac{5.5}{0.75+3.0+5.5}\times 4.0$ $=2.38$ $=2.4$ V (2 s.f.)	
5(b)(i)	$E=\frac{1.5-0.56}{1.5}\times 2.4$ $=1.5$ V	
5(b)(ii)	The potential at C is higher than that at B. As C is shifted closer to A, the potential at C increases, thus increasing the potential difference between BC. Since the potential between BC will become larger than the terminal p.d. of cell Q, current will now flow through cell Q from C to B. OR This will lead to a potential difference across the internal resistance in cell Q, such that current will now flow through Q from C to B.	

No.	Solution	Remarks
6(a)(i)	$B = \dfrac{F}{IL\sin\theta}$	
6(a)(ii)	 Direction of force: into plane of paper.	
6(b)(i)	From $B = \dfrac{F}{BIL\sin\theta}$ where θ = 90° Force on opposite sides of the coil perpendicular to the field, *F = BIL x N*  Taking moments about the axis of rotation Sum of clockwise moment = sum of anti-clockwise moment 2 (*NBIL x L/*2) = Mg *x* $B = \dfrac{Mgx}{IL^2N}$	
6(b)(ii)	- with sides of *L*/2, length of wire making the coil is halved, - resistance is halved, so current is doubled (since emf is constant) - L^2 is now ¼ of its original value, so x is halved.	
7(a)	Each metal has a characteristic minimum amount of energy, needed to liberate an electron from its surface. This characteristic minimum amount of energy needed is called the work function energy, Φ of the metal.	
7(b)(i)	$E = hf$ $= \dfrac{hc}{\lambda} = \dfrac{(6.63\times10^{-34})(3\times10^{8})}{540\times10^{-9}}$ $= 3.68\times10^{-19}$ J	

7(b)(ii)	Intensity = $\frac{power}{area}$ $= \frac{Energy}{time \times area} = \frac{nhf}{tA}$ $= 150 = \frac{n}{t}(\frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{540 \times 10^{-9} \times 14 \times 10^{-6}})$ $\frac{n}{t} = 5.7 \times 10^{15}$ photons per unit time	
7(b)(iii)	$E = hf$ $= \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{540 \times 10^{-9}}$ $= 3.68 \times 10^{-19}$ J $= 2.3$ eV $hf = \phi + KE_{\max}$ $KE_{\max} = 2.3 - 1.9 = 0.4$ eV $= 6.43 \times 10^{-20}$ J	
7(c)(i)	As the bombarding electrons are slowed down suddenly upon hitting the target, X-rays are emitted and forms the continuous part of the spectrum. An electron may lose all or part of its energy in such a collision. The continuous X-ray spectrum is explained as being due to such ***bremsstrahlung*** collisions in which varying amounts of energy are lost by the electrons. An electron is stopped by a single (instead of multiple) impact and all its kinetic energy is used to produce one photon. This X-ray photon will possess the maximum possible energy and correspondingly, the shortest wavelength $\lambda_{\min}$.	
7(c)(ii)	 When the potential difference increases, $\lambda_{\min}$ decreases, since $eV_{AC} = \frac{hc}{\lambda_{\min}}$.	

	Characteristic X-rays remain at the same λ since it is characteristic of the target. For the same atoms, the atomic transitions involved remain unchanged and hence the wavelengths of the emitted photons are unchanged.	
8(a)	There are 3 positively charged particles as there are 3 lines curving to the left.	
8(b)(i)	$r \alpha \frac{p}{q}$ Compared to other tracks, the radius of the track in Fig. 8.3 is the smallest. The mass of electron is small. Its momentum and the radius will be small. Hence the proposal is possible.	
8(b)(ii)	The electron loses energy as it travels through the chamber. Its momentum and hence its radius decreases, resulting in a spiral.	
8(c)(i)	Conservation of charge gives (Charge of K^-) + (proton charge) = Total charge after collision (-e) + (+e) = (+e) + (–e) + (+e) + q_4 $\Rightarrow$ $q_4 = -e$	
8(c)(ii)	$r \alpha \frac{p}{q}$ Particle 3 has the lowest momentum because *r* is smallest.	
8(d)(i)	It causes little or no ionization in the target atoms, so it leaves no track.	
8(d)(ii)	They are oppositely charged, as the paths curve in opposite directions, implying that the magnetic force points in opposite directions, OR, because they are formed from a neutral particle.	
8(e)(i) 1. **8(e)(i) 2.**	(see table below)	

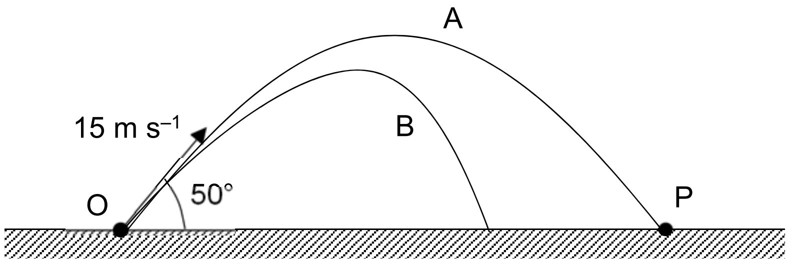
particle	p_x / 10^{-20} N s	p_y / 10^{-20} N s	p_z / 10^{-20} N s	E / 10^{-12} J
K^-	438.05	-13.24	0.81	1317.12
p	0.00	0.00	0.00	150.13
sum	438.05	-13.24	0.81	1467.25

particle	p_x / 10^{-20} N s	p_y / 10^{-20} N s	p_z / 10^{-20} N s	E / 10^{-12} J
K^-	79.03	1.48	11.95	252.50
Ω^-	7.98	-0.60	2.07	33.38
Ω^+	2.02	-6.52	-1.21	30.51
P	80.46	6.85	-3.76	285.22
K^0	189.10	-8.69	-13.07	574.78
sum	358.59	-7.48	-4.02	1176.39

8(e)(ii)1	$p_x = (438.05 - 358.59) \times 10^{-20} = +79.46 \times 10^{-20}$ N s $p_y = (-13.24 + 7.48) \times 10^{-20} = -5.76 \times 10^{-20}$ N s $p_z = (0.81 + 4.02) \times 10^{-20} = +4.83 \times 10^{-20}$ N s $E = (1467.25 - 1176.36) \times 10^{-12} = 290.86 \times 10^{-12}$ J	
8(e)(ii)2	$m = \sqrt{\frac{E^2 - (p_x{}^2 + p_y{}^2 + p_z{}^2)c^2}{c^4}}$ $= \sqrt{\frac{(290.87\times10^{-12})^2 - ((79.46\times10^{-20})^2 + (5.77\times10^{-20})^2 + (4.83\times10^{-20})^2)c}{c^4}}$ $= 1.835 \times 10^{-27}$ kg	

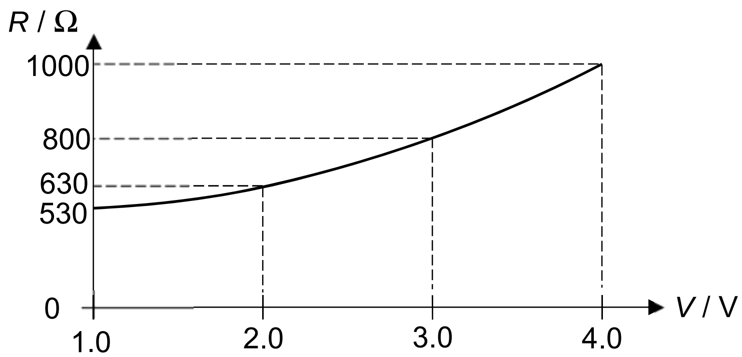
Answers to 2018 JC2 H2 Prelim P3 (H2 Physics)

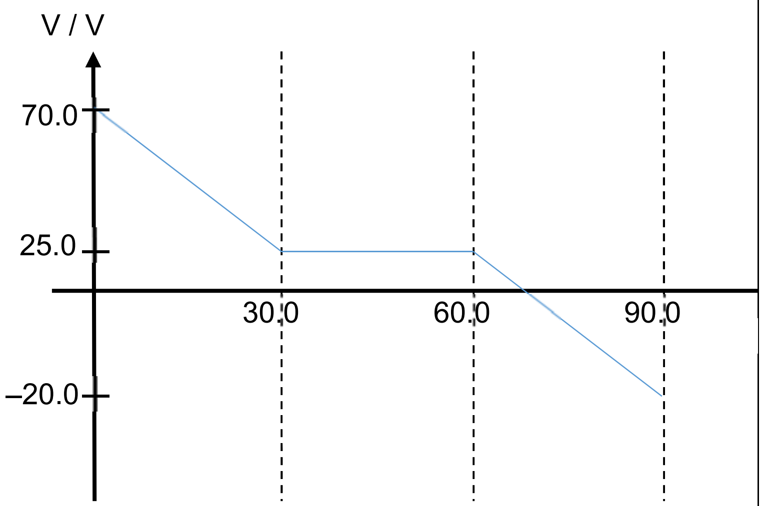
Suggested Solutions:

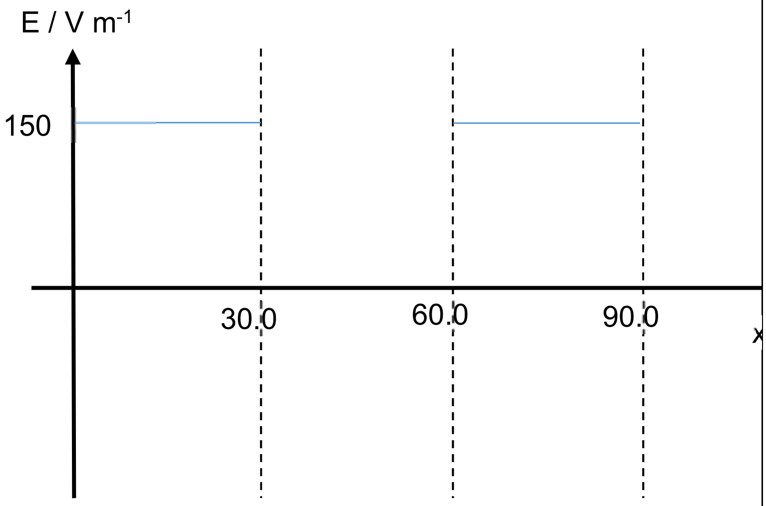
No.	Solution	Remarks
1(a)	Vertically, $s_y = u_y t + \frac{1}{2} a_y t^2$ $0 = 15\sin(50°)t - \frac{1}{2}(9.81)t^2$ Solving, t = 0 (not applicable) or 2.34 s. Horizontally, $s_x = u_x t$ $= 15\cos(50°)(2.34)$ $= 22.6$ m $= 23$ m (2 s.f.) Hence, OP = 23 m	
1(b)(i) **1(b)(ii)**	 	
2(a)(i)	$\Delta p = mv - mu$ $= 0.14(-4.0 - (5.4))$ $= -1.3$ N s	
2(a)(ii)	$F = \left\|\frac{\Delta p}{\Delta t}\right\| = \frac{1.3}{0.04} = 32.5$ N $F = N - mg$ $32.5 = N - 0.14(9.81)$ $N = 34$ N By Newton's 3rd law, force exerted by the ball on the bar = 34 N	
2(b)(i)	Taking moment about B, $34(75) + 0.45(9.81)(25) = F_A(20)$ $F_A = 133$ N	

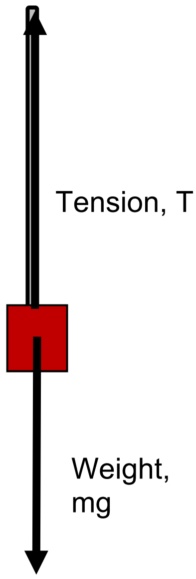
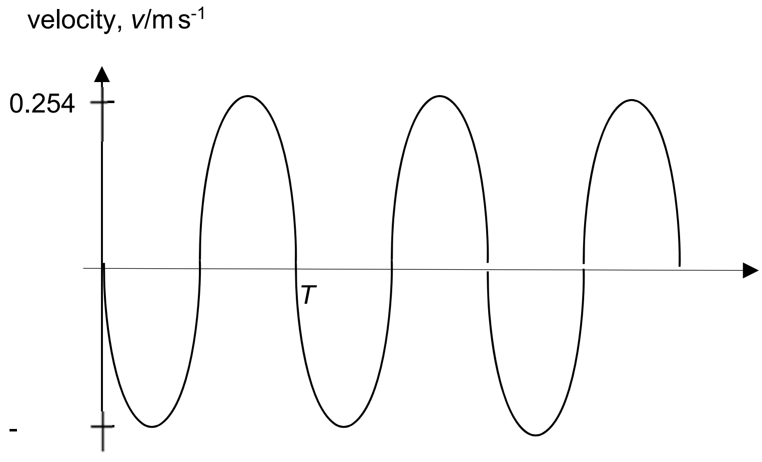
2(b)(ii)	$F_B = F_A + 34 + 0.45(9.81)$ $F_B = 171 \text{ N}$	
3(a)	▪ The gas consists of a *very large number of molecules in continuous random motion*. ▪ There are *no intermolecular forces* between molecules except during collisions between molecules. ▪ The gas molecules undergo *elastic collisions* with one another and with the walls of the container. ▪ The *duration of collisions between molecules or between molecules and the walls of the container is negligible* compared to the time interval between collisions. ▪ The *volume of the gas molecules is negligible* compared to the volume of the container.	
3(b)(i)	Using $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$. $\Rightarrow p = \frac{1}{3}\rho\langle c^2 \rangle$ $\Rightarrow \sqrt{\langle c^2 \rangle} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3(1.8.\times 10^5)}{2.7}}$ $= 447 \text{ m s}^{-1}$ $= 450 \text{ m s}^{-1}$	
3(b)(ii)1.	Internal energy of an ideal monatomic gas is given by $U = \frac{3}{2}nRT$ Since volume is doubled at constant pressure, its temperature is doubled. $\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}(2.5)(8.31)(576 - 288)$ $= 8.97 \times 10^3 \text{ J}$	
3(b)(ii)2.	Work done $W = p\Delta V = nR\Delta T$ $= (2.5)(8.31)(576 - 288)$ $= 5.98 \times 10^3 \text{ J}$ Since the volume of the gas increased, work is done by the gas. Thus, work done on the gas $= -5.98 \times 10^3 \text{ J}$	
3(b)(ii)3.	Using 1st law of thermodynamics, $\Delta U = Q + W$ $Q = \Delta U - W$ $= 8.97 \times 10^3 - (-5.98 \times 10^3)$ $= 1.49 \times 10^4 \text{ J}$	

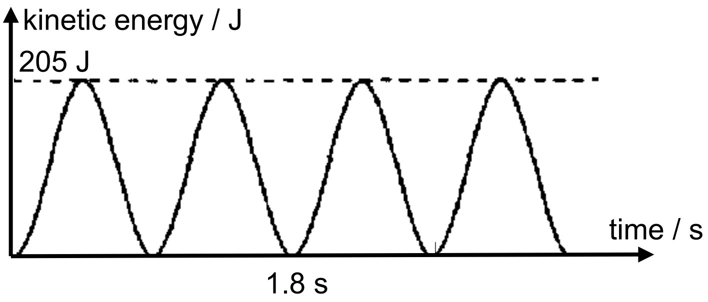
4(a)	The principle of superposition states that when two or more travelling waves of the same type meet at a point in space, the resultant displacement at that point is the vector sum of the displacements due to each of the waves at that point.	
4(b)(i)	Resultant displacement = 1.8 – 2.6 = – 0.8 x 10^{-4} cm	
4(b)(ii)	$\frac{I}{I'} = \left(\frac{3}{1}\right)^2$ $I' = 0.11I$	
4(c)(i)	Path diff = $\sqrt{20^2 + 31.7^2} - \sqrt{20^2 + 28.7^2}$ = 2.5 m Since P is third minima, $2.5 = \frac{5}{2}\lambda$ $\lambda = 1.0m$ $v = f\lambda$ $= \left(\frac{1}{3.0 \times 10^{-3}}\right)(1.0)$ $= 330$m/s	
4(c)(ii)	The intensity varies through 6 cycles of maximum and minimum.	
5(a)	***The root-mean-square (r.m.s.)*** voltage of an alternating current is defined as the ***<u>steady direct voltage</u>*** which <u>converts electrical energy to other forms of energy in a given resistance at the same rate</u> as the a.c.	
5(b)(i)	Turns Ratio $\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{240 \times 10^3}{12.0 \times 10^3}$ $= 20$	
5(b)(ii)	Transmitting current $= \frac{\text{power}}{\text{voltage}} = \frac{20 \times 10^6}{240 \times 10^3}$ $= 83.3$ A Power lost = $I^2R = (83.3)^2(200) = 1387778$ W =1390 kW	
5(b)(iii)	1 day 24 hrs Power lost in kWh = 24 x 1387.78 = 33360 kWh Amount lost = 33360 x 0.1 = $3340	

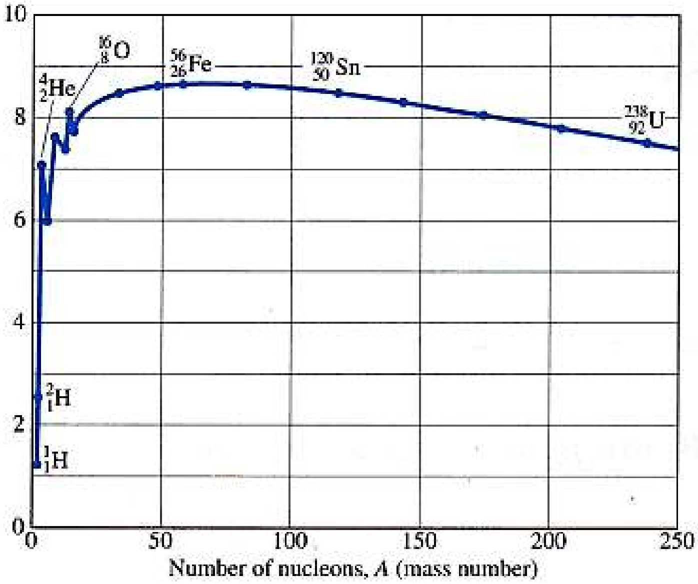
6(a)	When V = 1.4 V, I = 2.5 mA p.d. across variable resistor = 4.0 – 1.4 = 2.6 V $\text{resistance} = \dfrac{2.6}{2.5\times10^{-3}}$ $\approx 1040\ \Omega$ OR $\text{resistance of lamp} = \dfrac{1.4}{2.5\times10^{-3}} = 560\ \Omega$ $\dfrac{560}{560+R_V}\times 4.0 = 1.4$ $R_V \approx 1040\ \Omega$	
6(b)		
6(c)	When the temperature of the filament increases, the magnitude of the vibration of the lattice ions increases. This causes electrons to collide with the lattice ions more frequently, thus increasing the resistance.	
7(a)	The magnetic flux through any surface area is defined as the product of the component of the magnetic flux density normal to the plane of the surface and the area of the surface.	
7(b)	The suspended magnet is first repelled upwards as the dropped magnet approaches the left coil. As the left magnet approaches the left coil, there is a change of flux linkage associated with the coil. By Faraday's law of EMI, there will be an induced e.m.f.. This induced e.m.f. will cause a current to flow in the closed loops (of the left and right coils). This induced current will, by Lenz's law, flow in such a direction as to oppose the change causing it, i.e. it will be such that the top end of the left coil will be a South pole. This direction of current flow will cause the top end of the right coil to become a South	

	pole too. This causes a momentary repulsion of the suspended magnet. As the dropped magnet leaves the left coil, the suspended magnet is attracted downwards. As the dropped magnet leaves the left coil, the bottom end of the left coil becomes a South pole according to Lenz law. This means the top ends of both coils become a North pole as explained above. An attraction of the suspended magnet downwards is observed.	
7(c)	With switch S opened, the suspended magnet will not move as although there are still induced e.m.f. on the left coil, there is no induced current in the right coil and the right coil is thus not magnetised.	
8(a)	Electric field strength at a point is the electric force per unit positive test charge experienced by a charge placed at that point.	
8(b)(i)		

8(b)(ii)		
8(c)(i)	The electron would travel in a straight line or linear path in the direction of the resultant force towards plate A.	
8(c)(ii)	$a_x = \frac{qE}{m} = \frac{(1.6\times10^{-19})(100)}{9.11\times10^{-31}}$ $= 1.756\times10^{13}\text{ m s}^{-2}$ $S_X = u_x t + \frac{1}{2}a_x t^2$ $0.45 = \frac{1}{2}(1.756\times10^{13})(t)^2$ $t = 2.26\times10^{-7}\text{ s}$ $v_X = u_x + a_x t$ $= \left(1.756\times10^{13}\right)\left(2.26\times10^{-7}\right)$ $= 3.97\times10^{6}\text{ m s}^{-1}$	
9 (a)	Velocity is the rate of change of displacement of the body. Angular velocity is the rate of change of angular displacement of the body in oscillations.	

9 (b)(i)		
9 (b)(ii)	By conservation of energy, Loss in GPE = Gain in KE $mg(0.6-0.6\cos 6^0)=\frac{1}{2}mv^2$ $v=0.254 \text{ m s}^{-1}$	
9 (b)(iii)	$T-mg=\frac{mv^2}{r}$ $T=\frac{mv^2}{r}+mg$ $=\frac{(0.8)(0.254)^2}{0.6}+0.8(9.81)=7.93 \text{ N}$ Tension in rod is equal to the force on pivot.	
9 (b)(iv)		

9 (c)(i)	When the **driving frequency is equal to the natural frequency** of the oscillating system, maximum energy is transferred from the periodic force to the system, which **causes the system to oscillate with maximum amplitude.** This phenomenon is called **resonance**.	
9 (c)(i) 1.	$x = x_o \sin \omega t$ $= 0.18 \sin(\frac{2\pi}{T})t$ $= 0.18 \sin 3.52t$	
9 (c)(i) 2.	$a = \lvert -\omega^2 x \rvert$ $= (3.52)^2 (0.08)$ $= 0.99 \text{ m s}^{-2}$	
9 (c)(i) 3.	$KE_{max} = \frac{1}{2} m\omega^2 x_o^2$ $= \frac{1}{2}(1020)(3.52)^2(0.18)^2$ $= 205 \text{ J}$	
9 (c)(i) 4.		
10(a)	The half-life $t_{\frac{1}{2}}$ of a radioactive nuclide is the average time taken for the nuclei to disintegrate to half its initial number of nuclei.	
10(b)(i)1.	Probability of decay per second is the decay constant λ. $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{45 \times 24 \times 60 \times 60} = 1.8 \times 10^{-7} \text{ s}^{-1}$	
10(b)(i)2.	$A = \lambda N$ $\Rightarrow N = \frac{A}{\lambda} = \frac{8.5 \times 10^{7}}{1.8 \times 10^{-7}} = 4.8 \times 10^{14}$	
10(b)(i)3.	$A = A_o \exp(-\lambda t)$ $\Rightarrow \frac{A_o}{5} = A_o \exp\left(-\left(1.8 \times 10^{-7}\right)t\right)$ $t = 8.94 \times 10^{6} \text{ s}$	

10(b)(ii)	The time is shorter as some of the ^{59}Fe is removed from the body through excretion.	
10(c)(i)		
10(c)(ii)	When a nuclei of lower mass number undergoes nuclear fusion, the products have higher mass number and thus have higher binding energy per nucleon. More energy is then released when they are formed from their component particles as compared to the energy that is needed to break the reactant into their constituent particles, resulting in a net release of energy.	
10(c)(iii) 1.	The nucleus *X* is a neutron.	
10(c)(iii) 2.	Change in mass $= \Delta m$ $= \left[(2.014102 + 3.016050) - (4.002603 + 1.008665)\right]u$ $= 0.018884u = 3.13 \times 10^{-29}$ kg Energy produce by a single reaction $= \Delta mc^2$ $= 0.018884 \times (1.66 \times 10^{-27}) \times (3.0 \times 10^8)^2$ $= 2.82 \times 10^{-12}$ J Number of reactions possible from 150 kg of mixture $= \dfrac{150}{(2.014102 + 3.016050)u}$ $= 1.796 \times 10^{28}$ Energy produced $= (1.796 \times 10^{28})(2.82 \times 10^{-12})$ $= 5.07 \times 10^{16}$ J	

10(c)(iii) 3.	Amount of energy available for the submarine $= 0.15\left(5.07\times10^{16}\right)=7.61\times10^{15}$ J Length of time $= \dfrac{7.61\times10^{15}}{110\times10^{6}}=6.91\times10^{7}$ s $=2.2$ years	

2018 JC2 Prelim Physics Practical Suggested Mark Scheme

No.	Solution	Remark
1(a)(i)	d_o = 29.0 cm no need repeat (range – 25 cm to 35 cm)	[1] -value of d_o to nearest mm with unit
1(b)(i)	θ = 50° 1 d.p. – zero mark no need repeat	[1] - use of protractor to measure to nearest degree - value of θ with unit
1(b)(ii)	$\text{percentage uncertainty} = \frac{\Delta\theta}{\theta}\times 100\%$ $= \frac{2}{50}\times 100\%$ $= 4.0\%$ Max 2 s.f.	[1] - percentage uncertainty in θ correctly calculated, using $\Delta\theta$ between 2° to 3°
1(b)(iii)	d = 31.5 cm - arger than (a)(i)	[1] - use of metre rule to measure to nearest mm - value of d to nearest mm with correct unit
1(c)	θ = 44° d = 35.5 cm	[2] - value of θ to nearest degree with unit and smaller than (b)(i) - value of d to nearest mm with unit and larger than (b)(iii)
1(d)(i)	$P_{100} = \frac{(0.100+0.050)(9.81)}{(\tan 50°)(0.315-0.290)} = 50$ $P_{200} = \frac{(0.200+0.050)(9.81)}{(\tan 44°)(0.355-0.290)} = 39$ Quantities should be changed to S.I. Units, in m and kg.	[2] - values calculated correctly
1(d)(ii)	The lowest number of significant figures of the values used in the computation of P is two hence the final result of P is also two significant figures. Must mention 2 s.f. not least s.f.	[1] for correct explanation

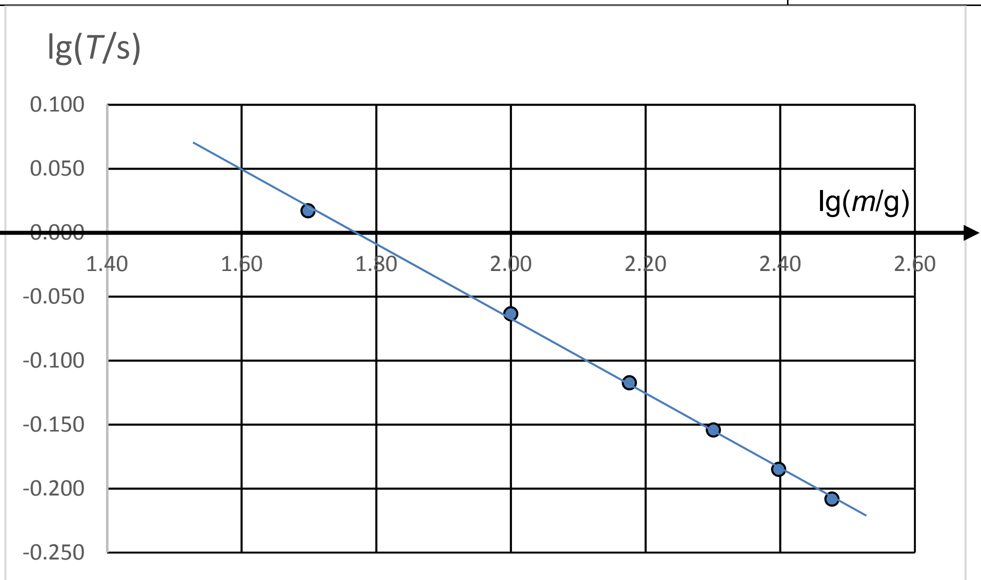
1(d)(iii)	Percentage difference in values of P $= \frac{50-39}{50} \times 100\%$ $= 22\%$ Since the two values of P differ by more than 4%, the percentage difference exceeds the acceptable error range. Hence, the experimental results do not support the suggested relationship.	[1] - valid conclusion based on the calculated values of P, using percentage difference - candidate must compare the percentage difference with the value in (b)(ii) to make a conclusion
1(e)(i)	Relevant points might be: • It is difficult to measure θ (or d) accurately as the hand may be shaking while holding up the protractor (or metre rule). • string not parallel to ground – use set square	[1] for valid error
1(e)(ii)	Relevant suggestion and explanation might be: • Clamp the protractor (or metre rule) so that they are stable and fixed in position while readings are taken. • Use set square etc to ensure string is horizontal.	[1] for valid suggestion
2(a)(v)	N = 20 t_1 = 20.7 s t_2 = 20.9 s $T = \frac{t_1 + t_2}{2N} = \frac{20.7 + 20.9}{2(20)}$ =1.04s Range of 0.90 s to 1.2 s.	[1] for t - 1 d.p. in s - more than 20s - repeated readings [1] for T calculated correctly and in 3 s.f. and units
2(b)(i)	It is difficult to judge whether the discs are horizontal or not, thus affecting the measurement of length l. It is difficult to judge the start and end of each complete oscillation thus affecting the measurement of T. The system oscillates in more than one mode of oscillations, which affects the measurement of T. - use 2 clamps to make disc B horizontal	[1]
2(b)(ii)	Place a spirit level on each disc to check whether it is horizontal. Attach a needle on the rim of disc A and use it as a fiducial marker to mark the start and end of each oscillation. Use a small displacement and take readings only when the oscillation is stable and in one mode of oscillation.	[1]

2(c)(i)

m / g	T / s	lg (m / g)	lg (T / s)
50	1.04	1.70	0.017
100	0.864	2.000	-0.063

[1] No. of d.p. of lg(m/g) and lg(T/s) is the same as no. of s.f. of m and T.

2(c)(ii)



[1] - all points plotted correctly (check 3 points)

[1] - best fit line

2(c)(iii)

lg(0.745)= - 0.128 [1]

From the graph, lg(m/g)= 2.21 [1]
m = 162 g

3(a)(ii)

R = 5.1 Ω

3(a)(iii)

I_1 = 28.7 mA
I_2 = 15.1 mA

[2] record to 1 d.p. in mA

3(b)

R / Ω	I_1 / mA	I_2 / mA	$\frac{I_1}{I_2}$
5.1	23.7	34.5	0.687
7.5	24.0	32.4	0.741
10	24.4	30.2	0.808
22	25.8	22.8	1.13
33	27.0	18.7	1.44
47	28.7	15.1	1.90

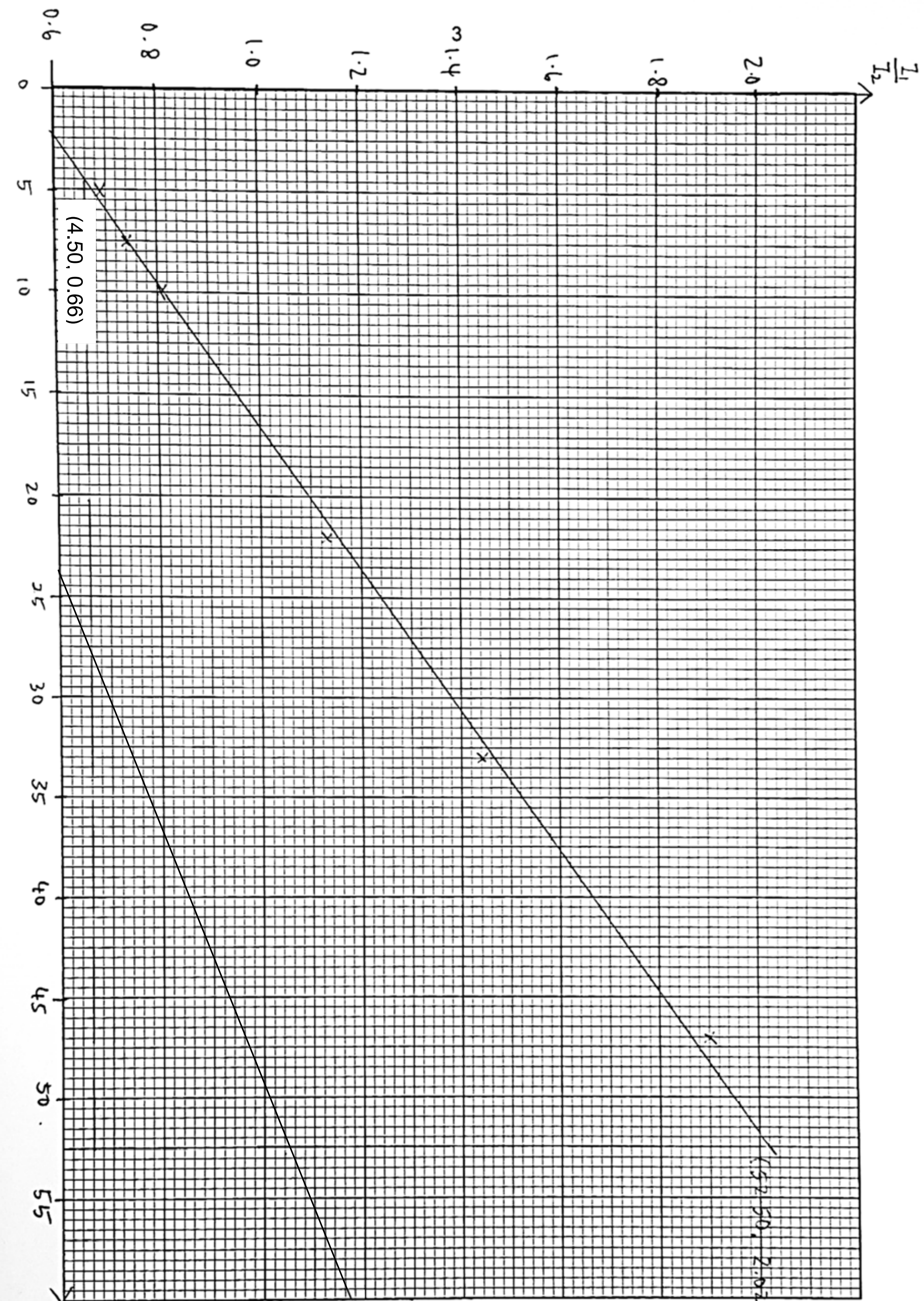
- deduct 1 mark if R has 1 d.p. for 10 Ω to 47 Ω.

[2] for 6 sets of readings (award only [1] for 5 sets of readings)
[1] for correct d.p. for raw data
[1] for correct sf for processed data
[1] for correct calculation
[1] Correct headings and units

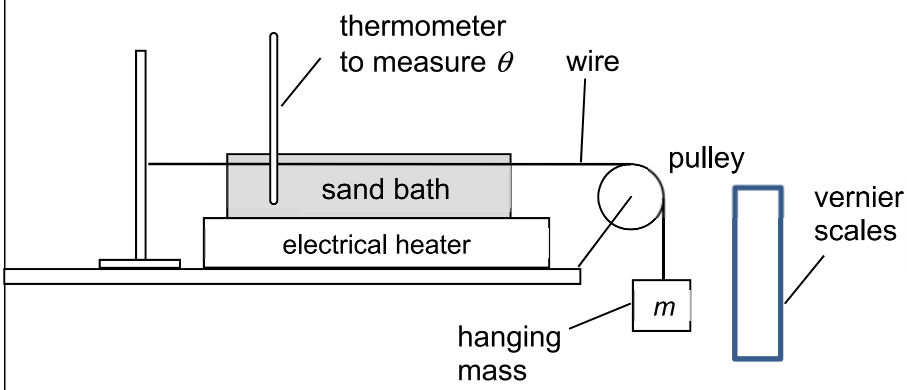
3(c)	Refer to attached graph.	[1] correct axes and units, scale [1] correct plotting of points to half the smallest division [1] best fit line
3(c)	$\text{gradient} = \frac{2.02 - 0.66}{52.50 - 4.50}$ $= \frac{1.36}{48.00}$ $= 0.0283$ Hence, *P* = 0.0283 Ω^{-1} Using the coordinates (52.50, 2.02) $2.02 = (0.0283)(52.50) + C$ $C = 0.53$ Hence, *Q* = 0.53 - gradient coordinates read correctly to half division.	[1] correct labelling of gradient coordinates of triangle and correct size of triangle, correct substitution of the gradient [1] for correct determination/ calculation of *y*-intercept [1] correct calculation and unit for *P* [1] correct calculation and no unit for *Q*
3(d)	$M = \frac{1}{P} = \frac{1}{0.0283} = 35.3\ \Omega$ for 0.80 m $R' = \frac{35.3}{0.80} = 44\ \Omega\,m^{-1}$ From the table the wire used is swg 42.	[1] for correct calculation of *R*' and identification of the wire used
3(e)	$Q = \frac{40\text{ cm}}{80\text{ cm}} = 0.50$ $\text{percentage difference} = \frac{0.53 - 0.50}{0.50} \times 100\%$ $= 6\%$ Since the value of Q here and that determined in (d) has a small difference of 6% of each other, the results support the theory. - use 10% as reference in future if no prior percentage uncertainty computed.	[1] correct reasoning
3(f)(i)	Refer to attached graph. Graph of smaller gradient (increased length increases resistance of M and thus decreases value of *P*. Q the *y*-intercept decreased (length of N unchanged but length of M increased).	[1] for correct conclusion
3(f)(ii)	The constantan wire would overheat.	[1] for correct answer

3(g)	In the setup in Fig. 3.1, connect a voltmeter in parallel to resistor Y. Firstly, conduct the experiment by varying the swg (diameter) of the wire used in N, while keeping the length of the wire constant. Obtain 6 sets of readings of the swg and the p.d. across resistor Y, and plot a suitable graph to represent the relationship between these variables. Secondly, conduct the experiment by varying the length of the wire used in N, while keeping the swg of the wire constant. Obtain 6 sets of readings of the length and p.d. across Y, and plot a suitable graph to represent the relationship between these variables.	[1] [1] [1]

(f)(i)



[3]

4	**<u>Aim</u>** : To investigate how the length of a wire changes with time as the temperature of the wire is changed.	
	<u>Independent variable</u> :- temperature of wire θ (change in temp - incorrect	[1] correct indep and dep variables
	<u>Dependent variable</u> : increase in length, *x*, of the wire measured using a vernier scales (length only - incorrect)	
	<u>Controlled variables</u>: - material of wire - length and diameter of wire - load $F = mg$ (at least one control variables above needed only)	[1] correct controlled variables
	<u>Diagram</u> : 	[1] show wire in sand bath or water bath [1] must have hanging mass
	<u>Procedure</u> : a) Set up the apparatus as shown above. b) Embed the wire into the sand bath and attach a mass *m* to the wire. The load is $F = mg$. c) Switch on the electrical heater. Using a thermometer, measure and record the temperature θ of the sand bath when it is constant. This will also be the temperature of the wire. d) Start the stopwatch and after a time t = 5 min, measure the length, *x*, at which the mass has fallen, using the vernier scale. e) Compute $\frac{x}{t}$, the increase in length with time. f) Now, increase the temperature of the sand bath by changing the power supply of the electric heater but keeping the load constant. Repeat steps (c) to (e) to obtain at least 6 readings.	[1] how to measure the temperature of the wire [1] how to obtain *x* [1] to compute $\frac{x}{t}$ [1] for repeat readings at different temperature

	g) If $\frac{x}{t} = k\theta^n$ $\lg\left(\frac{x}{t}\right) = n\lg\theta + \lg k$ Plot a graph of $\lg\left(\frac{x}{t}\right)$ versus $\lg\theta$. *k* and *n* can be obtained as follows: *n* =gradient of graph *k* = $10^{\text{vertical intercept}}$ **<u>Further details</u>** : *Precautions to improve accuracy :* - Place a pointer at the bottom of the mass to reduce parallax error with reading the increase in length. - Use a thermocouple to measure the temperature of the wire instead. *Safety precautions* : - Ensure retort stand is firming clamped onto the table to prevent it from toppling. - Avoid contact with the wire and sand bath as they are hot and could cause burns if touched with bare hands. - if water bath used, dry up any water spillage.	[1] use of log equation to reach conclusion [1] how to determine *n* and *k* [1] any one [1] any one

RAFFLES INSTITUTION
2018 Preliminary Examination

PHYSICS **9749/01**
Higher 2

25 September 2018
Paper 1 Multiple Choice Questions **1 hour**

Additional Materials: OMR Form

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your index number, name and class on the OMR Form in the spaces provided. Shade the appropriate boxes.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.
Choose the one you consider correct and record your choice **in soft pencil** on the OMR Form.

Read the instructions on the OMR Form very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an appropriate scientific calculator is expected, where necessary.

This document consists of **17** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	T / °C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin\omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos\omega t = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin\omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 The density of a liquid is calculated by measuring its mass and its volume. The measurements taken are as shown.

$$\text{mass of beaker} = (20 \pm 1)\ \text{g}$$

$$\text{mass of beaker and liquid} = (70 \pm 1)\ \text{g}$$

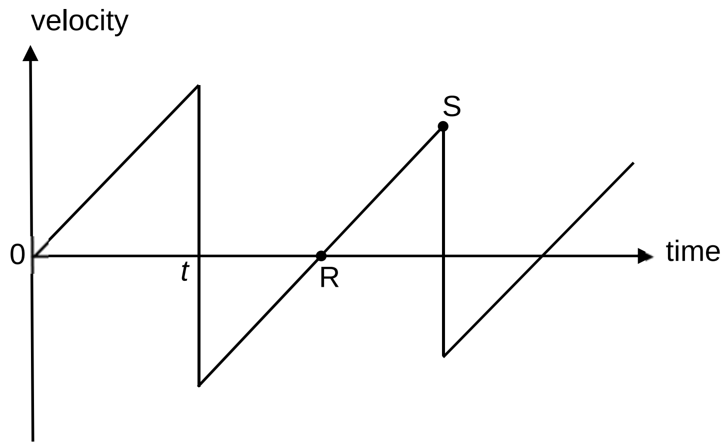
$$\text{volume of liquid} = (10.0 \pm 0.6)\ \text{cm}^3$$

The density of the liquid calculated is 5.0 g cm^{-3}.

What is the uncertainty in this value of density?

A 0.1 g cm^{-3} **B** 0.4 g cm^{-3} **C** 0.5 g cm^{-3} **D** 2.6 g cm^{-3}

2 A ball released from rest above a hard, horizontal surface undergoes several bounces. The graph shows the variation with time of the velocity of the bouncing ball.

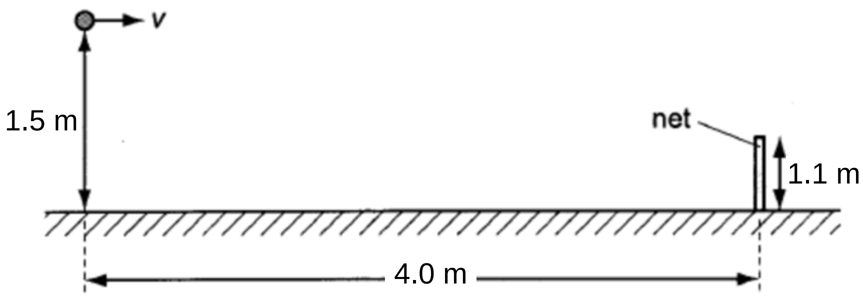


The time taken for the ball to first reach the ground after release is *t*. With each bounce, the ball loses $\frac{7}{16}$ of the kinetic energy it has just before the bounce.

Assuming air resistance is negligible, which of the following gives the time duration, in terms of *t*, between points R and S on the graph?

A 0.44 *t* **B** 0.56 *t* **C** 0.66 *t* **D** 0.75 *t*

3 In a junior tennis match, a player hits an incoming tennis ball such that it leaves his racket horizontally with speed v as shown.

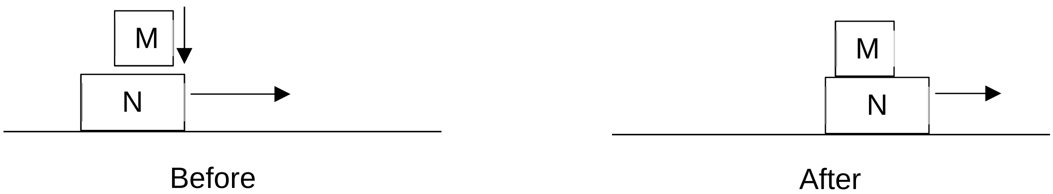


The tennis ball is hit at a height of 1.5 m above the ground and 4.0 m from the net. It just clears the net, which is 1.1 m high. Neglect the effects of air resistance.

What is the value of v?

A 7.2 m s^{-1} **B** 8.4 m s^{-1} **C** 14 m s^{-1} **D** 49 m s^{-1}

4 Mass M is dropped gently onto another mass N that is initially sliding on a smooth horizontal surface at constant velocity. After landing, the two masses move forward as one body as shown.



Which of the following statements regarding the two masses is incorrect?

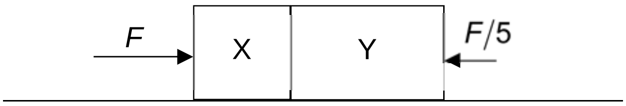
A The total mechanical energy of the two masses is conserved because they move with the same velocity after the collision.

B Mass N slows down during the collision because M exerts a decelerating force on N.

C The total horizontal momentum of the two masses is conserved because the resultant horizontal force acting on them is zero.

D There is heat produced in the collision because the collision is inelastic.

5 Two blocks X and Y, of masses m and $3m$ respectively, are placed in contact on a smooth horizontal surface. Forces F and $F/5$ are applied on either side of the blocks as shown.



What is the magnitude of the force exerted by block X on block Y during their subsequent motion?

A $\frac{F}{5}$ **B** $\frac{3F}{5}$ **C** $\frac{3F}{4}$ **D** $\frac{4F}{5}$

6 A sphere resting on a smooth inclined plane is tied to a string that loops over a pulley as shown in Fig. (a).

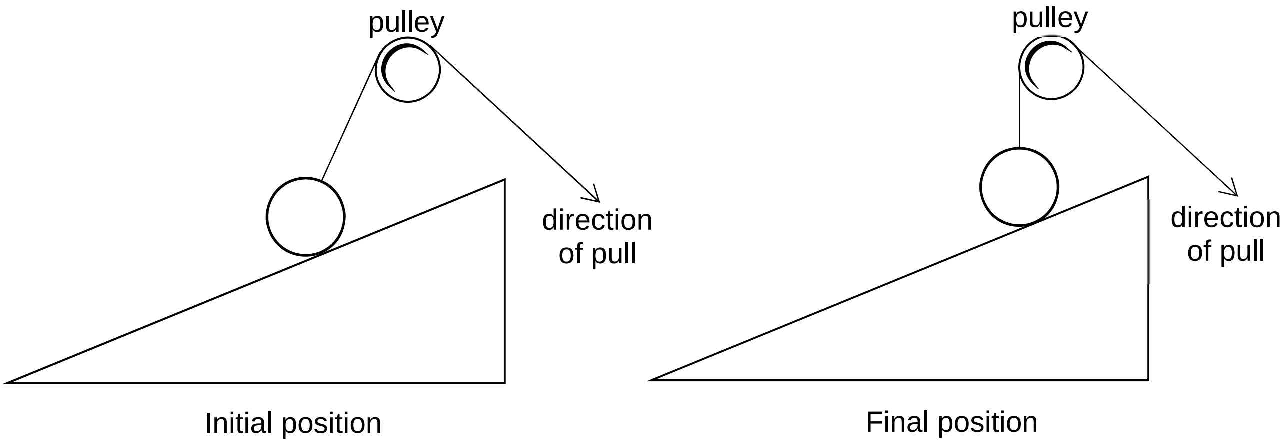


Fig. (a) **Fig. (b)**

The string is slowly pulled until the end connected to the sphere becomes vertical as shown in Fig. (b). At this instant, the forces acting on the sphere are

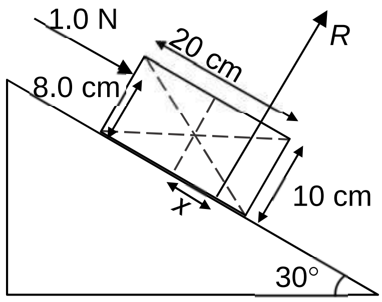
A weight, tension and normal reaction.

B weight and tension.

C weight and normal reaction.

D tension and normal reaction.

7 A uniform rectangular block of dimensions 20 cm by 10 cm and weight 5.0 N is placed on a rough surface inclined at 30° to the horizontal. A force of 1.0 N parallel to the surface is then applied on the block 8.0 cm from its base.



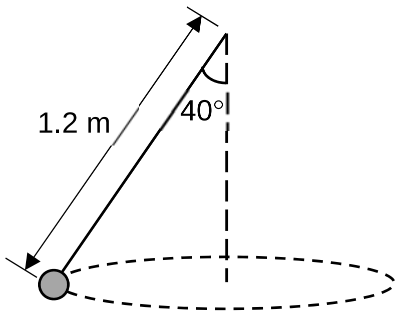
Given that the block remains in equilibrium, what is the distance *x* between the line of action of the normal contact force *R* exerted by the surface on the block and the centre of the block?

A 0.7 cm **B** 1.8 cm **C** 2.9 cm **D** 4.7 cm

8 It takes 4.0 J of work to stretch a spring 10 cm from its unstretched length. Given that the spring obeys Hooke's Law, what is the additional work required to stretch it a further 10 cm?

A 4.0 J **B** 6.0 J **C** 12 J **D** 16 J

9 A simple pendulum of length 1.2 m is swung such that the mass goes round in a uniform circular motion in the horizontal plane. The string makes an angle of 40° with the vertical.



What is the speed of the mass in its circular path?

A 2.5 m s^{-1} **B** 2.8 m s^{-1} **C** 3.0 m s^{-1} **D** 3.3 m s^{-1}

10 A satellite is moved from a circular orbit of radius R_1 around the Earth to a new circular orbit of radius R_2 where $R_2 > R_1$.

What happens to its gravitational potential energy and kinetic energy?

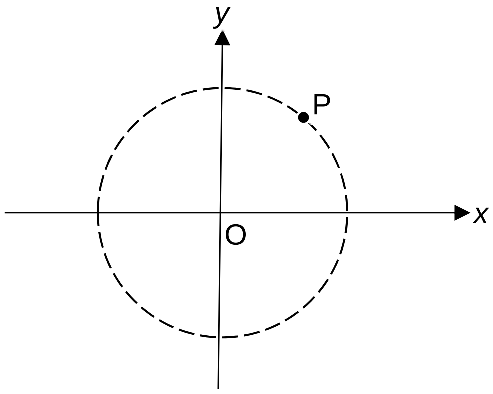
	potential energy	kinetic energy
A	increases	decreases
B	decreases	decreases
C	increases	increases
D	decreases	increases

11 The ratio of the densities and the ratio of the radii of Planet X to Planet Y are $\frac{9}{4}$ and $\frac{3}{1}$ respectively.

What is the ratio $\frac{\text{escape speed from the surface of Planet X}}{\text{escape speed from the surface of Planet Y}}$?

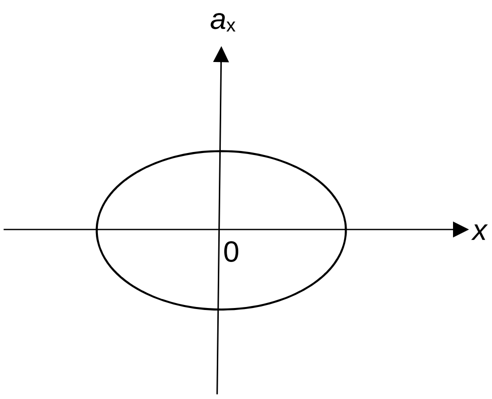
A 0.578 **B** 2.60 **C** 4.50 **D** 13.5

12 A particle P performs uniform circular motion about the origin O in the x-y plane as shown.

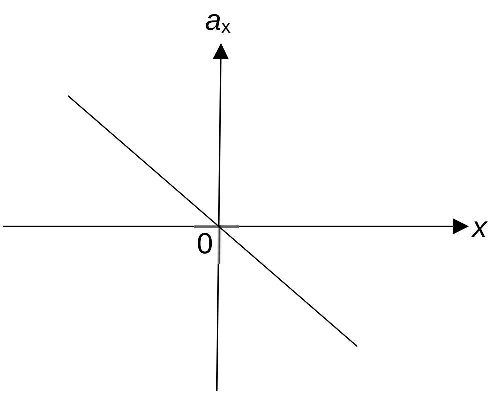


Which of the following graphs shows the relationship between the *x*-component of the acceleration a_x and the displacement in the *x*-direction?

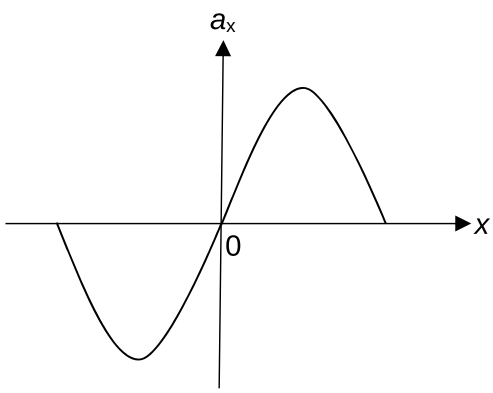
A



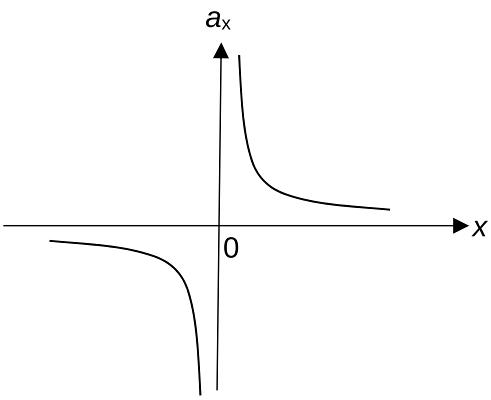
B



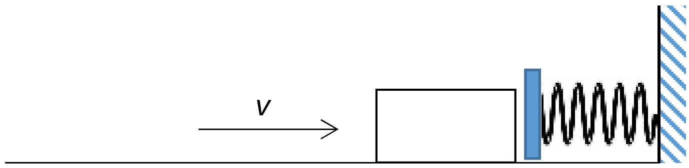
C



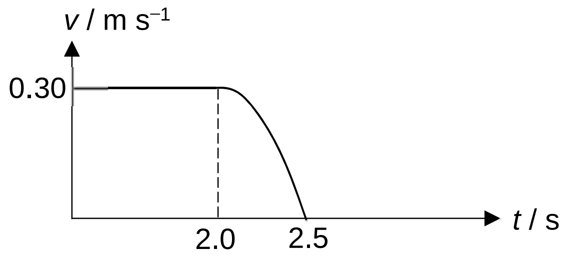
D



13 A block of mass 0.500 kg sliding on a smooth table at 0.30 m s^{-1} collides with a board attached to a spring which obeys Hooke's Law.



The graph shows the variation with time *t* of the velocity *v* of the block up to the moment just before it reverses its motion.

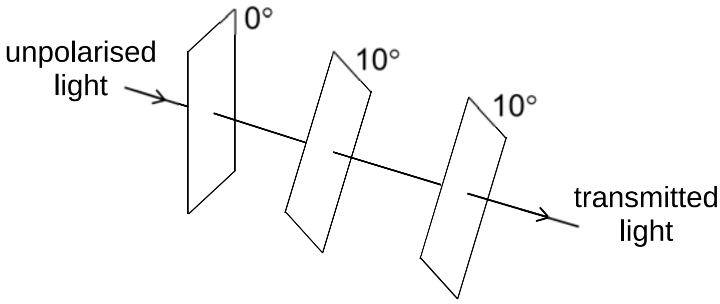


Given that the magnitude of the acceleration of the block is directly proportional to the compression of the spring, what is the maximum compression experienced by the spring?

A 0.024 m **B** 0.075 m **C** 0.095 m **D** 0.94 m

14 A narrow, parallel beam of unpolarised light is directed towards three ideal polarising filters.

The beam meets the first filter with its axis of polarisation vertical. The axis of polarisation of the second filter is at an angle of 10° to the first filter. The third filter has its axis of polarisation parallel to the second filter as shown.

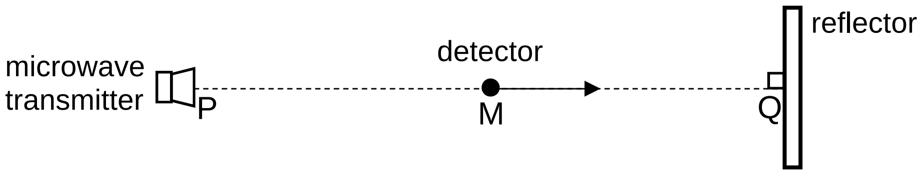


The third filter is now turned.

At what angle must the third filter be with respect to the second filter so that the intensity of the transmitted light is reduced to one-third of the intensity of the unpolarised light?

A 34° **B** 44° **C** 47° **D** 54°

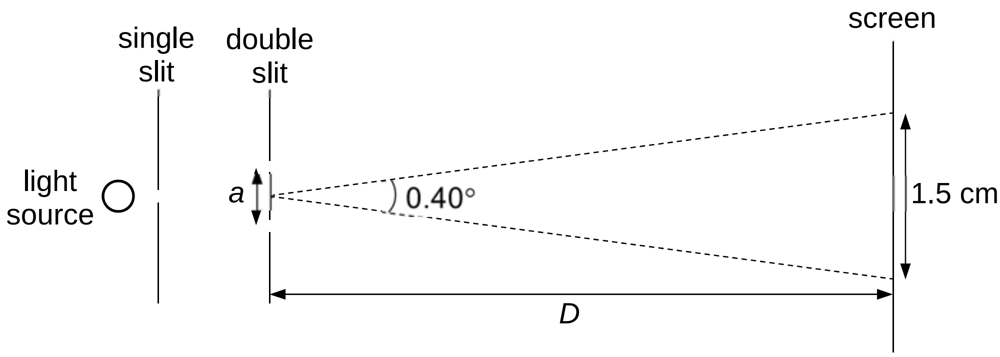
15 A microwave transmitter emits waves that are incident normally on a reflector. A microwave detector is initially at the point M where it detects a maximum intensity. As it moves along the line PQ towards Q, the detector picks up a series of maximum and minimum intensity signals.



If the detector moves with a speed of 2.0 m s^{-1} and the frequency at which maximum intensity signals are picked up is 10 Hz, what is the distance moved by the detector from its initial position at M when it detects the first minimum intensity signal?

A 0.05 m **B** 0.10 m **C** 0.20 m **D** 0.40 m

16 A two-source interference experiment is set-up as shown. The light source emits light of wavelength 600 nm. The distance between the second order bright fringes on the screen is 1.5 cm and their angular separation is $0.40°$.



What are the values of the slit separation *a* and the distance *D* between the double slits and the screen?

	a / mm	*D* / m
A	0.17	1.1
B	0.34	1.1
C	0.17	2.1
D	0.34	2.1

17 The root-mean-square (r.m.s.) speed of the molecules of a fixed mass of an ideal gas at a certain temperature is *c*. If the pressure is increased by 25% while its volume is decreased by 25%, what will be the r.m.s. speed of the molecules?

A 0.88 *c* **B** 0.94 *c* **C** 0.97 *c* **D** *c*

18 A frictionless and well-insulated bicycle pump is used to inflate a basketball. After several compression cycles, the air in the basketball becomes warmer than the surrounding air.

Which one of the following statements best explains this observation?

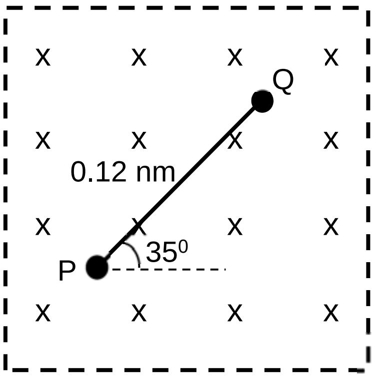
A The air molecules collide with the inner wall of the basketball more frequently.

B Work is done on the air in the basketball and the internal energy remains unchanged.

C The internal energy of air in the basketball increases as work is done on the air and thermal energy is supplied to it.

D Work is done on the air in the basketball and since little thermal energy escapes, the internal energy increases.

19 Two ions P and Q, of charge +*e* and –*e* respectively, are linked to form a molecule and placed in a uniform electric field that is directed into the page. The distance between P and Q is 0.12 nm. The electric field strength is 4200 V m^{-1}.



Which of the following gives the resultant force and initial torque on the molecule?

	resultant force / N	torque / Nm
A	1.3×10^{-15}	4.6×10^{-26}
B	1.3×10^{-15}	8.1×10^{-26}
C	0	4.6×10^{-26}
D	0	8.1×10^{-26}

20 An oil-drop of mass m, carrying a charge q, is in the region between two horizontal plates. When the potential difference between the upper and lower plates is V, the oil-drop is stationary. The potential difference is then increased to $2V$.

What is the initial upward acceleration of the oil-drop? Assume negligible upthrust.

A g **B** $2g$ **C** $\frac{2qV}{m} - g$ **D** $\frac{2qV}{m}$

21 A potential difference of 6 V is applied across a resistor for a time interval of 10 s. The current flowing through the resistor is 2 A.

Which of the following statements is incorrect?

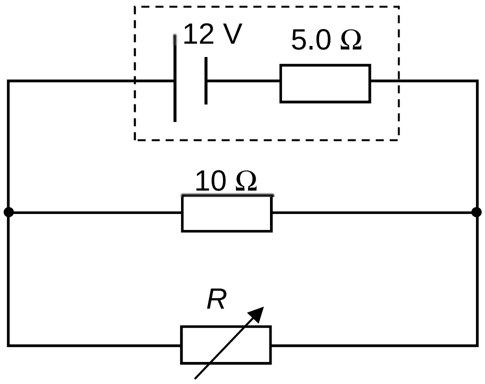
A The resistance of the resistor is 3 Ω.

B The energy dissipated in the resistor is 12 J.

C The charge passing through the resistor is 20 C.

D The potential difference across the resistor is 6 J C^{-1}.

22 A battery of e.m.f. 12 V and internal resistance 5.0 Ω is connected to a fixed resistor of resistance 10 Ω and a variable resistor of resistance R as shown. The battery delivers maximum power to the external resistance when the external resistance is equal to the internal resistance of the battery.



What is the value of R and the power dissipated across the 10 Ω fixed resistor when maximum power is delivered?

	R / Ω	P / W
A	5.0	7.2
B	10	3.6
C	10	14
D	5.0	3.6

23 Fig. (a) shows the top view of two long parallel wires, wire X and wire Y, carrying currents I_X and I_Y respectively in a direction perpendicular to the plane of the paper. The distance between wire X and wire Y is *L*.

Fig. (b) shows the variation of the net magnetic field at distances to the right of wire Y along the line joining wire X and wire Y. At a distance *d* from wire Y, the net magnetic field is zero.

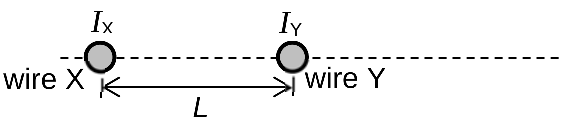


Fig. (a) top view (not to scale)

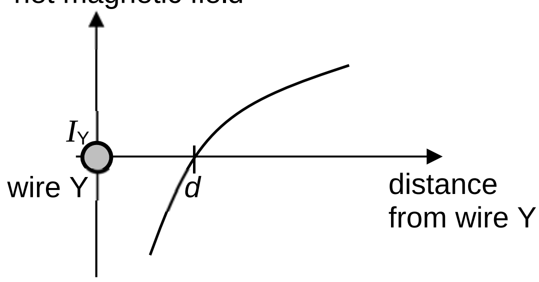


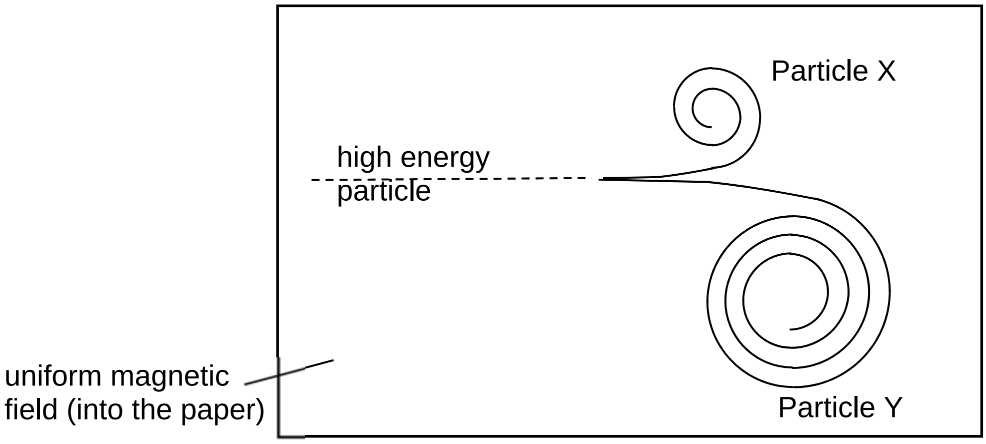
Fig. (b)

Given that the ratio $\frac{I_X}{I_Y}$ is 4.00 and taking the upwards direction to be positive, which of the following gives the relative direction of I_X and I_Y and the value of *L* in terms of *d*?

	relative direction of I_X and I_Y	*L* in terms of *d*
A	I_X and I_Y flow in opposite directions	*d*
B	I_X and I_Y flow in the same direction	*d*
C	I_X and I_Y flow in opposite directions	3*d*
D	I_X and I_Y flow in the same direction	3*d*

24 A high energy particle which carries no charge enters a region of uniform magnetic field directed into the paper. The particle subsequently disintegrates to form two particles X and Y which have the same mass and same magnitude of charge.

The paths of X and Y are shown in the diagram and the initial radius of Y is twice the initial radius of X.



Which of the following statements is correct?

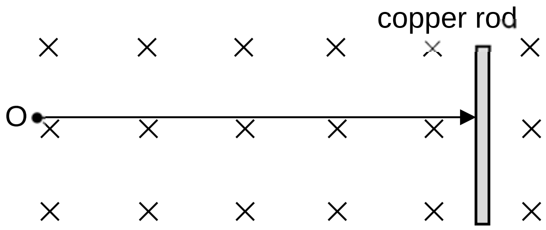
A Particle X is negatively charged, particle Y is positively charged.

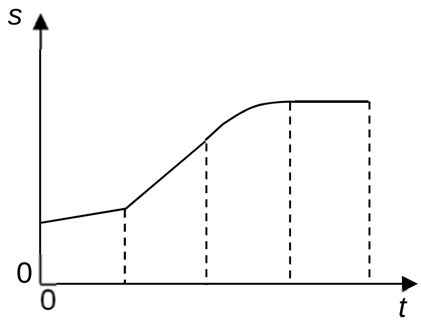
B The ratio of the initial kinetic energy of particle X to particle Y is 0.25.

C The speeds of both particles are increasing steadily.

D Particle X has a larger momentum than particle Y.

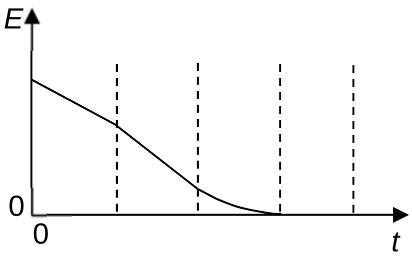
25 A copper rod is moved at right angles to a uniform magnetic field as shown in the diagram. The graph on the right shows the variation with time *t* of the displacement *s* of the copper rod from point O.



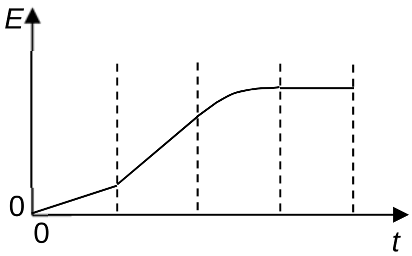


Which graph best shows the variation with time *t* of the e.m.f. *E* induced across the rod?

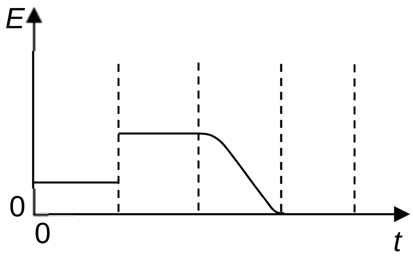
A



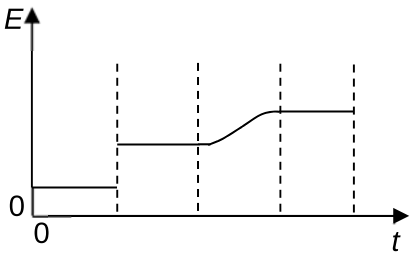
B



C



D



26 A heater is connected to a 110 V sinusoidal alternating current and it dissipates energy at a mean rate of 800 W. The same heater, with its resistance unchanged, is then connected to a 156 V d.c. supply.

At what rate does the heater dissipate energy now?

A 400 W **B** 800 W **C** 1100 W **D** 1600 W

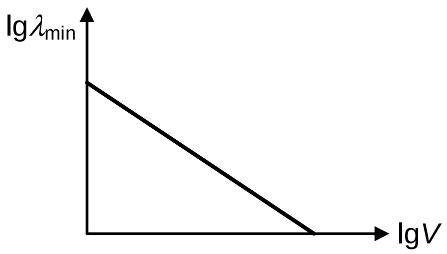
27 Light of wavelength λ strikes a photo-sensitive surface and electrons are ejected with maximum kinetic energy E. If the maximum kinetic energy is to be increased to $2E$, the wavelength must be changed to λ' where

A $\lambda' = \lambda/2$ **B** $\lambda/2 < \lambda' < \lambda$ **C** $\lambda < \lambda' < 2\lambda$ **D** $\lambda' = 2\lambda$

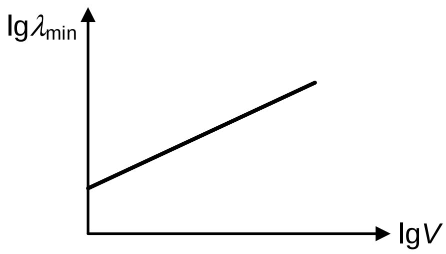
28 Electrons accelerated from rest by a potential difference V are directed to hit a metallic target to produce X-rays. It produces continuous as well as characteristic X-rays.

If λ_{min} is the shortest possible wavelength of X-ray in the spectrum, which of the following shows the variation with $\lg V$ of $\lg \lambda_{min}$?

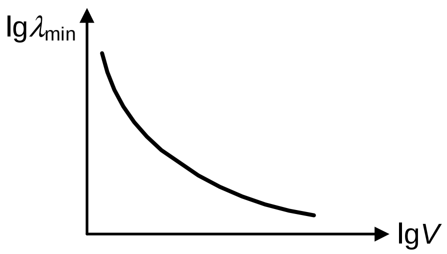
A



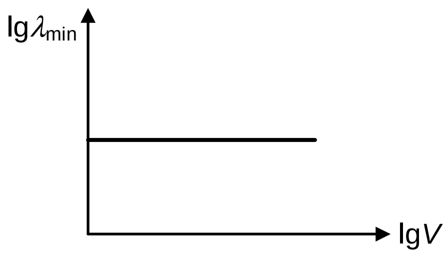
B



C



D



29 1 g of a sample which contains radioactive nuclei is left in the laboratory for 4 days. The radioactive nuclei emit β radiation and have a half-life of 2 days.

What is the mass of the sample at the end of that period?

A $\frac{1}{16}$ g **B** $\frac{1}{8}$ g

C $\frac{1}{4}$ g **D** slightly less than 1 g

30 The following process shows a stationary isotope of boron when capturing a slow moving neutron, splits to become a lithium isotope and an alpha particle.

$$^{10}_{5}B + ^{1}_{0}n \rightarrow ^{7}_{3}Li + ^{4}_{2}He$$

γ-ray is emitted in the process.

The nuclear binding energies are:

$^{10}_{5}B$: 64.94 MeV
$^{7}_{3}Li$: 39.25 MeV
$^{4}_{2}He$: 28.48 MeV

What is the energy of the γ-ray emitted, given that the total kinetic energy of $^{7}_{3}Li$ and $^{4}_{2}He$ is 2.31 MeV?

A 0.48 MeV

B 2.79 MeV

C 25.69 MeV

D 260.73 MeV

End of Paper 1

Centre Number	Index Number	Name	Class
S3016			

RAFFLES INSTITUTION
2018 Preliminary Examination

PHYSICS **9749/02**
Higher 2

13 September 2018
Paper 2 Structured Questions **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided in this booklet.
You may use pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions. The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 15
2	/ 10
3	/ 12
4	/ 11
5	/ 12
6	/ 20
Deduction	
Total	/ 80

This document consists of **20** printed pages and **1** blank page.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	T / °C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t = \pm \omega \sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 **(a)** **(i)** State Newton's Second Law of Motion as applied to a *system of bodies*.

....

....

.... [2]

(ii) Explain the implication of Newton's Second Law for a *system of bodies* isolated from all external forces.

....

....

.... [2]

(b) Two blocks A and B are held together with a light spring in between them as shown in Fig. 1.1. The spring has a force constant 80 N m^{-1} and is compressed by 0.060 m.

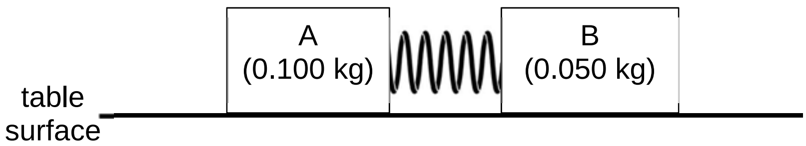


Fig. 1.1

The masses of blocks A and B are 0.100 kg and 0.050 kg respectively. Upon release, the two blocks move off in opposite directions on a smooth table surface and the spring falls off.

(i) On Fig. 1.2, sketch a graph to show the variation with time *t* of the force exerted by the spring on block B during which B is being pushed away from block A.

Fig. 1.2

[2]

(ii) Determine the final speeds of the two blocks.

speed of block A = ... m s^{-1}

speed of block B = ... m s^{-1} [4]

(c) As block B slides forward, it topples over at the edge of the table and lands on a horizontal uniform plank hinged to a wall at O. The centre of block B is at a horizontal distance of 0.15 m from the free end of the plank. The plank is supported by a rope attached to the wall as shown in Fig. 1.3.

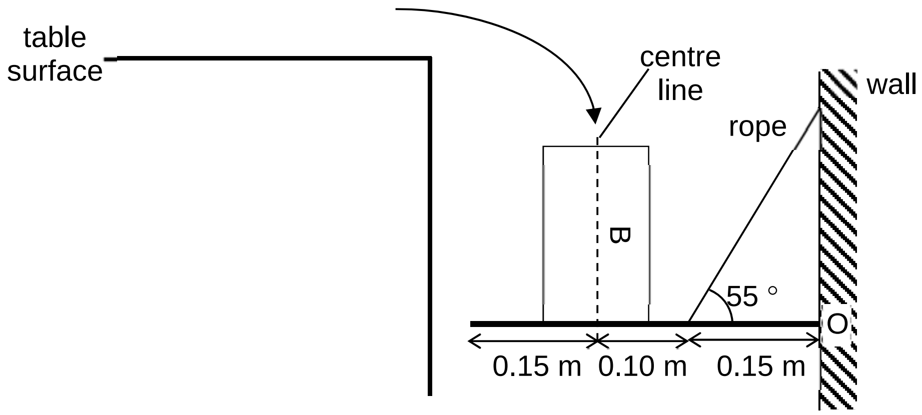


Fig. 1.3

Given that the weight of the plank is 4.0 N, calculate

(i) the tension in the rope after B is at rest on the plank,

tension = ... N [2]

(ii) the magnitude of the horizontal and vertical components of the force exerted by the hinge on the plank,

magnitude of horizontal component = ... N

magnitude of vertical component = ... N [2]

(iii) the angle θ that the force by the hinge on the plank makes with the horizontal. On Fig. 1.3, draw and label the force *F* by the hinge and indicate the angle θ.

θ = ... ° [1]

2 **(a)** A speaker emits sound waves uniformly in all directions. Fig. 2.1 shows the variation with time *t* of the displacement *x* of an air molecule at a point Q that is 120 cm from the speaker.

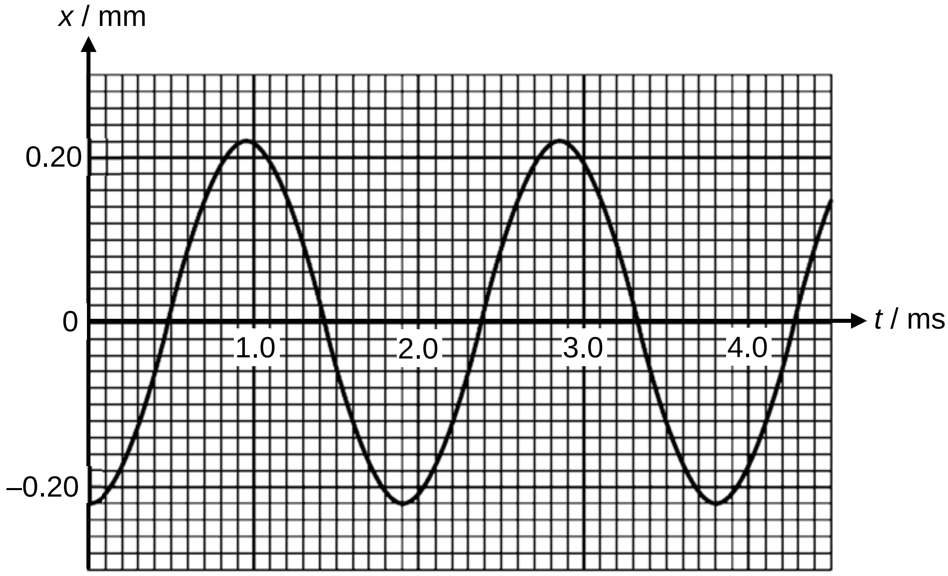


Fig. 2.1

(i) Use Fig. 2.1 to determine the

1. frequency *f* of the sound waves,

f = ... Hz [1]

2. uncertainty in *f* calculated in **(a)(i)1.** caused by reading the scale of the graph.

uncertainty in *f* = ... Hz [3]

(ii) Determine the next earliest time after 1.5 ms when the motion of the air molecule at Q has a phase difference of $\frac{4}{5}\pi$ compared to its phase at 1.5 ms.

time = ... ms [2]

(iii) If the power of the source is reduced to 0.25 of its initial value, calculate the distance from the speaker that will have the same intensity as that at point Q.

distance = ... cm [2]

(b) The wave arriving at point Q is progressive in nature. A stationary wave may be formed when two identical waves travelling in opposite directions superpose.

State the differences between the particles of a progressive wave and particles of a stationary wave in the following aspects:

(i) amplitude,

....

....

.... [1]

(ii) phase difference.

....

....

.... [1]

3 **(a)** Fig. 3.1 shows two chambers, X and Y, connected by a small pipe which is fitted with a valve. Both chambers are filled with ideal gas and the valve was initially closed. The volume of chambers X and Y are 2.5 m^3 and 4.0 m^3 respectively. Chambers X and Y are held at temperatures of 450 K and 300 K respectively.

The valve is then opened and a state of equilibrium is reached with the temperatures in each chamber remaining unchanged.

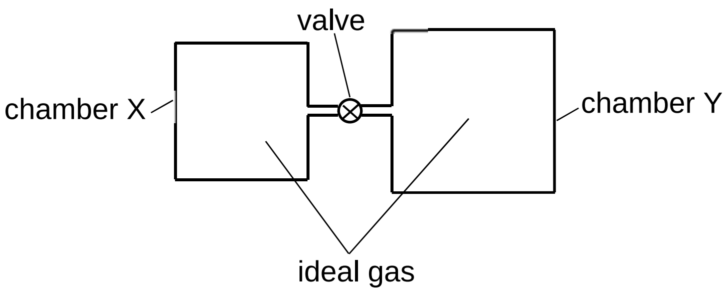


Fig. 3.1

(i) Determine the number of moles of ideal gas in chamber X, given that the number of moles of ideal gas in chamber Y is 1.2 after equilibrium has been reached.

number of moles of ideal gas in X = ... [2]

(ii) Calculate the pressure in both chambers after equilibrium has been reached.

pressure = ... Pa [1]

(iii) The valve is now closed and a pump is used to remove some ideal gas from chamber Y.

State and explain, using the kinetic theory of gas, why the pressure in chamber Y decreases, assuming no change in its temperature.

....

....

....

.... [1]

(b) A system of a fixed mass of ideal gas undergoes a cycle of changes. Fig. 3.2 shows the variation with volume *V* of the pressure *p* of the ideal gas as it undergoes the cycle ABCA.

Process A to B is isothermal, process B to C is isovolumetric and process C to A is adiabatic where there is no heat transfer into or out of the system of ideal gas.

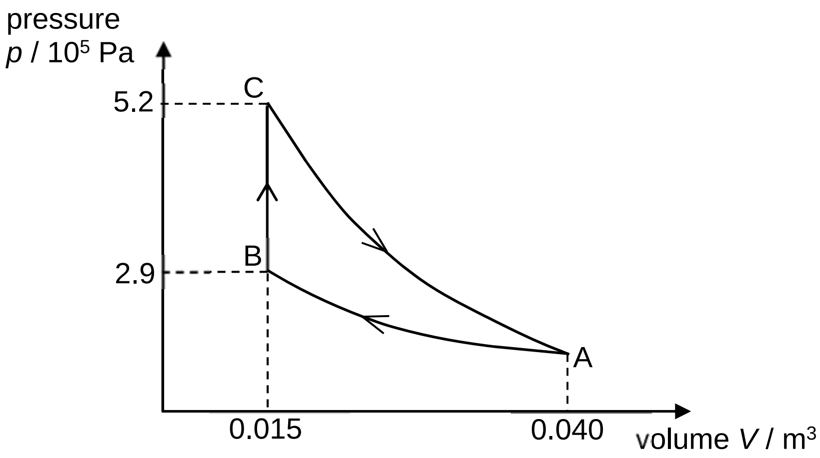


Fig. 3.2

Given that the mass of the ideal gas is 0.060 kg, calculate

(i) the pressure of the ideal gas in state A,

pressure = ... Pa [2]

(ii) the root-mean-square (r.m.s.) speed of the ideal gas molecules in state A,

r.m.s. speed = ... m s^{-1} [2]

(iii) the thermal energy absorbed by the system of ideal gas from B to C.

thermal energy = ... J [3]

(iv) Suggest one other way in which the adiabatic process C to A could be achieved in practice, other than by thermally insulating the system of gas.

....

.... [1]

4 **(a)** State, in words, the relation between the electric field strength *E* and potential *V* at a point.

....

.... [1]

(b) Two positively charged metal spheres, P and Q, of diameters 32 cm and 16 cm respectively, each carrying a charge of +7.2 nC, are isolated in space, as shown in Fig. 4.1.

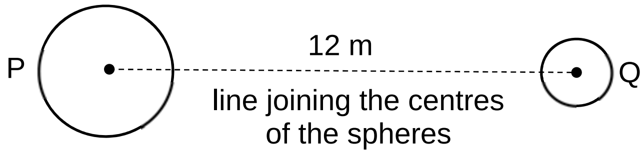


Fig. 4.1

The centres of the spheres are separated by a distance of 12 m. The distance *x* is measured from the centre of sphere P along the line joining the centres of the two spheres. Assume charges remain uniformly distributed on the surfaces of the spheres.

(i) State the value of *x* for which a stationary charged particle remains stationary when placed at this distance from the centre of sphere P.

x = ... m [1]

(ii) Calculate the electric potential at the point where the stationary charged particle remains stationary as stated in **(b)(i)**.

electric potential = ... V [1]

(iii) Sketch on Fig. 4.2, the variation with distance *x* of the electric potential *V* along the line joining the centres of the two spheres. Indicate on the horizontal axis your value of *x* in **(b)(i)**.

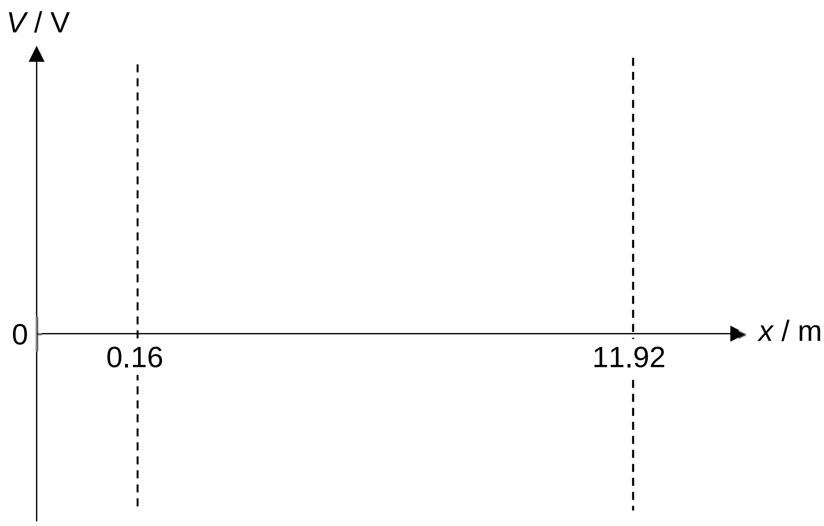


Fig. 4.2 (not to scale)

[3]

(iv) A positively charged particle is released at x = 0.16 m (surface of P).

With reference to your graph in **(b)(iii)**,

1. state and explain whether it will reach x = 11.92 m (surface of Q),

....

....

....

.... [2]

2. describe and explain the entire motion of this particle, using energy considerations or otherwise.

....

....

....

....

....

.... [3]

5 **(a)** **(i)** Distinguish between electrical resistance and resistivity.

....

....

.... [1]

(ii) A metal wire XY of resistance 2.0 Ω has a diameter of 1.0 mm and a resistivity of 1.5×10^{-6} Ω m.

Calculate the length of the wire.

length = ... m [1]

(b) A battery of e.m.f. 6.0 V with negligible internal resistance is connected to the metal wire XY and a light bulb of resistance 4.0 Ω as shown in Fig 5.1. The length of the connecting wire joining the negative terminal of the battery to the lamp is 0.20 m.

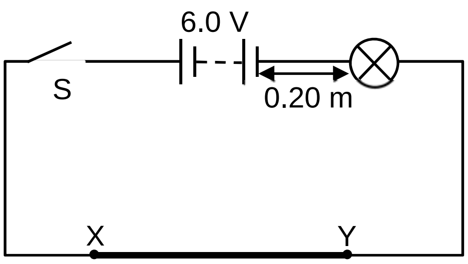


Fig. 5.1

(i) Switch S is closed. Calculate the current in the circuit.

current = ... A [1]

(ii) The connecting wires of diameter 1.0 mm are made of copper.

Given that the density and molar mass of copper are 8.96×10^3 kg m^{-3} and 64.0 g respectively, calculate the average drift velocity in the copper wires.

Assume that the number of conduction electrons is equal to the number of copper atoms in the wire.

drift velocity = ... m s^{-1} [3]

(iii) Calculate the time it would take for an electron to move from the negative terminal of the battery to the light bulb.

time = ... s [1]

(iv) The light bulb lights up in a time much lesser than the time calculated in **(b)(iii)**. Explain this observation.

....

....

....

.... [2]

(c) The light bulb is removed from the circuit in Fig. 5.1.

A cell with e.m.f. 3.0 V and internal resistance 0.50 Ω and a galvanometer are now connected to the circuit as shown in Fig. 5.2.

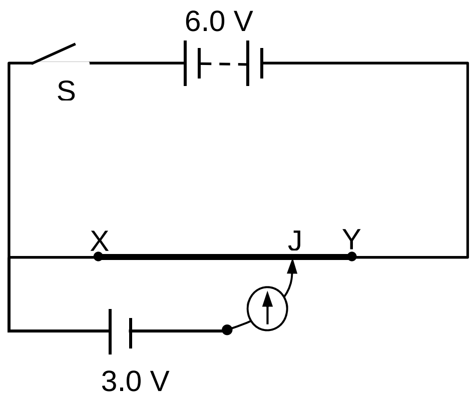


Fig. 5.2

(i) Calculate the length XJ when the galvanometer reads zero.

length XJ = ... m [1]

(ii) A 1.0 Ω resistor is now connected across the 3.0 V cell.

Calculate the new length XJ when the galvanometer reads zero.

length XJ = ... m [2]

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6 The electrical generator in a power station is driven by a steam turbine. The turbine absorbs thermal energy from a boiler and produces useful work. However, thermal energy must also be removed from the turbine by a cooling system as shown in Fig. 6.1.

The operating efficiency e of the turbine is defined by

$$e = \frac{\text{useful work output}}{\text{thermal energy input}}$$

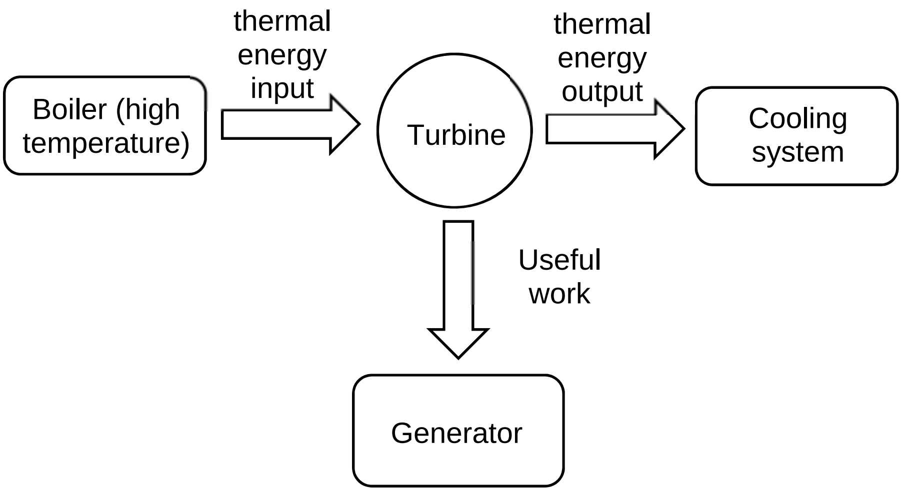

Fig. 6.1

The efficiency of heat engines, of which the turbine is an example, can never exceed a certain value which is fixed by temperatures of the boiler and the cooling system. This ideal efficiency e_{max} is given by the equation

$$e_{max} = \frac{T_2 - T_1}{T_2}$$

where T_2 is the thermodynamic temperature of the boiler and T_1 is the thermodynamic temperature of the cooling system.

Further data for a particular power station situated in Newtown, United Kingdom, are given in Fig. 6.2 below.

Electrical power output	200 MW
Efficiency of electrical generator	100%
Operating efficiency of turbine	31%
Ideal efficiency of turbine	52%
Effective temperature of cooling system (The cooling system uses water which enters at a temperature of 283 K and leaves at 291 K.)	330 K
Specific heat capacity of water in cooling system	4200 J kg^{-1} K^{-1}

Fig. 6.2

(a) Calculate the ideal efficiency e_{max} if the boiler temperature is 100 °C and the cooling system is at 27 °C.

e_{max} = ... [2]

(b) **(i)** Fig. 6.3 shows values of T_2 and e_{max} for a particular value of T_1.

T_2 / K	e_{max}
333	0.048
373	0.15
450	0.30
600	0.47
750	0.58

Fig. 6.3

Plot the variation with T_2 of e_{max} on the axes in Fig. 6.4.

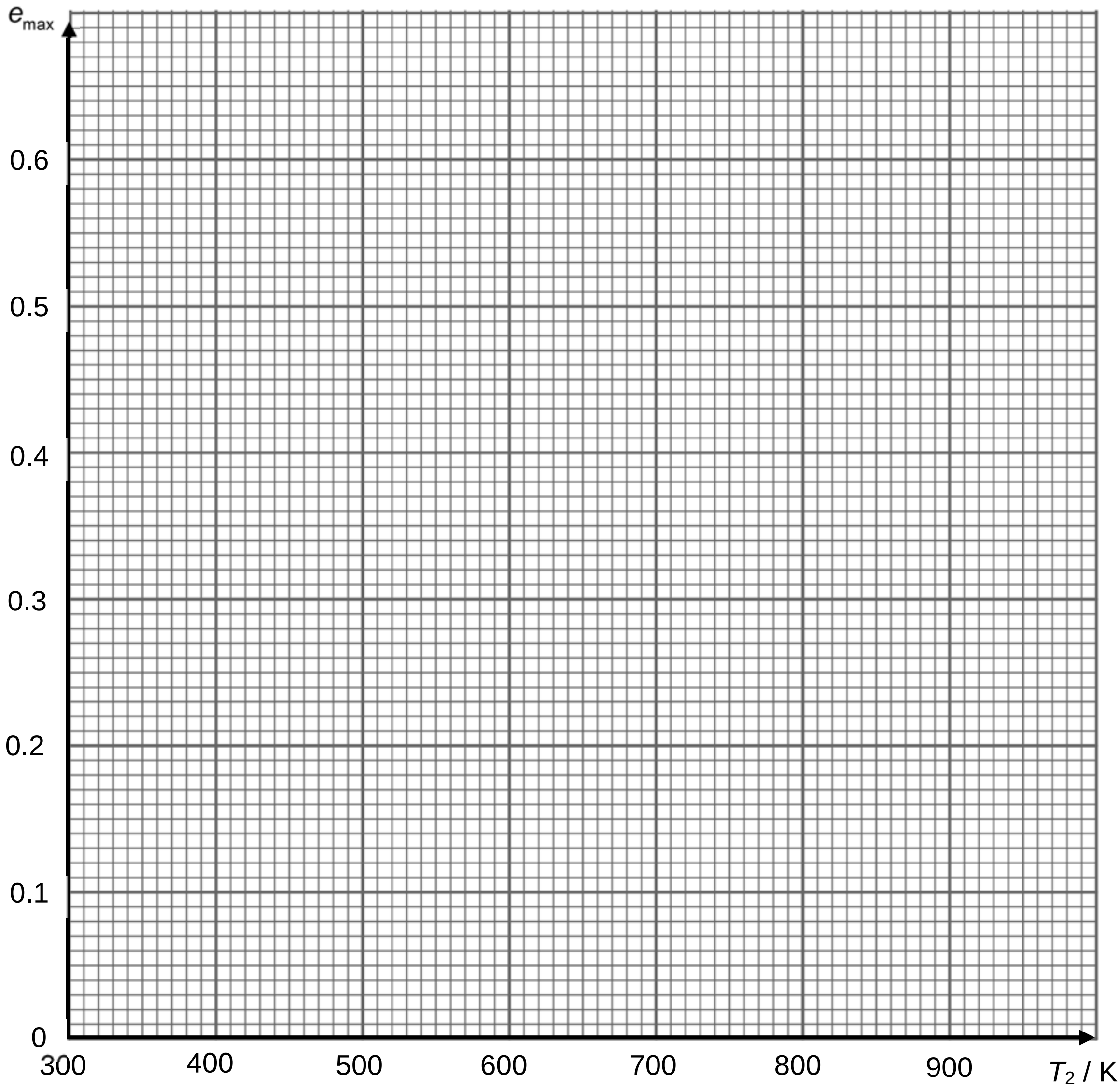

Fig. 6.4

[3]

(ii) From the graph, deduce the value of T_2 for which $e_{max} = 0$.

T_2 = ... K [1]

(iii) Hence, deduce the value of T_1.

T_1 = ... K [1]

(iv) Explain why it is not practical to attain an efficiency of 1.

....

....

....

.... [2]

(c) For the power station in Newtown, calculate

(i) the effective boiler temperature,

effective boiler temperature = ... K [1]

(ii) the rate of input of thermal energy to the turbine,

rate of input of thermal energy = ... W [1]

(iii) the rate at which thermal energy is removed from the turbine,

rate at which thermal energy is removed = ... W [1]

(iv) the required rate of flow of water through the cooling system.

rate of flow of water = ... kg s^{-1} [2]

(d) Suggest a reason for the discrepancy between the ideal efficiency of the turbine and its operating efficiency.

....

.... [1]

(e) A significant fraction of the electrical power produced in the UK by burning fossil fuels is used for domestic heating. Two suggestions for improvement are as follows:

(i) Burn the fossil fuel in the home instead of at the power station.

(ii) Cogeneration or combined heat and power (CHP) mechanisms which use the thermal energy output from the turbine for domestic heating.

Comment critically on these suggestions.

....

....

....

....

....

.... [2]

(f) Approximately 95% of Singapore's electricity is produced from fossil fuels (natural gas, coal, petroleum). Due to the lack of natural resources, most of the fossil fuels are imported from neighbouring countries. To enhance the nation's energy security and reduce our carbon footprint, the government has been exploring alternative energy sources.

(i) Suggest, with a reason, the renewable energy source that is the most viable option for Singapore.

....

....

.... [2]

(ii) State and explain a limitation in the deployment of the renewable energy source suggested in **(f)(i)** on a large scale to generate electricity reliably in Singapore.

....

.... [1]

End of Paper 2

Centre Number	Index Number	Name	Class
S3016			

RAFFLES INSTITUTION
2018 Preliminary Examination

PHYSICS **9749/03**
Higher 2

18 September 2018
Paper 3 Longer Structured Questions **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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Section A
Answer **all** questions.

Section B
Answer **one** question only and **circle the question number** on the cover page.

You are advised to spend one and half hours on Section A and half an hour on Section B.
The number of marks is given in brackets [ ] at the end of each question or part question.

***This booklet only contains Section A.**

For Examiner's Use		
Section A	1	/ 10
	2	/ 12
	3	/ 12
	4	/ 13
	5	/ 13
Section B (circle 1 question)	6	/ 20
	7	/ 20
Deduction		
Total		/ 80

This document consists of **15** printed pages.

Data

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gravitational potential	ϕ	=	$-Gm/r$
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pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
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magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided.

1 During a space expedition on the Moon, a table tennis ball is dropped in a large, enclosed container on the surface of the Moon. The container contains air from the Earth. Special arrangements are made to ensure that the pressure of the air is maintained at the Earth's atmospheric pressure. The variation with time *t* of the speed *v* of the table tennis ball is shown in Fig. 1.1.

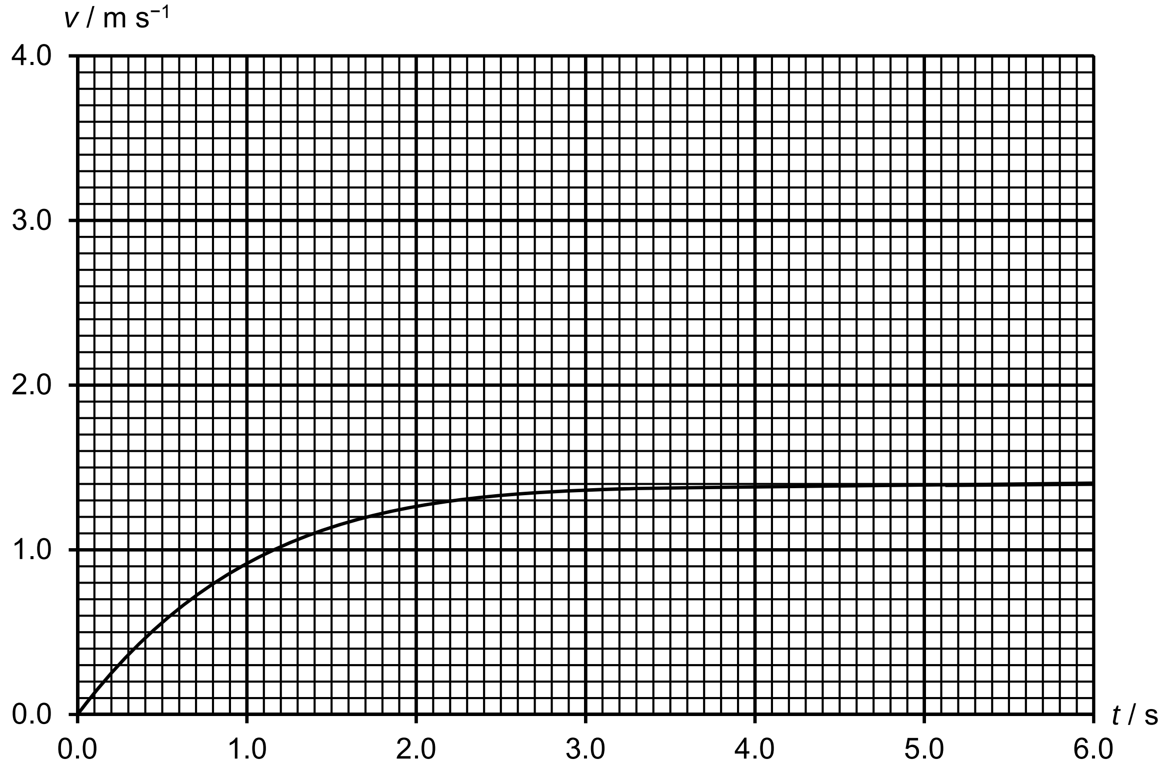


Fig. 1.1

The mass of the table tennis ball is 2.7 g.

(a) **(i)** Use Fig. 1.1 to determine the acceleration of free fall *g* of the ball on the surface of the Moon. Show your construction on Fig. 1.1.

g = ... m s^{-2} [2]

(ii) If the table tennis ball were dropped *outside* the container, determine the time taken for it to reach the value of the constant speed in Fig. 1.1.

time = ... s [1]

(b) The resistive force F acting on the table tennis ball is related to its speed v by the equation

$$F = kv$$

where k is a constant.

(i) Calculate the maximum resistive force experienced by the ball as it falls inside the container.

maximum resistive force = ... N [1]

(ii) Using your answer in **(b)(i)**, deduce the value of k.

k = ... kg s^{-1} [1]

(iii) Determine the maximum speed of the table tennis ball if this experiment is conducted on the surface of the Earth.

maximum speed = ... m s^{-1} [2]

(iv) Sketch, on Fig. 1.1, a new graph showing the variation with time t of the speed v of the table tennis ball when the experiment is repeated with the following changes made independently:

1. Liquid nitrogen of 1.5 times the mass of the ball is injected into the ball. Label this graph P.

2. The ball is thrown vertically downwards with an initial speed of 4.0 m s^{-1}. Label this graph Q.

[3]

2 **(a)** **(i)** Define gravitational field strength.

....

.... [1]

(ii) Hence, state with a reason, if gravitational field strength is a scalar or vector quantity.

....

.... [1]

(iii) State Newton's law of gravitation and use your definition in **(a)(i)** to write down an expression for the gravitational field strength *g* at a distance *R* from a point mass *M*.

....

....

....

....

.... [2]

(b) The mass of planet Jupiter is 1.90×10^{27} kg and its radius is 7.14×10^{7} m. The radius of Jupiter's orbit around the Sun is 7.79×10^{11} m. The mass of the Sun is 1.99×10^{30} kg.

(i) Calculate the ratio

$$\frac{\text{gravitational field strength on the surface of Jupiter due to the Sun}}{\text{gravitational field strength on the surface of Jupiter due to the mass of Jupiter}}.$$

ratio = ... [2]

(ii) Hence explain if the gravitational field strength due to the Sun on the surface of Jupiter can be neglected.

....

.... [1]

(c) The Galilean moons are the largest moons of Jupiter which were first discovered by Galileo in January 1610. Some of the data of the 3 Galilean moons closest to Jupiter are given in Fig. 2.1.

Name of moon	Io	Europa	Ganymede
Average orbital radius / m	4.22×10^{8}	6.71×10^{8}	1.07×10^{9}

Fig. 2.1

(i) For moons revolving around a planet in circular orbits, determine that the orbital period T of a moon is given by

$$T^2 = KR^3$$

where R is the radius of the orbit and K is a constant. Explain your working clearly.

[3]

(ii) Hence, show that the orbital period of Io : Europa : Ganymede is 1 : 2 : 4 approximately.

[2]

3 A test-tube is partially loaded with small ball bearings such that it is able to float upright in water of density ρ as shown in Fig. 3.1. The bottom of the test-tube is a distance H below the water surface.

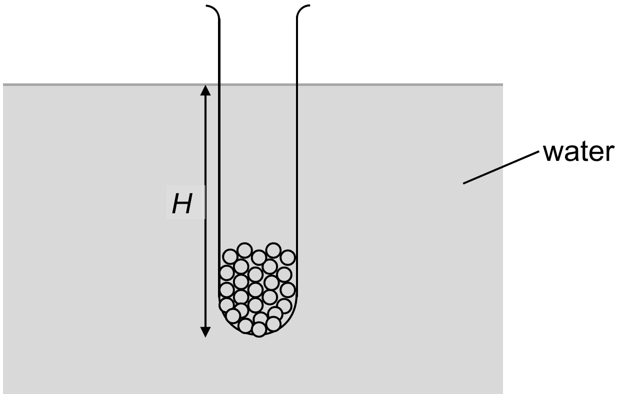


Fig. 3.1

Ignoring its rounded bottom, the test-tube may be regarded as a cylinder of cross sectional area A and mass m. The mass of the ball bearings added is M.

(a) Derive an expression that relates H to A, ρ, M and m.

[2]

(b) The test-tube is displaced vertically by displacement y and then released. Ignoring dissipative forces,

(i) write down, in terms of ρ, A, g and y, an expression for the net force acting on the loaded test-tube,

.... [1]

(ii) show that the acceleration of the test-tube is given by

$$a = -\left(\frac{\rho A g}{M + m}\right) y$$

where g is the acceleration of free fall.

[1]

(c) It is given that $\rho = 1.00 \times 10^3$ kg m^{-3}
$A = 6.0 \times 10^{-4}$ m^2
$M = 0.012$ kg
$m = 0.025$ kg

Show that the period of oscillation of the test-tube is 0.50 s.

[3]

(d) In practice, it is observed that the variation with time t of the vertical displacement y of the test-tube is as shown in Fig. 3.2.

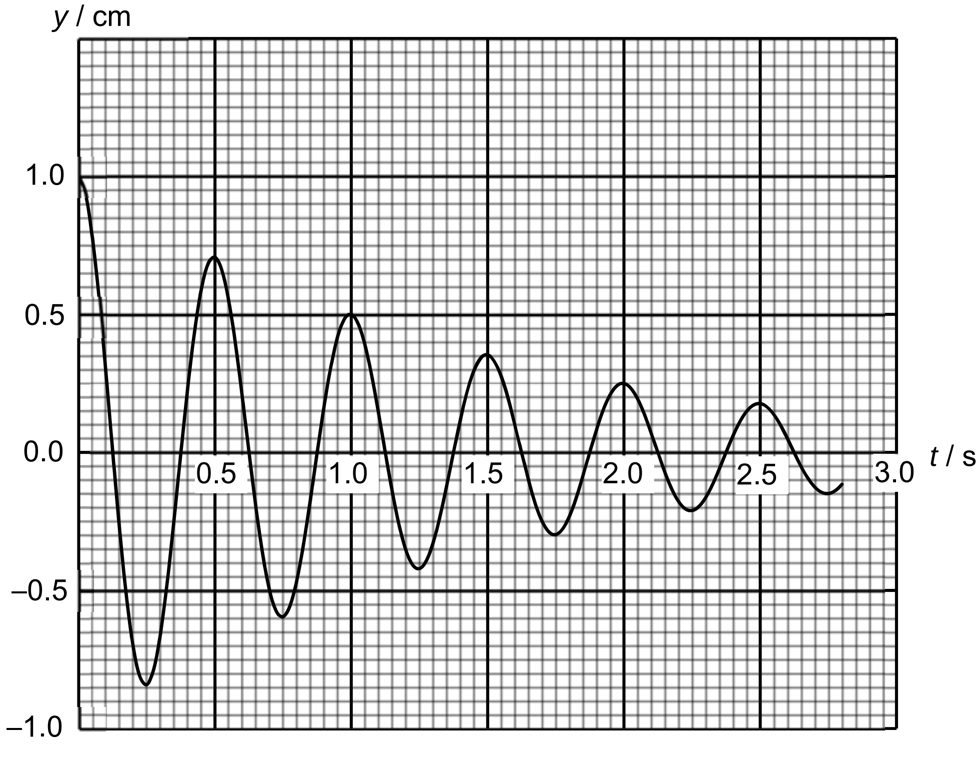


Fig. 3.2

Explain why the amplitude of the oscillations decreases gradually over time.

....

....

.... [2]

(e) To sustain the oscillations of the test-tube, low-amplitude water waves of frequency 0.30 Hz are generated on the surface of the water.

(i) Sketch a graph to show the variation with time *t* of the vertical displacement *y* of the test-tube when it is oscillating steadily. Numerical values are not required for the graph.

[1]

(ii) It is observed that the amplitude of the vertical oscillations of this test-tube is rather small. Without changing the water waves, suggest with reasoning how the amplitude of the oscillations of this test-tube may be increased.

....

....

....

.... [2]

4 **(a)** **(i)** State the principle of superposition.

....

....

.... [2]

(ii) Use Huygen's principle to explain the interference pattern formed when waves of a single wavelength pass through a single slit.

....

.... [1]

(b) A parallel beam of light of wavelength 600 nm from a point source is incident normally on a rectangular slit of width 0.30 mm as shown in Fig. 4.1. Light passing through the slit is incident on a screen placed a distance *D* from the slit.

The centre of the interference pattern formed on the screen is at O. The angle a light ray emerging from the slit makes with the normal line between the slit and the screen is θ.

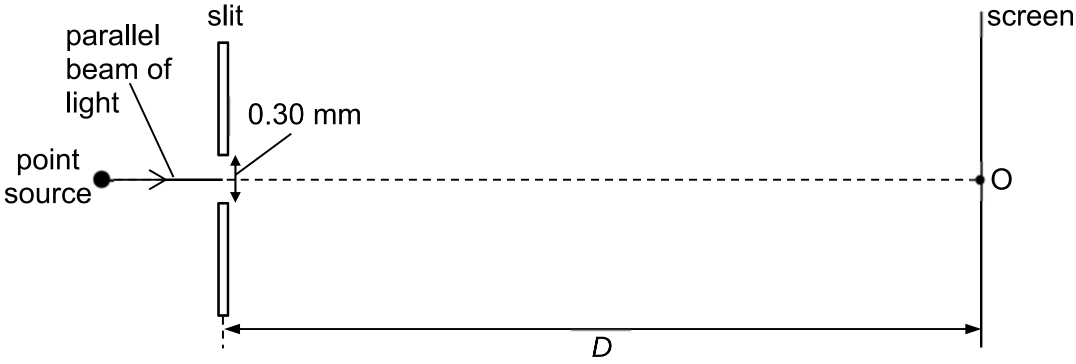


Fig. 4.1 (not to scale)

(i) On the axes in Fig. 4.2, sketch a graph to show the variation with $\sin\theta$ of the intensity I of the light on the screen. Include appropriate values along the $\sin\theta$ axis.

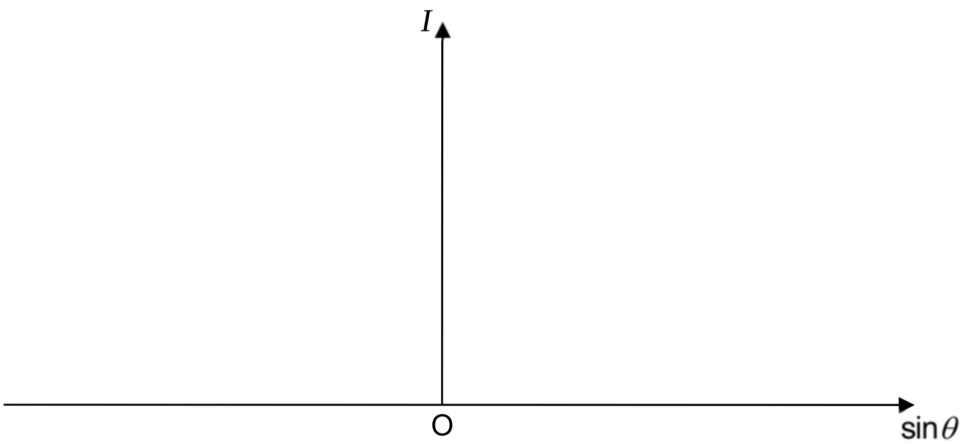


Fig. 4.2

[3]

(ii) Another identical point source of light is placed at a distance of 1.0 mm from the first point source as shown in Fig. 4.3. Both sources are 0.25 m from the slit. Light from each source forms a separate interference pattern on the screen.

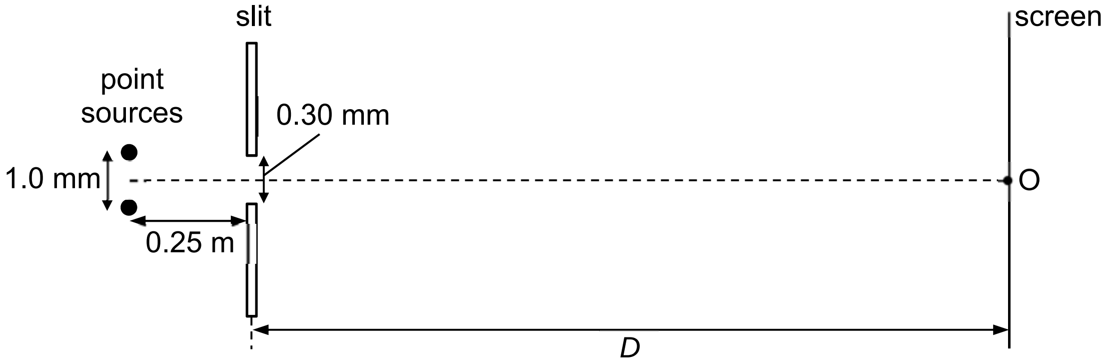


Fig. 4.3 (not to scale)

Determine, with appropriate calculations, if it is possible to resolve the images of the two sources on the screen.

The two interference patterns can / cannot be resolved. [2]

(c) The single slit in Fig. 4.1 is replaced with double slits each with the same slit width of 0.30 mm and with a slit separation of 1.2 mm. There is only one point source and light from the point source is incident normally on the slits.

(i) Determine the number of maxima observed within the central fringe of the single slit interference pattern. Explain your working clearly.

number of maxima = ... [3]

(ii) If the width of the central fringe is 12 mm, calculate the perpendicular distance *D* between the double slits and the screen.

D = ... m [2]

5 **(a)** State Faraday's law of electromagnetic induction.

....

....

.... [1]

(b) Fig. 5.1 shows a coil of 400 turns and cross-sectional area of 4.2×10^{-4} m^2 placed in the middle of a long solenoid. The coil is connected to a sensitive ammeter. The solenoid is connected to a variable resistor and a sinusoidally-alternating voltage supply.

The variation with time *t* of the magnetic flux density *B* in the solenoid is shown in Fig. 5.2.

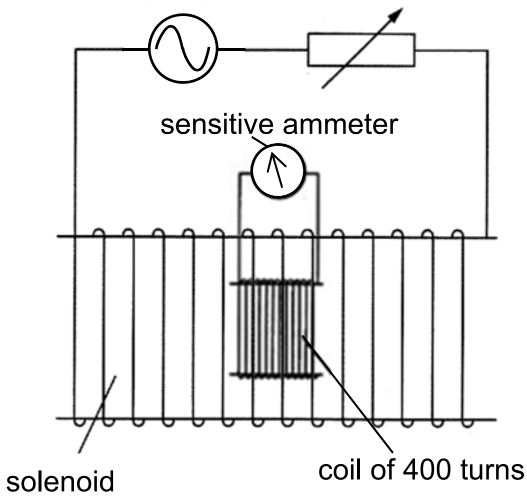


Fig. 5.1

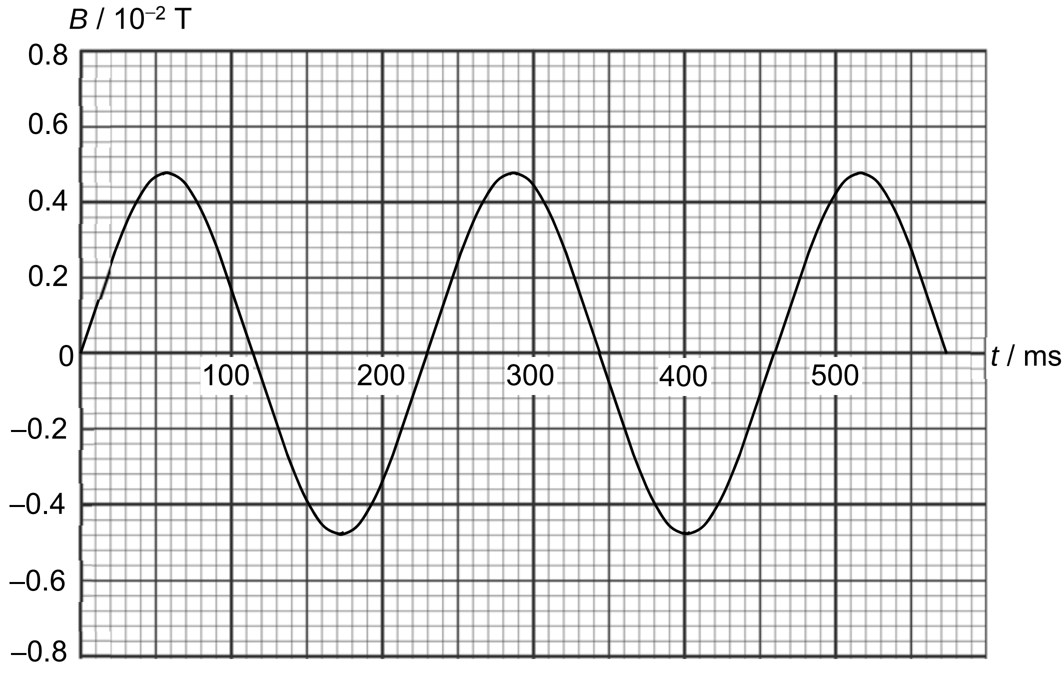


Fig. 5.2

(i) Explain, with reference to the magnetic field in the solenoid, why the sensitive ammeter deflects in opposite directions.

....

....

....

....

.... [2]

(ii) Using Fig. 5.2,

1. state a value of t when the magnitude of the induced e.m.f. is maximum,

t = ... s [1]

2. hence determine the maximum induced current in the coil given that the resistance of the coil is 5.0 Ω,

maximum induced current = ... A [3]

3. calculate the mean power dissipated by the coil.

mean power dissipated = ... W [2]

(iii) Sketch on Fig. 5.3, a graph to show the variation with time t of the induced current i in the coil from t = 0 ms to t = 460 ms. Include appropriate scale markings on the vertical axis.

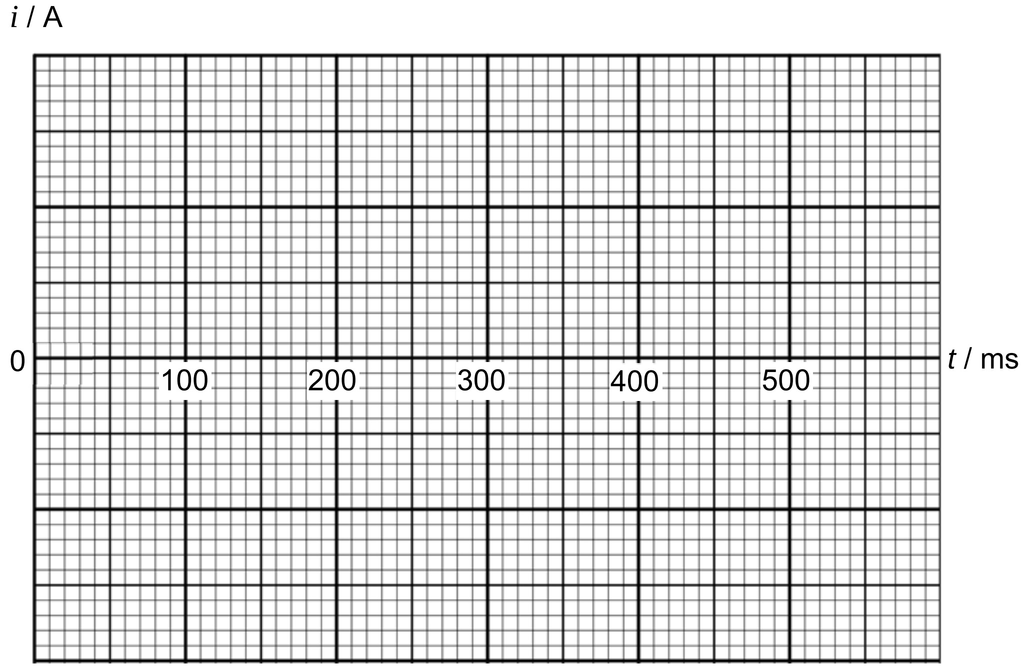


Fig. 5.3

[2]

(iv) Sketch on Fig. 5.4, a graph to show the variation with time t of the power P dissipated in the coil from t = 0 ms to t = 460 ms. Include appropriate scale markings on the vertical axis.

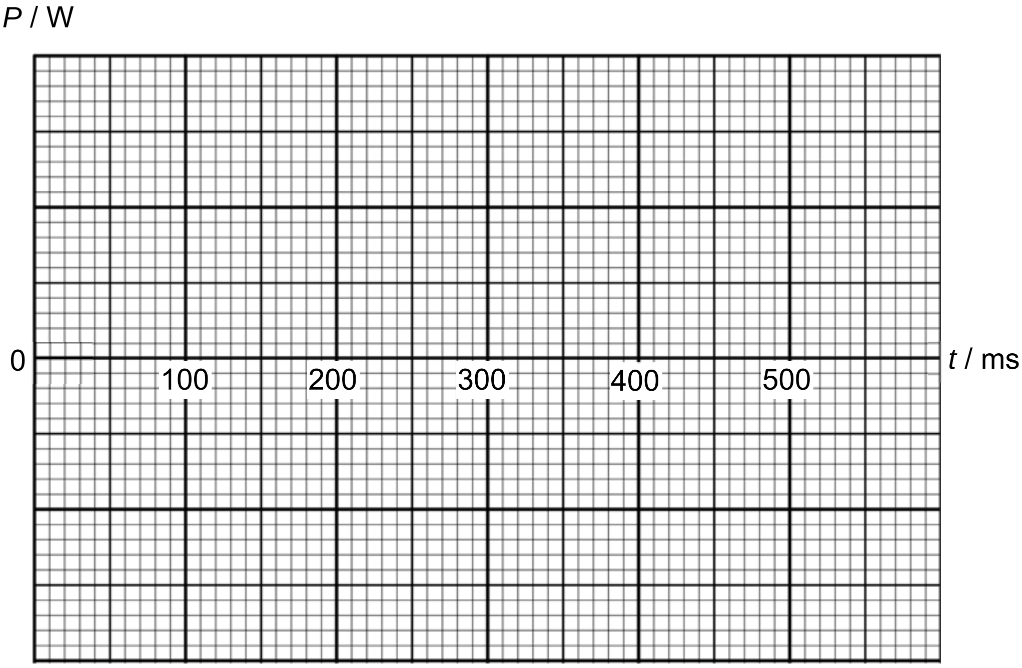


Fig. 5.4

[2]

End of Paper 3 Section A

Centre Number	Index Number	Name	Class
S3016			

RAFFLES INSTITUTION
2018 Preliminary Examination

PHYSICS **9749/03**
Higher 2

18 September 2018
Paper 3 Longer Structured Questions **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided in this booklet.
You may use pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only and **circle the question number** on the cover page.

You are advised to spend one and half hours on Section A and half an hour on Section B.
The number of marks is given in brackets [ ] at the end of each question or part question.

***This booklet only contains Section B.**

For Examiner's Use		
Section B (circle 1 question)	**6**	/ 20
	7	/ 20
Deduction		

This document consists of **9** printed pages.

Section B

Answer **one** question from this Section in the spaces provided.

6 **(a)** The energy levels of a hypothetical one-electron atom are given by

$$E_n = -\frac{27.90}{n^2} \text{ eV}$$

where $n = 1, 2, 3, \ldots$

(i) Calculate the energies of the four lowest energy levels and construct a clearly labelled energy level diagram.

[3]

(ii) If the atoms are in the ground state and are bombarded by electrons of kinetic energy 26.5 eV, determine the highest energy level that an atom can reach. Show your working clearly.

highest energy level = ... [3]

(iii) Indicate, with arrows, in your energy level diagram in **(a)(i)** all the possible transitions that produce emission lines when these atoms de-excite. [2]

(iv) Calculate the longest and the shortest wavelengths of the photons emitted during these transitions.

longest wavelength = ... nm

shortest wavelength = ... nm [2]

(b) In a modern X-ray tube, electrons are accelerated through a large potential difference and the X-rays are produced when electrons strike a metal target embedded in a large piece of copper.

Fig. 6.1 shows an energy level diagram of an atom of a hypothetical metal.

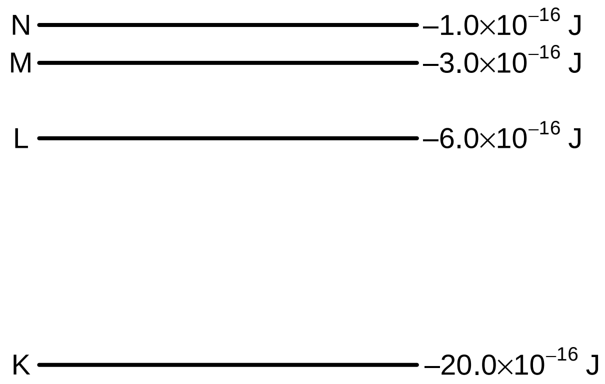


Fig. 6.1

The emission spectrum of the metal when it is bombarded by a beam of fast-moving electrons is shown in Fig. 6.2.

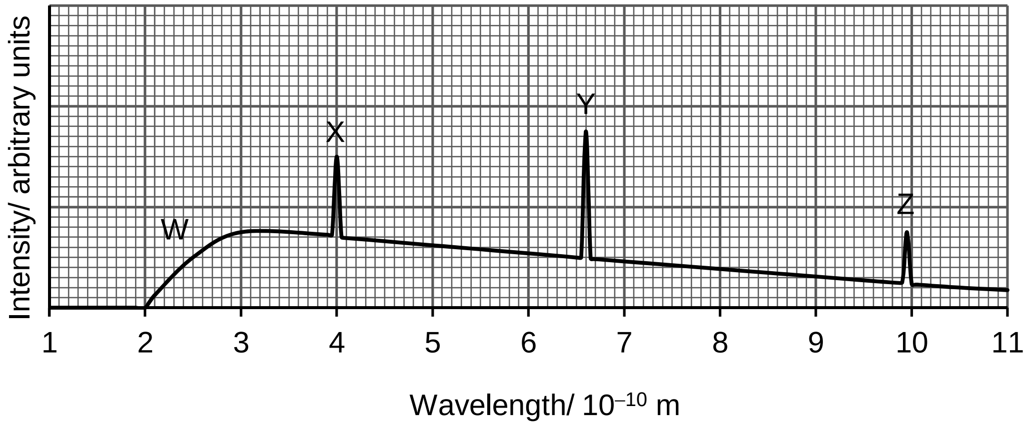


Fig. 6.2

(i) Describe the processes that occur at the target which produce the continuous spectrum W.

....

....

....

....

....

....

....

....

.... [4]

(ii) Calculate the accelerating potential of the X-ray tube.

accelerating potential = ... V [3]

(iii) Using Fig. 6.1, deduce which of the lines X, Y and Z in Fig. 6.2 correspond to L_α, L_β and M_α lines.

L_α = ...

L_β = ...

M_α = ... [2]

(iv) Explain why the K spectral lines are missing from Fig. 6.2.

....

.... [1]

7 The count rate C of a mixture of two radioactive nuclides X and Y is measured and the variation with time t of ln C is plotted and shown in Fig. 7.1. The readings show the count rate after the background count rate has been subtracted from it.

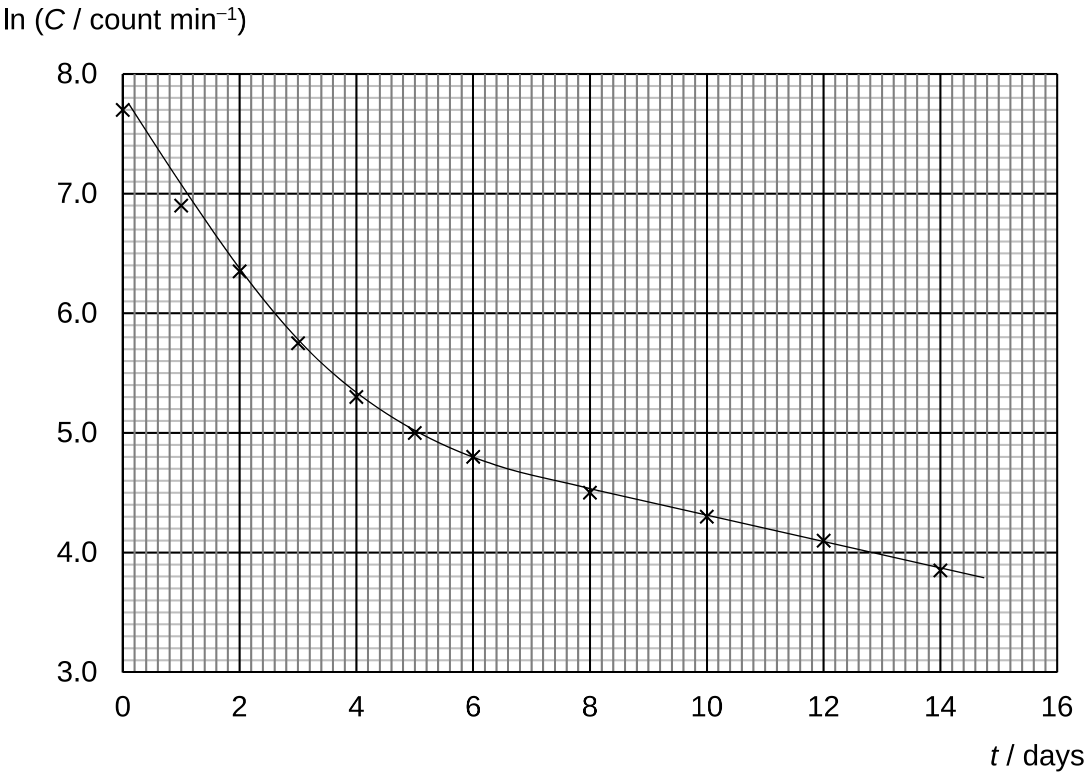


Fig. 7.1

It is known that the half-life of X is much longer than that of Y. The graph approaches a straight line eventually.

(a) By using an equation with the symbols defined below, explain why the graph approaches a straight line eventually.

Given C_X : count rate of X at time t,
C_{X_0} : initial count rate of X,
λ_X : decay constant of X.

....

....

....

....

.... [3]

(b) **(i)** Determine the initial count rate of X and its half-life using information from Fig. 7.1.

initial count rate = ... count min^{-1}

half-life = ... days [5]

(ii) Estimate the count rate of the mixture at t = 19 days.

count rate = ... count min^{-1} [2]

(c) One of the radioactive nuclides in the mixture can be used as a tracer to check whether the thyroid gland is absorbing iodine normally from the blood in a human body. The tracer nuclei decay by emitting beta particles and gamma rays, and the gamma rays are monitored from outside the body close to the thyroid using a detector.

A dose of iodine with the tracer is injected into a patient's blood, and 20% of that dose is absorbed by the thyroid gland. The detector records 0.40% of the gamma rays emitted.

(i) Suggest a reason why the beta particles are not monitored.

....

.... [1]

(ii) Suggest a reason why the detector records only 0.40% of the gamma rays emitted from the radioactive nuclei inside the thyroid.

....

.... [1]

(iii) In administering radioactive nuclides for medical applications, factors such as the half-life of the source must be considered.

Suggest two other significant factors that should be considered.

....

....

....

....

.... [2]

(d) Source Y has a half-life of 20 hours. In the absence of source Y, a constant average count-rate of 15 s^{-1} is recorded by a radiation detector.

Immediately after source Y is placed 30 cm from the detector, the average count-rate rises to 100 s^{-1}.

Determine the distance the detector should be placed from source Y in order to detect the same average count-rate of 100 s^{-1} 60 hours later.

Assume that source Y is a point source emitting radiation in all direction.

(Sample X is not present in this part of the experiment.)

distance = ... cm [4]

(e) Fig. 7.2 shows the variation with time of the cumulative counts (total count) of a small sample of X and of the background radiation.

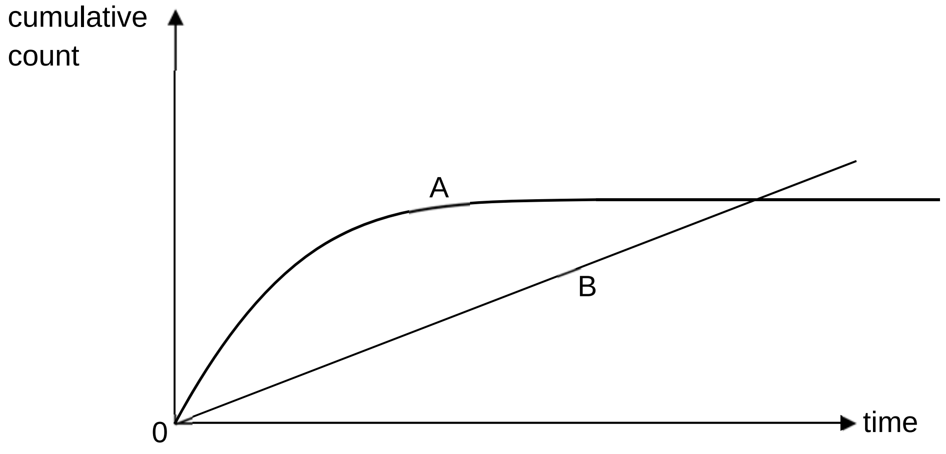


Fig. 7.2

(i) State and explain which graph, A or B, in Fig. 7.2 represents the cumulative count of the background radiation.

....

.... [1]

(ii) Sketch and label on Fig. 7.2, a graph that represents the cumulative count of a sample of Y that has half the initial number of nuclei as that of sample X.

[1]

End of Paper 3 Section B

RI Prelim P4 (2018)

Question 1		
	Item	**Quantity**
1.	Wire '**W**' taped onto one side of half–metre rule	1
2.	Small magnet	1
3.	Cradle tied to cotton thread	1
4.	Wooden pointer	1
5.	Retort stand, boss and clamp	1 set
6.	Paper protractor	1
7.	Half–metre rule	1
8.	Digital multi–meter	1
9.	2.0 V accumulator	1
10.	Switch	1
11.	Rheostat	1
12.	Plug & croc clip wires	2
13.	Croc clip & croc clip wires	3
14.	Wooden pieces	2
15.	Blu Tack	Small amount
16.	Sandpaper	1 small pc

Question 2		
	Item	**Quantity**
1.	Plywood board	1
2.	Wooden rod	1
3.	Retort stand with boss (no clamp needed)	1 set
4.	Small bottle with cap	1
5.	Post-it	2 pieces
6.	Blu Tack	Small amount
7.	Metre rule	1
8.	Protractor	1

Question 3		
	Item	**Quantity**
1.	Digital multi–meter	2
2.	Plug & croc clip wires	4
3.	Resistor of 1 Ω	2
4.	Wire attached onto a metre rule	1
5.	Switch	1
6.	2.0 V accumulator	1
7.	Croc clip & croc clip wires	6

Centre Number	Class Index Number	Name	Class
S3016			

RAFFLES INSTITUTION
2018 Preliminary Examination

PHYSICS **9749/04**
Higher 2 **20 August 2018**

Paper 4 Practical **2 hours 30 minutes**

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift, laboratory and calculator model(s) in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift	
Laboratory	
Calculator model (s)	
For Examiner's Use	
1	/ 9
2	/ 14
3	/ 20
4	/ 12
Total	/ 55

1 In this experiment, you will investigate the effect on a magnet due to the magnetic flux density produced by a current in a straight wire.

(a) **(i)** Position the thread holding the cradle between two pieces of wood and secure it using the clamp of a retort stand.

Place the magnet in the suspended cradle and use some Blu Tack to secure the pointer to the top of the magnet. The pointer should be horizontal.

Note : DO NOT make any markings on the paper–protractor.

Arrange the paper–protractor on the bench-top beneath the suspended magnet so that the pointer is aligned along the 0°–180° line of the paper–protractor. Fasten the paper–protractor to the bench top with Blu Tack.
The pointer should be about 2 cm above the 0°–180° line of the paper–protractor.

Wire **W** is secured to the side of a half-metre rule. Lay the wire **W** along the 90°– 270° line of the paper–protractor as shown in Fig. 1.1.

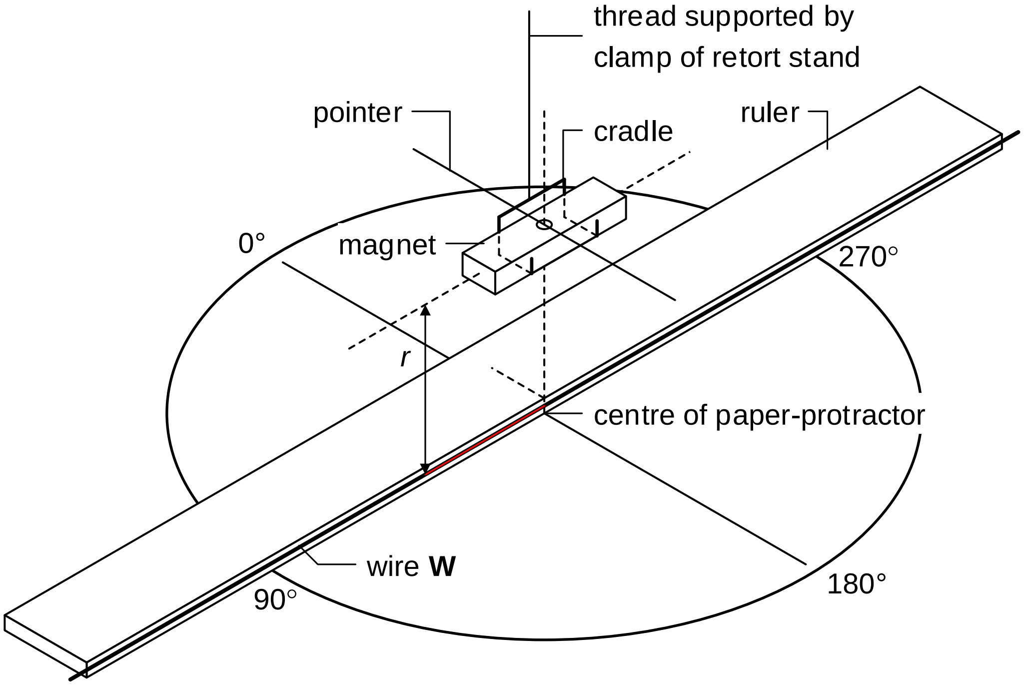


Fig. 1.1

(ii) Measure and record the height *r* from the centre line of the magnet to wire **W**.

r = ... [1]

(b) **(i)** Without shifting the position of wire **W**, connect it to the circuit shown in Fig. 1.2.

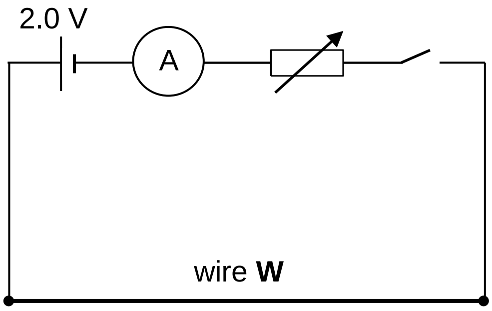


Fig. 1.2

Close the switch and adjust the rheostat to obtain a current of about 1 A through wire **W**. The magnet should be deflected from its initial position. If there is no current detected, use a piece of sandpaper to remove the layer of coating at the tips of wire **W**.

(ii) Record the current I through the wire.

I = ... [1]

(iii) Measure and record the acute angle of deflection θ of the pointer from the 0° mark of the paper–protractor.

θ = ... [1]

(iv) The magnetic flux density B at the magnet produced by the current in wire **W** and the horizontal component of the Earth's magnetic field B_H that causes the bar magnet to set in the N–S direction are related by the equation $B = B_H \tan\theta$.

It is suggested that the magnetic flux density B at a height r produced by the current I in wire **W** is $B = 2.0 \times 10^{-7} \dfrac{I}{r}$.

Determine the value of B_H in tesla.

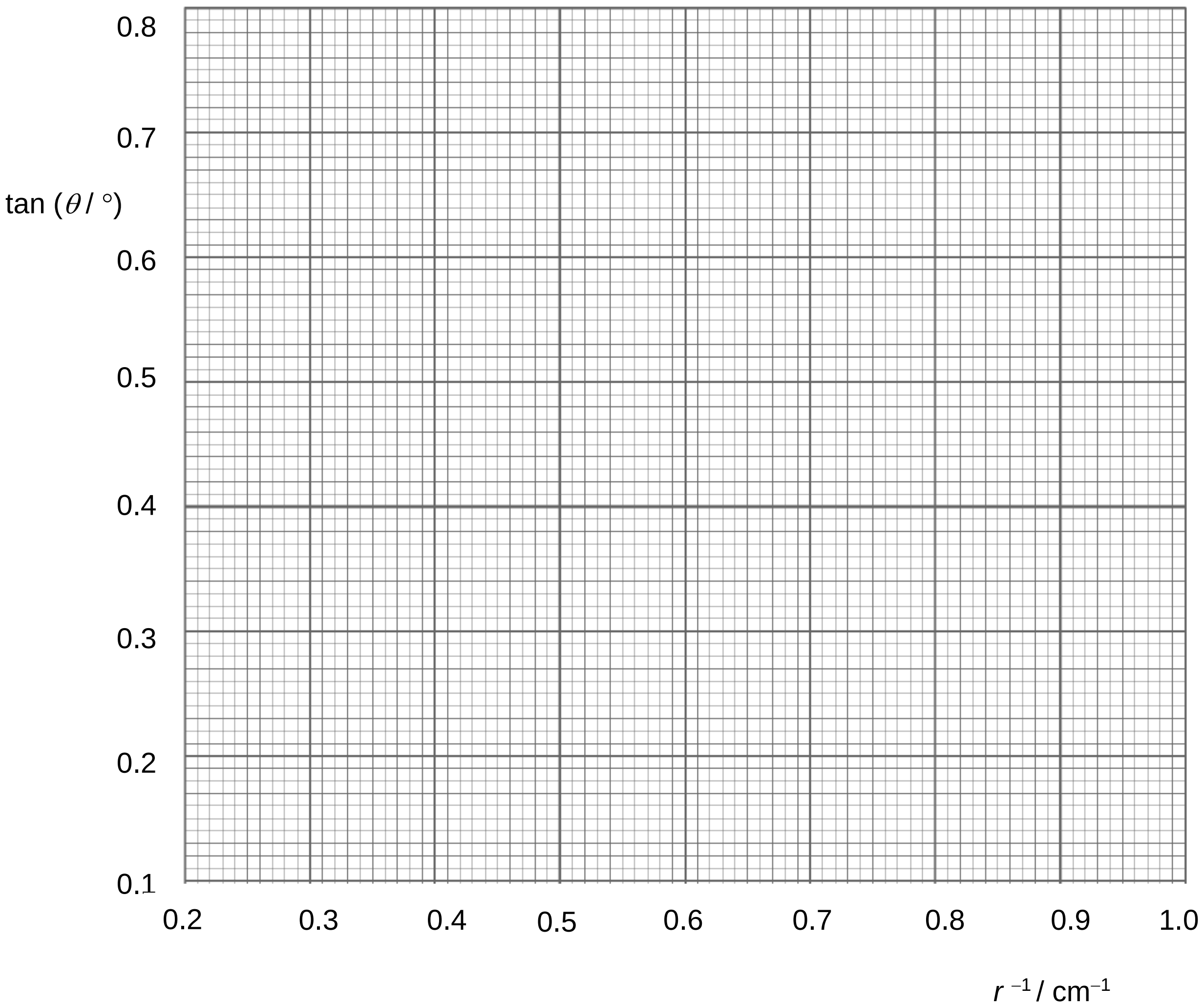
B_H = ... T [2]

(c) The experiment is repeated with a fixed current in the wire and the magnet suspended at different distances *r* from the wire.

The results are shown in the table below.
Values of r^{-1} and tan θ are included.

r / cm	θ / °	r^{-1} / cm^{-1}	tan (θ / °)
1.1	33	0.91	0.65
1.5	27	0.67	0.51
2.5	17	0.40	0.31
3.5	12	0.29	0.21
4.5	10	0.22	0.18

(i) Plot the points on the grid below and draw the straight line of best fit. [1]



(ii) Determine the *y*-intercept of the line.

y-intercept = ... [2]

(iii) Use your answer in **(c)(ii)** to state whether tan θ is inversely proportional to *r*.

....

....

.... [1]

[Total: 9]

2 In this experiment, you will investigate the motion of a cylindrical container on an inclined surface.

(a) Measure and record the length *L* of the shorter side of the board, as shown in Fig. 2.1.

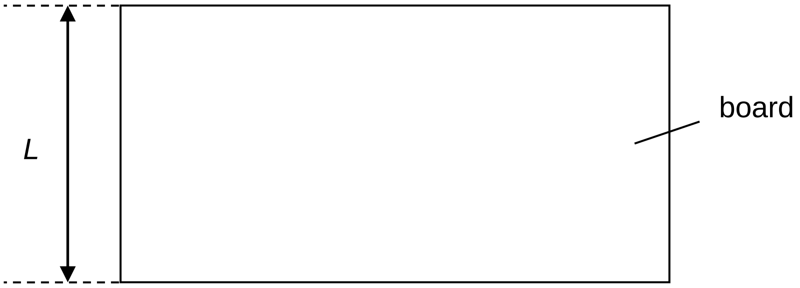


Fig. 2.1

L = ... [1]

(b) (i) Set up the board as shown in Fig. 2.2. Clamp the wooden rod using the boss of the retort stand such that the board can rest on a long portion of the rod.

You may use some Blu Tack to fix the position of the board to the bench-top.

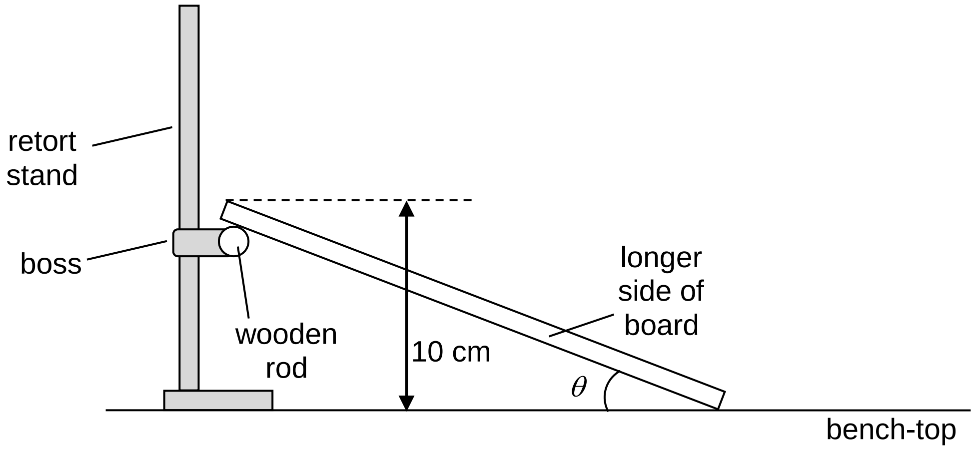


Fig. 2.2

The distance between the top of the board and the bench-top should be about 10 cm.

(ii) Measure and record the angle θ as shown in Fig. 2.2.

θ = ... [1]

(c) **(i)** Place the cylindrical container on the board as shown in Fig. 2.3.
The lid of the container should be aligned with the edges of the board

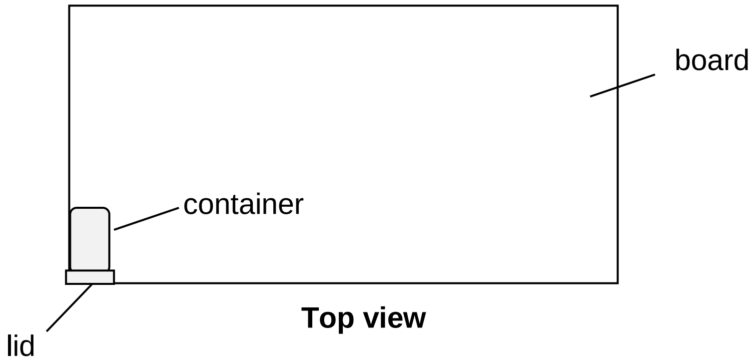


Fig. 2.3

(ii) Release the container. The container should follow the path shown in Fig. 2.4.

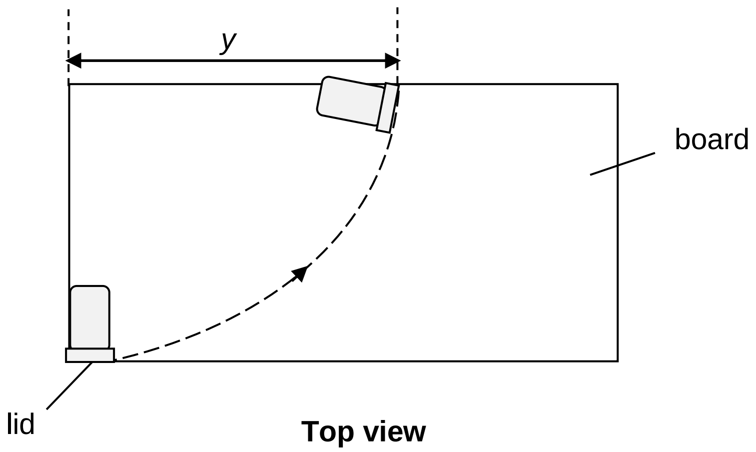


Fig. 2.4

(iii) Measure and record the distance *y*, as shown in Fig. 2.4.

Note : DO NOT make any markings on the board.

You may use the small strips of Post-it provided to indicate the position of *y*. Remove the Post-it at the end of the experiment.

y = ... [1]

(iv) Estimate the percentage uncertainty in your value of *y*.

percentage uncertainty = ... [1]

(d) **(i)** Calculate D using

$$D = \frac{L^2 + y^2}{L}$$

....

D = ... [1]

(ii) Justify the number of significant figures that you have given for your value of D.

....

.... [1]

(e) **(i)** Increase the angle θ.

(ii) Repeat **(b)(ii)**, **(c)(i)** to **(iii)** and **(d)(i)**.

θ = ... [1]

y = ... [1]

D = ... [1]

(f) It is suggested that the relationship between D and θ is

$$D = k \sin \theta$$

where k is a constant.

(i) Using your data, calculate two values of k.

first value of k = ...

second value of k = [2]

(ii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your value in **(c)(iv)**.

....

....

.... [1]

(g) **(i)** Suggest a significant source of error in this experiment.

....

.... [1]

(ii) Suggest an improvement that could be made to the experiment to address the error identified in **(g)(i)**. You may suggest the use of other apparatus or a different procedure.

....

.... [1]

[Total: 14]

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3 In this experiment, you will determine the diameter of a resistance wire using an electrical method.

(a) Set up the apparatus as shown in Fig 3.1. The resistance of resistors R_1 and R_2 are both R = 1.0 Ω. The e.m.f. of the power supply is 2.0 V.

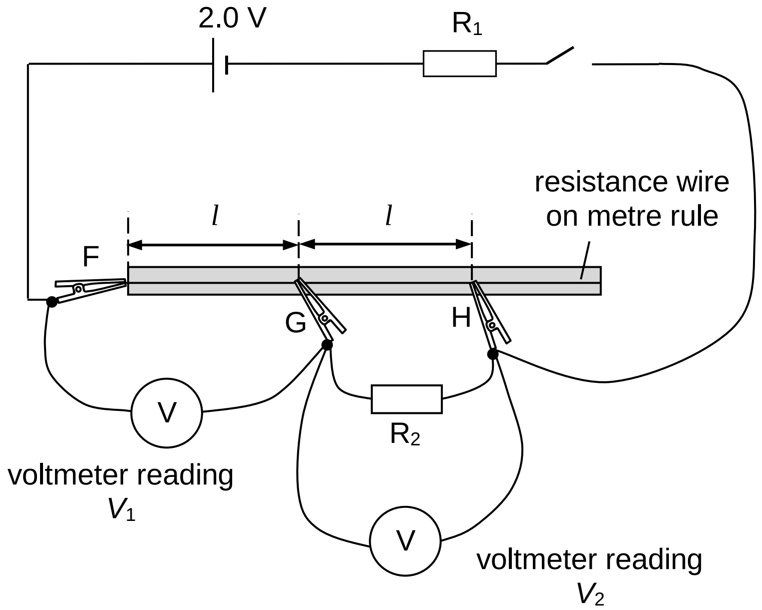

Fig. 3.1

(i) By adjusting the crocodile clips G and H, set the distance l to approximately 20 cm.

(ii) The distance l between clips F and G and clips G and H should be the same. Measure and record l.

l = ... [1]

(b) **(i)** Close the switch.

(ii) Record the voltmeter readings V_1 and V_2 .

V_1 = ...

V_2 = ... [1]

(iii) Open the switch.

(c) Increase l and repeat **(a)(ii)** and **(b)** for further sets of readings of l, V_1 and V_2.

....

[6]

(d) Theory suggests that V_1, V_2 and l are related by the expression

$$\frac{V_1}{V_2} = Pl + Q$$

where P and Q are constants.

Plot a suitable graph to determine the values of P and Q.

P = ...

Q = [4]

[3]

(e) Comment on any anomalous data or results that you may have obtained. Explain your answer.

....

....

.... [1]

(f) The quantity P is given by the expression

$$P = \frac{\rho}{AR}$$

where ρ is the resistivity of the material of the wire and A is the cross-sectional area of the wire.

(i) Given $\rho = 6.75 \times 10^{-7}\ \Omega$ m, determine the diameter d of the wire.

d = ... [1]

(ii) In the expression $\frac{V_1}{V_2} = Pl + Q$, Q is independent of the resistance of the wire.

The experiment is repeated using a different type of resistance wire having a smaller resistivity but with the same thickness.

On the graph grid on page 13, sketch a second graph to represent the new results. Label it **Z**. [1]

(g) A second method is used to determine the diameter of the resistance wire.

Set up the multimeter as suggested in Fig. 3.2 such that it can be used to measure resistance. **Note that the model of your multimeter may differ from Fig. 3.2.**

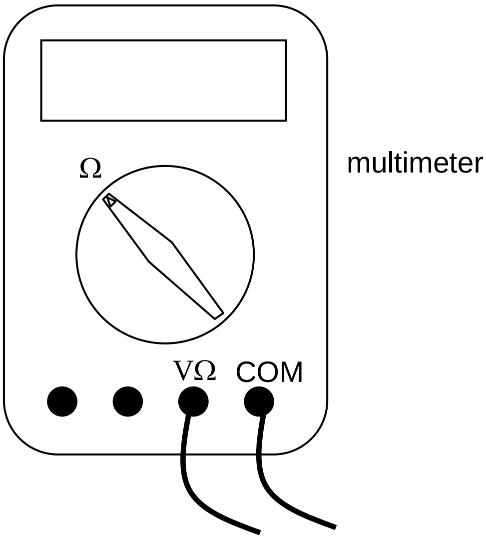

Fig. 3.2

(i) Disconnect the resistance wire from the power source.

Measure the resistance of a portion of the resistance wire and record the length x of this portion of the wire and its corresponding resistance *R'*.

x = ...

R' = ... [1]

(ii) Using $R' = \frac{\rho x}{A'}$, where *A'* is the cross-sectional area of the resistance wire, calculate the diameter d' of the resistance wire.

d' = ... [1]

[Total: 20 marks]

4 Shock absorption is one of the primary considerations when buying a tennis shoe. Shock absorption affects comfort and performance, and is a critical factor in injury prevention. The shock absorption properties of foams and rubbers used in a tennis shoe depends on several factors such as impact speed, force, angle and thickness.

The dynamic energy density x is one quantity used in the study of the shock absorption ability of materials and is defined as:

$$x = \frac{mgh}{t}$$

where g is the acceleration of free fall,
m is the mass of the incident body,
h is the initial height above the surface of the material the incident body is dropped from,
and t is the thickness of the shock absorbing material.

The maximum decelerating force y on the incident body is another quantity used in the study of the shock absorption ability of materials.

x and y are related by:

$$y = Ae^{Bx}$$

where A and B are constants and e is the natural exponential.

You are provided with rubber sheets of different thickness and a force sensor that is connected to a computer screen to give an output showing the variation of the decelerating force on the incident body with time. Fig. 4.1 shows a force sensor which is a very thin piece of circular metal that measures the force acting on its entire surface.

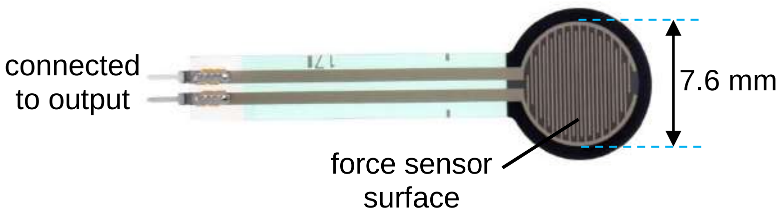

Fig. 4.1

Design an experiment to determine the shock absorption ability of rubber sheets of different thickness t and the values of A and B.

You should draw a diagram to show the arrangement of your apparatus and you should pay particular attention to

(a) the equipment you would use,
(b) the procedure to be followed,
(c) the placement of the force sensor,
(d) the control of variables,
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

....

[12]

End of Paper 4

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Paper 1 Answers

1	C	**6**	B	**11**	C	**16**	D	**21**	B	**26**	D
2	D	**7**	D	**12**	B	**17**	C	**22**	B	**27**	B
3	C	**8**	C	**13**	C	**18**	D	**23**	C	**28**	A
4	A	**9**	A	**14**	A	**19**	D	**24**	B	**29**	D
5	D	**10**	A	**15**	B	**20**	A	**25**	C	**30**	A

Paper 1 Suggested Solutions

1 **C**

$$m_{Liq} = m_{Total} - m_{Beaker} = 70 - 20 = 50 \text{ g}$$

$$\mathrm{V}m_{Liq} = \mathrm{V}m_{Total} + \mathrm{V}m_{Beaker} = 1 + 1 = 2 \text{ g}$$

$$\rho = \frac{m_{Liq}}{V_{Liq}}$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m_{Liq}}{m_{Liq}} + \frac{\Delta V_{Liq}}{V_{Liq}} = \frac{2}{50} + \frac{0.6}{10.0}$$

$$\Delta\rho = \left(\frac{2}{50} + \frac{0.6}{10.0}\right)(5.0) = 0.5 \text{ g cm}^{-3} \text{ (1 s.f.)}$$

2 **D** After first bounce,

$$KE_{left} = \left(1 - \frac{7}{16}\right)KE_{initial} = \frac{9}{16}KE_{initial} = \left(\frac{3}{4}\right)^2 \frac{1}{2}mv_0^2 = \frac{1}{2}m\left(\frac{3}{4}v_0\right)^2$$

where v_0 is the speed just before the ball hits the ground

If the height of the second triangle is now $\frac{3}{4}v_0$, time duration of the second triangle is $\frac{3}{4}t = 0.75t$ (due to similar triangles). Since air resistance is negligible, the time taken by the ball to move up after the first bounce is the same as the time taken to move down to the ground again.

OR

Since air resistance is negligible, the gradient of the velocity-time graphs will all be the same with the value of *g*.

$$\frac{v_0}{t} = g \quad \Rightarrow \quad v_0 = gt$$

$$KE_{left} = \left(1 - \frac{7}{16}\right)KE_{initial} = \frac{9}{16}KE_{initial} = \left(\frac{3}{4}\right)^2 \frac{1}{2}mv_0^2 = \frac{1}{2}m\left(\frac{3}{4}v_0\right)^2$$

speed after bounce, $v_1 = \frac{3}{4}v_0$

$$\mathrm{V}t = \frac{v_1}{g} = \left(\frac{3}{4}v_0\right)\left(\frac{1}{g}\right) = \left(\frac{3}{4}gt\right)\left(\frac{1}{g}\right) = \frac{3}{4}t = 0.75t$$

3 **C** Horizontal motion:

$$s_x = vt$$

$$t = \frac{s_x}{v} = \frac{4.0}{v}$$

Vertical motion:

$$s_y = \frac{1}{2}gt^2$$

$$1.5 - 1.1 = \frac{1}{2}g\left(\frac{4.0}{v}\right)^2$$

$$v = 14 \text{ m s}^{-1}$$

4 **A** This is a completely inelastic collision. Hence, total mechanical energy is **not** conserved.

5 **D** By Newton's second law,

$$\text{net force, } F - \frac{F}{5} = (m + 3m)a$$

$$a = \left(\frac{4}{5}F\right)\left(\frac{1}{4m}\right) = \frac{F}{5m}$$

Consider the forces acting on Y:

$$F_{XY} - \frac{F}{5} = 3m \times \frac{F}{5m}$$

$$F_{XY} = \left(3m \times \frac{F}{5m}\right) + \frac{F}{5} = \frac{4F}{5}$$

6 **B** There cannot be any normal reaction when the sphere is in equilibrium because it will be the only force with a horizontal component that is not balanced.

7 **D** Taking moments about the point on the base of the block through which R acts,

$$(5.0\cos 30°)x = (5.0\sin 30°)(10/2 \times 10^{-2}) + 1.0(8.0 \times 10^{-2})$$

$$x = 0.0473 \text{ m} = 4.7 \text{ cm}$$

8 **C** Work done to stretch it 10 cm:

$$\frac{1}{2}k(0.10)^2 = 4.0$$

$$k = 800 \text{ N m}^{-1}$$

Work done to stretch it 20 cm:

$$\frac{1}{2}(800)(0.20)^2 = 16$$

Additional work required = 16 – 4 = 12 J

9 **A** $T\cos 40° = mg$ --- (1)

$T\sin 40° = \dfrac{mv^2}{1.2\sin 40°}$ --- (2)

$\dfrac{(2)}{(1)}$ $\tan 40° = \dfrac{v^2}{g \times 1.2\sin 40°}$ $\Rightarrow$ $v = 2.5 \text{ m s}^{-1}$

10 **A** The equations for potential energy and kinetic energy are given by :

$E_p = -\dfrac{GMm}{R}$ and $E_k = \dfrac{GMm}{2R}$

As R increases, E_p increases (becomes less negative) and E_k decreases.

11 **C** For a body to escape a planet's gravitational influence from its surface:

$$-\frac{GMm}{R} + \frac{1}{2}mv^2 \geq 0 \Rightarrow v_{escape} = \sqrt{\frac{2GM}{R}}$$

and since $M = \dfrac{4}{3}\rho\pi R^3$

$$v_{escape} = \sqrt{\frac{2G\left(\frac{4}{3}\rho\pi R^3\right)}{R}} = \sqrt{\frac{8G\rho\pi R^2}{3}}$$

$$v_{escape} \propto R\sqrt{\rho}$$

$$\therefore \frac{v_{escape,X}}{v_{escape,Y}} = \frac{R_x\sqrt{\rho_x}}{R_Y\sqrt{\rho_Y}} = \frac{R_x}{R_y}\sqrt{\frac{\rho_x}{\rho_Y}} = \left(\frac{3}{1}\right)\sqrt{\left(\frac{9}{4}\right)} = \frac{9}{2} = 4.50$$

12 **B** The components of the particle's motion in the horizontal x-direction is simple harmonic. Hence $a \propto -x$.

13 **C** Between 2.0 s and 2.5 s, the block is in contact with the spring and its motion is simple harmonic i.e. the graph is ¼ of a cosine graph.

Period when block is in SHM = 4 × 0.5 s = 2.0 s

$\Rightarrow \omega = 2\pi/T = 3.14$ rad s^{-1}

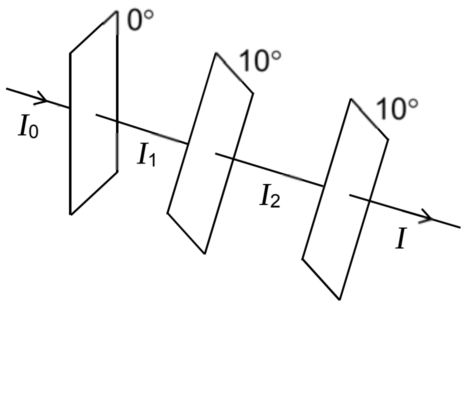
$x_o = v_o/\omega = 0.30/\pi = 0.095$ m

14 **A** Using Malus' law,

$I_2 = I_1\cos^2 10° = \dfrac{1}{2}I_0\cos^2 10°$

$I = I_2\cos^2\theta$

where θ is the angle between the axes of polarisation of the second and third filters



$I = I_2\cos^2\theta = \dfrac{1}{2}I_0\cos^2 10°\cos^2\theta$

$\dfrac{1}{3}I_0 = \dfrac{1}{2}I_0\cos^2 10°\cos^2\theta$

$\theta = \cos^{-1}\sqrt{\dfrac{2}{3\cos^2 10°}} = 33.99 = 34°$

15 **B**

distance travelled in 1 s = $10\times\frac{1}{2}\lambda$

time taken to travel $\frac{1}{2}\lambda=\frac{1}{10}$ s

distance = speed $\times$ time

$$\frac{1}{2}\lambda=2.0\times\frac{1}{10}$$

$$\lambda=2\left(2.0\times\frac{1}{10}\right)=0.40\text{ m}$$

At initial position M, detector detects maximum intensity (antinode).
Minimum intensity detected will be ¼ wavelength away (node).

$$\text{distance moved}=\frac{1}{4}\lambda=\frac{1}{4}(0.40)=0.10\text{ m}$$

16 **D**

$$\tan\left(\frac{0.40°}{2}\right)=\frac{1.5\times10^{-2}}{2D}$$

$$D=\frac{1.5\times10^{-2}}{2\tan\left(\frac{0.40°}{2}\right)}=2.1\text{ m}$$

$$a\sin\theta=2\lambda$$

$$a=\frac{2\left(600\times10^{-9}\right)}{\sin\left(\frac{0.40°}{2}\right)}=3.44\times10^{-4}=0.34\text{ mm}$$

OR

$$x=\frac{\lambda D}{a}$$

$$a=\frac{\lambda D}{x}=\frac{600\times10^{-9}\times2.1}{\left(1.5\times10^{-2}\right)/4}=0.34\text{ mm}$$

17 **C**

$$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$$

$$T_2=P_2V_2\left(\frac{T_1}{P_1V_1}\right)=(1.25P)(0.75V_1)\left(\frac{T_1}{P_1V_1}\right)=0.9375T_1$$

$$E_K=\frac{1}{2}mc^2=\frac{3}{2}kT$$

$$c^2\propto T\quad\Rightarrow\quad c\propto\sqrt{T}$$

$$c_2=\sqrt{\frac{T_2}{T_1}}c=\sqrt{\frac{0.9375T_1}{T_1}}c=0.97c$$

18 **D** For a fixed mass of gas in the pump and basketball,

$$\Delta U=W+Q$$

Compression implies $W > 0$. Well-insulated pump/basketball implies $Q\approx0$.
Hence, $\Delta U > 0$ (increases) and the temperature of the gas increases.

19 **D** Electric force acting on ion P is eE (in direction of the E field), and that acting on ion Q is also eE (but in the opposite direction to the E field).

Resultant force on the molecule is therefore zero.

$$\begin{aligned}\text{Torque of couple} &= Fd \\ &= qEd \\ &= \left(1.60\times10^{-19}\right)(4200)\left(0.12\times10^{-9}\right) \\ &= 8.1\times10^{-26}\ \text{Nm}\end{aligned}$$

20 **A** When oil drop is at equilibrium, $qE = mg$

$$q\frac{V}{d} = mg$$

When p.d. is 2V, net force $= q\dfrac{2V}{d} - mg$

$$\begin{aligned}&= 2mg - mg \\ &= mg \quad \text{(upwards)}\end{aligned}$$

Upward acceleration is thus g.

21 **B** $E = IVt = 2\times6\times10 = 120$ J

22 **B** Effective external resistance for max. power delivered = 5 Ω

$$\frac{1}{R}+\frac{1}{10}=\frac{1}{5}$$

$\therefore R = 10\ \Omega$

Potential difference across the 10 Ω resistor

$$=\frac{5}{10}(12) = 6\ \text{V}$$

$$P = \frac{V^2}{R} = \frac{6^2}{10} = 3.6\ \text{W}$$

23 **C** At d, the net field due to both wires is zero.
Hence the magnetic flux density of each wire is equal in magnitude and opposite in directions. This means I_X and I_Y are in opposite directions.

$$\begin{aligned}B_X &= B_Y \\ \frac{\mu_o I_X}{2\pi(L+d)} &= \frac{\mu_o I_Y}{2\pi d} \\ \frac{I_X}{I_Y} &= \frac{L+d}{d} = 4.00 \\ L &= 3d\end{aligned}$$

24 **B** Since both X and Y have the same mass to charge ratio,

$$\frac{KE_X}{KE_Y} = \left(\frac{v_X}{v_Y}\right)^2 = \left(\frac{R_X}{R_Y}\right)^2 = \left(\frac{1}{2}\right)^2 = 0.25$$

25 **C** Since $|E| = BLv = BL\frac{ds}{dt}$, the magnitude of E can be deduced from the gradient of the s-t graph.

26 **D** Resistance of heater $R = \frac{{V_{AC}}^2}{P} = \frac{110^2}{800} = 15.125\ \Omega$

Power dissipated when d.c. supply is used $= \frac{{V_{DC}}^2}{R} = \frac{156^2}{15.125} = 1609\ \text{W}$

27 **B** $\frac{hc}{\lambda} = E + \Phi$ and $\frac{hc}{\lambda'} = 2E + \Phi$

$\Rightarrow \quad \frac{\lambda'}{\lambda} = \frac{E + \Phi}{2E + \Phi}$

Since $\frac{1}{2} < \frac{E + \Phi}{2E + \Phi} < 1 \quad \Rightarrow \quad \lambda/2 < \lambda' < \lambda$

28 **A** Shortest wavelength

$\lambda_{\min} = \frac{hc}{eV}$

$\Rightarrow \quad \lg \lambda_{\min} = \lg\left(\frac{hc}{e}\right) - \lg V$

Graph of $\lg \lambda_{\min}$ against $\lg V$ is a straight line with negative gradient and positive intercept.

29 **D** The sample consists of the parent as well as the daughter nuclei.
β particles are electrons that have mass much smaller than that of the parent nuclei.
Hence the mass of the sample is only slightly smaller than its initial mass, differing only by the small mass of β particles emitted.

30 **A** energy released = (39.25) + (28.48) – (64.94) = 2.79 MeV
γ-ray energy = 2.79 – 2.31 = 0.48 MeV

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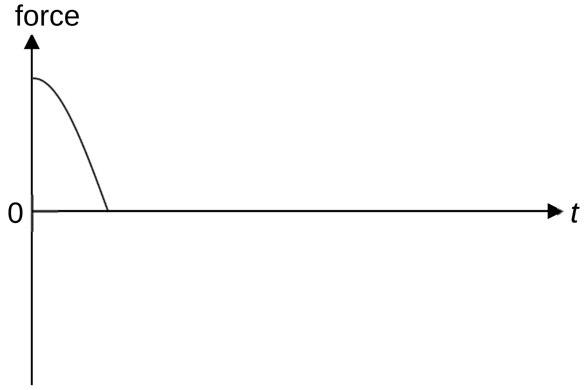
Paper 2 – Solutions

1 **(a)** **(i)** The rate of change of (total) momentum of a system of bodies is directly proportional to the resultant external force acting on the system and the direction of the change is in the direction of the force.

(ii) If the system is isolated from all external forces, then the resultant external force acting on it is zero. By Newton's second law, the total momentum of the system will not change, which means that it is conserved.

(b) **(i)**



One quarter of SHM sinusoidal function

(ii) By conservation of energy,

$$\frac{1}{2}m_Av_A^2+\frac{1}{2}m_Bv_B^2=\frac{1}{2}kx^2$$
$$0.100v_A^2+0.050v_B^2=80\times(0.060)^2=0.288$$
$$2v_A^2+v_B^2=5.76 \quad \text{----- (1)}$$

By conservation of momentum,

$$m_Av_A+m_Bv_B=0$$
$$v_B=-2v_A \quad \text{----- (2)}$$

Substitute (2) into (1),

$$2v_A^2+4v_A^2=5.76$$
$$v_A=0.98\text{ m s}^{-1}$$

Hence, $v_B=1.96\text{ m s}^{-1}$

(c) **(i)** Taking moments about O,

$$T\sin55^\circ\times0.15=(0.050\times9.81\times0.25)+(4.0\times0.20)$$
$$T=7.509=7.51\text{ N}$$

(ii) Resolving the forces horizontally,

$$F_x=T\cos55^\circ=7.509\times\cos55^\circ=4.307=4.31\text{ N}$$

Horizontal component is 4.31 N
(Direction is leftward.)

Resolving the forces vertically,

$F_y + T\sin 55^{\circ} = (0.050 \times 9.81) + 4.0$

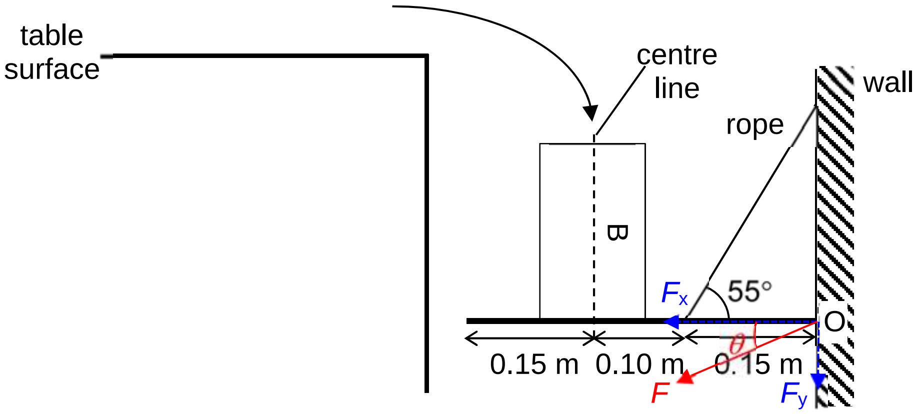
$F_y = (0.050 \times 9.81) + 4.0 - (7.509 \times \sin 55^{\circ}) = -1.661 = -1.66$ N

Vertical component is 1.66 N

(Direction is downward.)

(iii) $\tan\theta = \dfrac{F_y}{F_x} = \dfrac{1.661}{4.307}$

$\theta = 21.09^{\circ} = 21.1^{\circ}$



2 (a) (i) 1. 1 cycle

$T = 1.90$ ms

$f = \dfrac{1}{T} = \dfrac{1}{(1.90 \times 10^{-3})} = 526.3 = 526$ Hz

(Students are allowed to use one or more cycles.)

2. uncertainty in the time scale is the smallest division: 0.1 ms

If used one period in (a)(i)1., $\Delta T = 0.1$ ms

$\dfrac{\Delta f}{f} = \dfrac{\Delta T}{T}$

$\Delta f = \dfrac{\Delta T}{T} \times f$

$= \dfrac{0.1}{1.9} \times 526.3$

$= 27.7 = 30$ Hz (1 s.f.)

Absolute uncertainty given to 1 s.f.

OR

If used two periods in (a)(i)1., $2\Delta T = 0.1$ ms

$\Delta T = \dfrac{1}{2}(0.1) = 0.05$ ms

$$\frac{\Delta f}{f} = \frac{\Delta T}{T}$$
$$\Delta f = \frac{\Delta T}{T} \times f$$
$$= \frac{0.05}{1.90} \times 526.3$$
$$= 13.85 = 10 \text{ Hz (1 s.f.)}$$

Absolute uncertainty given to 1 s.f.

(ii)
$$\phi = \frac{\Delta t}{T} \times 2\pi$$
$$\frac{4}{5}\pi = \frac{\Delta t}{T} \times 2\pi$$
$$\Delta t = \left(\frac{4\pi}{5}\right)\left(\frac{T}{2\pi}\right) = \frac{2}{5}(1.90) = 0.76 \text{ ms}$$

$$1.50 + 0.76 = 2.26 \text{ ms}$$

(iii)
$$I = \frac{P}{4\pi r^2} \quad \Rightarrow \quad I \propto \frac{P}{r^2}$$
$$\frac{I_1}{I} = \frac{P_1}{r_1^2} \times \frac{r^2}{P}$$
for $I_1 = I$
$$r_1^2 = \frac{P_1}{P} r^2$$
$$r_1 = \sqrt{\frac{0.25P}{P}} r = \sqrt{0.25}(120) = 60 \text{ cm}$$

(b) (i) All the particles in a progressive wave oscillate with the same amplitude.
The particles in a stationary wave oscillate with amplitudes that range from zero at the nodes to a maximum at the antinodes.

(ii) All the particles within a wavelength of a progressive wave have different phases.
All the particles between two adjacent nodes of a stationary wave have the same phase. Particles in adjacent segments have a phase difference of π radians.

3 (a) (i) At equilibrium, pressures in both chambers are the same.

Using $pV = nRT$
$$\frac{n_X R T_X}{V_X} = \frac{n_Y R T_Y}{V_Y}$$
$$n_X = n_Y \frac{T_Y}{T_X} \frac{V_X}{V_Y} = (1.2)\left(\frac{300}{450}\right)\left(\frac{2.5}{4.0}\right)$$
$$= 0.50 \text{ mol}$$

(ii)
$$p = \frac{nRT}{V}$$
$$p_X = \frac{1.2 \times 8.31 \times 300}{4.0} \quad \text{OR} \quad p_Y = \frac{0.50 \times 8.31 \times 450}{2.5}$$

$p_X = p_Y = 747.9 = 750$ Pa

(iii) With some gas removed, there are <u>fewer gas molecules</u> in Y which results in a <u>smaller overall rate of change of momentum</u> of molecules as they collide with the walls of the chamber. Hence the <u>average force</u> on the walls <u>decreases</u> which implies gas pressure is reduced.

(b) **(i)** Since process A to B is isothermal $\therefore$ $T_A = T_B$

$\therefore\ p_A V_A = p_B V_B$

$$p_A = \frac{(2.9\times10^5)(0.015)}{0.040}$$
$$= 1.09\times10^5 = 1.1\times10^5 \text{ Pa}$$

(ii) Using $p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$

$$\langle c^2\rangle = \frac{3pV}{Nm} = \frac{3(1.09\times10^5)(0.040)}{0.060}$$
$$c_{rms} = \sqrt{\langle c^2\rangle} = 466.9 = 470 \text{ m s}^{-1}$$

(iii)
$$\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}\Delta(pV)$$
$$\Delta U = \frac{3}{2}(p_C V_C - p_B V_B)$$
$$= \frac{3}{2}\left[0.015(5.2\times10^5 - 2.9\times10^5)\right]$$
$$= 5175 = 5200 \text{ J}$$

Using the First Law of Thermodynamics,

$\nabla U = W + Q = 0 + Q$

$Q = 5200$ J

(iv) By ensuring that the process from C to A takes place <u>rapidly</u> such that there is <u>insufficient time for any heat transfer</u> to take place between the system and its surroundings.

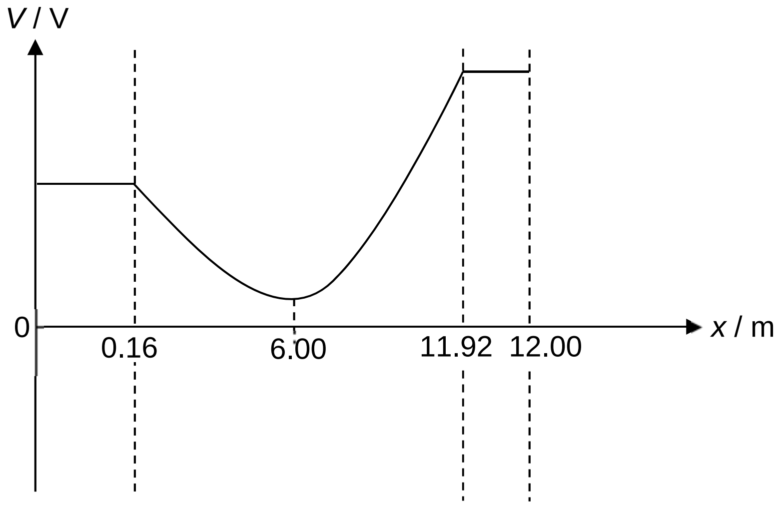
4 **(a)** Electric field strength is numerically equal to the potential gradient at that point.
OR
Electric field strength is the negative of the potential gradient.

(b) **(i)** 6.0 m

(ii)

$$\frac{Q}{4\pi\varepsilon_0 r}\times 2=\frac{7.2\times10^{-9}}{4\pi\times8.85\times10^{-12}\times6.0}\times2$$
$$=21.6=22\text{ V}$$

(iii)



(iv) **1.** No it will not reach the surface of Q.
It does not have sufficient kinetic energy to reach Q, as the electric potential at the surface of Q is higher than the electric potential at the surface of P.

2. Being positively charged, it will be repelled by sphere P's electric field and moves with increasing kinetic energy as the electric potential decreases towards *x* = 6.0 m / mid-point.
After passing *x* = 0.60 m, it moves towards sphere Q with decreasing kinetic energy as the electric potential increases, but it does not have sufficient energy to reach Q.
Its kinetic energy drops to zero somewhere before 11.92 m and it returns to sphere P with its kinetic energy increasing towards *x* = 0.60 m then decreasing after *x* = 0.60 m, and the cycle repeats again.

OR

Being positively charged, it will be repelled by sphere P's electric field and accelerates towards the point *x* = 0.60 m as the resultant electric field is in the positive *x*-direction, as shown by the negative of the potential gradient.
After passing *x* = 0.60 m, it decelerates towards sphere Q as the resultant electric field direction is in the negative *x*-direction, and its velocity reaches zero before reaching Q.
It will then return to sphere P, accelerating towards *x* = 0.60 m, then decelerating after the mid-point, and the cycle repeats again.

5 **(a)** **(i)** Resistance of a conductor is defined as the <u>ratio</u> of the potential difference across it to the current flowing through it i.e. $R = \frac{V}{I}$

Resistivity is the <u>constant of proportionality</u> for the relationship between a conductor's resistance and its length and cross-sectional area i.e. $R = \rho \frac{l}{A}$

OR

Resistance of a conductor is <u>dependent on the length and cross-sectional area</u> (i.e. $R = \rho \frac{l}{A}$) of the conductor whereas resistivity is a <u>characteristic of the conductor's material</u> which is independent of length and cross-sectional area.

(ii)

$$R = \frac{\rho L}{A}$$
$$L = \frac{RA}{\rho}$$
$$= \frac{(2.0)\left[\pi\left(1.0\times10^{-3}/2\right)^2\right]}{1.5\times10^{-6}}$$
$$= 1.047 = 1.0 \text{ m}$$

(b) **(i)**

$$V = RI$$
$$I = \frac{V}{R}$$
$$= \frac{6.0}{2.0+4.0}$$
$$= 1.0 \text{ A}$$

(ii) number density of conduction electrons,

$$n = \frac{\text{no. of mol}\times N_A}{\text{volume}}$$
$$= \frac{\text{density}}{\text{molar mass}}\times N_A$$
$$= \frac{8.96\times10^3}{0.064}\times\left(6.02\times10^{23}\right)$$
$$= 8.428\times10^{28} = 8.4\times10^{28} \text{ m}^{-3}$$

$$I = nAv_dq$$
$$v_d = \frac{I}{nAq}$$
$$= \frac{1.0}{\left(8.43\times10^{28}\right)\left[\pi(1.0\times10^{-3}/2)^2\right]\left(1.60\times10^{-19}\right)}$$
$$= 9.440\times10^{-5} = 9.4\times10^{-5} \text{ ms}^{-1}$$

(iii)
$$t = \frac{d}{v_d}$$
$$= \frac{0.20}{9.44 \times 10^{-5}}$$
$$= 2.119 \times 10^3 = 2.1 \times 10^3 \text{ s}$$

(iv) When the switch is closed, the electric field is established in the circuit almost instantaneously.
Hence, all free electrons including those in the lamp filament present in the circuit will start to drift at the same time.

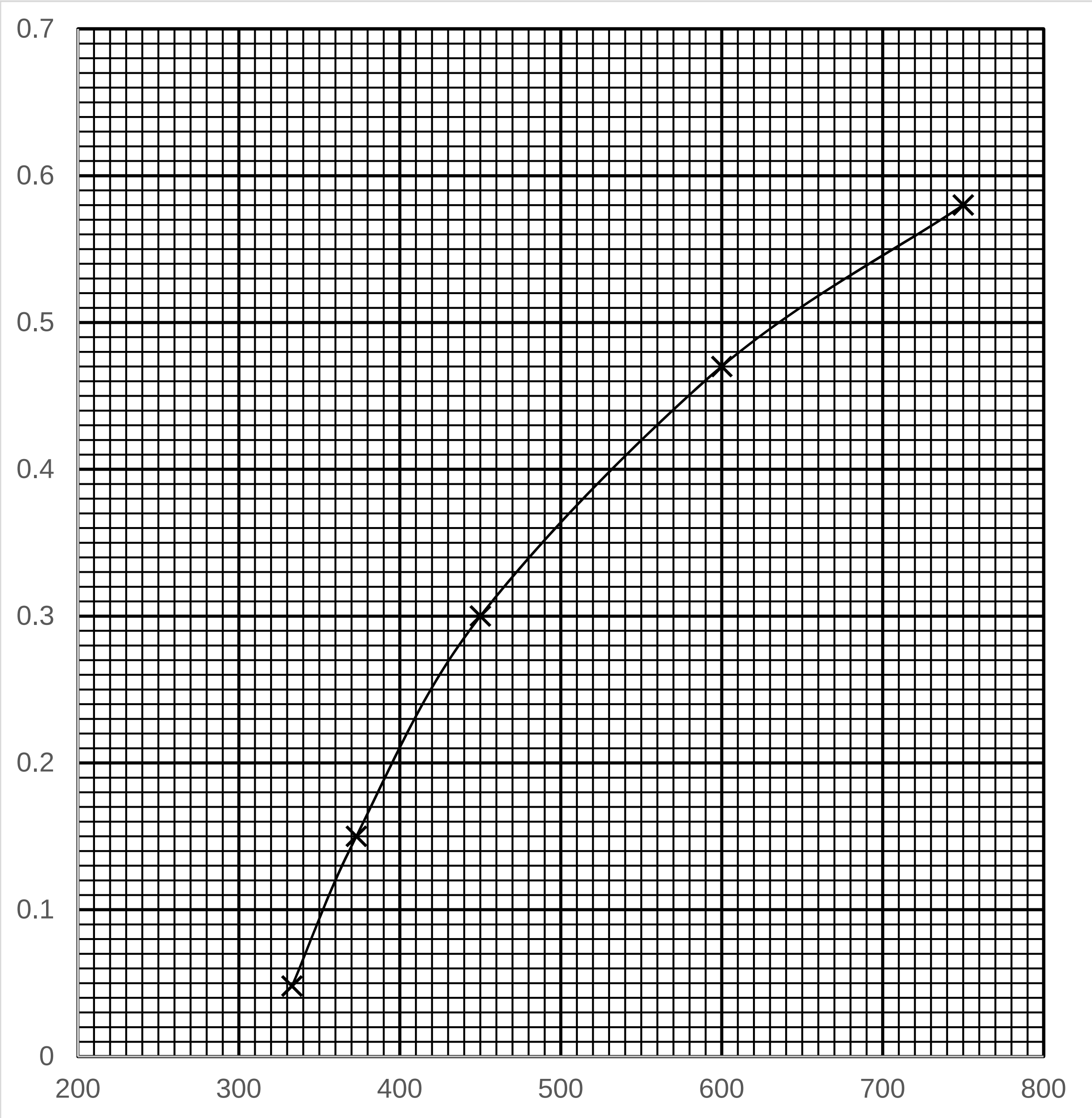
(c) **(i)**
$$L_{XJ} = \frac{V_{XJ}}{V_{XY}} L_{XY}$$
$$= \frac{3.0}{6.0}(1.0)$$
$$= 0.50 \text{ m}$$

(ii)
$$L_{XJ} = \frac{V_{XJ}}{V_{XY}} L_{XY}$$
$$= \left(\frac{\frac{1.0}{1.0+0.5}(3.0)}{6.0} \right)(1.0)$$
$$= 0.333 = 0.30 \text{ m}$$

6 **(a)**

$$e_{max} = \frac{373-300}{373}$$
$$= 0.196$$

(b) **(i)**



(ii) 320 K

(iii)

$$e_{max} = \frac{T_2 - T_1}{T_2} = 1 - \frac{T_1}{T_2}$$

When $e_{max} = 0$,

$$1 - \frac{T_1}{T_2} = 0$$

$$T_1 = T_2 = 320 \text{ K}$$

(iv) To obtain ideal efficiency close to 1, either T_2 would have to be very high or T_1 would have to be very low.
The components of the heat engine may not be able to withstand the high temperature.
At very low temperatures, water used in the cooling system may freeze.

(c) **(i)** $0.52 = \frac{T_2 - 330}{T_2}$

$T_2 = 688$ K

(ii) $0.31 = \frac{200}{\text{rate of thermal energy input}}$

rate of thermal energy input $= 6.45 \times 10^8$ W

(iii) Rate of thermal energy output

$= (6.45 - 2.00) \times 10^8$

$= 4.45 \times 10^8$ W

Alternative:

$= 0.69 \times (6.45 \times 10^8)$

$= 4.45 \times 10^8$ W

(iv) $4.45 \times 10^8 = \frac{m}{t} c\Delta T$

$\frac{m}{t} = \frac{4.45 \times 10^8}{(4200)(291 - 283)}$

$= 13200$ kg s^{-1}

(d) There could be energy lost due to friction between moving parts of the turbine **or** heat loss to the surroundings.

(e) The efficiency of the turbine is low (31% from from Fig. 6.2). Burning fossil fuel at home may be more efficient. However, there will be a lot of harmful emissions which would not be contained.
There is a large percentage of thermal energy (69%) which would be used in cogeneration plants. This energy would otherwise be wasted.

(f) **(i)** Solar power.
Singapore is situated at the equator and receives sunshine almost all year round.

OR Singapore receives more solar radiation than temperate countries.

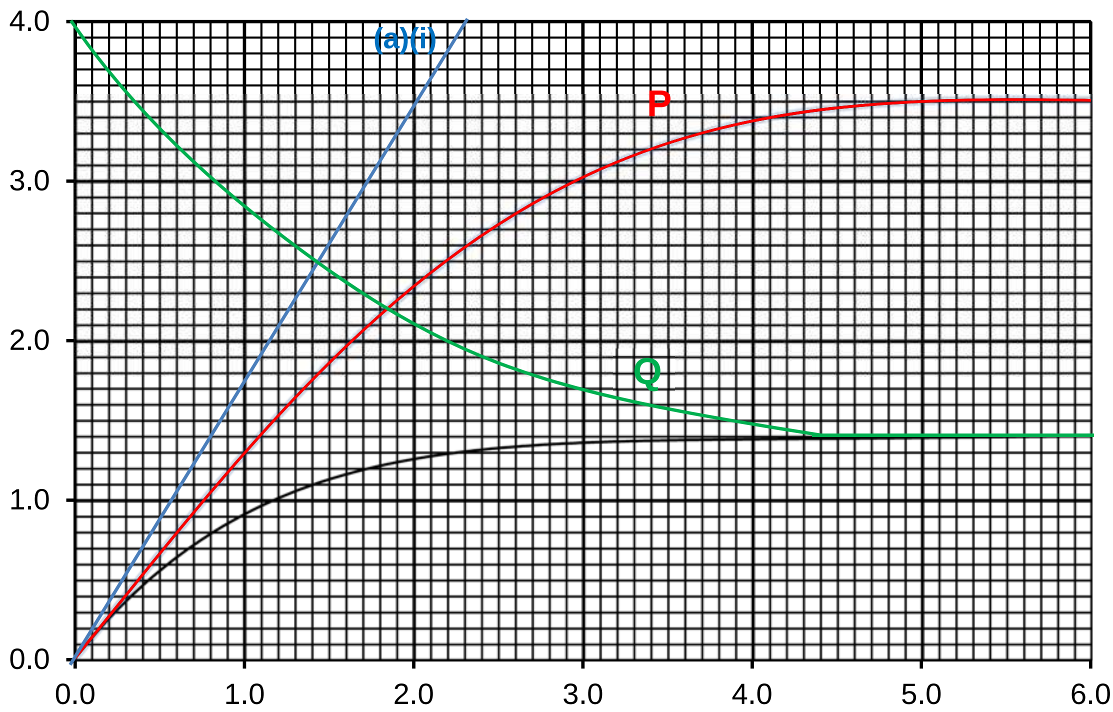
(ii) Singapore's small physical size, high population density and land scarcity limit the amount of available space to install solar panels.
OR
The output of a solar cell is variable and dependent on weather conditions compared with a conventional generator that produces a stable output. As such, output from solar cell is largely dependent on environmental factors and weather conditions such as the amount of sunlight, cloud cover and shadow. This can result in imbalances between supply and demand.

2018 Raffles Institution Preliminary Examinations – H2 Physics

Paper 3 – Solutions

Section A

1



(a) **(i)** (The graph is a curve. This implies there is non-constant acceleration due to effect of air resistance. Only at t = 0 is the acceleration equal to g)

Draw tangent at t = 0

acceleration = gradient $= \dfrac{4.00}{2.30} = 1.74 \text{ m s}^{-2}$

(ii) The Moon's surface has no atmosphere (very negligible compared to Earth). There is no air resistance outside the container.

Read off from tangent (as this is the v-t graph for no air resistance):
v = 1.4 m s^{-1}, t = <u>0.80 s</u>

or use equation: $v = u + at$
(substitute value of a from (a)(i), v = 1.4, u = 0)

(b) **(i)** At terminal velocity, resistive force F reaches its maximum value.

$$F_{max} = mg$$
$$= 0.0027(1.74)$$
$$= 4.70 \times 10^{-3} \text{ N}$$

(ii) $kv_T = mg$ (v_T is terminal velocity on Moon)

$$k(1.40) = 4.70 \times 10^{-3}$$
$$k = 3.36 \times 10^{-3} \text{ kg s}^{-1}$$

(iii) $kv'_T = mg$ (v'_T is terminal velocity on Earth)

$$3.36\times10^{-3}v'_T = 0.0027(9.81)$$

$$v'_T = 7.89 \text{ m s}^{-1}$$

(iv) **1.** Total mass is 2.5 x initial mass.

$kv_T = mg$

$$v_T = \frac{mg}{k} = \frac{2.5(4.70\times10^{-3})}{3.36\times10^{-3}} = 3.50 \text{ m s}^{-1}$$

Initial gradient is the same, and graph always above the original (but below the tangent) – B1

Curve reaches terminal velocity 3.5 m s^{-1} – B1

(time it reaches terminal velocity is later – not marking pt)

2. Starts from 4.0 m s^{-1}

Curve must show speed decreasing to v_T – B1

2 **(a)** **(i)** The gravitational field strength at a point in space is defined as the gravitational force experienced per unit mass at that point.

(ii) Gravitational field strength is a vector since it is defined using gravitational force which is a vector.

(iii) Newton's law of gravitation states that two point masses attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Since gravitational field strength g is defined as the gravitational force acting per unit mass:

$$g = \frac{F_G}{m} = \frac{GMm}{r^2 m} = \frac{GM}{r^2}$$

(b) **(i)**

$$\frac{g_{\text{Sun}}}{g_{\text{Jupiter}}} = \frac{\left(\frac{GM_{Sun}}{r_{sun}^{2}}\right)}{\left(\frac{GM_{Jupiter}}{r_{Jupiter}^{2}}\right)} = \frac{M_{Sun}}{M_{Jupiter}}\left(\frac{r_{Jupiter}}{r_{Sun}}\right)^2$$

$$= \left(\frac{1.99\times10^{30}}{1.90\times10^{27}}\right)\left(\frac{7.14\times10^{7}}{7.79\times10^{11}}\right)^2$$

$$= 8.80\times10^{-6}$$

(ii) Since the gravitation field strength due to the Sun on the surface of Jupiter is only ~10^{-6} (< 0.001%) that of the gravitational field strength on the surface of Jupiter due to its mass, it can be neglected.

(c) **(i)** For a moon in circular orbit about its planet, the centripetal force is provided by the gravitational force acting on the moon by the planet:

$$\frac{GM_pM_m}{R^2} = M_mR\omega^2$$

Since $T = \dfrac{2\pi}{\omega}$, *we have* $\omega = \dfrac{2\pi}{T}$

$$GM_p = R^3\omega^2 = R^3\left(\frac{2\pi}{T}\right)^2$$

Rearranging, we have:

$$T^2 = \frac{4\pi^2}{GM_p}R^3$$

Since M_p *is the mass of the planet,* $\dfrac{4\pi^2}{GM_p}$ *is a constant*

$$\therefore\ T^2 = KR^3 \text{ where } K = \frac{4\pi^2}{GM_p}$$

(ii) Since $T^2 \propto R^3$

$$\frac{T_E}{T_I} = \sqrt{\left(\frac{R_E}{R_I}\right)^3} = \sqrt{\left(\frac{R_E}{R_I}\right)^3} = \sqrt{\left(\frac{6.71\times10^8}{4.22\times10^9}\right)^3} = 2.01 \approx 2$$

$$\frac{T_G}{T_I} = \sqrt{\left(\frac{R_G}{R_I}\right)^3} = \sqrt{\left(\frac{R_G}{R_I}\right)^3} = \sqrt{\left(\frac{1.07\times10^9}{4.22\times10^8}\right)^3} = 4.04 \approx 4$$

Hence, the ratio of the orbital period of Io: Europa: Ganymede is 1: 2: 4

3 **(a)** Since the test-tube is in equilibrium, $F_{net} = (M+m)g - \rho(AH)g = 0$

$$(M+m)g = \rho(AH)g$$

$$H = \frac{(M+m)}{\rho A}$$

(b) **(i)** $-\rho Agy$

(ii) $-\rho Agy = (M+m)a$

$$a = -\frac{\rho Ag}{M+m}y$$

(c) By comparing with $a = -\omega^2 x$,

$$\omega^2 = \frac{\rho Ag}{M+m}$$

$$T = \frac{2\pi}{\omega}$$

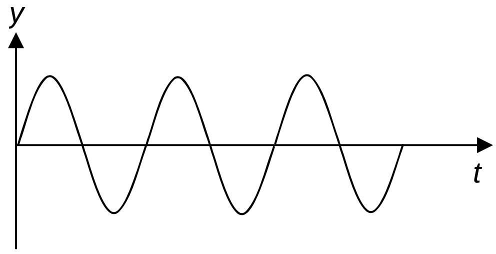
$$= 2\pi\sqrt{\frac{M+m}{\rho Ag}}$$

$$= 2\pi\sqrt{\frac{0.012+0.025}{1000\times6.0\times10^{-4}\times9.81}}$$

$$= 0.498 \approx 0.50 \text{ s}$$

(d) As the test-tube oscillates, it experiences drag force exerted by the water . This results in light damping and energy is gradually lost as heat.

(e) **(i)**



(ii) The amplitude of oscillation is small because the frequency of the driving force (the waves) is too low (0.30 Hz) compared to the natural frequency of the test-tube (2 Hz).

The amplitude of the oscillations can be increased by adding ball bearings to the test-tube to decrease the natural frequency so that it is closer to the frequency of the driving force.

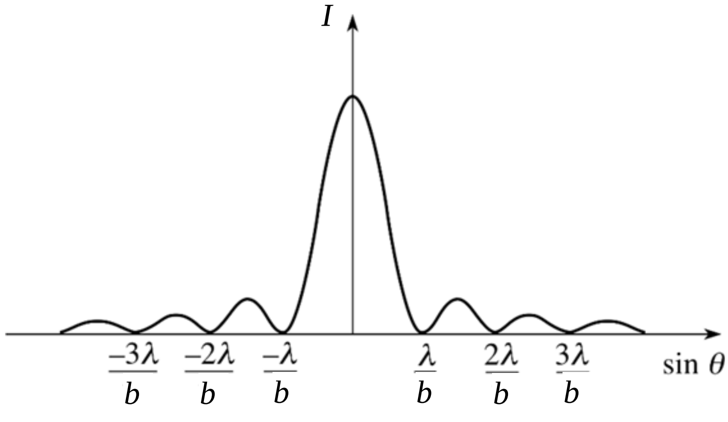
4 **(a)** **(i)** The principle of superposition states that when two or more waves of the same kind meet at a point in space, the resultant displacement at that point is equal to the vector sum of the displacements of the individual waves at that point.

(ii) According to Huygen's principle, all the points on the wavefronts that pass through the single slit are individual sources of circular wavelets which interfere with one another by the principle of superposition to form the interference pattern.

(b) **(i)** For single slit diffraction, $b\sin\theta = m\lambda$

Positions of minima, $\sin\theta = \dfrac{\lambda}{b}m = \dfrac{600\times10^{-9}}{0.30\times10^{-3}}m = \left(2.0\times10^{-3}\right)m$

where $\dfrac{\lambda}{b} = 2.0\times10^{-3}$



(ii) limiting angle of resolution for the single slit, $\theta_{min} \approx \dfrac{\lambda}{b} = 2.0\times10^{-3}$ rad

$\theta \approx \dfrac{s}{r} = \dfrac{1.0\times10^{-3}}{0.25} = 4.0\times10^{-3}$ rad

Since $\theta > \theta_{min}$, the interference patterns due to the two point sources of light can be resolved.

(c) (i) Position of first minima of the single slit diffraction envelope is given by:
$b\sin\theta = \lambda$ ----- (1)
where *b* is the slit width

Positions of maxima of the double slit interference pattern is given by:
$a\sin\theta = n\lambda$ ----- (2)
where *a* is the slit separation

Where the first minima of the single slit diffraction envelope coincide with a double slit maxima, θ is the same in equations (1) and (2).

$\frac{(2)}{(1)}$: $n = \frac{a}{b} = \frac{1.2}{0.30} = 4$
Hence the 4th orders will be missing from the double slit interference pattern.

Number of maxima in the central region / within the diffraction envelope
= 3 + 3 + 1 = 7
(3 maxima on either side of the principle axis and the central maximum)

(ii)

$$\tan\theta = \frac{12\times10^{-3}}{2}\times\frac{1}{D}$$

$$D \approx \frac{12\times10^{-3}}{2\theta}$$

$$= \frac{12\times10^{-3}}{2\left(2.0\times10^{-3}\right)}$$

$$= 3.0 \text{ m}$$

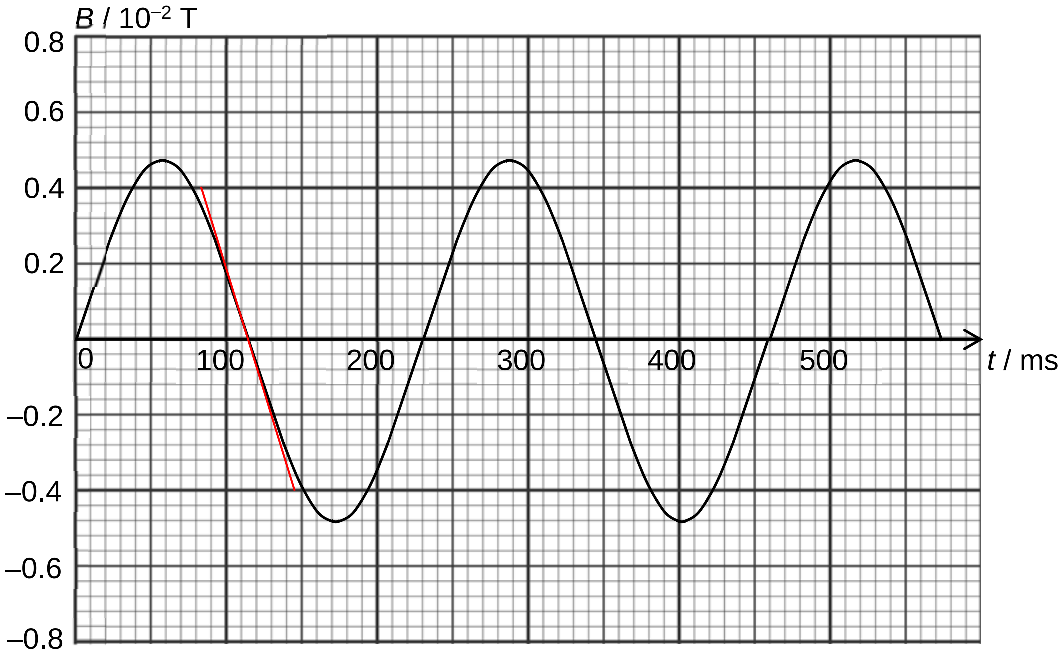
5 **(a)** Faraday's law of electromagnetic induction states that the induced e.m.f. is proportional to the rate of change of magnetic flux linkage.

(b) **(i)** When magnetic field increases in the positive direction, induced current decreases in the negative direction. When magnetic field reaches maximum, induced current becomes zero. As magnetic field decreases in the positive direction, induced current increases in the positive direction until it reaches a minimum value when B = 0.

This corresponds to Lenz's law as induced current flows in a direction to produce effects that opposes the change producing it. Hence sensitive ammeter deflects in opposite directions.

(ii) **1.** Accept t = 115, 230, 345 or 450 $\times 10^{-3}$ s

2.



Using (85×10^{-3}, 0.40×10^{-2}) and (145×10^{-3}, -0.40×10^{-2}),

$$\left|\frac{dB}{dt}\right|_{max} = \frac{\left(-0.40\times10^{-2} - \left(-0.40\times10^{-2}\right)\right)}{\left(145\times10^{-3} - 85\times10^{-3}\right)} = 0.1333$$

$$i_{max} = \frac{E_{max}}{R} = \frac{AN}{R}\left|\frac{dB}{dt}\right|_{max} = \frac{4.2\times10^{-4}\times400\times0.1333}{5.0}$$

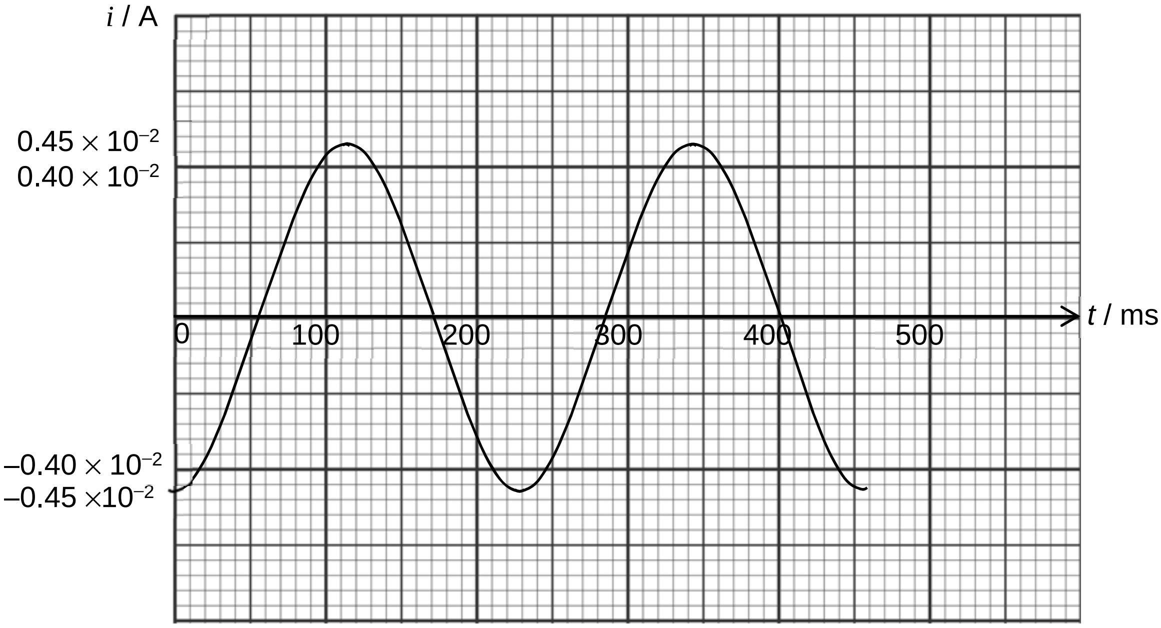
$$\therefore i_{max} = 4.5\times10^{-3}\text{ A}$$

3.

$$\langle P\rangle = \frac{P_o}{2} = \frac{i_{max}^2 R}{2} = \frac{\left(4.479\times10^{-3}\right)^2\times5.0}{2}$$

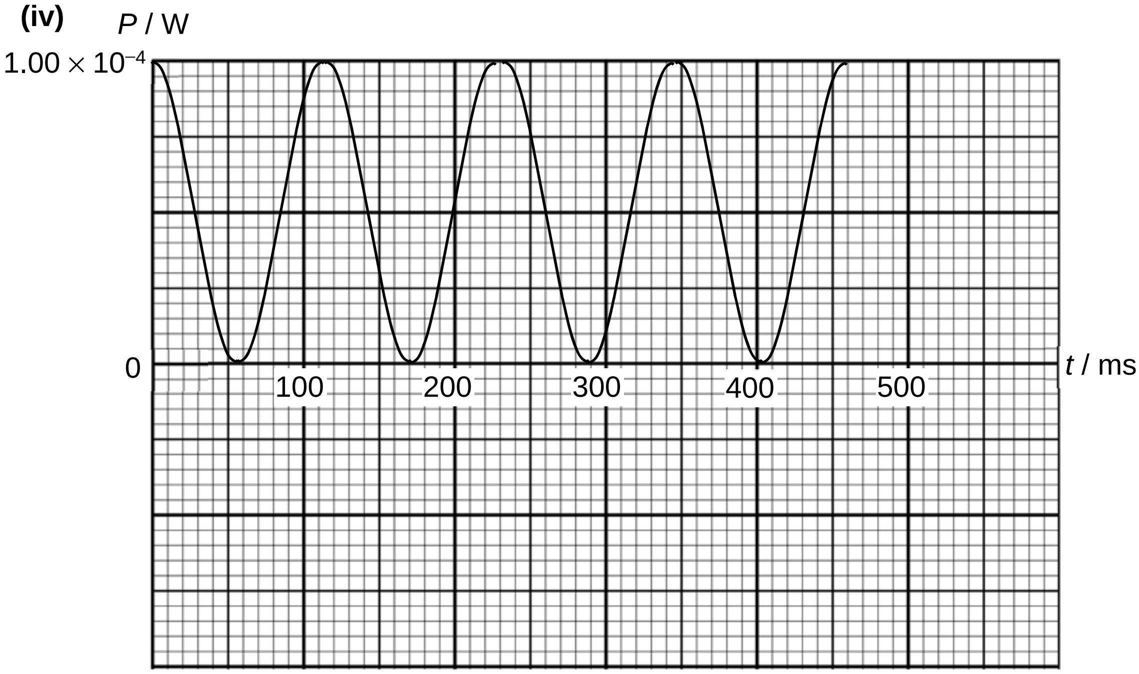
$$\therefore \langle P\rangle = 5.0\times10^{-5}\text{ W}$$

(iii)



i / A
0.45 × 10⁻²
0.40 × 10⁻²
–0.40 × 10⁻²
–0.45 × 10⁻²
0
100
200
300
400
500
t / ms

(iv)

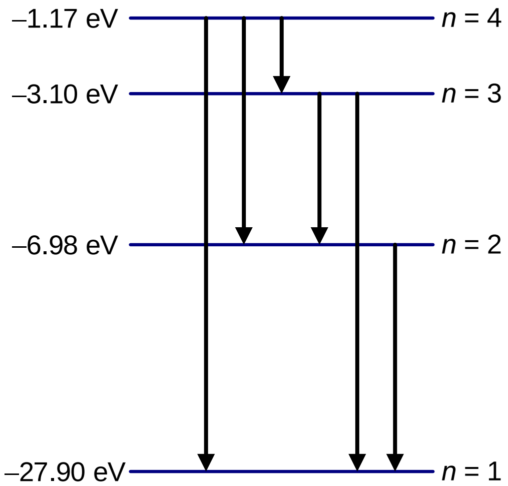


P / W
1.00 × 10⁻⁴
0
100
200
300
400
500
t / ms

Section B

6 (a) (i)

n	E_n / eV
1	–27.90
2	–6.975
3	–3.100
4	–1.744



(ii)

n	ΔE / eV
$1 \rightarrow 2$	20.92
$1 \rightarrow 3$	24.80
$1 \rightarrow 4$	26.16
$1 \rightarrow 5$	26.78

(iii) Refer to diagram above.

(iv) To calculate wavelength, we use

$$\Delta E = \frac{hc}{\lambda} \quad \Rightarrow \quad \lambda = \frac{hc}{\Delta E}$$

Longest wavelength

$$\lambda = \frac{hc}{\Delta E_{4\rightarrow 3}} = \frac{6.63\times10^{-34}\times3.00\times10^{8}}{1.36\times1.60\times10^{-19}} = 914 \text{ nm}$$

Shortest wavelength

$$\lambda = \frac{hc}{\Delta E_{4\rightarrow 1}} = \frac{6.63\times10^{-34}\times3.00\times10^{8}}{26.16\times1.60\times10^{-19}} = 47.5 \text{ nm}$$

(b) (i) Bombarding electrons experience (rapid) deceleration when they are deflected by or collide/interact with the nuclei/atoms in the target metal.
During each of these interactions, an electron loses a fraction of its K.E. and emit a photon with energy equals the loss in K.E.
Since an electron can loses varying amount of its K.E. (due to different degree of deceleration), emitted X-ray photons will have a continuous range of energy up to the entire K.E. of the bombarding electrons. Hence the continuous spectrum W.
The most energetic X-ray photon with the minimum wavelength has energy equals to K.E. of bombarding electron.

(ii) Maximum energy of electron is equal to energy of photon with shortest wavelength.

$$E_{\max} = \frac{hc}{\lambda_{\min}}$$

Accelerating potential

$$V = \frac{hc}{e\lambda_{\min}} = \frac{6.63\times10^{-34}\times3.00\times10^{8}}{1.60\times10^{-19}\times2.00\times10^{-10}}$$

$$= 6220 \text{ V}$$

(iii) L_α = Y
L_β = X
M_α = Z

(iv) The energy of the bombarding electron is insufficient to knock out an electron from the K-shell of the atom.

7 **(a)** (total count rate $C = C_x + C_y$)
As half-life of X is much longer than Y, after about 8 days, the activity (or count-rate) of Y becomes negligible, hence the total count rate is only given by X.
($C \approx C_x$)

As the count rate of X obeys the exponential decay law

$$C_X = C_{X_0} e^{-\lambda_X t}$$

$$\ln C_X = \ln C_{X_0} - \lambda_X t$$

A graph of ln C_X against t is a straight line (with gradient $-\lambda_X$ and vertical intercept $\ln C_{X_0}$).

(b) **(i)** Extrapolate the straight line portion to find y–intercept, to get the initial count rate of X.

Value of y–intercept = 5.4

$$\ln C_{X_0} = 5.4$$

$$C_{X_0} = e^{5.4}$$

$$= 221 = 220 \text{ counts per minuite (2 or 3 s.f.)}$$

Slope of the straight line = – λ_X = (3.90 – 4.50) / (14.0 – 8.0) = – 0.10 day^{-1}

OR

Taking coordinates of the extrapolated line
Slope of the straight line = – λ_X = (3.90 – 5.40) / (14.0 – 0) = – 0.11 day^{-1}

$$t_{1/2} = \frac{\ln 2}{\lambda_X} = \frac{\ln 2}{0.11}$$

$$= 6.3 \text{ days (or 6.9 days)}$$

(ii) After 19 days, the count rate is nearly all due to X.

$$C_X = C_{X_0} e^{-\lambda t}$$
$$= 220\, e^{-0.11(19)}$$
$$= 27 \text{ counts per minute}$$

(c) **(i)** The range of beta particles through the human body is short.
OR
The penetrative power of beta particles is weak.

(ii) The gamma rays are emitted in all directions (and the detector is small and only measures the rays at a point).

(iii)
- The physical state of the source (solid, liquid, or in solution) as it affects the way the source is administrated into the body.
- The nuclide used should decay to a stable product (so that it no longer emits radioactive substance longer than it should).
- If the nuclide is introduced to the human body, it must be able to be removed naturally e.g. in urine, exhaled or excreted.
- The source should not be carcinogenic or toxic.

(d) Background count = 15 s^{-1}
Corrected initial count-rate (due to Y alone) = 100 – 15 = 85 s^{-1}

Count-rate after 3 $t_{1/2}$ is $85 \times \left(\frac{1}{2}\right)^3 = 10.625$ s^{-1}

Assuming emission is in all direction hence count-rate $\propto 1/r^2$

$$\frac{C_2}{C_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$\frac{85}{10.625} = \left(\frac{30}{r}\right)^2$$

$$r = 10.6 \text{ cm}$$

Note:
The correct answer can also be obtained even if background is not accounted for :

$$C_2 = C_1 \times \left(\frac{1}{2}\right)^3 = \frac{C_1}{8}$$

Hence

$$\frac{C_2}{C_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$\frac{C_1 / 8}{C_1} = \left(\frac{30}{r}\right)^2$$

$$\frac{1}{8} = \left(\frac{30}{r}\right)^2$$

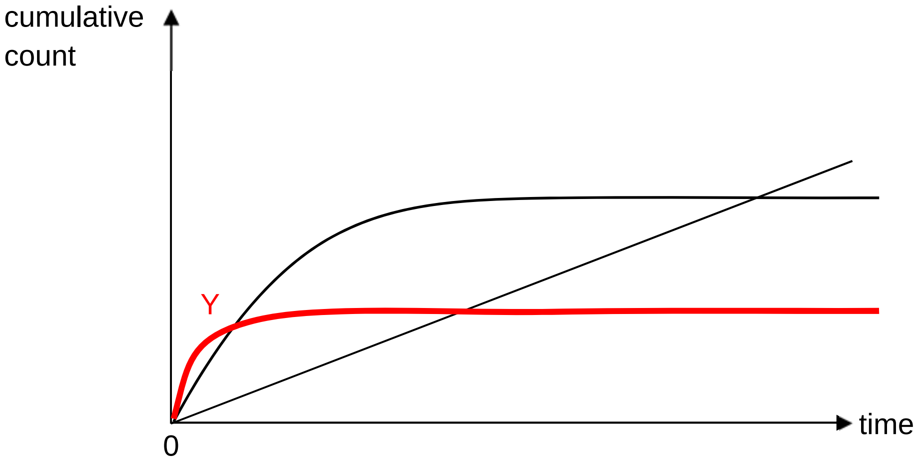
$$r = 10.6 \text{ cm}$$

which is independent of what C_1 is (whether background is considered or not).

This is unique in this context. Students should still be aware that in general, background count needs to be subtracted when accounting for radioactivity of the nuclides.

(e) **(i)** Graph B
Since count rate (of background) is constant, the total count increases at a constant rate.

(ii)



*Initial increase is greater than X, reaches plateau sooner than X. Lower final total count.

The following workings are for infor only:

X's half-life = 6.9 days
Y's half-life = 20 hours

$$A_0 = \frac{\ln 2}{t_{1/2}} N_0$$

For X: $A_0 = \frac{\ln 2}{6.9 \times 24} N_0 = 0.004 N_0$

For Y: $A_0 = \frac{\ln 2}{20} \frac{N_0}{2} = 0.017 N_0$

$$A = -\frac{dN}{dt}$$

Graph is equivalent to ($N_0 - N$) against time.
Hence gradient of graph is proportional to A.
Since initial activity of Y > X, hence initial gradient of Y > X

(a) (ii) Measure and record the height r from the centre line of the magnet to wire **W**.

2.0 cm
1.9 cm
Average = 2.0 cm

r = 2.0 cm [1]

(b) (ii) Record the current I through the wire.

I = 1.15 A [1]

(iii) Measure and record the acute angle of deflection θ of the pointer from the 0° mark of the paper–protractor.

9°
10°
Average = 10°

θ = 10° [1]

(iv) Determine the value of B_H in tesla.

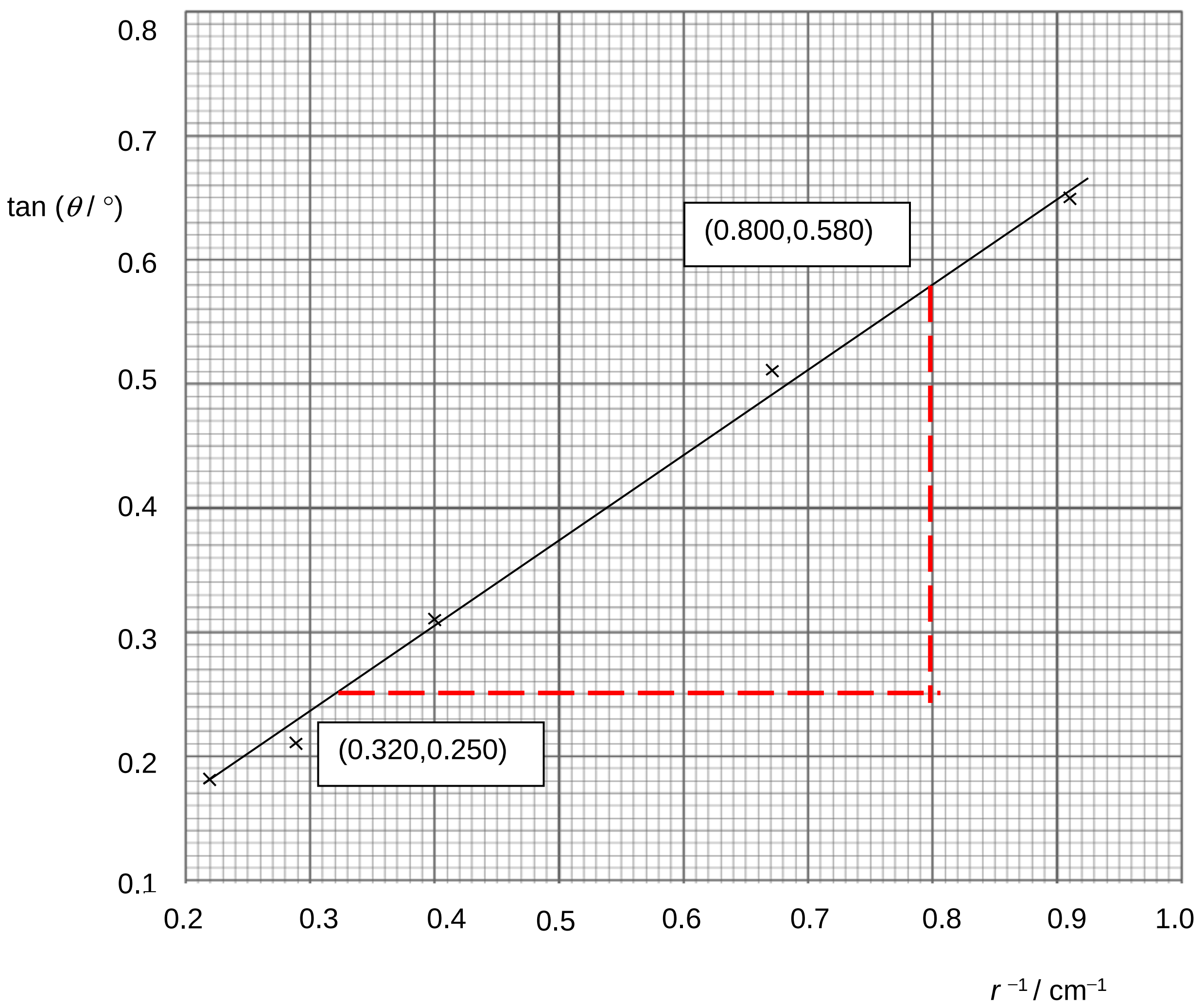
From $B = B_H \tan\theta$ and $B = 2.0\times10^{-7}\dfrac{I}{r}$,

$$\Rightarrow B_H = \frac{2.0\times10^{-7}}{\tan\theta}\times\frac{I}{r} = \frac{2.0\times10^{-7}}{\tan10^\circ}\times\frac{1.15}{0.020} = 6.5\times10^{-5}\text{ T}$$

Note: Magnetic flux density in Singapore is 4.2×10^{-5} T with a dip of 13°55'.

B_H = 6.5×10^{-5} T [2]

(c) (i) Plot the points on the grid below and draw the straight line of best fit. [1]



(ii) Determine the *y*-intercept of the line.

Using points
(0.800,0.580) and (0.320,0.250)

$$\frac{y_2 - y_1}{x_2 - x_1} = \frac{y_2 - y_{intercept}}{x_2 - 0}$$

$$\frac{0.250 - 0.580}{0.320 - 0.800} = \frac{0.250 - y_{intercept}}{0.320 - 0}$$

$$y_{intercept} = 0.030$$

y-intercept = ... [2]

(iii) Use your answer in **(c)(ii)** to state whether tan *θ* is inversely proportional to *r*.

Since the y-intercept is not zero, tan *θ* is not inversely proportional to *r*.
OR
Since the y-intercept is close to zero, tan *θ* is inversely proportional to *r*. The slight variation from zero may be due to systematic errors in the experiment. [1]

[Total: 9]

Comments:

- In **(a)(ii)**, many candidates did not repeat the measurement of *r*. Candidates are advised to repeat the measurement of quantities which are subject to the possibility of a variation and record a minimum of two readings as well as to show the computation of the average of the quantity.
    - Some candidates are still uncertain as to the precision of length measurements using a metre ruler. It should be 1 d.p. in cm or 3 d.p. in m. A handful of candidates recorded *r* to be much greater than 2 cm and this is not given any credit.
- In **(b)(ii)**, repeating of measurement is not necessary as the current reading does not fluctuate. Some candidates obtained current readings in the mA range. This could be due to loose connections at the contact points or that the ends of the copper wire are not completely free of insulation in which case sandpapering is necessary and was obviously not done.
- In **(b)(iii)**, many candidates did not repeat the measurement of θ thus recorded a single data. As the angle θ is subjected to some variation, repeating θ is necessary (no credit given for not doing so).
    - Some candidates recorded obtuse values of θ. This is incorrect as it is merely a scale reading taken from the paper-protractor. This scale reading should be subtracted from 180°. Hence no credit is given for recording obtuse values of θ. Quite a large number of candidates recorded θ to a precision of 1 d.p. which is incorrect. It should be recorded to the nearest degree.
- In **(b)(iv)**, a handful of candidates had calculated B instead of B_H. In addition, some candidates had used I = 1 A in their calculation of B_H even though their experimental I is not exactly 1 A. Candidates are reminded to use their own experimental data in computing values unless otherwise stated. Many also did not convert *r* to m from cm.
- In **(c)(i)**, a number of candidates declared the last data point as anomalous. No credit is given for the best-fit line drawn as all the data points should be used in drawing the line of best fit. Many candidates recorded the two coordinates used in calculating the y-intercept to the wrong precision (mainly 2 d.p.). They should be recorded to 3 d.p..
- In **(c)(ii)**, quite a large number of candidates used data from the table rather than from the best-fit line in determining the gradient, before finding the y-intercept. As these data from the table may not lie on the line, candidates will be penalized 1 mark for doing so.
    - Some candidates read-off the y-intercept from the graph. This is incorrect as the y-axis does not intersect the x-is at $r^{-1} = 0$. No credit is given (loss of 2 marks) if this is done.
- In **(c)(iii)**, many candidates explained that since tan θ increases linearly with r^{-1}, tan θ is therefore inversely proportional to *r*. This is not technically correct as there could be a finite or a reasonably large y-intercept and that the best-fit line does not pass through the origin. If the y-intercept is deemed sufficiently small to be regarded as negligible, then candidates must conclude such is the case and hence tan θ is indeed inversely proportional to *r*.

2 **(a)** Measure and record the length L of the shorter side of the board, as shown in Fig. 2.1.

L = 30.0 cm [1]

(b) **(ii)** Measure and record the angle θ as shown in Fig. 2.2.

θ = 10° [1]

(c) **(iii)** Measure and record the distance y, as shown in Fig. 2.4.

y_1 = 47.0 cm
y_2 = 49.0 cm
y_3 = 48.0 cm

Y = y = 48.0 cm [1]

(iv) Estimate the percentage uncertainty in your value of y.

$\Delta y = (y_{max} - y_{min}) / 2 = 1.0$ cm

$$\frac{\Delta y}{y} \times 100\% = \frac{1.0}{48.0} \times 100\% = 2.1\%$$

percentage uncertainty = 2.1 % [1]

(d) **(i)** Calculate D using

$$D = \frac{L^2 + y^2}{L}$$

$$D = \frac{L^2 + y^2}{L}$$
$$= \frac{30.0^2 + 48.0^2}{30.0}$$
$$= 107$$

D = 107 cm [1]

(ii) Justify the number of significant figures that you have given for your value of D.

Since L and y are in 3 s.f. therefore D is expressed as 3 s.f. [1]

(e) **(ii)** Repeat **(b)(ii)**, **(c)(i)** to **(iii)** and **(d)(i)**.

y_1 = 57.0 cm
y_2 = 59.0 cm
y_3 = 59.0 cm

$$D = \frac{L^2 + y^2}{L}$$
$$= \frac{30.0^2 + 58.3^2}{30.0}$$
$$= 143$$

θ = 20° [1]

y = 58.3 cm [1]

D = 143 cm [1]

(f) **(i)** Using your data, calculate two values of *k*.

1[st] set of readings : $k = D / \sin\theta = 107 / \sin 10° = 616$
2[nd] set of readings : $k = D / \sin\theta = 143 / \sin 20° = 418$

first value of *k* = 616 cm

second value of *k* = 418 cm [2]

(ii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your value in **e(iv)**.

$$\frac{k_1 - \langle k \rangle}{\langle k \rangle} \times 100\%$$
$$= \frac{616 - 517}{517} \times 100\%$$
$$= 19\%$$

which is greater than percentage uncertainty of *y*.
Hence the results do not support the suggested relationship.

[1]

(g) **(i)** Suggest a significant source of error in this experiment.

(ref below) [1]

(ii) Suggest an improvement that could be made to the experiment to address the error identified in **(g)(i)**. You may suggest the use of other apparatus or a different procedure.

(ref below) [1]

[Total: 14]

Errors	**Improvement**
Difficult to ensure starting position is the same (eg starting position of container not parallel to edge of board), hence value of *y* measured will not be accurate.	Improved method of ensuring starting position is the same, e.g. use of another straight board aligned with edge of the slanted board and push container against it before releasing.
Difficult to measure *y* accurately as container moves too fast.	Align a **scale** (e.g. metre rule) on the edge of board where the container will roll past. Use of video recording and playback to accurately determine the length *y*. **Alternatively** Coat the container with paint (or ink) such that the trail left behind can be used to determine the length *y*.
Difficulty in releasing container without applying force, hence affecting the value of *y*.	Improved method of releasing e.g. using a card to hold container and swiftly remove card horizontally (or in direction parallel to the slope).

Comments:

- In **(b)(ii)**, the length of board provided is around 60 cm, if students follow instructions such that the top of board is about <u>10 cm</u> from the table top, then the angle should be around $\sin^{-1}(10/60) = 9.6° \approx 10$ °.
  Students who have readings that deviate a lot from this value most probably did not follow the instructions carefully.

- In **(d)(ii)**, students who wrote "since least s.f. of *raw data* is 3 s.f., hence *D* is expressed as 3 s.f." are not awarded credit, as *raw data* may also refer to the angle θ.

- The following "error" discussions are not awarded credit:
  - "*Difficult* to measure *y*" without elaborating why it is difficult. Need to mention the difficulty arises due to the cylinder moving "too fast".
  - "Rod is not horizontal". Even if the supporting rod is not horizontal, the board can still be placed such that edge of board rest aligned with the table.
- The following "improvement" discussions are not awarded credit:
  - Use of "carbon paper", "chalk" or "water" to trace the path of the cylinder. Not practical as the plastic container will be too light to make clear markings.
  - Use of "Blu Tack" or "adhesive" to stop the cylinder at the edge of the board. Not practical as the cylinder most likely will hit and re-bounce upon hitting the surface.

- In stating the "errors", students are reminded to state which quantity is affected by the error, (e.g. *y* in this experiment).
- In the analysis of uncertainty **(d)(i)** and **(f)(ii)**, some students attempt to analyze the uncertainty of the trigonometric function and simply assume $\Delta(\sin\theta)$ to be the same as $\Delta\theta$, or simply assume ΔL to be zero. The analysis of uncertainty of *D* from the equation $D = \frac{L^2 + y^2}{L}$ is often inaccurate for a number of students. Such treatments are not required.
  The main source of uncertainty in this experiment arises from the value of *y*. Hence a comparison with the percentage uncertainty of *y* suffices to conclude if the relationship is valid.

3 **(a)** **(ii)** The distance l between clips F and G and clips G and H should be the same. Measure and record l.

l = 20.0 cm [1]

(b) **(ii)** Record the voltmeter readings V_1 and V_2 .

V_1 = 0.466 V

V_2 = 0.284 V [1]

(c) Increase l and repeat **(a)(ii)** and **(b)** for further sets of readings of l, V_1 and V_2.

l / cm	V_1 / V	V_2 / V	$\frac{V_1}{V_2}$
20.0	0.466	0.284	1.64
25.0	0.533	0.313	1.70
30.0	0.590	0.309	1.91
35.0	0.638	0.328	1.95
40.0	0.686	0.325	2.11
45.0	0.748	0.321	2.33

[6]

(d) Plot a suitable graph to determine the values of P and Q.

Plot graph of $\frac{V_1}{V_2}$ against l where P is the gradient and Q is the vertical-intercept.

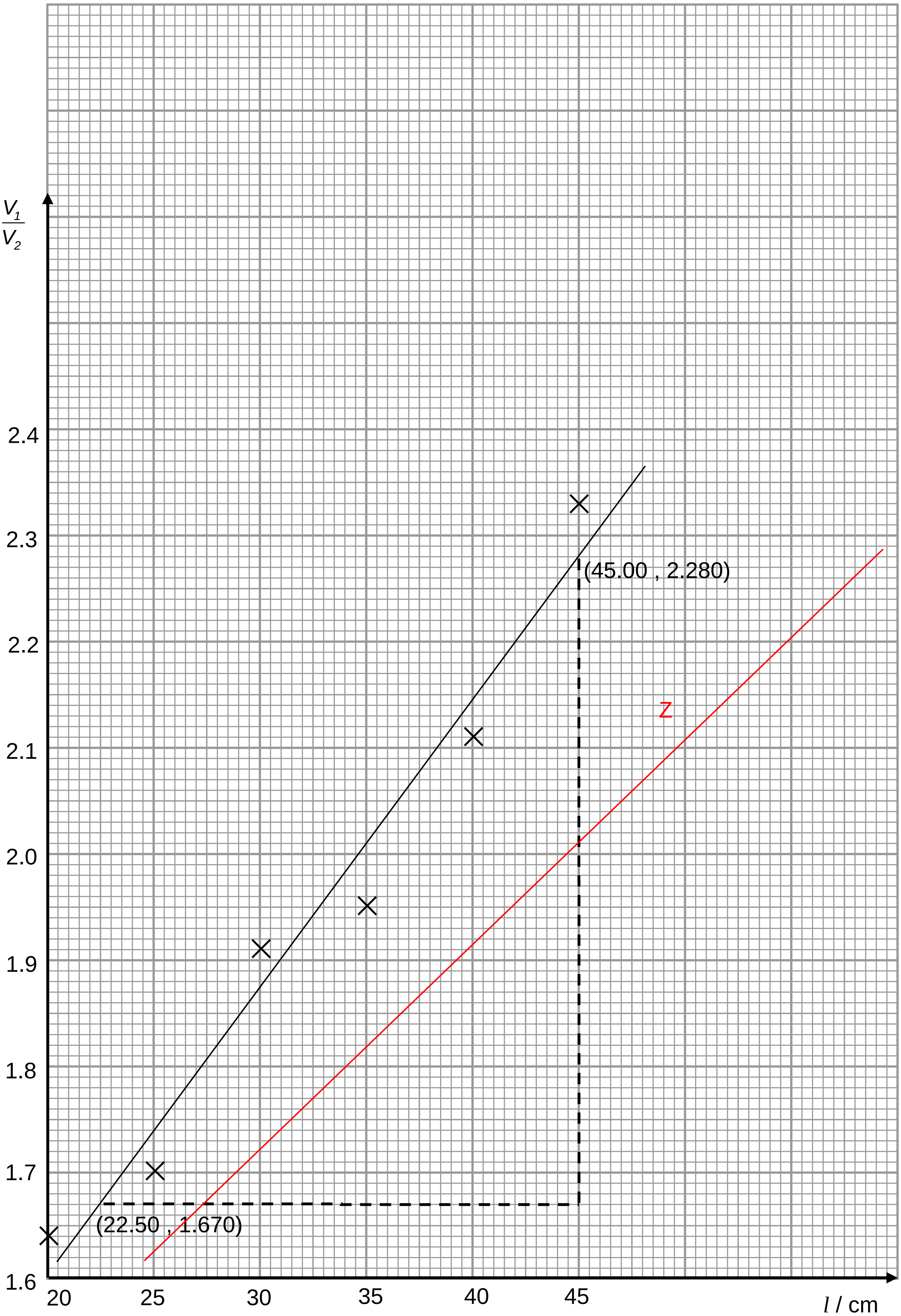
Using points (22.50, 1.670) and (45.00, 2.280),

$$\text{gradient} = \frac{2.280 - 1.670}{45.00 - 22.50} = \frac{0.610}{22.50}$$
$$= 0.0271 \quad \text{(3 s.f.)}$$

Using (22.50, 1.670) and gradient = 0.0271,
1.670 = (0.0271)(22.50) + vertical-intercept
1.670 = (0.610) + vertical-intercept
vertical intercept = 1.060
P = gradient = 0.0271 cm^{-1}
Q = vertical intercept = 1.060

P = 0.0271 cm^{-1}

Q = 1.060 [4]



V1/V2
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
20
25
30
35
40
45
l / cm
(45.00 , 2.280)
(22.50 , 1.670)
Z

[3]

(e) Comment on any anomalous data or results that you may have obtained. Explain your answer.

Since all the points lie on or close to the best-fit line, there is no anomalous data

OR

There is an anomalous data as it lies far from the best-fit line compared to the other points

OR

While there is some scatter of points, they generally follow a linear trend, hence there is no anomalous data. [1]

(f) **(i)** Given $\rho = 6.75 \times 10^{-7}\ \Omega$ m, determine the value of the diameter d of the wire.

$$P = \frac{\rho}{AR_2} = \frac{4\rho}{\pi d^2 R_2}$$

$$\Rightarrow d = \sqrt{\frac{4\rho}{P\pi R_2}} = \sqrt{\frac{4 \times 6.75 \times 10^{-7}}{2.71 \times \pi \times 1.0}}$$

$$\therefore d = 5.63 \times 10^{-4} \text{ m}$$

d = 5.63×10^{-4} m [1]

(ii) In the expression $\frac{V_1}{V_2} = Pl + Q$, Q is independent of the resistance of the wire.

The experiment is repeated using a different type of resistance wire having a smaller resistivity but with the same thickness.

On the graph grid on page 13, sketch a second graph to represent the new results. Label it **Z**. [1]

(Smaller ρ implies smaller gradient. Z is a line with gentler slope, but do not cross original line.)

(g) **(i)** Measure the resistance of a portion of the resistance wire and record the length x of this portion of the wire and its corresponding resistance R'.

x = 0.600 m

R' = 1.8 ohm [1]

(ii) Using $R' = \frac{\rho x}{A'}$, where A' is the cross-sectional area of the resistance wire, calculate the diameter d' of the resistance wire.

A = ρx / R = $(6.75 \times 10^{-7})(0.600) / 1.8$

$= 2.25 \times 10^{-7}$

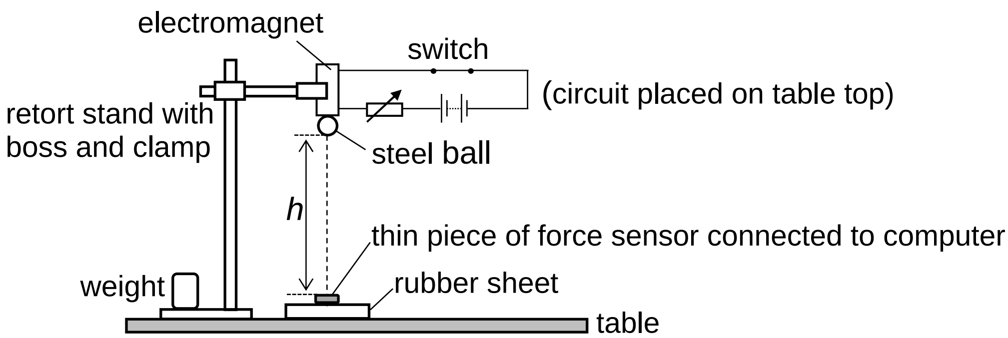
A = $\pi d^2 / 4$

d = 5.35×10^{-4} m

d' = 5.35×10^{-4} m [1]

[Total: 20 marks]

4 Diagram



Problem Definition

Independent variable: dynamic energy density *x*

Dependent variable: maximum decelerating force *y*

Control variables: initial height *h* above the rubber sheet from where the object is dropped; mass *m* of object dropped

Procedure

1. Set up the apparatus as shown but without the force sensor.

2. Measure and record the mass *m* of the steel ball using an electronic weighing balance.

3. Measure the thickness *t* of a rubber sheet at all four sides with a pair of Vernier calipers. Calculate and record the average value for *t*.

4. Place the rubber sheet on the table top.
   Clamp an electromagnet above the rubber sheet.

5. Close the switch to the electromagnet.
   Adjust the rheostat such that the steel ball can be held in position by the electromagnet as shown in the diagram.

6. Open the switch and allow the steel ball to fall vertically onto the rubber sheet. Note visually where the steel ball hits the rubber sheet. Adjust the positon of the rubber sheet such that the steel ball hits the centre of the rubber sheet.

7. Secure, with a thin piece of sticky tape, the force sensor on the surface of the rubber sheet. The force sensor should be at the centre of the rubber sheet where the steel ball hits it.

8. Close the switch to the electromagnet and place the steel ball as shown in the diagram.

9. Measure *h* with a meter rule. Calculate $x = \frac{mgh}{t}$.

10. Open the switch and allow the steel ball to fall vertically onto the force sensor. The computer output to the force sensor will track and show the variation of the decelerating force on the steel ball with time. From the graph output, read and record the value of the maximum decelerating force *y*.

11. Repeat steps 8 and 10 to obtain another value of *y*.
Calculate and record the average value of *y*.

12. Repeat steps 1, 3, 5 to 11 to obtain 10 sets of readings for *x* and *y* by varying *t*.

13. Keep the mass *m* constant by using the same steel ball throughout.
Measure, using a meter rule, the initial height *h* before each set of reading to ensure that *h* remains constant.

Analysis

$y = Ae^{Bx}$

$\ln y = lnA + Bx$

Plot a graph of ln *y* against *x*. A straight line graph will be obtained.

gradient $G = B$

vertical intercept $R = \ln A$

$A = e^{R}$

Safety Precautions

1. The steel ball used may have to be relatively massive. Place a barrier around the rubber sheet so that steel ball does not roll / bounce off the table, damaging the surroundings.

Additional Details

1. Position the electromagnet above the centre of the rubber sheet such that the steel ball hits the centre of the rubber sheet so that the ball experiences the same shock absorbing effect all round itself.

2. Before taking readings, determine the value of *h* that gives the largest force reading at all times, as measured by the force sensor.

3. The diameter of the steel ball chosen should be slightly larger than the diameter of the force sensor. This ensures that the force acts on almost the entire surface of the force sensor. The force measured will then be the actual force acting at the point of incidence between the steel ball and rubber sheet. If the force sensor is large relative to the steel ball, the force reading will be smaller than the actual force.
(The force sensor measures the average force acting over its entire surface.)

RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749 / 1
PAPER 1

19 SEPTEMBER 2018

1 HOUR

CANDIDATE NAME											
CENTRE NUMBER	S					**INDEX NUMBER**					
CLASS	6										

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre number, index number and class above.

There are ***thirty*** *questions in this paper. Answer* ***all*** *questions. For each question, there are four possible answers,* ***A***, ***B***, ***C*** *and* ***D***.

Choose the ***one*** *you consider correct and record your choice in* ***soft pencil*** *on the separate* ***Answer Sheet***.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on the Question Paper.
The use of an approved scientific calculator is expected where appropriate.

The total number of marks for this paper is **30**.

This Question Paper consists of 15 printed pages and 1 blank page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	T / K = T / °C + 273.15
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $= \pm \omega\sqrt{(x_0^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the one you consider to be correct.

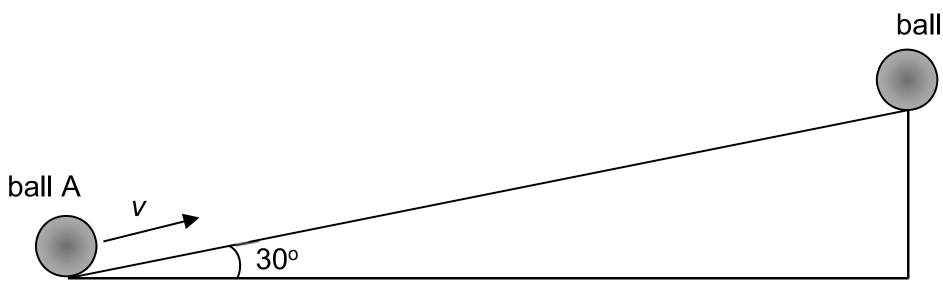
1 The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ of the liquid. The speed is given by the equation

$$v = k\left(\frac{\Delta P}{\rho}\right)^n$$

where k is a constant that has no units. What is the value of n?

A $\frac{1}{2}$ **B** 1 **C** $\frac{3}{2}$ **D** 2

2 Ball A is launched up the slope from the bottom of a smooth inclined plane with an initial speed v. At the same time that ball A is launched, ball B is released from rest at the top of the inclined plane. The two balls meet at the mid-point of the inclined plane after two seconds.



Given that the mass of ball A is twice that of ball B, what is the speed v?

A 4.9 m s^{-1}

B 9.8 m s^{-1}

C 17 m s^{-1}

D 20 m s^{-1}

3 A ball is thrown vertically upwards. It reaches its maximum height of motion and comes back to the original point where it was launched.

Given that air resistance to the motion of the ball is not negligible, which of the following statements about the ball is correct?

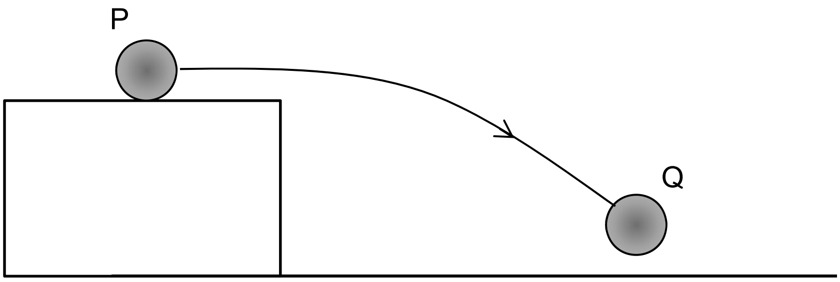
A The ball is accelerating at – 9.81 m s^{-2} throughout its motion.

B The ball is decelerating at a decreasing rate when it is moving upwards.

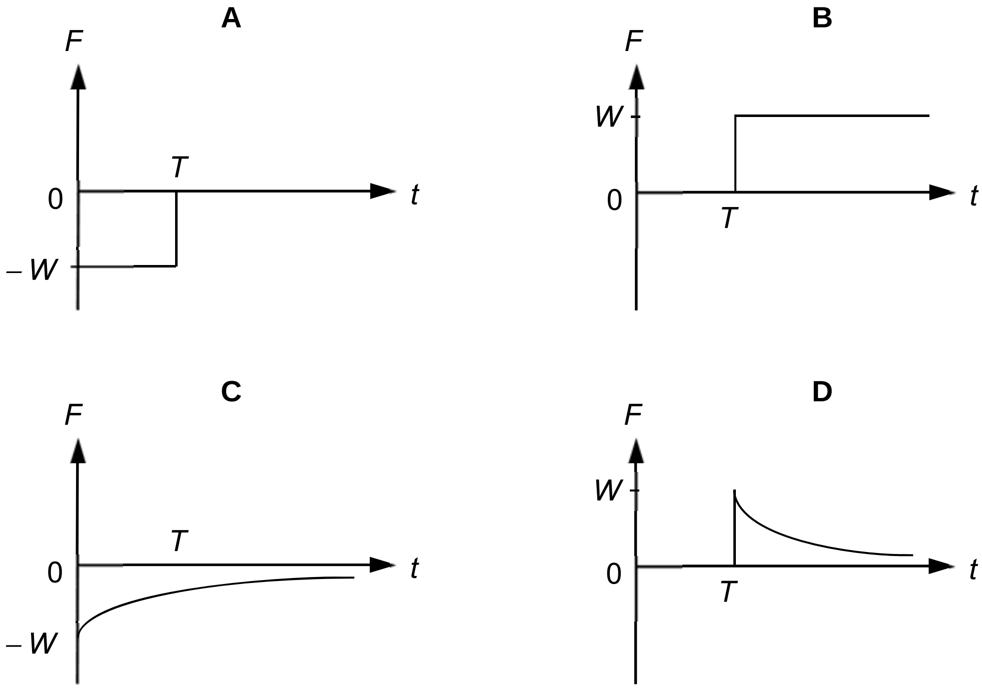
C The ball is decelerating at an increasing rate when it is moving upwards.

D The ball is accelerating at an increasing rate when it is moving downwards.

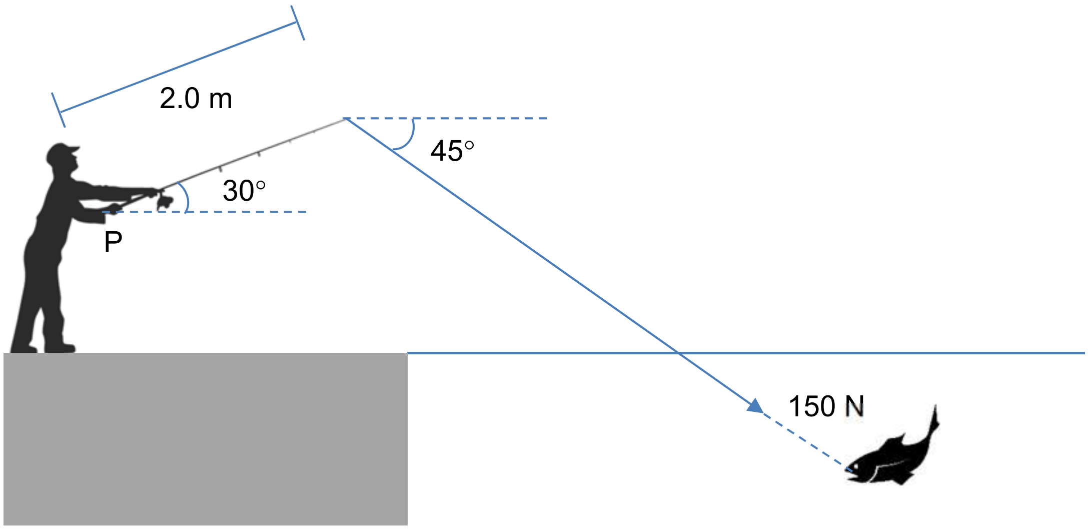
4 A ball of weight *W* moves along a smooth horizontal surface until it falls off the edge at time *T*.



Given that air resistance is not negligible, which of the following graphs shows the variation with time *t* of the resultant vertical force *F* acting on the ball as it moves from P to Q?



5 A man's 2.0 m long fishing pole makes an angle of 30° with the horizontal.



What is the moment exerted by the fish about the man's hand at P?

A 75 N m

B 77 N m

C 110 N m

D 290 N m

6 A 3.50 g balloon is filled with helium (density = 0.180 kg m^{-3}) to a volume of 5.00 m^3 and is then connected to the top of a table via a light spring of constant k = 100 N m^{-1}. The balloon causes the spring to stretch.

What is the extension of the spring when the balloon is in equilibrium given that the density of air is 1.29 kg m^{-3}?

A 0.055 m

B 0.201 m

C 0.544 m

D 0.632 m

7 A mini rocket of mass 90 kg requires 28 kW of useful power in order to travel horizontally at a constant speed. The driving force on the rocket is given as 760 N.

What is the useful power required by the rocket to travel vertically at the same constant speed?

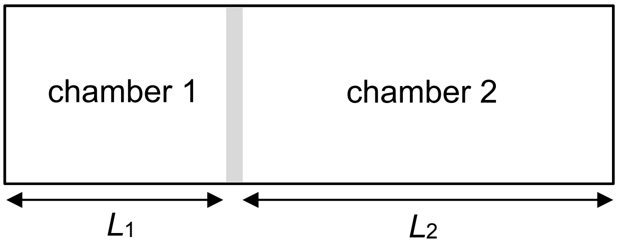
A 28 kW

B 33 kW

C 61 kW

D 68 kW

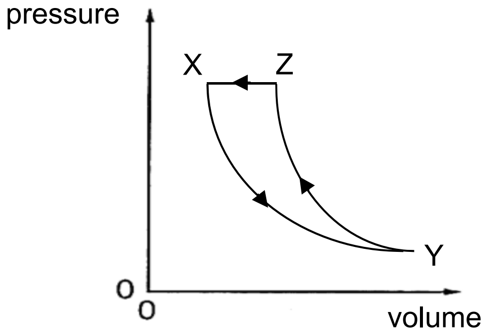
8 The closed cylinder shown in the figure below has a freely moving piston separating chambers 1 and 2. Chamber 1 contains 20 mg of nitrogen gas and chamber 2 contains 45 mg of helium gas. The relative molecular mass of nitrogen is 28 and that of helium is 4.



When both pressure and thermal equilibrium are established between chamber 1 and 2, what is the ratio of L_1 / L_2?

A 0.063 **B** 0.44 **C** 2.3 **D** 16

9 A fixed mass of an ideal gas undergoes the changes represented by XYZX below.

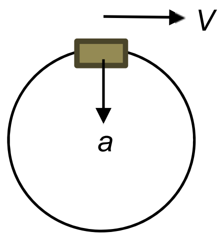


Which one of the following sets could describe this set of changes?

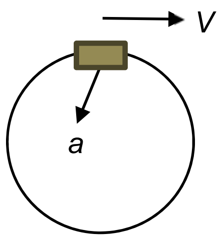
	XY	YZ	ZX
A	isothermal expansion	adiabatic compression	pressure reduction at constant volume
B	adiabatic expansion	isothermal compression	compression at constant pressure
C	isothermal expansion	adiabatic compression	compression at constant pressure
D	adiabatic expansion	isothermal compression	pressure reduction at constant volume

10 A drone is performing a stunt for its audience on the ground by flying in a vertical circle. Which diagram shows the resultant acceleration *a* acting on the drone at the instant where its velocity is *v* and is speeding up?

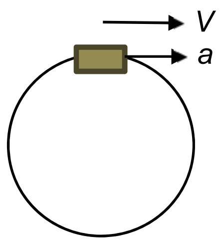
A



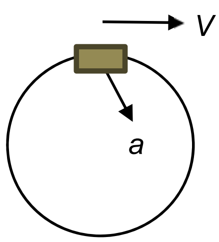
B



C



D



11 A spacecraft orbiting a planet in uniform circular motion has an antenna detached gently from it.

Neglecting air resistance, which statement best describes the motion of this detached antenna?

A It will move off in a straight line away from the planet.

B It will take a parabolic path into the planet.

C It will continue to orbit in uniform circular motion.

D It will drop straight down into the planet.

12 A satellite of mass 80 kg moves from a point where its gravitational potential energy due to Earth is −4800 MJ, to another point where its gravitational potential energy is −1600 MJ.

In which direction does the satellite move and what is the change in gravitational potential between these two points?

A closer to the Earth and a decrease of 40 MJ kg^{-1} of potential

B closer to the Earth and a decrease of 3200 MJ kg^{-1} of potential

C further from the Earth and an increase of 40 MJ kg^{-1} of potential

D further from the Earth and an increase of 3200 MJ kg^{-1} of potential

13 A particle executes simple harmonic motion about a point. Its maximum speed is 6.0 m s^{-1} and its maximum acceleration is 2.0 m s^{-2}.

What is the amplitude of its motion and its period?

	amplitude / m	period / s
A	0.33	0.35
B	0.33	18
C	18	0.33
D	18	19

14 An oscillating system has a natural period of 1.0 s. A periodic force of 2.0 Hz is then applied to the system, reaching a steady state.

What is the time interval between successive instances where the magnitude of the displacement is at a maximum?

A 0.25 s

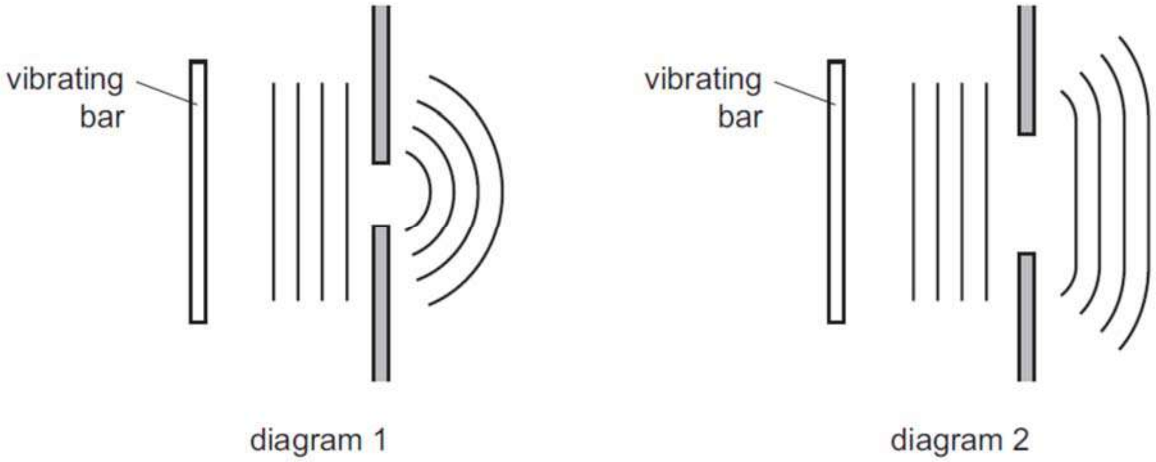
B 0.50 s

C 0.75 s

D 1.0 s

15 Diagram 1 shows a ripple tank experiment in which plane waves are diffracted through a narrow slit in a metal sheet. Diagram 2 shows the same tank with a slit of greater width.

In each case, the pattern of the waves incident on the slit and the emergent pattern are shown.



Which action would cause the waves in diagram 2 to be diffracted more and so produce an emergent pattern closer to that shown in diagram 1?

A decreasing the density of the liquid

B decreasing the frequency of vibration of the bar

C decreasing the speed of the waves by making the water in the tank shallower

D increasing the amplitude of vibration of the bar

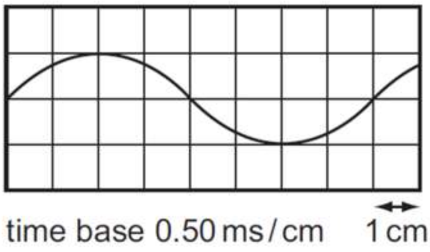
16 A standing sound wave is set up between a loudspeaker and a wall.

A microphone is connected to a cathode-ray oscilloscope (c.r.o.) and is moved along a line directly between the loudspeaker and the wall. The amplitude of the trace on the c.r.o. rises to a maximum when the microphone is at a position X, falls to a minimum and then rises once again to a maximum at a position Y.

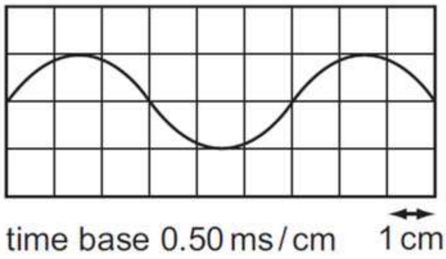
The distance between X and Y is 33.4 cm. The speed of sound in air is 334 m s^{-1}.

Which diagram represents the c.r.o. trace of the sound received by the microphone at X?

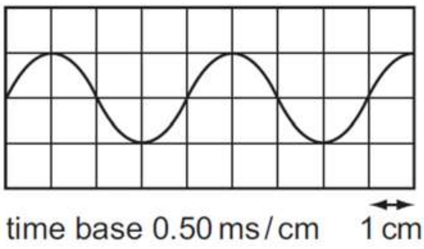
A



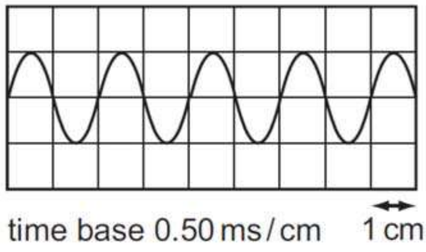
B



C



D

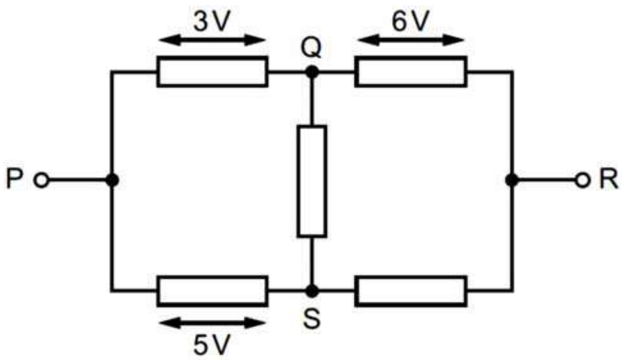


17 There is a current flowing from P to R in the resistor network shown.

The potential difference (p.d.) between P and Q is 3 V.

The p.d. between Q and R is 6 V.
The p.d. between P and S is 5 V.

Which row in the table is correct?



	p.d. between Q and S	p.d. between S and R
A	2 V	4 V
B	2 V	10 V
C	3 V	4 V
D	3 V	10 V

18 A uniform copper rod of cross-sectional area 8.0×10^{-6} m^2 has 8.5×10^{28} conduction electrons per cubic metre. A current flows through the rod when a potential difference is applied across it.

Given that the drift velocity of electrons in the rod is 2.3×10^{-5} m s^{-1}, what is the current in the rod?

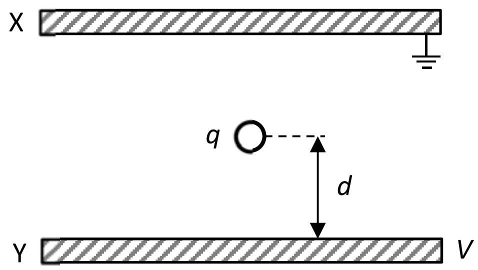
A 0.25 A

B 0.40 A

C 2.5 A

D 4.0 A

19 An oil drop of charge *q* and mass *m* is suspended at the midpoint of parallel charged plates X and Y. The drop is at a distance *d* from plate Y. Plate X is earthed while Y is held at a potential of *V* with a total charge of Q_Y.



What is the expression for the potential *V*?

A $\dfrac{mgd}{q}$

B $\dfrac{2mgd}{q}$

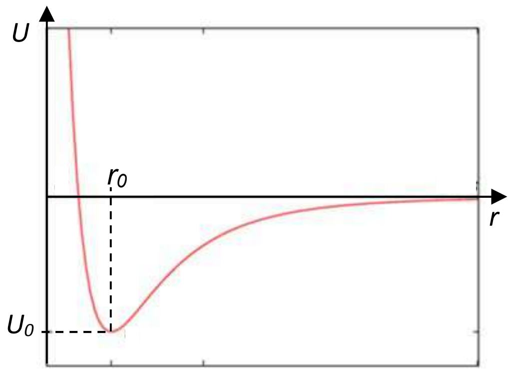
C $\dfrac{mg}{q}$

D $\dfrac{Q_Y}{4\pi\varepsilon_0 d}$

20 The simplified interaction between a pair of atoms can be represented by an equation relating the electric potential energy of the atoms,

$$U = \frac{A}{r^{12}} - \frac{B}{r^{6}}$$

where *U* is the electric potential energy of the atoms, *r* is the separation between them and *A* and *B* are constants. The variation of *U* with *r* is as shown below.



Which of the following statements is correct?

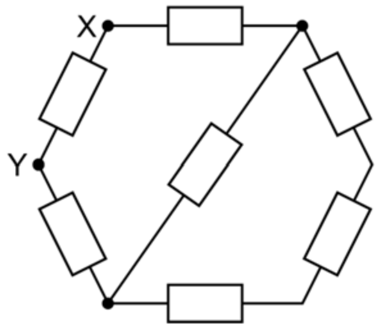
A The atoms experience no interatomic forces at the separation of r_0.

B The atoms experience the strongest forces of attraction as *r* decreases from r_0.

C To separate the atoms, the atoms must decrease electric potential energy by a magnitude of U_0.

D As the separation between the atoms increases from r_0, the magnitude of net force acting on the atoms increases then decreases.

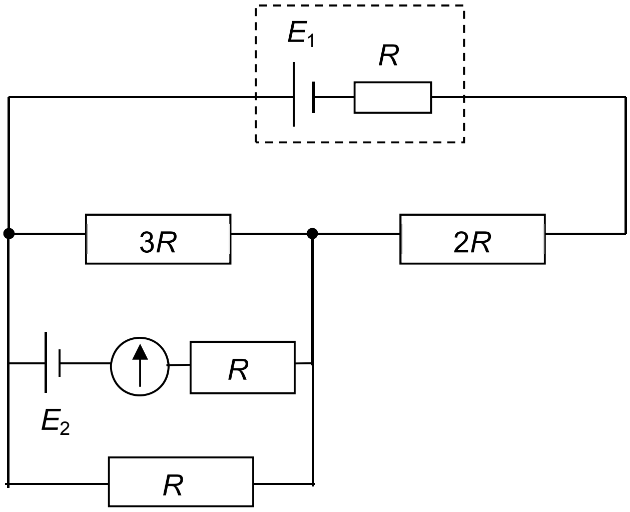
21 The diagram shows a network of 7 resistors, each with resistance *R*.



What is the resistance between points X and Y?

A $\frac{2}{3}R$ **B** $\frac{3}{5}R$ **C** $\frac{7}{11}R$ **D** $\frac{11}{15}R$

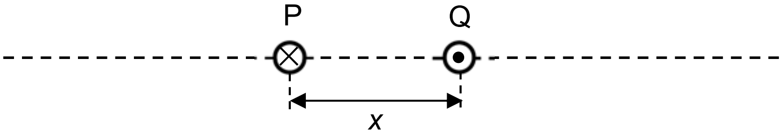
22 Two cells of e.m.f. E_1 and E_2 have internal resistances R and zero respectively. The cells are connected to resistors of resistances 3R, 2R and R, as shown below.



If the galvanometer shows no deflection, what is the ratio $\frac{E_1}{E_2}$?

A 0.60 **B** 1.0 **C** 1.7 **D** 2.0

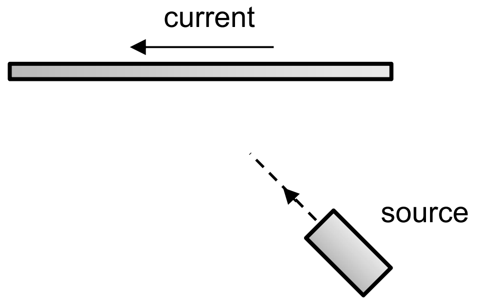
23 Two parallel wires P and Q are placed a distance x from each other. P carries a current of I vertically down into the paper while Q carries twice the current of P vertically out of the paper.



A third current-carrying wire R is placed along the dotted line, parallel to wires P and Q, and experiences no net force from wires P and Q. Which of the following is a possible combination of the position of wire R, and the direction and magnitude of current in R?

	position of R	direction of current in R	magnitude of current in R
A	x to the left of P	out of paper	$2I$
B	0.5x to the left of P	into paper	I
C	2x to the left of P	out of paper	I
D	x to the right of Q	out of paper	I

24 The diagram shows a long horizontal wire carrying a steady current. A source fires a beam of electrons towards the wire at an angle of 45°.



As the beam approaches the wire, the electrons experience an electromagnetic force from the field of the current.

What is the initial direction of this force?

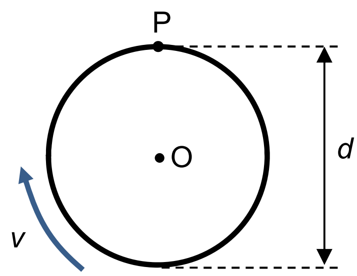
A in a direction parallel to the wire

B in a vertical direction towards the wire

C in a direction at 90° to the original path towards the wire

D in a direction at 90° to the original path away from the wire

25 An aluminium disc of diameter *d* rotates about its centre. A point on the rim moves at a constant speed *v*. It is placed in a uniform magnetic field *B* perpendicular to its surface. A steady electromotive force (e.m.f.) *E* is generated between the centre O and the rim at P.



What is the expression for the e.m.f *E* generated?

A $\frac{Bdv}{4}$

B $\frac{Bdv}{2}$

C Bdv

D Bv

26 A half-wave rectified sinusoidal alternating current has r.m.s. current of I.
Which expression is correct for the peak current I_0?

A $\frac{I}{\sqrt{2}}$ **B** $\frac{I}{2}$ **C** $\sqrt{2}\,I$ **D** $2\,I$

27 The velocity of a proton is twice the velocity of an electron.

Assuming the mass of a proton is approximately 2000 times larger than the mass of an electron, what is the ratio of the de Broglie wavelength of the proton to that of the electron?

A 2.5×10^{-4} **B** 0.50 **C** 2.0 **D** 4000

28 A metal plate with work function energy of 2.6 eV, is illuminated with electromagnetic radiation of wavelength 80 nm.

What is the maximum velocity of emitted photoelectrons?

A 1.5×10^{6} m s^{-1}

B 2.1×10^{6} m s^{-1}

C 2.5×10^{6} m s^{-1}

D 6.7×10^{7} m s^{-1}

29 Nuclear decay is both spontaneous and random in nature.

Which row gives the correct experimental evidence for these properties?

	spontaneous nature of decay	random nature of decay
A	the decay rate is not affected by pressure	the decay rate is not affected by temperature
B	the decay rate is not affected by temperature	the rate at which radiation is received at a counter fluctuates
C	the rate at which radiation is received at a counter fluctuates	the decay rate is not affected by temperature
D	the decay rate is not affected by temperature	the decay rate is not affected by pressure

30 Uranium $^{238}_{92}U$ decays to form lead $^{206}_{82}Pb$ by a series of alpha and beta emissions.

For each decay of uranium $^{238}_{92}U$ to lead $^{206}_{82}Pb$, how many α−particles and β−particles are emitted?

	α−particles	β−particles
A	6	2
B	6	8
C	8	4
D	8	6

END OF PAPER

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RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749 / 2
PAPER 2

10 SEPTEMBER 2018

2 HOURS

CANDIDATE NAME											
CENTRE NUMBER	S					**INDEX NUMBER**					
CLASS	6										

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre number, index number and class in the spaces at the top of this page and on all work you hand in.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected where appropriate.

Candidates answer on the Question Paper.
No Additional Materials are required.

*Answer **all** questions.*

The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINERS' USE	
Paper 2	
1	/ 5
2	/ 10
3	/ 10
4	/ 12
5	/ 8
6	/ 9
7	/ 8
8	/ 18
Deduction	
Paper 2	/ 80

This document consists of **26** printed pages.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	T / K = T / °C + 273.15
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $= \pm \omega \sqrt{(x_0^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 A student sets up the circuit shown in Fig. 1.1 in order to determine the resistivity of a piece of wire.

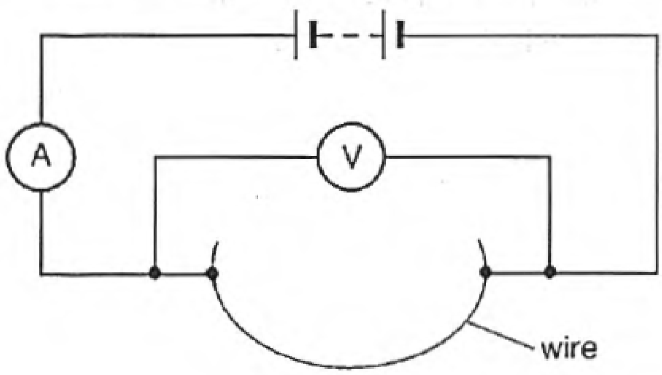

Fig. 1.1

(a) The following readings were obtained:

Reading of voltmeter, V	Reading of ammeter, I	Length of Wire, L	Diameter of Wire, d
1.50 ± 0.01 V	0.82 ± 0.01 A	63.2 ± 0.1 cm	0.48 ± 0.02 mm

(i) Show that the resistivity is given by $\rho = \dfrac{V\pi d^2}{4IL}$.

[1]

(ii) Hence or otherwise, calculate the resistivity of the wire together with its associated uncertainty.

resistivity = ……………………… Ω m [4]

2 **(a)** State the two conditions necessary for a system to be in equilibrium.

1 ……………………………………………………………………………………………

……………………………………………………………………………………………

2 ……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) A rigid buoy is connected via an elastic rope of elastic constant 500 N m^{-1} vertically to the sea bed. When rope is vertical and buoy is in equilibrium, the rope has an extension of 1.80 m.

Horizontal currents in the sea water travelling in the direction of left to right then cause the buoy to be displaced so that the elastic rope makes an angle of θ with the seabed. The elastic rope also extends further by 0.70 m.

(i) Sketch a free body diagram of all the forces acting on the buoy when it is subjected to the sea currents on Fig. 2.1. Label the angle θ and forces clearly.

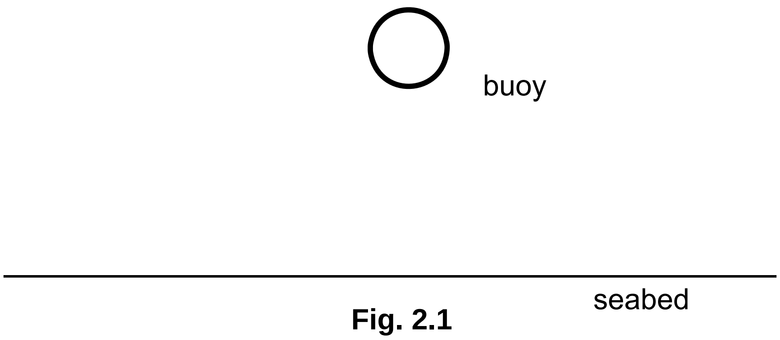

Fig. 2.1

[2]

(ii) Determine the magnitude of the force exerted by the elastic rope on the buoy when there are currents acting on it.

force = ……………………… N [1]

(iii) Determine the resultant of the weight and upthrust acting on the buoy. Show your working clearly

force = ……………………… N [2]

(iv) Hence, determine the magnitude of the force exerted by the currents on the buoy.

force = ……………………… N [1]

(c) Using your values in **(b),** determine the angle *θ.*

angle = ………………………° [2]

3 **(a)** **(i)** Define *gravitational potential* at a point in a gravitational field.

....

....

.... [1]

(ii) Explain why gravitational potential is always negative.

....

....

....

....

.... [2]

(b) Fig. 3.1 shows the variation of gravitational potential between the surface of Moon and the surface of Earth along the line joining their centres.

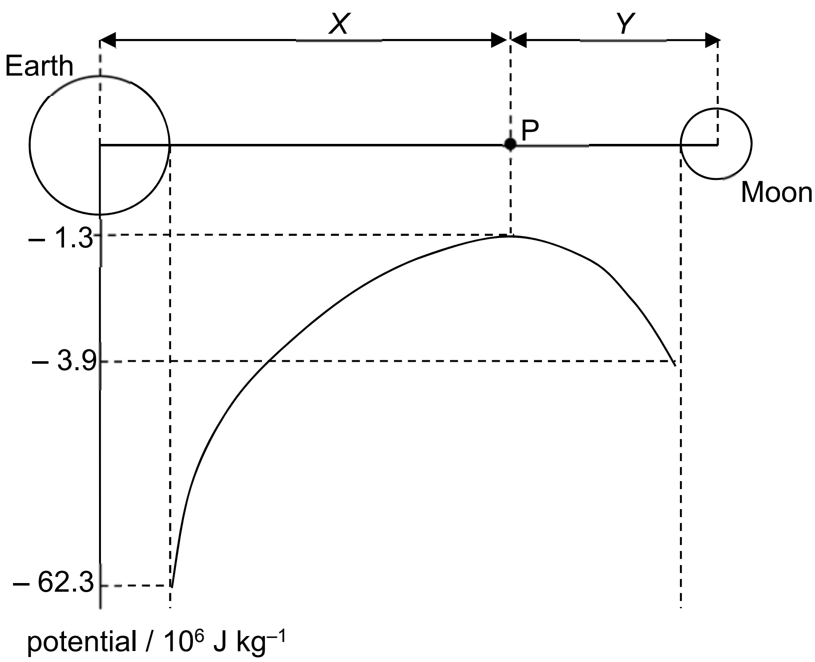

Fig. 3.1

Explain why the gradients of the graph near the surface of Earth and that near the surface of Moon have opposite signs.

....

....

....

.... [2]

(c) Two moons A and B move in circular orbits about a planet, as illustrated in Fig. 3.2.

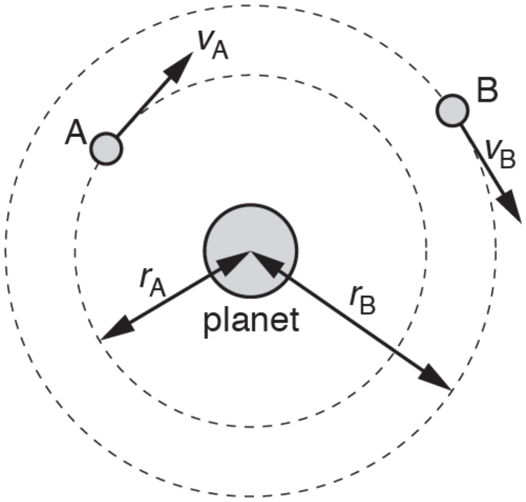

Fig. 3.2

Moon A has an orbital radius r_A of 1.3×10^8 m, linear speed v_A and orbital period T_A.
Moon B has an orbital radius r_B of 2.2×10^{10} m, linear speed v_B and orbital period T_B.

(i) Determine the ratio $\frac{v_A}{v_B}$

ratio = ……………………… [2]

(ii) Show that $\frac{T_A}{T_B} = 4.5 \times 10^{-4}$.

[1]

(iii) The planet spins about its own axis with angular speed 1.7×10^{-4} rad s^{-1}. Moon A is always above the same point on the planet's surface. Determine the orbital period T_B of moon B.

T_B = ……………………… s [2]

4 Object P of mass 5.0 kg is resting on a frictionless surface and is in equilibrium while connected to a spring as shown in Fig. 4.1. The spring that is fastened to the wall has an elastic constant k = 100 N m^{-1}.

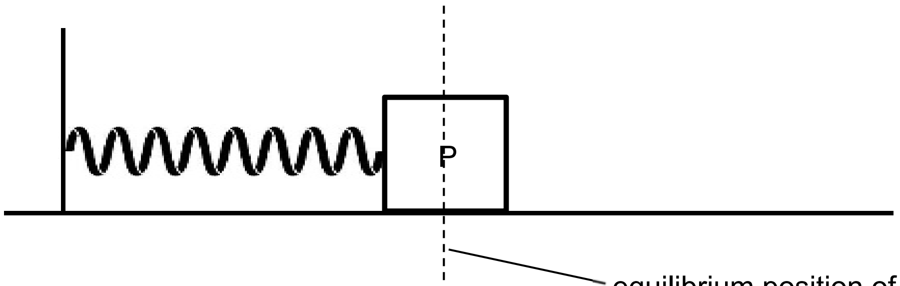

Fig. 4.1

(a) **(i)** P is displaced to the right and then released.

Explain why the subsequent horizontal motion of P while connected to the spring will be simple harmonic. Draw a free-body diagram of P in the space below to illustrate your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [3]

(ii) Hence or otherwise, show that the period of oscillation for P is 1.4 s.

[2]

(b) A second object Q of mass 3.0 kg is slowly pushed against P, compressing the spring by 0.20 m as shown in Fig. 4.2.

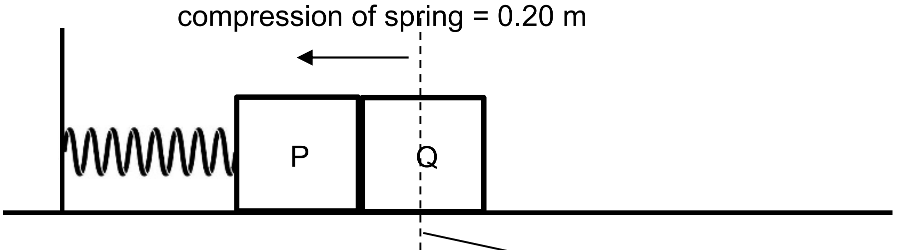

Fig. 4.2

The system is then released, and both objects start moving to the right on the frictionless surface.

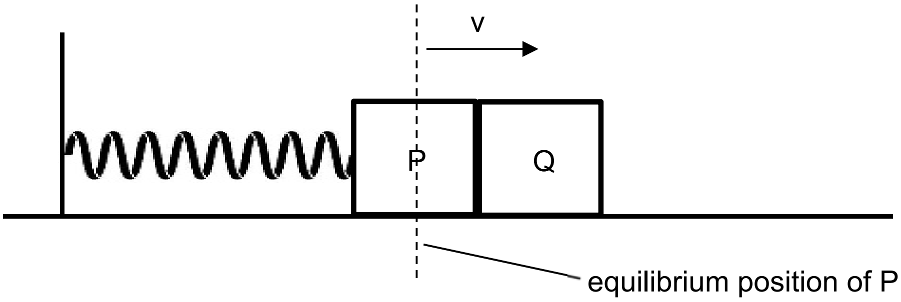

Fig. 4.3

(i) When P reaches the equilibrium point, Q loses contact with it and moves to the right with speed *v*.

Determine speed *v*.

v = ……………………… m s^{-1} [2]

(ii) Determine the amplitude of the oscillatory motion of P after it loses contact with Q

amplitude = ……………………… m [1]

(iii) Hence, determine the distance that P and Q are apart when the spring is fully stretched for the first time.

distance = ……………………… m [2]

(c) While P is oscillating about the equilibrium point, object R is dropped on it just when P is at its amplitude. R sticks to P and then moves along with P for the subsequent motion.

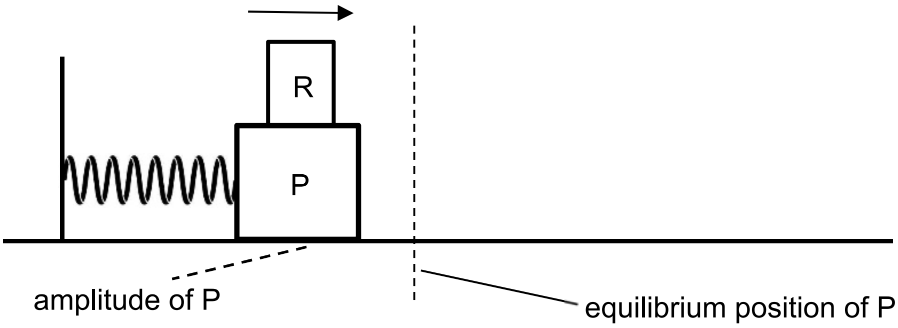

Fig. 4.4.

Explain how the subsequent frequency and amplitude of the motion will be different.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

5 **(a)** Distinguish between electromotive force (e.m.f.) and potential difference (p.d.) using energy considerations.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(b) In order to determine the internal resistance *r* of a 12.00 V battery, a student sets up the circuit shown in Fig. 5.1. The variable resistor CD has a maximum resistance of 1000 Ω.

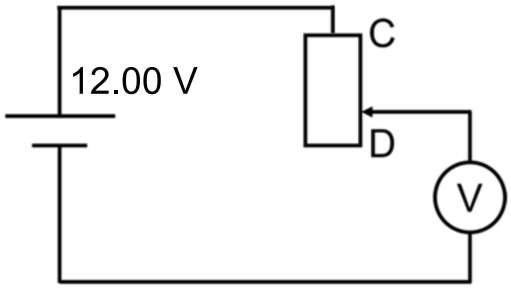

Fig. 5.1

It is found that when the sliding contact of the variable resistor is placed at C, the digital voltmeter reading is 11.99 V. When the sliding contact is moved down from C to D, the digital voltmeter reading drops from 11.99 V to 11.00 V.

(i) State the potential difference across the internal resistance of the battery when the sliding contact of the variable resistor is placed at C.

potential difference = ……………………… V [1]

(ii) Explain why the presence of internal resistance in the battery reduces its output power.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [1]

(c) **(i)** Using the results of **(b)(i)**, show that *R* = 1199 *r* where *R* is the resistance of the voltmeter and *r* is the internal resistance.

[1]

(ii) Hence or otherwise, determine *R* and *r*.

R = ……………………… Ω

r = ……………………… Ω [3]

6 In a cathode ray oscilloscope, an electron beam is fired from rest, with an accelerating voltage of 1.0 kV and strikes a fluorescent screen that is 14.0 cm from the end of the vertical deflection plates as shown in Fig. 6.1. Depending on the potential difference between the horizontal and vertical deflection plates, the beam can be manipulated to draw waveforms on the screen.

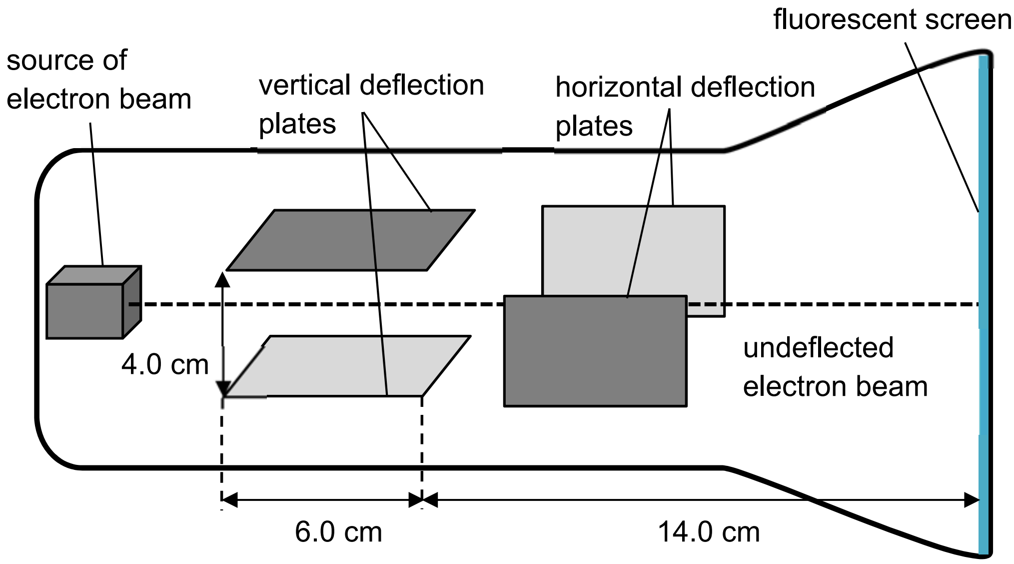

Fig. 6.1 (not to scale)

An alternating voltage is applied across the vertical deflection plates. The time-base is set at 5.0 ms per division and the vertical scale of the display is set at 5.0 V per division. The waveform on the screen is shown in Fig. 6.2.

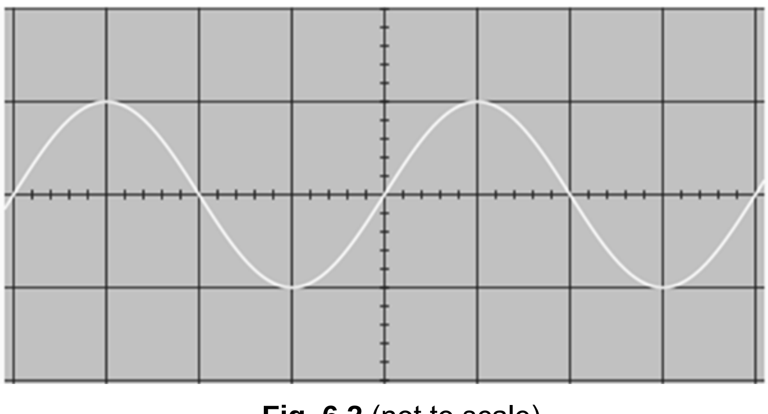

Fig. 6.2 (not to scale)

(a) Calculate the speed of the electrons just before they enter the region between the vertical deflection plates.

speed = ……………………… m s^{-1} [2]

(b) Show that the time taken for an electron in the beam to travel between the vertical deflection plates is 3.2 ns.

[1]

(c) The actual applied voltage to the vertical deflection plates is 20 times that of the reading on the screen.

Determine the maximum vertical deflection of the electron beam when it reaches the fluorescent screen.

maximum vertical deflection = ……………………… m [4]

(d) Describe and explain how the waveform in Fig. 6.2 would be different if the electron beam was replaced with a proton beam.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………….. [2]

7 **(a)** In order to light up a set of lamps, each having a resistance of 20 Ω, a student sets up a circuit as shown in Fig. 7.1.

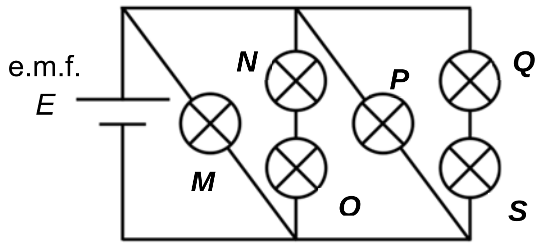

Fig. 7.1

(i) Determine the effective resistance of the circuit.

effective resistance = ……………………… Ω [1]

(ii) State and explain the relative brightness of the lamps.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [2]

(b) In another circuit shown in Fig. 7.2, a uniform wire AB of length 80.0 cm and resistance 1.5 Ω is connected in series with a resistor of 5.0 Ω and a cell of e.m.f. 9.0 V with internal resistance 1.0 Ω.

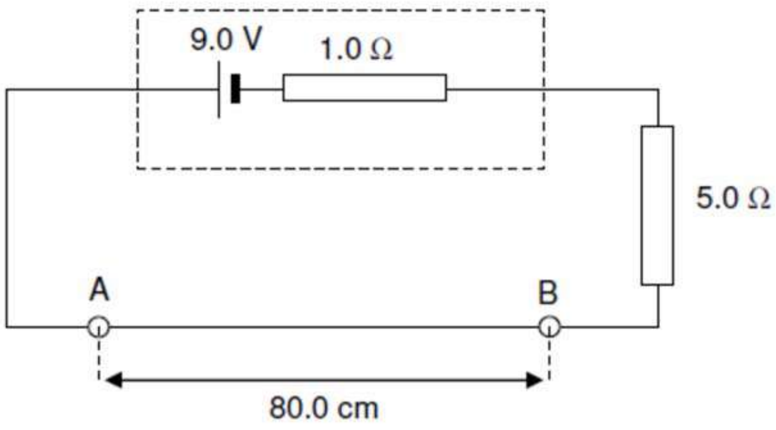

Fig. 7.2

(i) Calculate the potential difference across wire AB.

potential difference = ……………………… V [2]

(ii) A cell C of e.m.f. 1.5 V and internal resistance 0.80 Ω is connected to the circuit in Fig. 7.2, as shown in Fig. 7.3. The movable contact D can be connected to any point along wire AB.

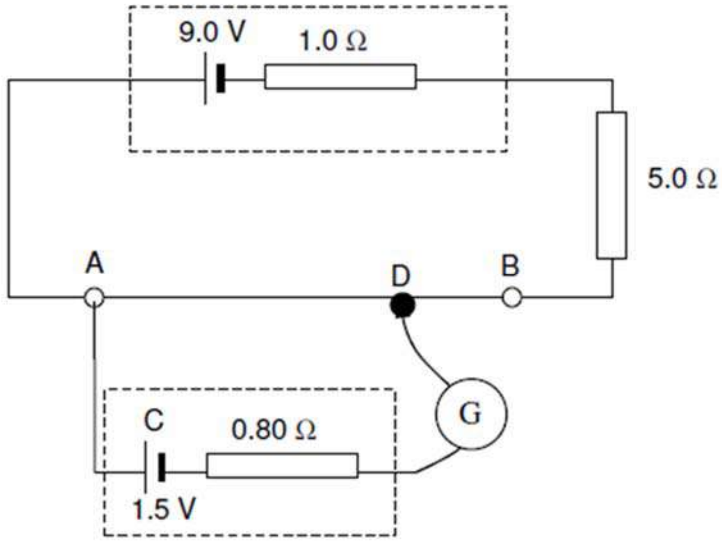

Fig. 7.3

Calculate the length of AD when there is zero current in the galvanometer.

length = ……………………… m [2]

(iii) Explain what would happen to the length of AD when there is zero current in the galvanometer, if the 5.0 Ω resistor in Fig. 7.3 is replaced by a 3.0 Ω resistor.

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

…………………………………………………………………………………… [1]

8 Read the following article and then answer the questions that follow.

Analysis of braking of a vehicle

Modern vehicles are provided with different types of brakes. In cars, the foot brake is the most important in respect of control and safety of a vehicle while the hand brake is used as a reserve brake.

One of the principal braking parameters of a vehicle is the deceleration *a*. This criterion should satisfy the following condition

$$a \geq [\,0.10 + 0.85\,(\varphi - 0.20)]\,g$$

where φ is the coefficient of cohesion and g is the acceleration due to gravity.

The values of the deceleration of braking calculated according to the formula depend on the physical features of the wheel and road friction.

In reference books for experts' examination of traffic accidents as well as in scientific references on dynamics of vehicles, the provided value of coefficient of cohesion of tyres with dry asphalt is $\varphi = 0.80$. The value of the coefficient of cohesion equal to 0.80 may be applicable only to old cars and tyres produced about the year 1980. For the present-day cars, the maximum coefficient of cohesion φ is between 1.00 to 1.20, if braking takes place on dry asphalt.

The anti-lock brake system (ABS) is required to ensure distribution of braking forces between the wheels to prevent the wheels from locking and therefore causing the car to skid. The majority of modern vehicles are equipped with ABS, and their real braking distance is close to the theoretically calculated one based on the maximum values of the coefficient of cohesion. So, the deceleration of such vehicles may be close to $g = 9.81\text{ m s}^{-2}$. For vehicles without ABS, the deceleration will be smaller.

(a) **(i)** Calculate the minimum deceleration of present-day cars with ABS while braking on dry asphalt.

minimum deceleration = ……………………….. m s^{-2} [1]

(ii) Assuming a car experiences constant deceleration during braking, calculate the maximum braking distance for a present-day car travelling at 50 km/h.

braking distance = ……………………….. m [2]

(iii) State and explain whether the braking distance of a vehicle will change while braking on wet asphalt.

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(iv) Suggest two disadvantages of modern vehicles that have very large deceleration when braking if travelling on an expressway.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [2]

(b) A car has two important braking devices and they function independently. The foot brake is operated by foot and the hand brake is operated by hand.

When a car has a brake test, two sets of measurements are made:

1. The maximum braking force on the wheels produced by operating the foot brake.
2. The maximum braking force produced by operating the hand brake.

Typical data for a car of mass 900 kg are as follows.

Description	Maximum braking force / N
Foot brake	6700
Hand brake	2000

In order to determine whether or not the brakes are satisfactory, the data are applied to a chart (called a nomogram) like the one shown in Fig. 8.1. This chart has three vertical lines marked with scales.

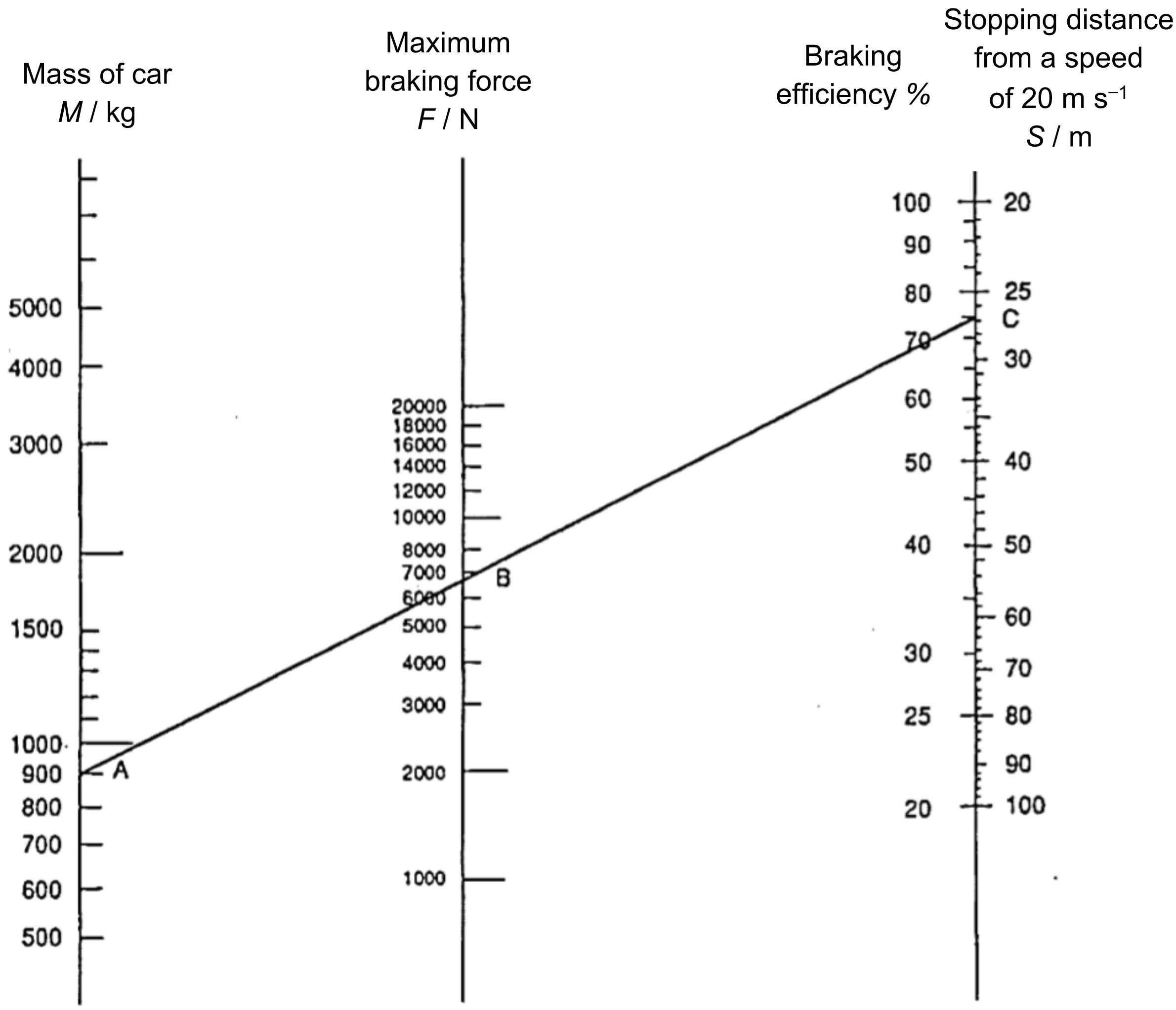

Fig. 8.1

The central vertical line is for the maximum braking force.
The left line is for the mass of the car.
The right line is for the braking efficiency and also for the stopping distance from an initial speed of 20 m s^{-1}.

The braking efficiency E is defined by the equation

$$E = \frac{\text{deceleration of car}}{\text{acceleration of free fall}} \times 100$$

As an example of the use of this chart for the car of mass 900 kg, the figures in the table show a maximum braking force for the foot brake of 6700 N. The point A corresponding to the mass and the point B corresponding to the braking force are joined to give a straight sloping line. This line is extended to cut the braking efficiency scale at the point C, and shows that in this particular case the stopping distance S from a speed of 20 m s^{-1} is about 27 m.

(i) In Fig. 8.1, draw a line to represent the results of the hand brake test on the car of mass 900 kg.

(ii) Read from the chart the braking efficiency corresponding to hand brake test.

braking efficiency = ……………………….. % [1]

(iii) Calculate the deceleration corresponding to this value of braking efficiency.

deceleration = ……………………….. m s^{-2} [1]

(iv) Show that the deceleration is approximately g = 9.7 m s^{-2} when both foot brake and hand brake are applied to stop a 900 kg car of speed of 20 m s^{-1}.

[1]

(v) Suggest why it is not advisable to use the braking technique in **(b)(iv)**.

…………………………………………………………………………………….

…………………………………………………………………………………. [1]

(c) Now consider a car of mass 1300 kg. The data for maximum braking force and stopping distance from 20 m s^{-1} are given in Fig. 8.2.

F / N	*s* / m
3000	88.0
4000	66.0
5000	54.0
6000	45.0
7000	
8000	32.5
10000	27.0
12000	23.0

Fig. 8.2

(i) Use Fig. 8.1 to determine the stopping distance when *F* = 7000 N. Show your construction on Fig. 8.1.

stopping distance = ……………………….. m [1]

(ii) On Fig. 8.3, plot the point corresponding to *F* = 7000 N and draw the line of best fit for all the points. [1]

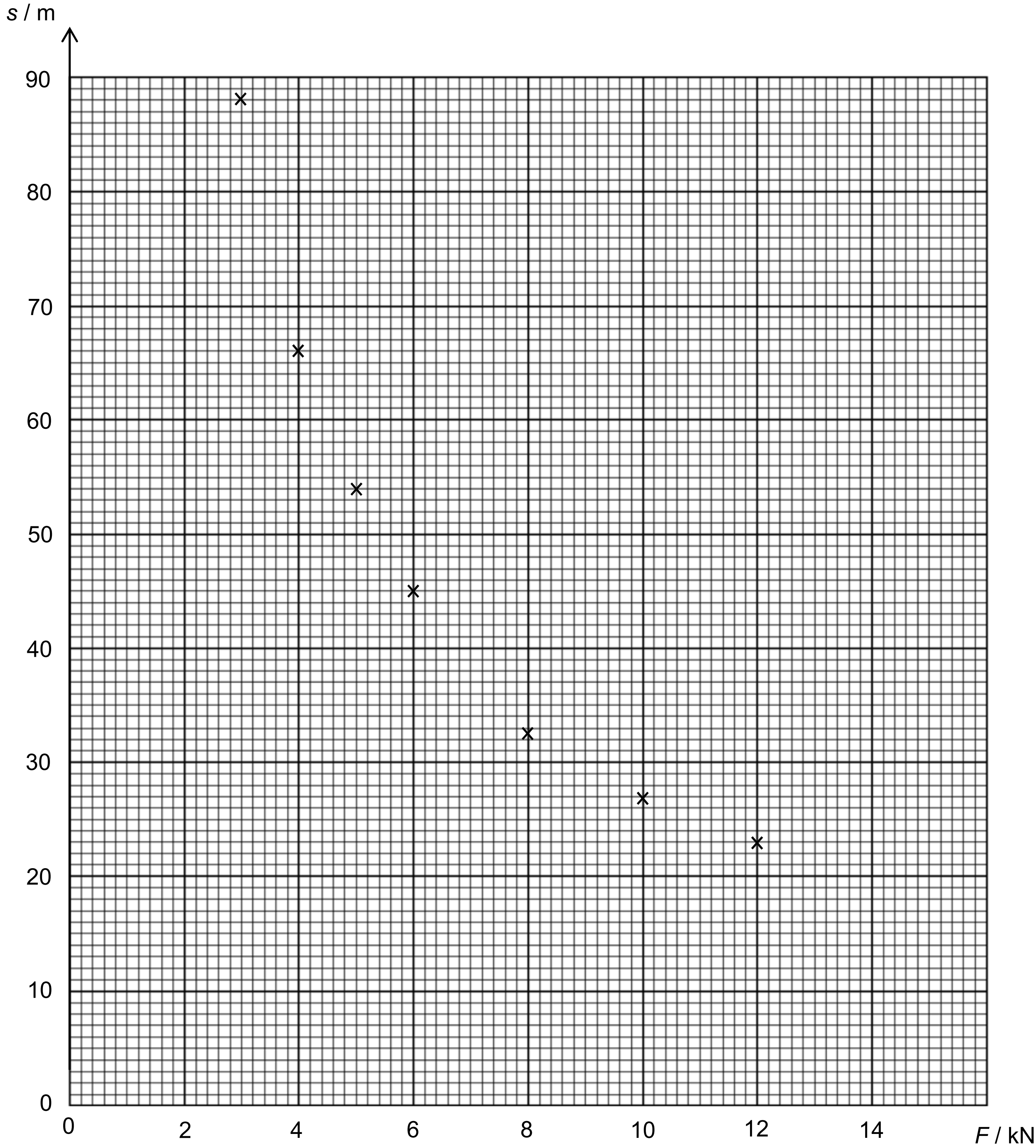

Fig. 8.3

(iii) Use Fig. 8.3 to determine the work done when the maximum braking force is 9000 N. State any assumptions made in your calculations.

work done = ……………………….. J

……………………………………………………………………………………….

…………………………………………………………………………………… [2]

(d) **(i)** A passenger of mass 70 kg was not wearing a seat belt and was sleeping at the front seat of a car. The car of mass 1300 kg was travelling at 20 m s^{-1} when a maximum braking force of 12000 N was applied on it.

Using Fig. 8.1 and the equation for braking efficiency, determine the minimum force that the passenger would have to apply to prevent himself from flying off the seat. Show your working clearly.

force = ……………………….. N [3]

(ii) Suggest whether the passenger would be able to prevent himself from flying off the seat.

……………………………………………………………………………………….

……………………………………………………………………………………….

…………………………………………………………………………………… [1]

END OF PAPER

RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749 / 3
PAPER 3

14 SEPTEMBER 2018

2 HOURS

CANDIDATE NAME	

CENTRE NUMBER	S					**INDEX NUMBER**					

CLASS	6	

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre number, index number and class in the spaces at the top of this page and on all work you hand in.
Candidates answer on the Question Paper.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer all questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of 25 printed pages and 1 blank page.

FOR EXAMINERS' USE	
Section A – do all questions	
1	**/ 6**
2	**/ 16**
3	**/ 6**
4	**/ 10**
5	**/ 12**
6	**/ 10**
Section B – do ONE question only	
7	**/ 20**
8	**/ 20**
Deduction	
TOTAL	**/ 80**

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	T / K = T / °C + 273.15
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $= \pm \omega\sqrt{(x_0^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided.

1 **(a)** An object of mass m is accelerated by a constant resultant force from rest to a speed v. By considering the work done on it, with reference to equations of motion, derive an expression for its kinetic energy E_k.

[3]

(b) A car of mass 820 kg is travelling at constant speed along a horizontal road. The engine of the car provides 37 kW and a constant drag force of 1.2 kN acts on the car throughout its motion.

(i) Show that the work done in overcoming the drag force during a time of 11 s is 410 kJ.

[1]

(ii) Calculate the maximum speed that the car can travel at if the engine provides half the original power. Show your working clearly.

maximum speed = ……………………… m s^{-1} [2]

2 **(a)** The first law of thermodynamics states that the increase in *internal energy* of a *closed* system is the sum of the *heat* supplied and work done on the system.

Explain what is meant by

(i) *internal energy*,

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………….. [1]

(ii) *closed* system,

…………………………………………………………………………………………

……………………………………………………………………………………….. [1]

(iii) *heat*.

…………………………………………………………………………………………

……………………………………………………………………………………….. [1]

(b) **(i)** An ideal gas occupies a volume V at a pressure p and a temperature of T inside an insulated container as shown in Fig. 2.1. It is held in place by a frictionless piston. The other section of the container contains a vacuum.

Using the first law of thermodynamics, explain why the temperature of the gas remains constant when the piston is no longer held in place and the gas is allowed to expand to occupy the entire volume of the container.

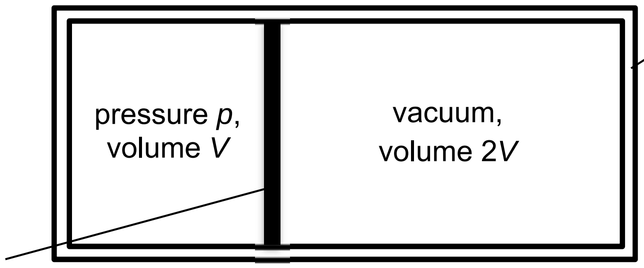

Fig. 2.1

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………….. [3]

(ii) Hence or otherwise, determine the ratio of the initial pressure to the final pressure of the gas.

ratio = ……………………… [2]

(c) In 1816, Robert Stirling patented the Stirling engine which operates by cyclic compression and expansion of air or other gas at different temperatures, such that there is a net conversion of thermal energy to mechanical work.

Figure 2.2 shows the cycle of changes that a gas undergoes in the Stirling engine.

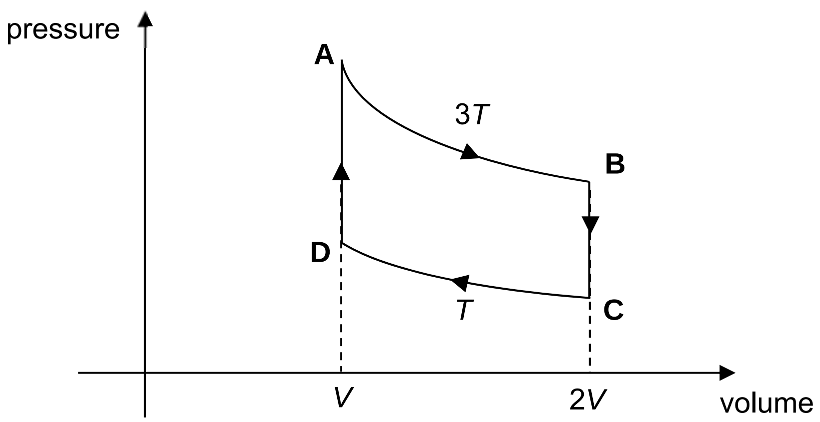

Fig. 2.2

Fig. 2.3 shows the processes that are involved in the cycle of changes.

section of cycle	description	heat supplied
A → B	increase of volume at constant temperature	
B → C	decrease of pressure at constant volume	
C → D	decrease of volume at constant temperature	
D → A	increase of pressure at constant volume	

Fig. 2.3

(i) Complete the table in Fig. 2.3 by writing ‘to’ or ‘from’. [2]

(ii) Determine, in terms of *n*, *R* and *T*, the change in internal energy for *n* mol of a monatomic ideal gas for the change D → A.

[1]

(iii) The work done on the gas for a change in volume at constant temperature can be given by the expression $W = n\,R\,T\,ln\frac{V_{initial}}{V_{final}}$.

Hence or otherwise, derive an expression for the net heat transferred to the gas during one cycle in terms of *n*, *R* and *T*. Explain your working clearly.

[3]

(iv) The efficiency of the Stirling engine shown is determined by the net work done by the system divided by the heat transferred to the system. Using your working in **(c)(i)** to **(iii)**, determine the efficiency.

efficiency = …………………… [2]

3 A 0.050 kg mass is attached to one end of an elastic string of unstretched length 0.50 m. The other end of the string is attached to a fixed support. The force constant of the elastic string is 40 N m^{-1}. The mass is rotated steadily on a smooth table in a horizontal circle of radius 0.70 m as shown in Fig. 3.1.

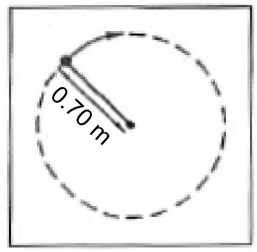

Fig. 3.1

Fig. 3.2 shows the side view of the string and mass.

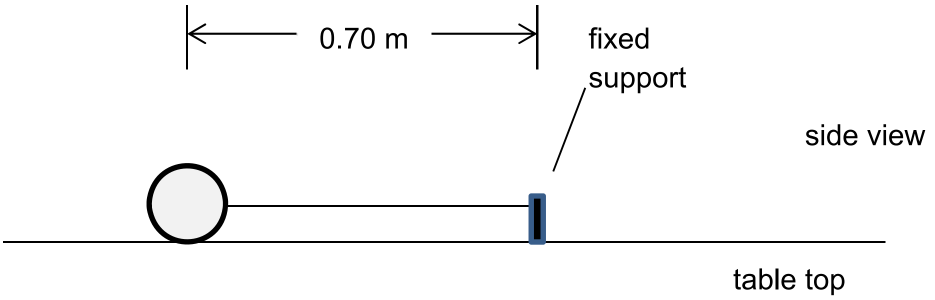

Fig. 3.2

(a) On Fig. 3.2, draw and identify the forces acting on the mass.

[2]

(b) Calculate the linear speed of the mass.

linear speed = ……………………… m s^{-1} [2]

(c) The mass is now rotated at a speed v in a vertical plane of radius r. Derive an expression, in terms of r, for the minimum speed at the highest point of the circular path at which the string *just* becomes slack.

[2]

4 A cyclotron uses a magnetic field to maintain alpha particles in nearly circular paths. Electromagnets with ferrous cores provide the required strong magnetic field as shown in Fig. 4.1.

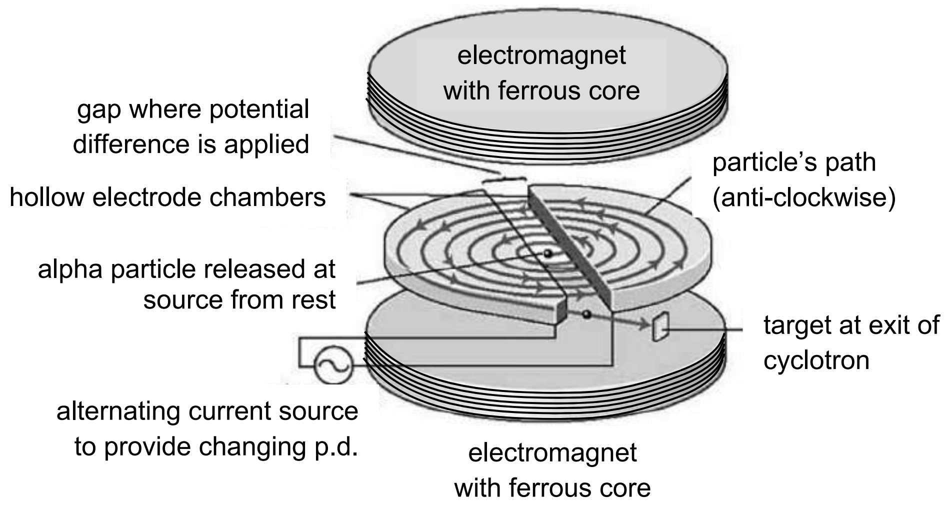

Fig. 4.1

The ions, originating from a source at the centre, released from rest, move within two D-shaped hollow electrode chambers called *dees*, separated by a very narrow gap.

Each time the ions pass into the gap between the *dees*, they are subjected to a potential difference applied between the *dees*, subsequently increasing the radius of curvature of their path. After many revolutions, the ions acquire high speeds and reach the outer edge of the cyclotron.

(a) State what is meant by a *magnetic field*.

……………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(b) On Fig. 4.1, draw arrows to indicate the direction of magnetic flux density provided by the electromagnets.

[1]

(c) **(i)** By considering the path taken by the alpha particles and forces acting on them in the cyclotron, derive an expression for the radius of curvature *r* of the path. Express your answer in terms of mass of ions, charge, linear speed *v*, and magnetic flux density *B*. Charge should be in terms of elementary charge *e* and mass in terms of unified atomic mass constant *u*. Show your working clearly.

[2]

(ii) Hence, explain why the radius increases each time after the ions pass between the *dees*.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………….. [1]

(d) The magnetic flux density in the dees provided by the electromagnets is equivalent to that at the centre of a solenoid of length 0.39 m, 3100 turns, and a current of 200 A flowing in it.

Show that the magnetic flux density in the dees is 2.0 T.

[1]

(e) The potential difference between *dees* varies periodically as shown in Fig. 4.2.

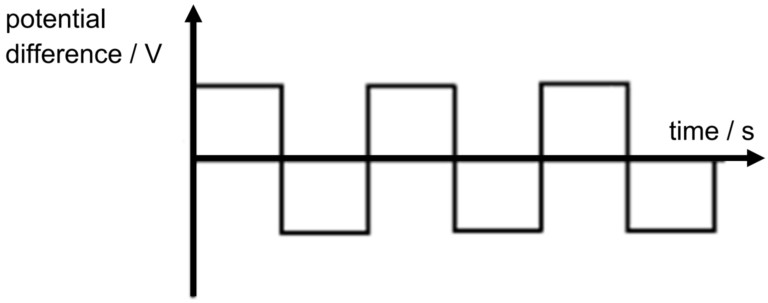

Fig. 4.2

The alpha particles reach an energy of 16 MeV after accelerating within the cyclotron for a duration of 0.52 ms and exiting the cyclotron at a radius of 0.29 m. Determine the potential difference between the *dees* at each crossing.

potential difference = ……………………… V [4]

5 **(a)** In order to investigate the photoelectric effect, a student set up the apparatus illustrated in Fig. 5.1.

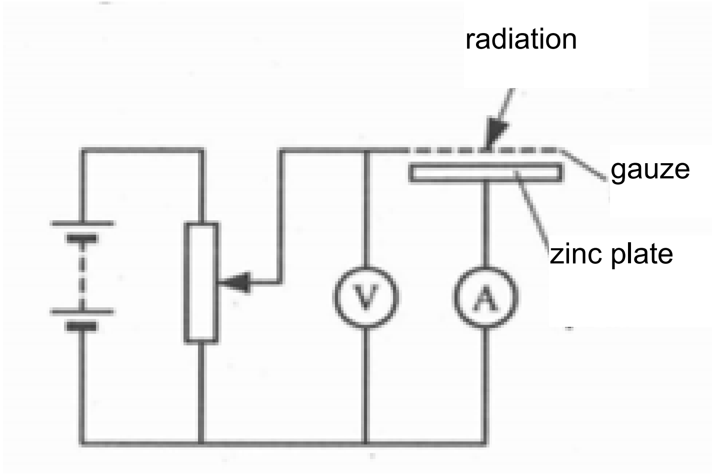

Fig. 5.1

The wavelength of the radiation incident on the zinc plate was varied. For two values of wavelength λ, the stopping voltage V_s required just to prevent electrons reaching the gauze was measured. The results are shown in Fig. 5.2.

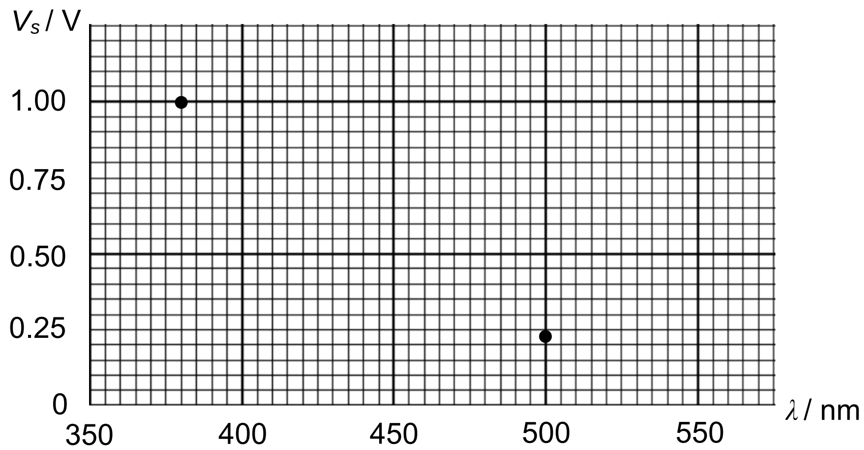

Fig. 5.2

(i) Define *work function energy*.

…………………………………………………………………………………………………

……………………………………………………………………………………….. [1]

(ii) Calculate the maximum speed of a photoelectron emitted from the metal surface by radiation of 380 nm.

maximum speed = ……………………… m s^{-1} [2]

(iii) Calculate the work function energy of the metal surface.

work function energy = ……………………… eV [2]

(iv) Suggest why it is not possible to deduce the threshold wavelength of this metal surface directly from Fig. 5.2, without further calculations.

…………………………………………………………………………………………………

……………………………………………………………………………………….. [1]

(b) In order to investigate the X-ray spectrum of a particular target metal, the student uses an X-ray tube where high energy electrons are fired on the target metal.

Fig 5.3 shows a sketch of the X-ray spectrum produced for the target metal. The tube voltage is 100 kV.

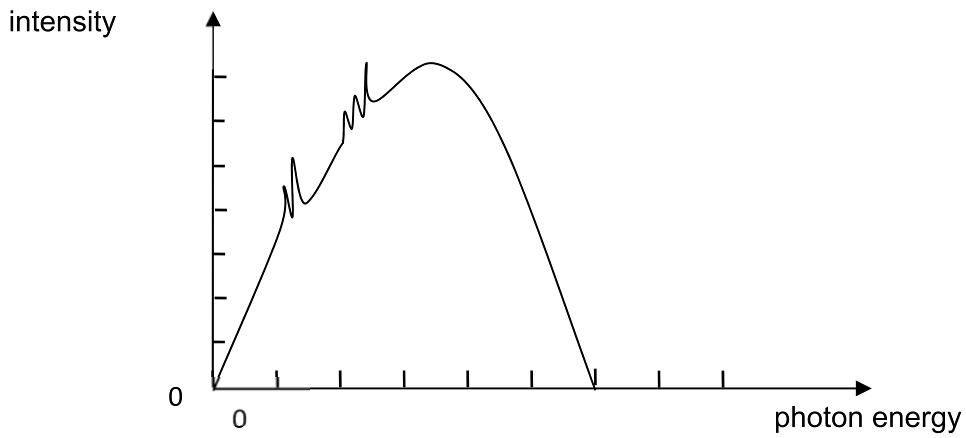

Fig. 5.3

The energy required to remove an electron from the various shells of the target metal atom is shown in Fig. 5.4.

type of shell	energy / 10^{-15} J
K	1.4
L	0.27
M	0.12

Fig. 5.4

(i) Given that the two sets of peaks in Fig. 5.3 correspond to the K and L spectrum lines, label K_α and L_β. [1]

(ii) On Fig. 5.3, sketch a spectrum for X-ray from the tube if the tube voltage is halved. [1]

(iii) Calculate the energy of the X-ray photon of longest wavelength in the K-spectrum of the target metal.

energy = ……………………… eV [2]

(iv) Explain the formation of K_β spectrum lines.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………….. [2]

6 The table shows the half-life of various radioactive nuclides.

nuclide	$^{197}_{84}Po$	$^{220}_{86}Rn$	$^{222}_{88}Ra$	$^{234}_{91}Pa$
half-life / s	60	52	38	70

The variation of the number of nuclei with time for one of these radioactive nuclides is shown in Fig. 6.1.

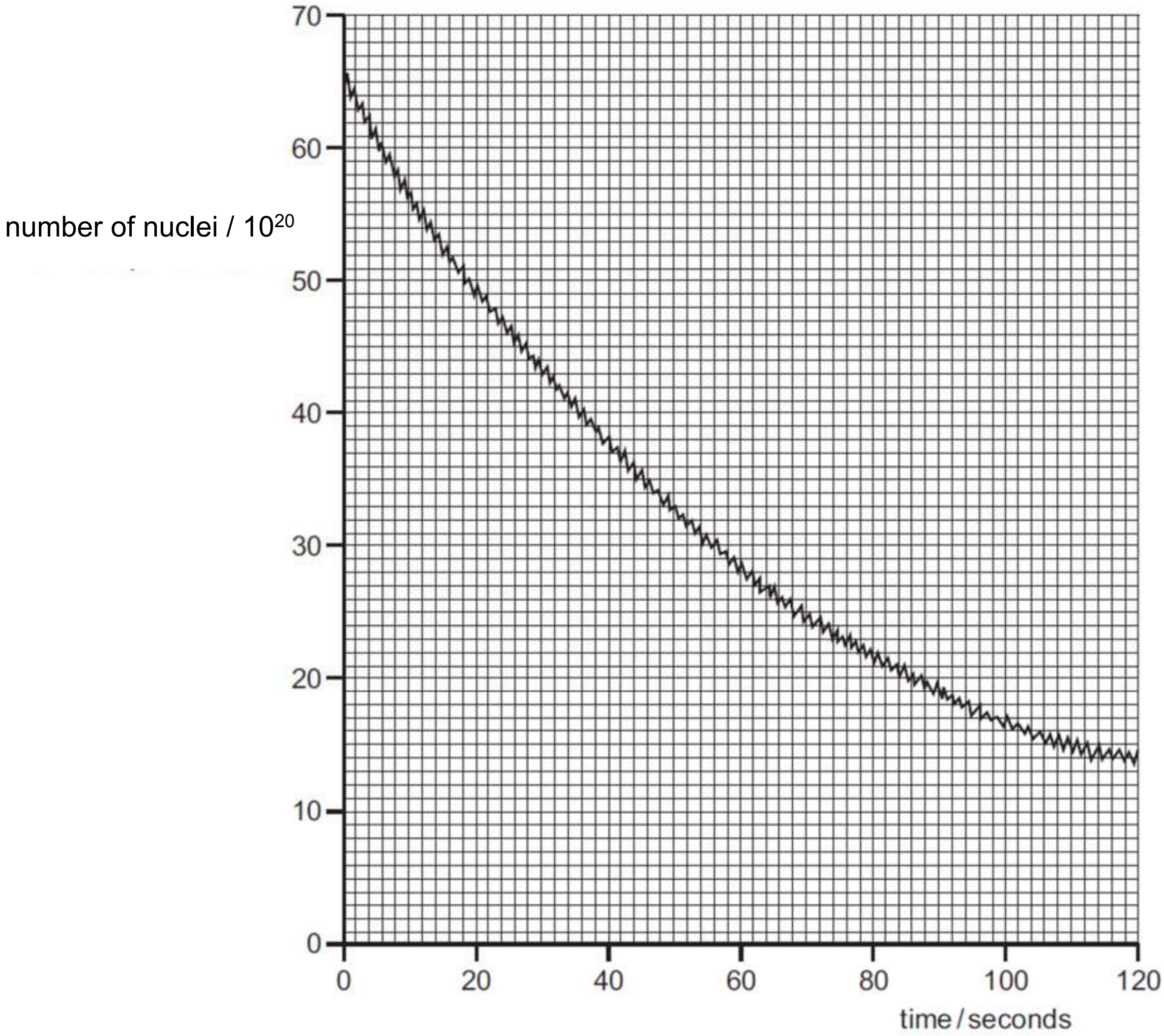

Fig. 6.1

(a) **(i)** Using Fig. 6.1, determine which is the decaying radioactive nuclide. Show your working clearly.

decaying radioactive nuclide = ……………………… [3]

(ii) Hence, calculate the initial activity of the radioactive nuclide.

initial activity = ……………………… Bq [2]

The decaying radioactive nuclide emits an alpha particle as it decays into a stable daughter nuclide Y.

(b) By plotting 3 points on Fig. 6.1, sketch a graph of the variation of number of daughter nuclide Y with time. Show your working clearly.

[2]

(c) Write a complete nuclear equation for the decay process.

[1]

(d) Given that linear momentum is conserved in this decay, show that the ratio $\frac{\text{initial kinetic energy of } \alpha\text{-particle}}{\text{initial kinetic energy of daughter nucleus Y}} = \frac{1}{4}A - 1$ where A is the nucleon number of the decaying radioactive nuclide.

[2]

Section B

Answer **one** question in this section in the spaces provided.

7 **(a)** A glass tube, open at both ends, has fine dust sprinkled along its length. A sound source is placed near one open end of the tube, as shown in Fig. 7.1.

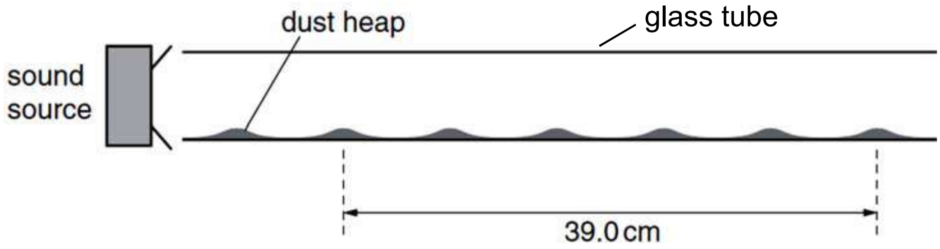

Fig. 7.1

(i) On Fig. 7.1, sketch the form of the stationary wave set up in the tube and mark, with the letter A, the position(s) of any displacement antinode(s) of the stationary wave. [2]

(ii) The distance between six heaps, as shown in Fig. 7.1, is 39.0 cm.

Show that the wavelength of the stationary wave is 15.6 cm.

[1]

(iii) The frequency at which these heaps are formed is 2.14 kHz.

Calculate the speed of sound in the tube.

speed = ……………………… m s^{-1} [2]

(iv) State the fundamental frequency at which a stationary wave can be set up in the tube.

fundamental frequency = ……………………… Hz [3]

(v) State and explain the change, if any, to the dust heaps if the right open end of the tube is blocked with a lid, keeping the frequency at 2.14 kHz.

…………………………………………………………………………………………..

…………………………………………………………………………………………. [2]

(b) Fig. 7.2 shows an arrangement used to determine the speed of microwaves in the laboratory.

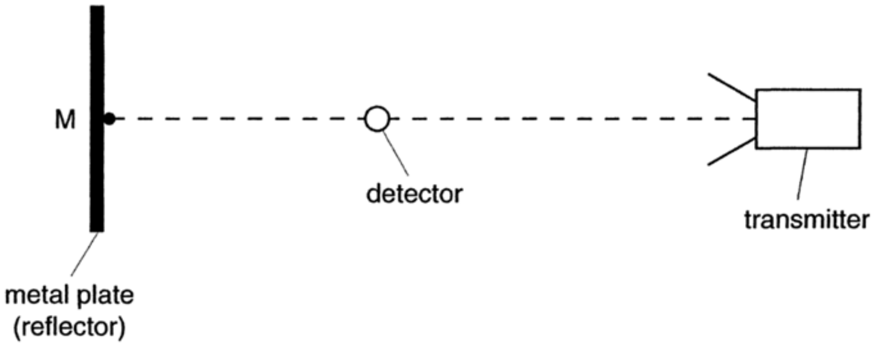

Fig. 7.2

A stationary wave is formed between the metal plate and the transmitter. As the detector is moved along a line between the transmitter and the point M, it registers a series of high intensity signals. The positions of these high intensity signals are marked by crosses on an axis as shown in in Fig. 7.3.

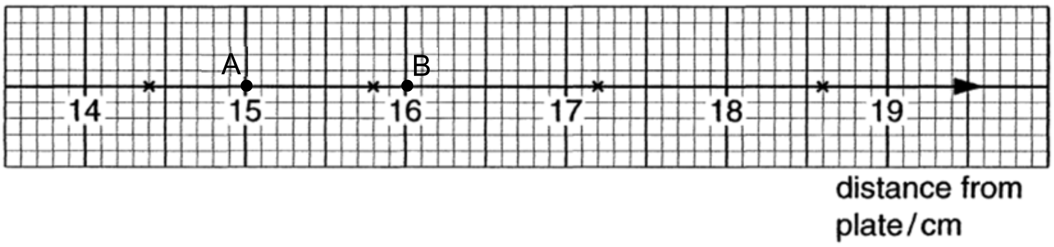

Fig. 7.3

(i) State the phase difference between points A and B.

phase difference = ……………………… rad [1]

(ii) The transmitter emits microwaves of frequency 10 GHz.

Use Fig. 7.3 to deduce an experimental approximation for the speed of the microwaves.

speed of microwaves = ……………………… m s^{-1} [2]

(iii) The detector is now fixed at a position of high intensity.

If the metal plate is moved away from transmitter at a speed of 1.0 cm s^{-1} while the detector is kept stationary, determine the frequency of the high intensity signals registered on the detector.

frequency = …………………… Hz [2]

The metal plate is now removed from the arrangement and a sheet of hardboard is inserted between the detector and the transmitter without either of these being moved as shown in Fig. 7.4. The hardboard is a soft boundary that partially reflects microwaves.

When the hardboard is inserted, the intensity of the wave drops to $\frac{1}{16}$ th of its original value.

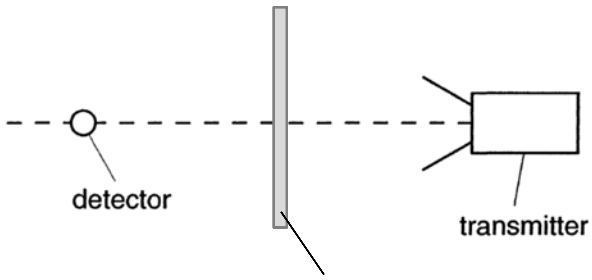

Fig. 7.4

(iv) Calculate the ratio of $\frac{\text{amplitude of detected wave after hardboard insertion}}{\text{amplitude of detected wave before hardboard insertion}}$.

ratio = ……………………… [2]

The metal plate is now placed back in original position as shown in Fig. 7.5.

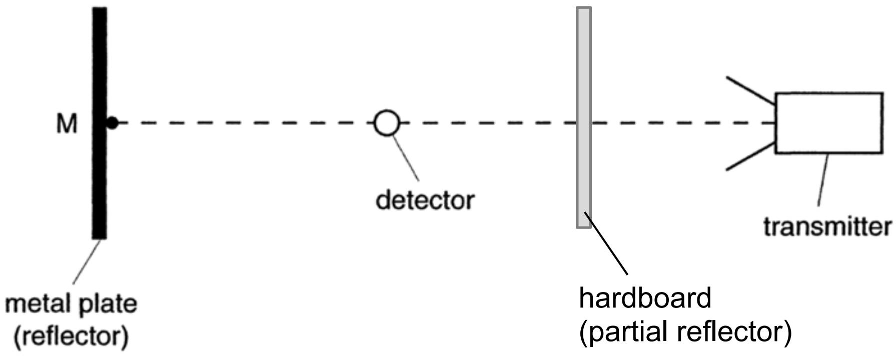

Fig. 7.5

(v) Fig. 7.6 shows the variation of intensity with position as the detector is moved between the transmitter and M at a particular frequency *before* the hardboard is inserted.

Sketch on Fig. 7.6 the variation of intensity with position as the detector is moved between the hardboard and M *after* the hardboard is inserted.

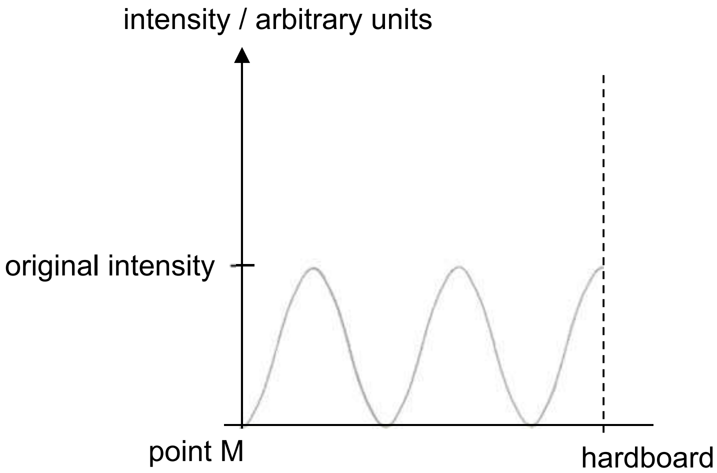

Fig. 7.6

[3]

8 A typical three-phase generator in turbines use for power generation consists of a rotating electromagnet surrounded by three sets of stationary wire coils AA', BB', CC', with angles of 120° between them, wrapped around metal cores to generate electricity, as shown in Fig. 8.1.

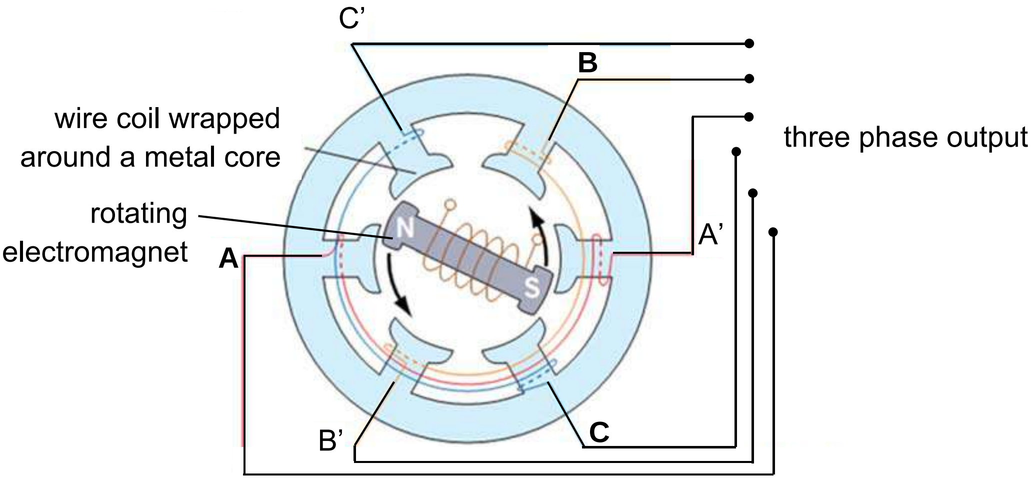

Fig. 8.1

Each set of coils (AA', BB', CC') is a solenoid that consists of wires tightly wound around a rigid metal core as shown in Fig. 8.2.

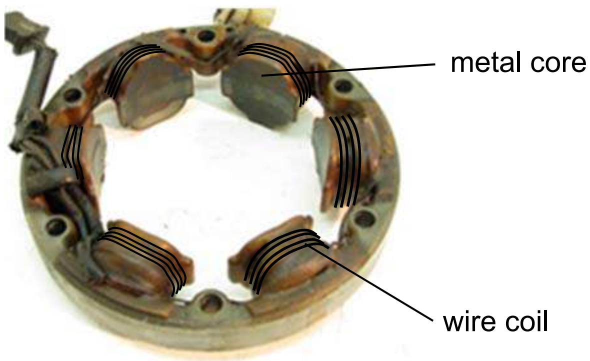

Fig. 8.2

The electromagnet shown in Fig. 8.1 can rotate about the axis perpendicular to the plane of the page, and is connected to turbine blades that rotate the electromagnet at a constant rate such that electricity can be generated in the coils.

(a) State Faraday's law of electromagnetic induction.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

………………………………………………………………………………………………….. [2]

(b) **(i)** Ignoring coils B and C, explain why the rotation of the electromagnet causes a sinusoidal e.m.f. to be induced in coil A.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………… [3]

(ii)

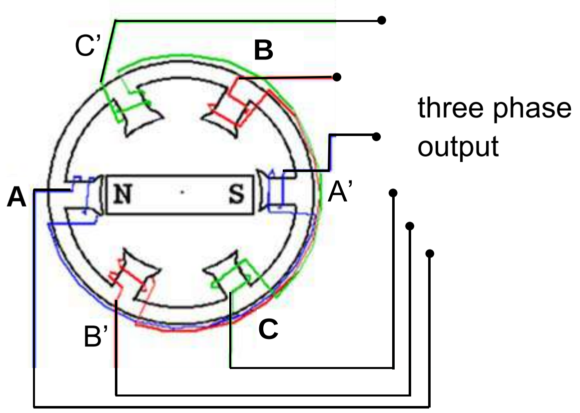

Fig. 8.3

At a particular instant, at time *t* = 0 s, the magnet is aligned with the set of coils labelled AA' as shown in Fig. 8.3.

Set AA' has a total of 500 turns with a diameter 0.10 m. The electromagnet generates an effective uniform magnetic flux density of 0.80 T at the position of the coils when its axis aligns with that of the coils.

Calculate the magnetic flux linkage of the coils at this instant. Give an appropriate unit.

magnetic flux linkage = …………………………… [3]

(iii) The variation with time of magnetic flux linkage of the coil is as shown in Fig. 8.4. The flux linkage varies sinusoidally with time.

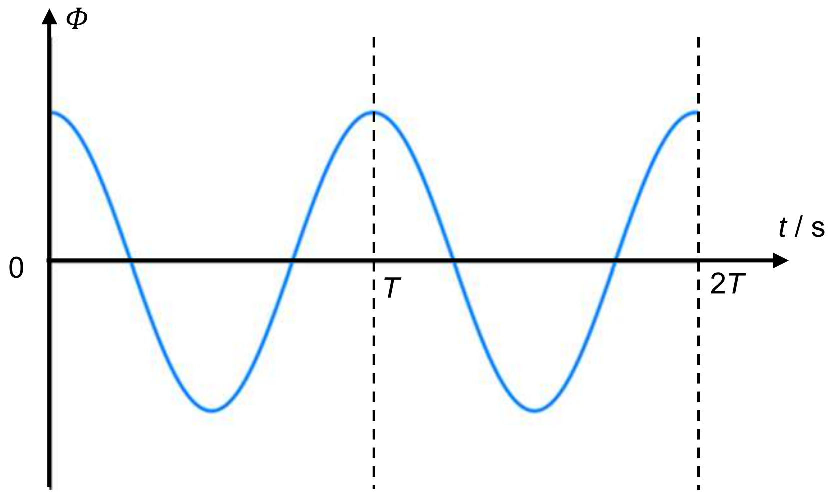

Fig. 8.4

When operating optimally, the magnet makes 1800 revolutions per minute.

Write an expression for the magnetic flux linkage Φ in the coil as a function of time t as shown in Fig. 8.4.

[1]

(iv) Hence, show that the maximum induced e.m.f. in the coil is 590 V.

[2]

(v) On Fig. 8.5, sketch the corresponding graph of the variation with time of induced e.m.f. in the coil AA'. Explain, with reference to Fig. 8.4, the position of maximum induced e.m.f. in your graph.

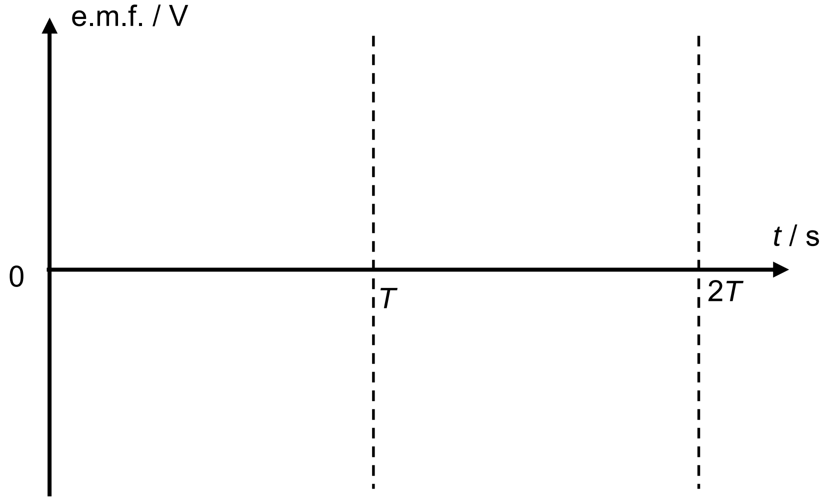

Fig. 8.5

....

....

....

.... [3]

(c) Two additional sets of wire coils BB' and CC' complete the three-phase generator as shown in Fig. 8.3. As the electromagnet rotates anti-clockwise, the induced e.m.f. in coils AA', BB' and CC' are $\frac{2\pi}{3}$ rad out of phase with each another.

On Fig. 8.5, sketch additional graphs to show how the induced e.m.f. in coils BB' and CC' vary with time. Label your sketches clearly.

[2]

(d) The output of the generator is connected to the input of an ideal transformer as shown in Fig. 8.6.

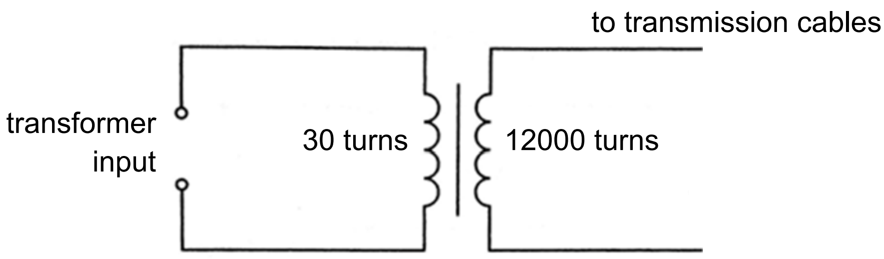

Fig. 8.6

The peak input current is measured to be 20 A. The transformer has 30 turns on its primary coil and 12000 turns on its secondary coil. The secondary coil circuit is connected to transmission cables used for power transmission to homes more than 20 km away.

(i) Explain what is meant by an *ideal* transformer.

…………………………………………………………………………………………………

………………………………………………………………………………………… [1]

(ii) Determine the r.m.s. current in the secondary coil.

r.m.s. current = ……………………… A [2]

(iii) Hence, or otherwise, suggest why the e.m.f. generated is stepped up to high voltages for long distance transmission.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………… [1]

END OF PAPER

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Question 1

Description	Quantity	Remarks
Red LED	1 pc	To replace for each student
LDR	1 pc	To replace for each student
2 V cells	2 pcs	
switch	1 set	
wires	10 pcs	
Digital voltmeter	1 set	
220 Ω resistor	1 pc	
10 kΩ resistor	1 pc	
A4 tracing paper	1 pc	To replace for each student
scissors	1 pc	
4 cm black opaque tube **(straw or shrink tubing)**	1 pc	To replace for each student
micrometer	1 set	
scotch tape	1 pc	
Half meter rule	1 pc	

Question 2

Description	Quantity	Remarks
30-cm plastic ruler (with hole at zero cm mark)	1 pc	
Vernier Calliper	1 set	
Retort stand with clamp	1 set	
Wooden cork that is split into halves	1 set	
Marker pen	1 pc	
Small metal bob	1 pc	
Large metal bob	1 pc	
String (50 cm)	2 pcs	To replace for each student
Half meter rule (shared with Question 1)	1 pc	
Stopwatch	1 set	
Scissors	1 pc	
Mass balance	shared	

Question 3

Description	Quantity	Remarks
Metre-long string with loops at end and centre	1 pc	To replace for each student
Retort stands with clamp	2 set	
Pulley	2 pc	
100 g mass hanger with 100 g mass	2 set	
50 g mass hanger with 50 g mass	1 pc	
20 g mass	5 pc	
Meter ruler	1 pc	
Bricks	2 pc	

RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749
PAPER 4
28 AUG 2018

2 HRS 30 MIN

CANDIDATE NAME											
CENTRE NUMBER	S					**INDEX NUMBER**					
CLASS	6										

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre and index number in the spaces at the top of this page.

Candidates answer on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.

SHIFT	
LABORATORY	
FOR EXAMINERS' USE	
1	**/10**
2	**/ 12**
3	**/ 21**
4	**/ 12**
TOTAL	**/ 55**

This document consists of **19** printed pages.

1 The resistance of a light-dependent resistor (LDR) changes when it is illuminated with light of different intensities.

In this question, you will investigate how the light detected by a LDR depends on the thickness of an absorber.

(a) **(i)** You are provided with a black tube of approximate length of 4 cm.

(ii) Use the tube and clear adhesive tape to make a cylinder that fits over the LDR and the light emitting diode (LED).

Cut the tube into two halves of approximately 2 cm each and fit the 2 tubes over the LDR and LED, as shown in Fig. 1.1.

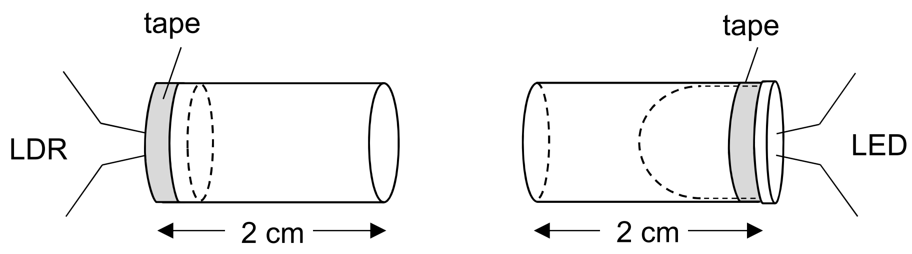

Fig. 1.1

(iii) Connect the circuit as shown in Fig. 1.2. Ensure the longer leg (red) of the LED is connected to the positive terminal of the battery.

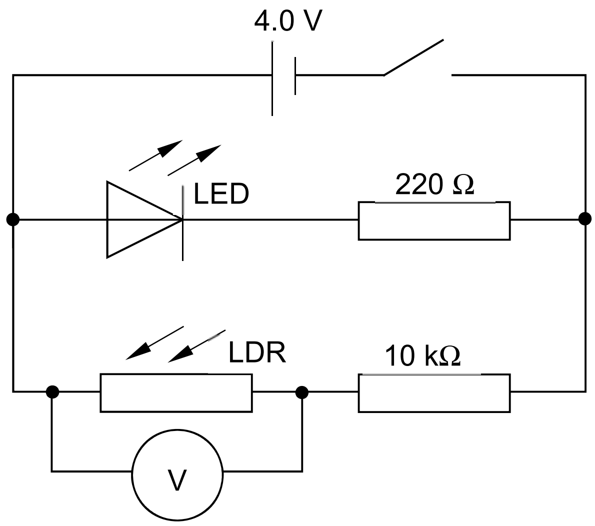

Fig. 1.2

(b) Close the switch and place the cylinders together, as shown in Fig. 1.3.

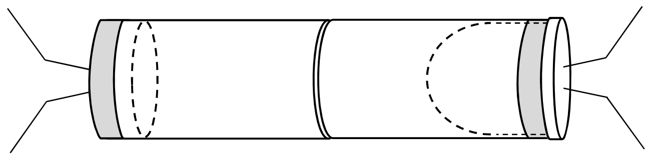

Fig. 1.3

Record the voltage V_0.

V_0 = ... [1]

(c) Fold the sheet of tracing paper in half four times so that you have 16 layers.

(i) Measure and record the thickness of these 16 layers.

thickness of 16 layers = ... [1]

(ii) Hence, calculate the thickness *t* of one layer of tracing paper.

t = ... [1]

(iii) Estimate the percentage uncertainty in your value of *t*.

percentage uncertainty = ... [1]

(d) **(i)** Place four layers of tracing paper between the LED and the LDR as shown in Fig. 1.4.

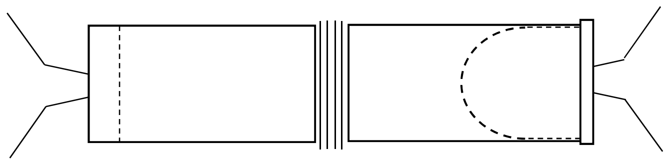

Fig. 1.4

Record the voltage *V*.

V_4 = ……………………………………

(ii) Repeat **(d)(i)** using eight layers of tracing paper.

V_8 = …………………………………… [1]

(e) **(i)** State and explain one significant source of error or limitation of the procedures for this experiment.

………………………………………………………………………………...

………………………………………………………………………………...

……………………………………………………………………………… [1]

(ii) Suggest an improvement that could be made to the experiment and explain how this addresses the error identified in **(e)(i)**. You may suggest the use of other apparatus or a different procedure.

………………………………………………………………………………...

………………………………………………………………………………...

……………………………………………………………………………… [1]

(f) Plan an experiment to investigate how the light detected by a LDR is affected by the angle between the polarising axes of a pair of *unmarked* polarising filters.

Your account should include:

- your experiment procedure
- how you would vary the angle between the polarising axes

…………………………………………………………………………………………..........

…………………………………………………………………………………………..........

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…………………………………………………………………………………………..........

…………………………………………………………………………………………..........

……………………………………………………………………………………….... [3]

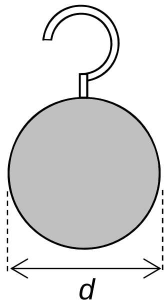
[Total: 10 marks]

2 In this question, you will investigate the oscillation of a pendulum hung from a flexible plastic ruler.

(a) **(i)** Measure and record the mass *m* of the small metal bob.

m = ...

(ii) Measure and record the diameter *d* of the small metal bob as shown in Fig. 2.1. Use a vernier calliper for your measurement.



side view

Fig. 2.1

d = ... [1]

(iii) Calculate the volume *V* of the small metal bob. You may assume the metal bob is spherical in shape.

V = ... [1]

(iv) Calculate the percentage uncertainty of the volume of the small metal bob.

percentage uncertainty = ……………………………… [1]

(b) Tie one end of the string to the small hole on the ruler. Secure the other end of the string to the small metal bob such that *L* is approximately 30 cm as shown in Fig. 2.2.

Ensure the horizontal distance *x* from the centre of the hole to the wooden cork is 25 cm. Use the retort stand to hold the wooden cork such that the ruler is horizontal.

side view

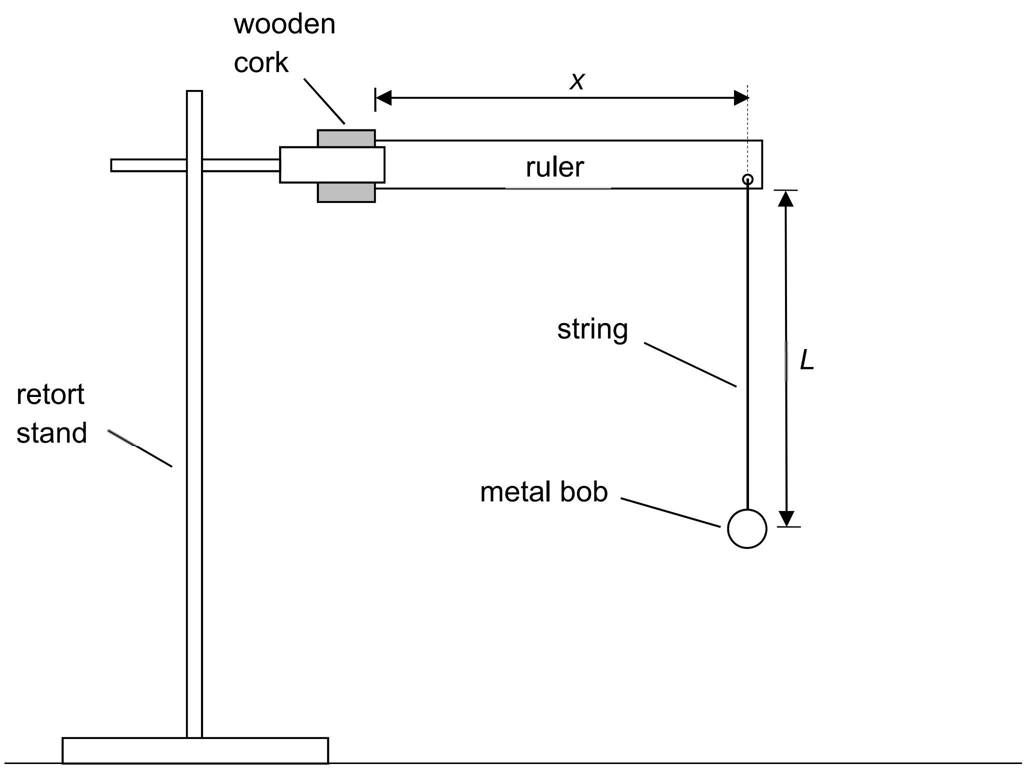


Fig. 2.2

(i) Set the metal bob oscillating by displacing and releasing it as shown in Fig. 2.3.

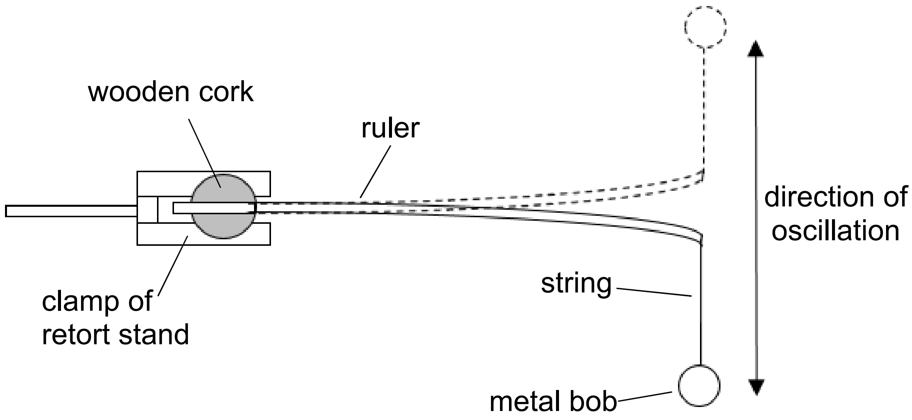
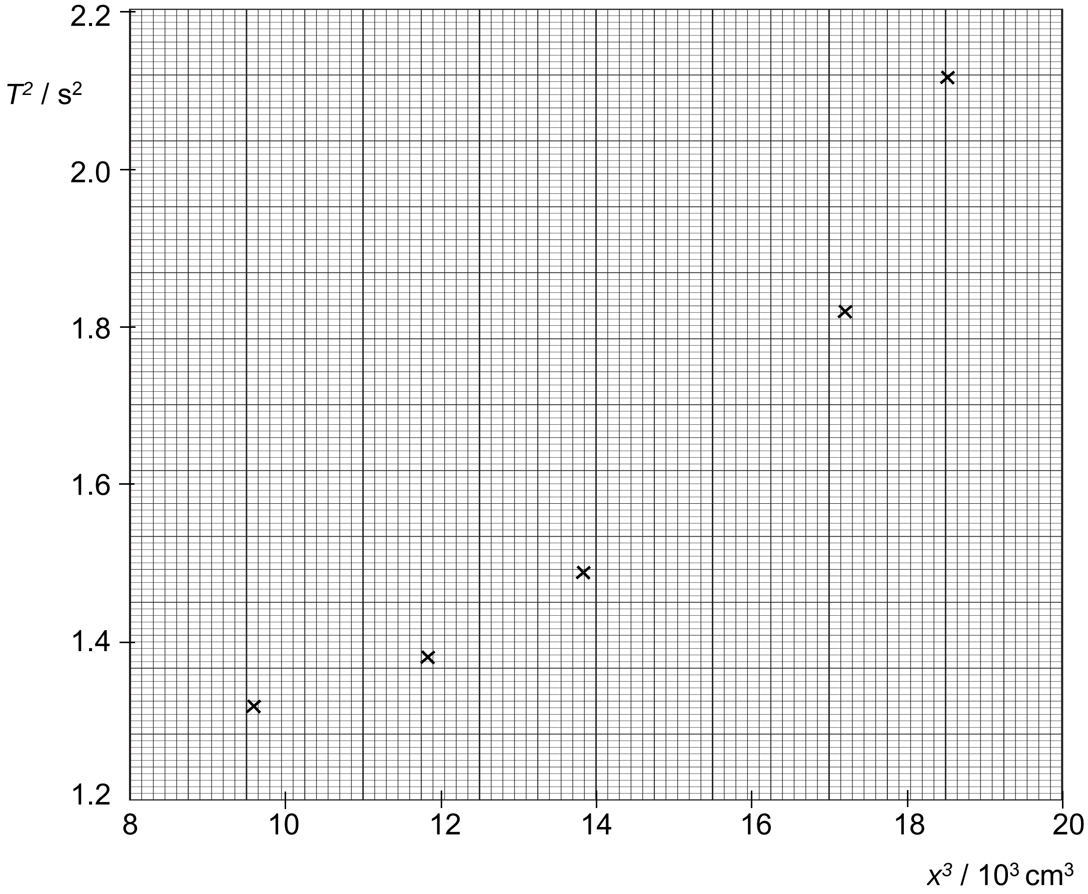


Fig. 2.3

Determine the period *T* of the oscillations. Show your working clearly.

T = …..…………………….. [1]

(ii) Plot the data obtained from **(b)(i)** on the grid and draw the line of best fit.



[2]

(c) **(i)** Remove the small metal bob in the setup and replace it with the large metal bob.

(ii) Repeat **(a)** and **(b)(i)** using the large metal bob instead.

m = ...

d = ...

V = ...

T = ... [2]

(d) It is suggested that $\sqrt{T} = k\dfrac{m}{V}$ where k is a constant.

(i) Use your values from **(a), (b)(i)** and **(c)(ii)** to determine two values for *k*. Give your values for *k* to an appropriate number of significant figures.

first value for k = ……………… $s^{0.5}\ cm^3\ g^{-1}$

second value for k = ……………… $s^{0.5}\ cm^3\ g^{-1}$ [1]

(ii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your value in **(a)(iv)**.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [1]

(iii) Suggest changes that could be made to the experiment to decrease the period of oscillation of the flexible plastic ruler.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [2]

[Total: 12 marks]

3 In this experiment, you will investigate the equilibrium of a mass and pulley system.

(a) Set up the apparatus as shown in Fig 3.1.

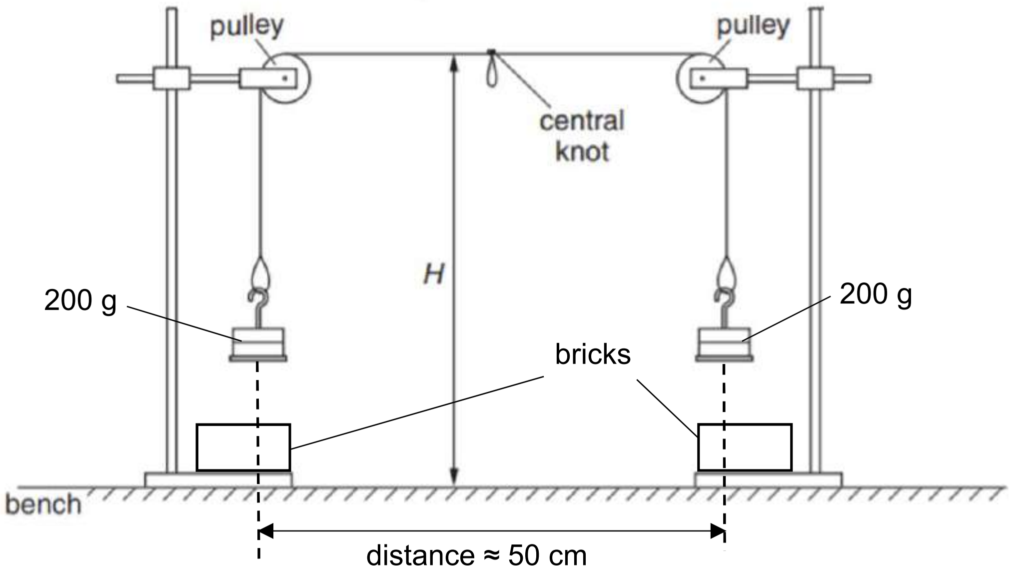


Fig. 3.1

Ensure that the distance between the masses are about 50 cm and the string with the central knot is horizontal with respect to the bench.

(b) Measure and record the height *H* of the central knot above the bench.

H = ………………………….. [1]

(c) **(i)** Suspend 100 g from the central loop as shown in Fig. 3.2.

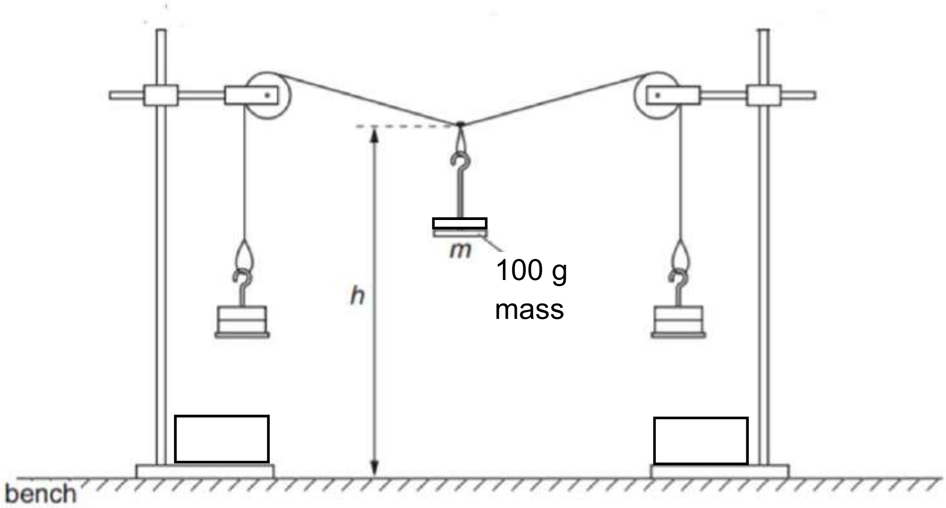


Fig. 3.2

(ii) Record the central suspended mass *m*.

m = ... [1]

(iii) Measure and record the height *h* of the central knot above the bench, as shown in Fig. 3.2.

h = ...

(iv) Calculate the deflection *y*, where $y = (H - h)$ and present it along with the associated uncertainty.

y = ... [2]

(d) Change *m* by adding 20 g masses to the hanger suspended from the central loop and repeat **(c)(ii)**, **(c)(iii)** and **(c)(iv)** until you have six sets of values for *m*, *h* and *y*.

Include in your table of results, values for $^{1}/_{y^2}$ and $^{1}/_{m^2}$.

[6]

(e) Theory suggests that the relationship between *y* and *m* is

$$\frac{1}{y^2} = \frac{p}{m^2} - q$$

where *p* and *q* are constants.

Plot a suitable graph to determine the value for *p* and *q*. Include the appropriate units for *p* and *q*.

p = ……………………………

q = …………………………… [4]

[3]

(f) Comment on any anomalous data or result that you may have obtained.

……………………………………………………………………………………………..……....

……………………………………………………………………………………………..……....

……………………………………………………………………………………….. [1]

(g) **(i)** Suggest two significant sources of error in this experiment.

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

……………………………………………………………………………… [2]

(ii) Suggest an improvement that could be made to the experiment to address one of the errors identified in **(g)(i)**. You may suggest the use of other apparatus or a different procedure.

…………………………………………………………………………………………...

…………………………………………………………………………………………...

……………………………………………………………………………… [1]

[Total: 21 marks]

4 A radioactive source undergoes β-decay, and materials of different densities and thickness may be used to shield the β-particles.

A student suggests that the intensity I of β-radiation passing through a material depends on the density ρ and thickness x of the material.

The relation between the intensity of β-radiation passing through the material, ρ and x may be written in the form

$$I = C\ \rho^m\ x^n$$

where C, m and n are constants.

You are provided with a small sample of strontium-90 which is a β-particle emitter, a Geiger-Muller (GM) tube, a ratemeter and sheets of material of different unknown densities. You may also use any of the other equipment usually found in a physics laboratory.

You may assume that the intensity of β-radiation is directly proportional to the number of β-particles.

Design an experiment to determine the values of C, m and n.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the identification and control of variables,
(b) the equipment you would use, particularly to determine properties of shielding material and the intensity of β-radiation,
(c) the procedure to be followed,
(d) how the values of C, m and n are determined from your readings,
(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

END OF PAPER

[12]

[Total: 12 marks]

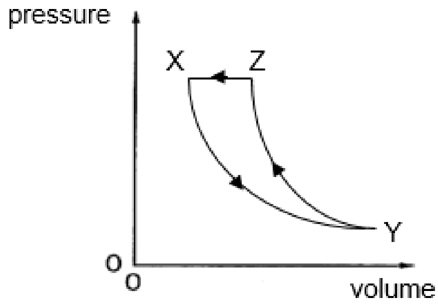
END OF PAPER

Solutions to MCQ

Q1 A	**Q6 C**	**Q11 C**	**Q16 C**	**Q21 D**	**Q26 D**
Q2 B	**Q7 C**	**Q12 C**	**Q17 A**	**Q22 B**	**Q27 A**
Q3 B	**Q8 A**	**Q13 D**	**Q18 C**	**Q23 A**	**Q28 B**
Q4 D	**Q9 C**	**Q14 A**	**Q19 B**	**Q24 D**	**Q29 B**
Q5 D	**Q10 D**	**Q15 B**	**Q20 D**	**Q25 A**	**Q30 D**

1	**Answer: A** Unit of v = m s^{-1} Unit of $\frac{\Delta P}{\rho} = \frac{\text{kg m s}^{-2}\text{ m}^{-2}}{\text{kg m}^{-3}} = \text{m}^2\text{ s}^{-2}$ $\left(\text{m}^2\text{ s}^{-2}\right)^n = \text{ms}^{-1}$ So n = $\frac{1}{2}$
2	**Answer: B** Let x be the distance travelled by A and B. Ball A: x = vt – 0.5gsinθ t^2 --- (1) Ball B: x = 0.5gsinθ t^2 --- (2) Solving (1) and (2), v = g(sin30°)(2) = 9.81 m s^{-1}
3	**Answer: B** Using Newton's second law, For the ball moving vertically upwards, – D – mg = ma a = $-\frac{D}{m} - g$ Drag force, D will reduce as speed of ball decreases when it is moving upwards. Hence, deceleration becomes less negative over time until it reaches the highest point.

4	**Answer: D** There is no vertical resultant force when the ball is still on the surface since the normal contact force balances the weight of the ball. When the ball is in mid-air, drag force opposes the motion of the ball which decreases the vertical resultant force.
5	**Answer: D** Moment provided by fish = force × perpendicular distance of line of action from the pivot, P = 150 × 2.0 sin75° = 289.8 N m
6	**Answer: C** Since the balloon is in equilibrium, upthrust on balloon = weight of balloon and helium + force by spring $$\rho_{air}V_{balloon}g = \rho_{helium}V_{balloon}g + m_{balloon}g + kx$$ $$(1.29)(5.0)g = (0.180)(5.0)g + (\frac{3.5}{1000})g + (100)x$$ x = 0.544 m
7	**Answer: C** When rocket is moving horizontally at constant speed, Thrust force F = Drag force P = Fv 28000 = 760v v = 36.84 m s^{-1} When rocket is moving vertically at constant speed, Thrust force F = Drag force + Weight of rocket = 760 + (90)(9.81) = 1642.9 N P = Fv = (1642.9)(36.84) = 60.5 kW
8	**Answer: A** When both chambers are in pressure and thermal equilibrium, $\frac{P_1}{T_1} = \frac{n_1R}{V_1} = \frac{P_2}{T_2} = \frac{n_2R}{V_2}$ $$\frac{n_1R}{V_1} = \frac{n_2R}{V_2};\ \frac{n_1}{n_2} = \frac{V_1}{V_2} = \frac{AL_1}{AL_2} = \frac{L_1}{L_2}$$ where *A* is the cross-sectional area of the cylinder. Hence the ratio of the lengths is equal to the ratio of the number of mol of gases $$\frac{n_1}{n_2} = \frac{\frac{20 \times 10^{-3}}{28}}{\frac{45 \times 10^{-3}}{4}} = 0.063$$

9	**Answer: C** ZX is a compression at constant pressure. An adiabatic compression will be accompanied by an increase in temperature of the system while adiabatic expansion will be accompanied by a decrease in temperature of the system. If XY is an isothermal expansion, then process YZ will be moving from a point of lower temperature to higher temperature, which is true, since there is a compression. 
10	**Answer: D** The vertical component of the acceleration is the centripetal acceleration which is present since the particle is performing circular motion. The horizontal component of the acceleration causes the speed of the object to increase.
11	**Answer: C** The antenna will have the same speed as the space-craft and is still bound in orbit. There is still gravitational force acting on it which causes it to move in circular motion.
12	**Answer: C** Since gravitational potential energy of satellite becomes less negative, there is an increase in potential energy and the satellite is moved further from the Earth. $\text{Increase in gravitational potential} = \dfrac{-1600-(-4800)}{80}$ $= 40 \text{ MJ kg}^{-1}$
13	**Answer: D** Since $v = \omega x_0 = 6.0$ m s^{-1} and $\lvert a \rvert = \omega^2 x_0 = 2.0$ m s^{-2}, $\omega = \lvert a \rvert / v = 2.0 / 6.0 = 0.333$ rad s^{-1}; $T = 2\pi / \omega = 18.9$ s $x_0 = v / \omega = 6.0 / 0.333 = 18.0$ m
14	**Answer: A** An oscillating system will have the same frequency as that of the periodic force applied to it. Thus the system will have a frequency of 2.0 Hz after being subjected to the force (Period = 1/2.0 = 0.50 s The time taken for it to go from one maximum displacement to the next is half a period (0.50 / 2 = 0.25 s)
15	**Answer:** B decrease *f*, λ increases so more diffraction distractor C: student mixed up $v = f\lambda$ decrease *v*, *f* constant, λ will decrease so less diffraction. distractor D: student may mistake larger amplitude for larger λ distractor A: decrease density, decrease speed of waves in water, same as C.

16	**Answer : C** ½ wavelength (peak to peak) = 33.4 cm = 0.334 m speed = 334 m s^{-1} Hence frequency = 334 / (2 x 0.334) = 500 Hz So period = 1/500 = 2.00 ms 1 cm ~ 0.5 ms 1 wave / period ~ 4 cm
17	**Answer: A** Let V_R = 0 V. V_Q = 6 V $V_P - V_Q = 3\text{ V} \Rightarrow V_P = 9\text{ V}$ $V_P - V_S = 5\text{ V} \Rightarrow V_S = 4\text{ V}$ Hence, V_{QS} = 6 – 4 = 2 V and V_{SR} = 4 – 0 = 4 V
18	**Answer : C** $I = nqvA$ $= (8.5\times10^{28})(1.60\times10^{-19})(2.3\times10^{-5})(8.6\times10^{-6})$ $= 2.5\text{ A}$
19	**Answer: B** Suspended, no net force, $F_E = F_G$ $qE = mg$ $q\dfrac{\Delta V}{seperation} = mg$ $V - 0 = \dfrac{mg(2d)}{q}$ D: if students use electric potential equation C: students think F_E = qV A: memorisation of V/d without considering d is separation
20	**Answer: D** $F_E = -\dfrac{dU}{dr}$ Gradient increases then decreases A: there are forces, just no net force B: strongest repulsion, not attraction C: EPE must increase, not decrease
21	**Answer: D** $(R_{XY})^{-1} = \left(R+\dfrac{3R\times R}{3R+R}+R\right)^{-1} + R^{-1}$ $R_{XY} = \dfrac{11}{15}R$

22 **Answer: B**

At null point, $\frac{R}{2R}E_2 = \frac{3R}{3R+2R+R}E_1$

Hence $\frac{E_1}{E_2} = 1.0$

23 **Answer: A**

$B = \frac{\mu_0 I}{2\pi r}$

$F_{\text{onR}} = BI_R L = \frac{\mu_0 I}{2\pi r} I_R L$

For F due to P = F due to Q: $\frac{\mu_0 I_P}{2\pi r_P} I_R L = \frac{\mu_0 I_Q}{2\pi r_Q} I_R L$

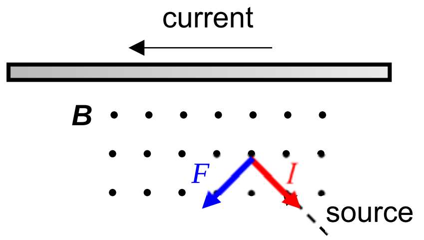
Therefore $\frac{r_P}{r_Q} = \frac{I_p}{I_q}$ (does not depend on I_R nor direction of current)

Since I_Q is twice I_P, $\frac{r_P}{r_Q} = \frac{1}{2}$

So position must be x to the left of P so that $\frac{r_P}{r_Q} = 0.5$

24 **Answer: D**

In a direction at 90° to the original path away from the wire



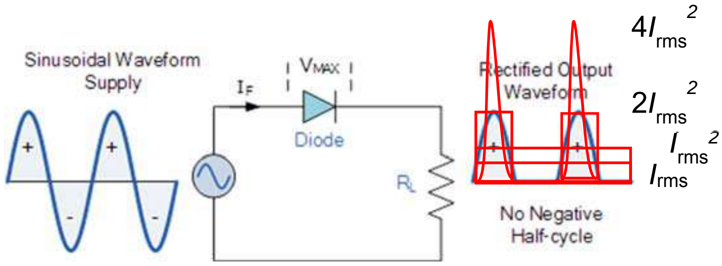
25 **Answer: A**

$$v = r\omega = 2\pi f r$$
$$f = \frac{v}{2\pi r}$$
$$\varepsilon = B\pi r^2 f$$
$$\varepsilon = \frac{B\pi r^2 v}{2\pi r} = \frac{Brv}{2} = \frac{Bdv}{4}$$

26 **Answer: D**

2 I

$$I_{rms} = \frac{I_0}{2}$$



27	**Answer: A** Using KE = $\frac{1}{2}mv^2$ = $\frac{p^2}{2m}$, $\frac{h^2}{2m\lambda^2} \rightarrow mv \propto \frac{1}{\lambda}$. $\frac{\lambda_p}{\lambda_e} = \frac{m_e}{m_p}\frac{v_e}{v_p} = 2.5 \times 10^{-4}$
28	**Answer: B** Using $\frac{hc}{\lambda} = \phi + E_{k,max}$, $\frac{(6.63 \times 10^{-34})(3 \times 10^8)}{(80 \times 10^{-9})} = (2.6)(1.6 \times 10^{-19}) + \frac{1}{2}(9.11 \times 10^{-31})v^2$ $v = 2.1 \times 10^6$ m s^{-1}
29	**Answer: B**
30	**Answer: D**

PRELIMINARY EXAMINATIONS 2018

H2 PHYSICS 9749/2 MARKSCHEME

1 **(a)** $R = \frac{V}{I}$ **and** $R = \frac{\rho L}{A}$**, hence** $\frac{V}{I} = \frac{\rho L}{A} \Rightarrow \rho = \frac{VA}{IL} = \frac{\pi V d^2}{4IL}$

(b) $\rho = \frac{\pi V d^2}{4IL} = \frac{1.50 \times \pi \times (0.48 \times 10^{-3})^2}{4 \times 0.82 \times 0.632} = 5.23 \times 10^{-7}\,\Omega$ m

$$\frac{\Delta\rho}{\rho} = \frac{\Delta V}{V} + \frac{\Delta I}{I} + \frac{\Delta L}{L} + 2\frac{\Delta d}{d} = \frac{0.01}{1.50} + \frac{0.01}{0.82} + \frac{0.1}{63.2} + 2\frac{0.02}{0.48} = 0.1037$$

$$\Delta\rho = 0.1037\rho = 0.1037 \times 5.23 \times 10^{-7} = 0.54 \times 10^{-7} \approx 0.5 \times 10^{-7}\,\Omega\text{m}$$

Hence, $\boldsymbol{\rho = (5.2 \pm 0.5) \times 10^{-7}\,\Omega}$ **m**

2 **(a)** Conditions for equilibrium:

1. The net/resultant force acting on the body must be zero.
   $\sum F = 0$ -- *Translational Equilibrium*

2. The net/resultant torque about any point must be zero.
   $\sum \tau = 0$ -- *Rotational Equilibrium*

No marks awarded if only equations are given.

(b) **(i)**

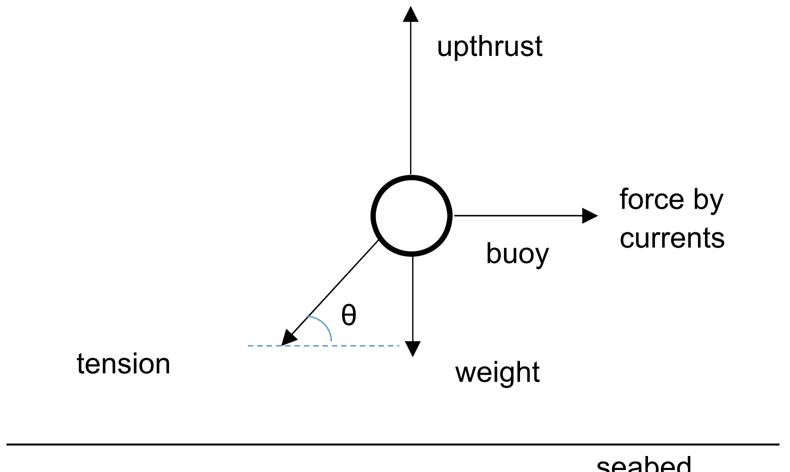


Fig. 2.1

Correct directions (components of the forces should be in all 4 directions) and θ

Correct labelling for the forces identified

Approximate length in both vertical and horizontal directions are the same, both marks awarded. If not, deduct 1.

(ii) $F = kx = 500 \times 2.5 = 1250$ N

(iii) When the buoy was initially at equilibrium, the resultant of the weight and upthrust is equal to the tension by the rope; $T + W = U \rightarrow U - W = T$

$F_{resultant} = kx = 500 \times 1.8 = 900$ N

(iv) The tension by the rope in (b)(ii) is equal in magnitude to the resultant of the force by currents, weight and upthrust

Force by currents = $\sqrt{1250^2 - 900^2} = 867.5$ N = 868 N (3 s.f.)

(c) $\theta = \tan^{-1}$ (900/867.5)

= 46.1° (3 s.f.)

If a different θ is labelled in previous diagram, e.c.f.

3 (a) (i) Gravitational potential at a point is defined as **work done per unit mass** by an external agent to **move a test mass from infinity to that point** in the gravitational field (without a change in kinetic energy)

(ii) Gravitational potential at **infinity is defined as zero** and since gravitational force is attractive,

work done by external agent to move an object from infinity to a point in the gravitational field **is negative**, so potential is negative

(b) The **gradient of the potential–displacemen**t graph gives the gravitational **field strength, which is a vector**, thus, **the sign indicates the direction** of the gravitational field strength

Near the earth, the net gravitational field strength is directed towards the earth due to its larger influence than the moon while **near the moon, the net gravitational field strength is directed towards the moon** due to its larger influence. Hence, **their sign are opposite**

(c) (i) 1. Since the gravitational force the planet exert on moon A and B provides the centripetal force for them to rotate about the planet,

$$\frac{GM_pM_A}{r_A^2} = \frac{M_{A}v_A^2}{r_A}$$ (together with statement for B1)

$$\frac{GM_p}{r_A} = \frac{v_A^2}{1}$$

Since GM_P are constant, $v_A^2 \alpha 1/r$,

$v_A / v_B = (r_B / r_A)^{1/2}$

$= (2.2 \times 10^{10} / 1.3 \times 10^8)^{1/2}$

$= 13$ (13.0)

Fractions not accepted

2. $v = 2\pi r / T$

$v \propto r / T$

$T_A / T_B = (r_A / r_B) \times (v_B / v_A)$

$= (1.3 \times 10^8 / 2.2 \times 10^{10}) \times (1 / 13)$

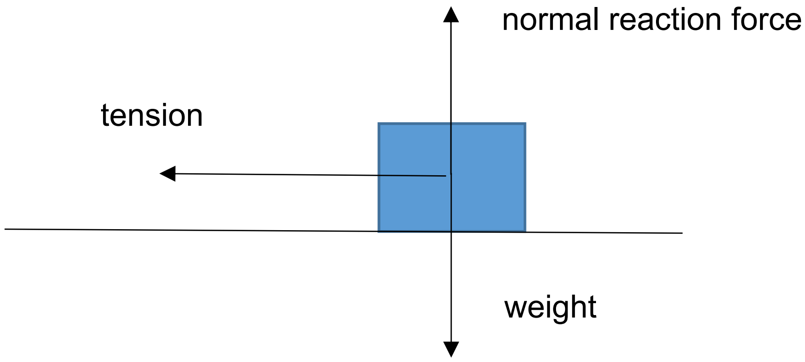
$= 4.5 (4.54) \times 10^{-4}$

(ii) $T = 2\pi / 1.7 \times 10^{-4} = 3.70 \times 10^4$ s

$T_B = 3.70 \times 10^4 / 4.54 \times 10^{-4}$

$= 8.1 \times 10^7$ s

4 (a) (i)



ma = – *kx*
a = – (*k* / *m*) *x*

Since the resultant force on P is the elastic force by the spring, the acceleration on P is directly proportional to the displacement of P from the equilibrium position.

Or **tension is directly proportional to displacement** from equilibrium position and is the resultant force (Second B1 mark)

The negative sign also shows that the direction of acceleration is always directed towards the equilibrium position.

(ii)
$$\omega^2 = \frac{k}{m}$$
$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{5}{100}}$$
= 1.405 s
= 1.4 (2 s.f.)

(b) (i) Loss in elastic potential energy = Gain in kinetic energy

$$\frac{1}{2}kx^2 = \frac{1}{2}(M+m)v^2$$
$$\frac{1}{2}(100)(0.2)^2 = \frac{1}{2}(5.0+3.0)v^2$$
$$v = 0.707\ m\ s^{-1}$$

(ii) Gain in elastic potential energy = Loss in kinetic energy

$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$$
$$\frac{1}{2}(100)(x)^2 = \frac{1}{2}(5.0)(0.707)^2$$
$$x = 0.158\ m$$

OR

$$v = \omega x_0$$
$$0.7071 = \frac{2\pi}{1.405}x_0$$
$$x_0 = 0.158\ m$$

(iii) Distance travelled by Q in quarter of a period
= 0.707 × 0.25(1.405) = 0.2484 m

Distance apart = 0.2484 – 0.1581 = 0.0903 m = 0.090 m (2 s.f.)

(c) The frequency will be <u>lower</u> since period will be longer according to $T = 2\pi\sqrt{\frac{m}{k}}$

Amplitude will be <u>same</u> since maximum elastic potential energy of system remains the same.

5 (a) E.m.f. is the **amount of energy transferred from non-electrical forms to electrical energy per unit charge** as it passes through a complete circuit while

p.d. is the **amount of electrical energy converted to other forms per unit charge** delivered between 2 points.

(b) (i) 0.01 V

(ii) Internal resistance reduces the terminal potential difference of the battery. Since the output power is proportional to its terminal p.d., the presence of internal resistance reduces the output power of the battery.

OR There is some power loss due to power dissipated due to the internal resistance.

(c) (i) 12.00 = I_1 (r +R) where I_1 r = 0.01 V and I_1 R = 11.99 V
Hence R = 1199 r,

(ii)
Also 12.00 = I_2 (r + R + 1000) where I_2 R = 11.00 V
Using R = 1199 r,
Hence I_2 (1199 r) = 11.00 V ⇒ I_2 r = 0.009174 V
1000 I_2 = 12.00 – 11.00 - 0.009174 = 0.9908 V
$I_2 = 9.908 \times 10^{-4}$ A

From 12.00 = 9.908 x 10^{-4} (r + 1199 r + 1000) $\Rightarrow$ r = 9.26 Ω

And R = 11100 Ω

6 **(a)** Loss in EPE of the E- field = Gain in KE of the electron

$qV = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2(1.6\times10^{-19})(1000)}{(9.11\times10^{-31})}}$

$= 1.8742 \times 10^7$ m s^{-1} = 1.87×10^7 m s^{-1}

(b) constant horizontal velocity as no horizontal accelerating forces (for vertical plates) (similar to projectile motion where horizontal velocity is usually constant).

time taken = $\frac{6.0\times10^{-2}}{1.8742\times10^7}$

= 3.20 ns (3 sf)

= 3.2 ns (2 sf)

Must show substitution and +1 sf to get M1

Allow e.c.f.

(c) Actual p.d. across plates = $5.0 \times 20 = 100$ V

Electric field strength $E = \frac{V}{d} = \frac{100}{4.0\times10^{-2}} = 2500$ N C^{-1}

Vertical acceleration = $\frac{qE}{m} = \frac{(1.6\times10^{-19})(2500)}{9.11\times10^{-31}} = 4.390770 \times 10^{14}$ m s^{-2}

Vertical velocity upon exiting vertical deflection plates

= $u + at = (4.39 \times 10^{14})(3.2 \times 10^{-9})$ = 1.405×10^6 m s^{-1}

Time taken for rest of 14 cm = $\frac{14\times10^{-2}}{1.874\times10^7} = 7.470 \times 10^{-9}$ s

Vertical displacement for first 6.0 cm

= $\frac{1}{2}at^2 = \frac{1}{2}(4.390770 \times 10^{14})(3.2 \times 10^{-9})^2$ = 2.248×10^{-3} m

Vertical displacement for next 14.0 cm

= $ut = (1.405 \times 10^6)(7.470 \times 10^{-9})$ = 1.0495×10^{-2} m

Distance between vertical divisions

= $1.0495 \times 10^{-2} + 2.248 \times 10^{-3}$ = 1.274×10^{-2} m

= 1.3×10^{-2} m

(d)
- smaller amplitude / deflection
- because <u>same charge, same force, but larger mass</u> (1000x), so deflection would be smaller

OR
- waveform is compressed horizontally
- because <u>same charge, same force, but larger mass</u> (1000x), so the applied voltage will not be sufficient to deflect the electron beam to the extreme ends.

OR
- waveform is inverted / reflected about the x-axis (timebase axis) <u>and</u> y-axis (voltage gain axis)
- because <u>opposite charge, deflection will be in the opposite direction</u>

7 (a) (i) Since the 4 branches have the same p.d., they are in parallel arrangement.

$$\frac{1}{R} = \frac{1}{20} + \frac{1}{40} + \frac{1}{20} + \frac{1}{40}$$

$$R = 6.66\ \Omega$$

(ii) Consider power delivered to each of the lamps,

$$P = \frac{V^2}{R}$$

For M and P, $P = \frac{E^2}{20}$

Consider lamps *N*, *O*, *Q* and *S* individually,

$$P = \frac{(0.5E)^2}{20}$$

Therefore M and P are brightest, N, O, Q and S are less bright (quarter brightness)

(b) (i) Using potential divider rule,

$$\left(\frac{1.5}{1.0 + 5.0 + 1.5}\right) 9.0 = V_{AB}$$

$$V_{AB} = 1.8\ \text{V}$$

(ii) 0 A in galvanometer: $V_{AD} = 1.5\ \text{V}$

Using potential divider rule,

$$\frac{1.5}{1.8} = \frac{L_{AD}}{0.800}$$

$$L_{AD} = 0.67\ \text{m}$$

(iii) When the $5.0\ \Omega$ resistor is replaced by a $3.0\ \Omega$ resistor, the p.d. across wire AB will be larger than 1.8 V and hence the balance length of AD will be shorter than in (b)(ii).

8 **(a)** **(i)** $a_x = [0.1 + 0.85(1.0 - 0.2)].g = 7.65 = 7.7 \text{ m s}^{-2}$

(ii) Using $v^2 = u^2 + 2as$,

$$0 = \left(\frac{50000}{3600}\right)^2 + 2(-7.65)s$$

$$s = 12.61 = 12.6\, m$$

(ii) The minimum deceleration will decrease as wet surfaces reduce the frictional force acting on the tyre.

Hence, the braking distance will increase.

(iv)
- Driver and passagers may experience discomfort in travelling in the vehicle.
- Tailgating vehicles may not brake in time and may result in collision.
- Tyre will wear out faster.

(b) **(i)**

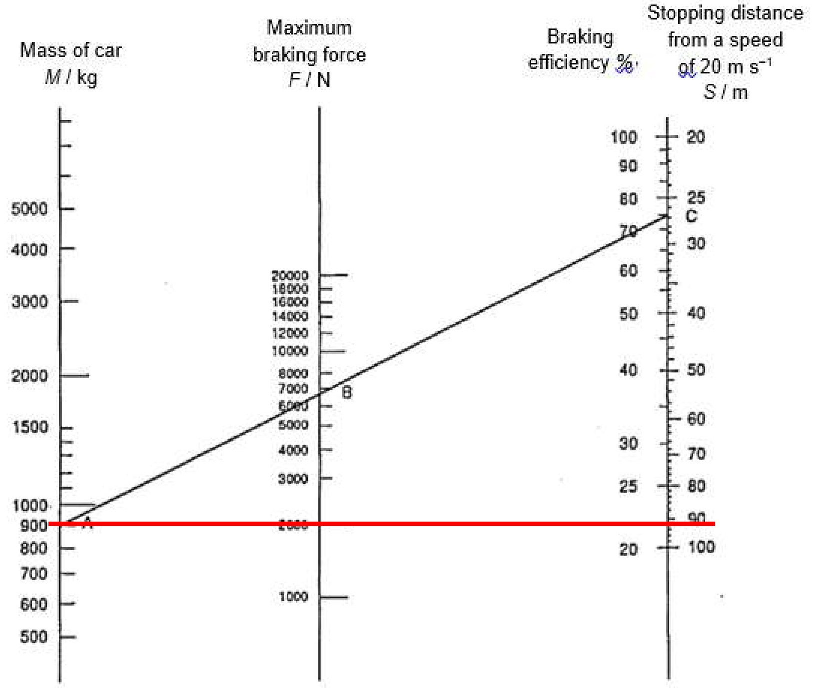


Fig. 8.1

(ii) 22 % , [or 22.5%]

(iii) 22 = (deceleration/9.81) x 100

deceleration = 2.16 m s^{-2}

or

F = ma

2000 = 900 a

a = 2.22 m s^{-2}

(iv) Using F = ma,

6700+2000 = (900)a

a = 9.67 m s^{-2} = 9.7 m s^{-2}

(v) Not advisable.

- The driver needs to use both his hands to control the steering wheel when braking at high speed. Hence, he should not use his hand to activate the handbrake.
- The car may skid as the car is not designed for both foot brake and hand brake to be used at the same time.

(c) **(i)** 38.0 m [allow 37.0 m to 39.0 m]

(ii) Point plotted correctly with best fit line drawn

(iii) Explain that work done is product of force and displacement coordinates in the graph. The coordinate is (9000, 29)

Work done = 9000 x 29 = 2.61 x 10^5 J
[to present answer in standard form]

Assumption: the braking force is constant throughout the deceleration.

(d) **(i)** Using Fig. 8.1, the braking efficiency is 87.5% for braking force of 12000 N. [allow 85% to 90%]

Hence, the deceleration of car = 0.875 x 9.81 = 8.58 m s^{-2}

Force = ma
= (70)(8.58)
= 600 N

(ii) v = u + at ,
0 = 20 + (-8.58)t
t = 2.3 s

The reaction time for the passengers could be longer than 2.3 s as he was sleeping and would not be able to react quickly when the car was braking.

<u>OR</u>

The force to restrain the passage could be too large at 600N.

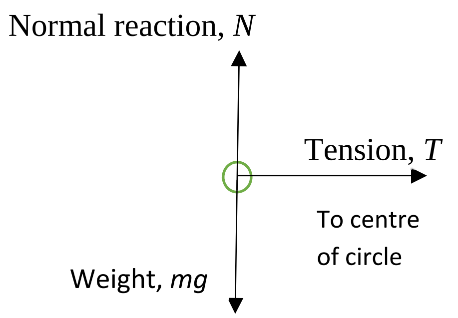
Section A

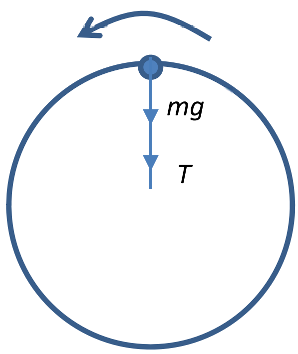
Answer **all** the questions in this Section in the spaces provided.

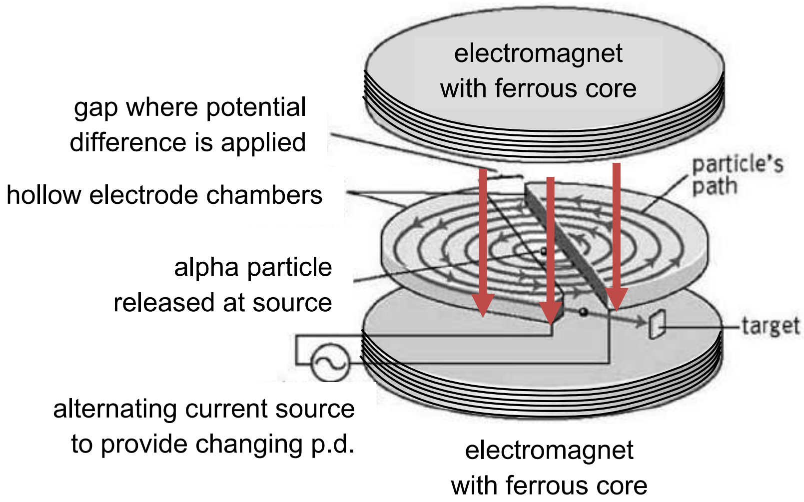
1	**(a)**		Work done on object = Fs Net force = ma So net work done on object = mas Equation of motion: $v^2 = u^2 + 2as$ For $u = 0$, $s = v^2/2a$ $= m((v^2 - u^2)/2)$ $= ½ mv^2$ (since $u = 0$) Work done = gain in kinetic energy So KE = $½ mv^2$	
	(b)	**(i)**	Work done = power x time = (37000)(11) = 407 kJ (3 sf) [need to show calculated raw value of 407] = 410 kJ (2 sf)(shown)	
		(ii)	Using $P = Fv$, and driving force = resistive forces at maximum speed. (37000/2) = 1200v v = 15.4 m s^{-1} [Cannot assume the car travels for 11 seconds]	

2	**(a)**	**(i)**	Internal energy of a system is the sum of the random distribution of kinetic and potential energies associated with the molecules of the system	
		(ii)	There is no exchange of materials with the environment.	
		(iii)	Flow (transfer) of thermal energy (OR thermal energy in transit).	
	(b)	**(i)**	$W = 0$ since the gas is expanding into a vacuum and $Q = 0$ since container is insulated, therefore change in $U = 0$ Since U is proportional to T, change in $T = 0$	
		(ii)	$P_1 / P_2 = V_2 / V_1$ ratio = 3	
	(c)	**(i)**	A to B & D to A: Heat supplied to B to C & C to D: Heat supplied from	

		(ii)	$$\Delta U = {}^{3}/_{2}\, n R \Delta T$$ $$\Delta U = {}^{3}/_{2}\, nR(2T) = 3nRT$$	
		(iii)	$Q_{A \to B} = -nRT ln\frac{V_i}{V_f} = nRT ln\frac{V_f}{V_i} = nR(3T)ln2$ $Q_{C \to D} = -nRT ln\frac{V_i}{V_f} = -nRT ln2$ For the other two process, the net heat supplied to system sums to be zero, so they can be excluded from calculations. $$Q_{net} = 3nRT ln2 - nRT ln2 = 2ln2\, nRT = 1.38\, nRT$$	
		(iv)	$e = \frac{W}{Q}$ $e = \frac{2ln2\, nRT}{(3ln2 + 3)nRT}$ $= 0.273$	

3	(a)		 Side view of forces acting on the mass.	
	(b)		Tension provides centripetal force for circular motion: $\frac{mv^2}{r} = kx$ = (40) (0.70-0.50) = **8.0 N** $v = \sqrt{\frac{(8.0)(0.70)}{0.050}}$ = **10.6 m s^{-1} = 11 m s^{-1}**	[

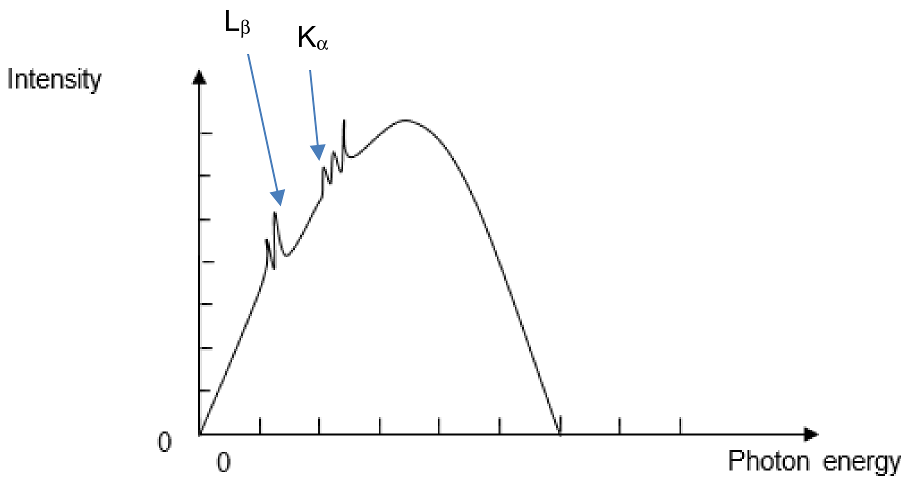
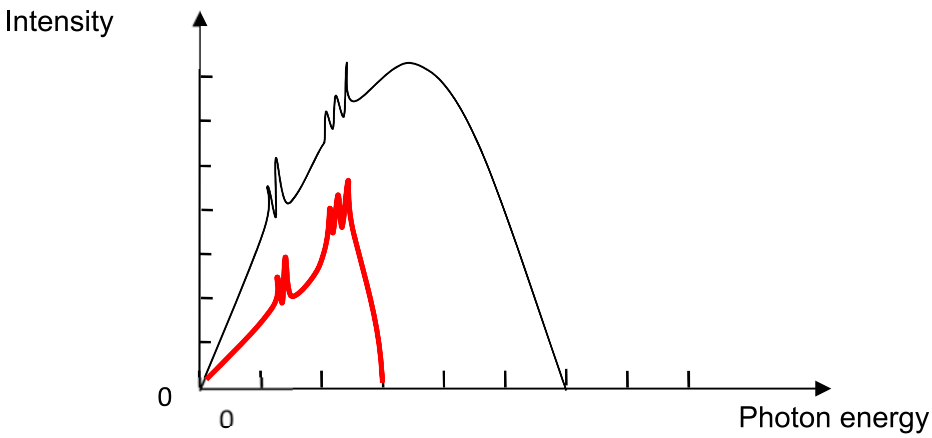
	(c)		 Consider the object moving in a circular path in a vertical plane. For circular motion of the object, $T + mg = \frac{mv^2}{r}$ where *T* and *m* are the tension in the string and the mass of the object respectively. To just become slack, the tension in the string just drops to zero [alternative M1]. Hence $mg = \frac{mv^2}{r}$ $v_{min} = \sqrt{rg}$ (or $\sqrt{9.81r}$ or $3.13\sqrt{r}$)	

4	(a)		region of space where a magnetic pole (or magnet), moving charged particle or current-carrying conductor will experience a magnetic force	
	(b)			

	(c)	**(i)**	Magnetic force provides for centripetal force for particles to move in a circular path: $\frac{mv^2}{r} = qvB$ $r = \frac{mv}{qB}$ Mass of alpha particle = 4u Charge of alpha particle = +2e $$r = \frac{4\text{u}v}{2\text{e}B} = \frac{2\text{u}v}{\text{e}B}$$ Correct substitution of both mass and charge in terms of u and e	
		(ii)	Only dependent variable is velocity as *B*, u and e are constant. Each time ions pass between, they are accelerated by the electric field due to potential difference between the dees. OR gains kinetic energy from potential difference (from electric potential energy) The velocity increases, therefore radius increases.	
	(d)		Magnetic flux density at centre of solenoid is given by $B = \mu_0 nI$ $B = (4\pi \times 10^{-7})\left(\frac{3100}{0.39}\right)(200)$ $B = 1.998$ T = 2.0 T (shown)	

	(e)		Magnetic force provides for centripetal force for particles to move in a circular path: $mv\omega = qvB$ $\omega = \frac{qB}{m}$ $T = \frac{2\pi m}{qB}$ $T = \frac{2\pi(4)(1.66 \times 10^{-27})}{2(1.6 \times 10^{-19})(2.0)}$ $T = 6.519 \times 10^{-8}$ s Every complete circle/cycle, the particle is accelerated twice Total number of times accelerated = 0.52×10^{-3} / $6.519\times10^{-8} \times 2$ = 15954 times Energy gained per acceleration across dees = $\frac{(16\times10^{6})(1.6\times10^{-19})}{15954}$ = 1.6047×10^{-16} J Energy gained = charge x potential difference p.d. = $\frac{1.6047\times10^{-16}}{(2)(1.6\times10^{-19})}$ = 501.5 V = 500 V (2 sf)	

5	**(a)**	**(i)**	Work function is defined as the minimum energy required to eject an electron from the surface of a metal.	
		(ii)	Using loss in EPE = gain in E_k, $0.5mv^2 = eV_s$ $0.5(9.11 \times 10^{-31})v^2 = (1.6 \times 10^{-19})(1)$ $v = 5.93 \times 10^5$ m s^{-1}	
		(iii)	$\frac{hc}{\lambda} = \phi + eV_s$ $\frac{hc}{380 \times 10^{-9}} = \phi + (1.6 \times 10^{-19})(1)$ $\Phi = 2.27\ eV$	
		(iv)	Cannot be read off directly, as the stopping voltage and the wavelength do not have a linear relationship (OR they have an inverse relationship with x-intercept is not shown in the diagram)	

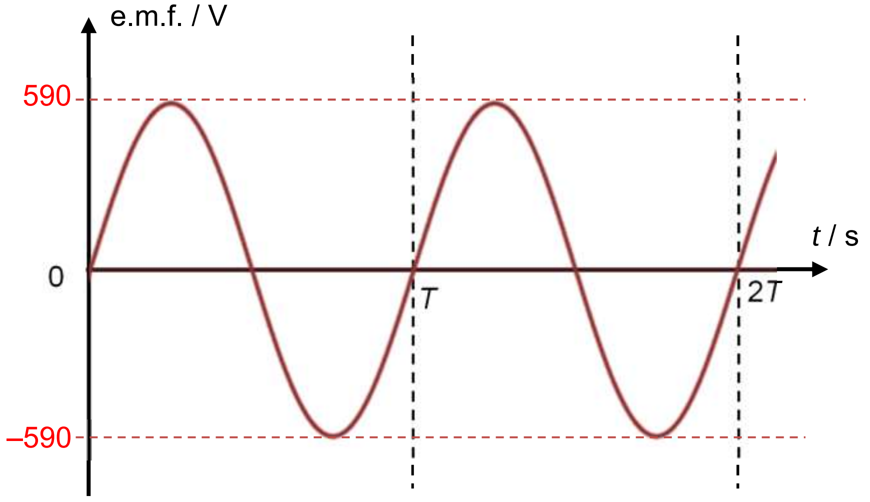
	(b)	**(i)**	 Fig. 5.3	
		(ii)	 • Lower intensity (than before, at all parts of new graph) • Half of original maximum photon energy • Same characteristic lines.	
		(iii)	Energy = (1.4 - 0.27) x 10^{-15} = 1.13 x 10^{-15} J = 7062 eV	
		(iv)	Accelerated (or high energy) incident electron 'collides' with an electron from the innermost shell kicking it out of the *K*-shell. The atom is excited due to the vacancy in the *K*-shell. An electron from the M-shell transits to the vacancy in the *K*-shell, emitting a photon.	

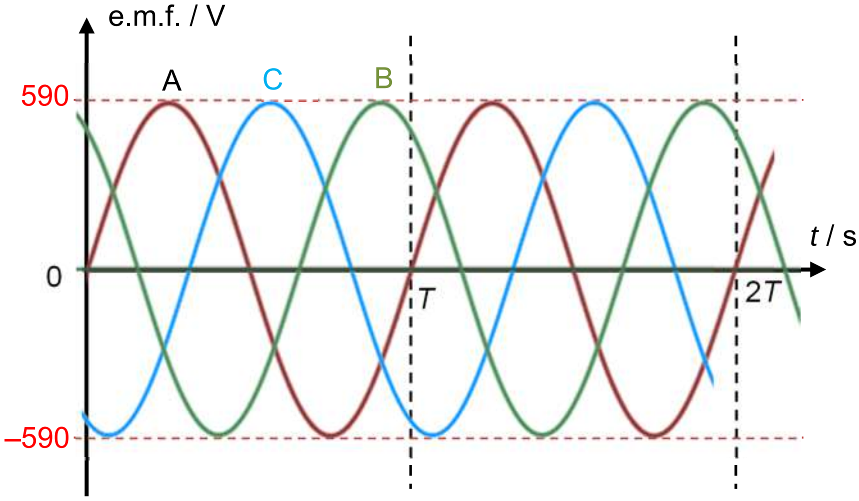
6	**(a)**	**(i)**	$C_0 = 65\ s^{-1}$ $C = C_0 e^{-\lambda t} = C_0 e^{-(\ln 2 / t_{½})\, t}$ When t = 46 s, C = 35 s^{-1} $\Rightarrow$ $35 = 65\, e^{-(\ln 2 / t_{½})(46)}$ $\Rightarrow t_{½} = 51.5$ s B1 for reading values correctly from graph, A1 for 52 s When t = 110 s, C = 15 s^{-1} $\Rightarrow$ $15 = 65\, e^{-(\ln 2 / t_{½})(110)}$ $\Rightarrow t_{½} = 52.0$ s B1 for repeated reading and/or average. So a student who reads t = 51 s from the graph at ½ C_0 = 32.5 s^{-1} will score 3 marks (losing last B1 mark) The decaying radioactive nuclide is $^{220}_{86}Rn$. A0	
		(ii)		
	(b)		At t = 120 s, C = 14 s^{-1} so count rate of Y = 65 – 14 = 51 s^{-1} B1 (can be for other points but with same concept) t = 0 , count rate of Y = 0 t = $t_{½}$, count rate of Y = ½ C_0 B1 for both points plotted with smooth exponential curve drawn throughd	
	(c)		$^{220}_{86}Rn \rightarrow {}^{4}_{2}\alpha + {}^{216}_{84}Y$ (ecf allowed)	
	(d)		linear momentum is conserved $0 = (A - 4)u\, v_Y + 4u\, v_\alpha$ M1 $(A - 4)u\, v_Y = 4u\, v_\alpha$ $(A - 4)\, v_Y / 4 = v_\alpha$ ratio $\frac{\text{initial kinetic energy of } \alpha\text{-particle}}{\text{initial kinetic energy of daughter nucleus Y}} = \frac{1/2\ (4u)\ v_\alpha^2}{1/2\ (A - 4)u\ v_Y^2} = \frac{(4)\ ((A - 4)\ v_Y / 4)^2}{(A - 4)\ v_Y^2}$ $= \frac{(4)\ (A - 4)^2}{(A - 4)(4)^2} = ¼\ (A - 4) = ¼\ A - 1$	

Section B

Answer **one** question in this section in the spaces provided.

7	**(a)**	**(i)**	displacement antinodes at where there are no heaps correct shape	
		(ii)	2.5λ = 39 cm	
		(iii)	v = fλ v = 2.14 × 10^3 × 15.6 × 10^{-2} = 334 m s^{-1} A1	
		(iv)	length of tube = 3. 5 × 15.6 × 10^{-2} = 54.6 cm L = ½ λ so λ = 109.2 cm f = v/λ = 305.7 = 306 Hz (3 s.f.)	
		(v)	clearly defined heaps of dust are no longer observed fundamental mode for a closed pipe of 54.6 cm requires 153 Hz (OR the fundamental frequency required would be different)	
	(b)	**(i)**	π rad	
		(ii)	1.5 wavelengths = 18.6 – 14.4 = 4.2 (length across 4 points) wavelength = 2.8 cm speed = 2.8 × 10^8 m s^{-1}	
		(iii)	metal plate moving away at 1.0 cm s^{-1} for every half-wavelength moved away, a high intensity signal is registered f = 1.0 / (½ × 2.8) = 0.71 Hz	
		(iv)	intensity ∝ amplitude^2 0.25 (¼ not accepted)	
		(v)	¼ A + ¼ A = ½ A so maximum intensity = 0.25 × original intensity max is now less than original, 0.25 I no change in positions of nodes or antinodes	

8	**(a)**		the e.m.f. induced in a conductor is directly proportional to the rate of change of magnetic flux linkage (or the rate of cutting of magnetic flux)	
	(b)	**(i)**	As the magnet rotates, the magnetic flux density of the magnet changes orientation (or alignment with coil or change in direction of magnetic field) which causes a change in magnetic flux linkage with the coil. With a constant rotational rate/speed/frequency, the magnetic flux linkage with the coil will vary sinusoidally with time (with cosωt), By Faraday's law, the induced e.m.f. in the coil, which is the rate of change of magnetic flux linkage, will also vary sinusoidally with time (with –sinωt).	
		(ii)	$\Phi = \text{NBA} = 500(0.80)(\pi(0.05)^2) = \pi = 3.14159$ Wb (or Wb turns) Correct substitution – C1 Correct answer – A1 Correct units – B1	
		(iii)	$\Phi = \text{NBAcos}\left(\frac{2\pi}{T}\text{t}\right)$ $=3.14\cos\left(\frac{2\pi}{\frac{60}{1800}}\text{t}\right)$ $=3.1\ \cos(60\pi\ \text{t})$ or $3.1\ \cos(190\ \text{t})$	
		(iv)	$E = -\frac{d\Phi}{dt} = \text{NBA}\omega\sin\omega\text{t}$ $\max = \text{NBA}\omega = \pi\left(2\pi\left(\frac{1800}{60}\right)\right)$ $= 592$ V	
		(v)	 Correct +ve sine curve with at least two cycles drawn Labelled maximum induced emf of value in (iv) of 590 V (allow ecf) Maximum induced emf is where the rate of change of magnetic flux linkage is greatest, which is where gradient is steepest on the graph in Fig. 8.4	

	(c)		 Two additional sinusoids that are roughly 1/3 of a cycle displaced from each other, and are of equal frequency and amplitude as each other Correct labelling of A, B and C (allow labelling as AA', BB', CC') (Allow e.c.f. if original A graph is wrongly drawn as –ve sine)	
	(d)	**(i)**	Power transfer from primary coil to secondary coil is 100% efficient (or no loss in power when transferring from primary to secondary) Or no hysteresis, etc.	
		(ii)	Since transformer is ideal, $\frac{Vs}{Vp} = \frac{Ns}{Np}$ $Vs = \frac{12000}{30}(590) = 236000$ V (peak) peak power at primary coil = (20)(590) = 11800 W peak current at secondary coil = 11800 / 236000 = 0.050 A r.m.s current in secondary coil = $0.050/\sqrt{2}$ = 0.03545 = 0.035 A OR $\frac{Vs}{Vp} = \frac{Ns}{Np} = \frac{Ip}{Is}$ $Is = \frac{30}{12000}(20)$ = 0.050 A r.m.s current in secondary coil = $0.050/\sqrt{2}$ = 0.03545 = 0.035 A	
		(iii)	Long distance transmission the resistance of the cables become significant A <u>low current</u> allows for <u>low power dissipation</u> (loss) in the transmission cables	

END OF PAPER

RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749
PAPER 4

28 AUG 2018

2 HRS 30 MIN

CANDIDATE NAME	

CENTRE NUMBER	S					**INDEX NUMBER**					

CLASS	6	

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre and index number in the spaces at the top of this page.

Candidates answer on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.

SHIFT	
LABORATORY	
FOR EXAMINERS' USE	
1	/10
2	/ 12
3	/ 21
4	/ 12
TOTAL	/ 55

This document consists of **19** printed pages.

1 The resistance of a light-dependent resistor (LDR) changes when it is illuminated with light of different intensities.

In this question, you will investigate how the light detected by a LDR depends on the thickness of an absorber.

(a) **(i)** You are provided with a black tube of approximate length of 4 cm.

(ii) Use the tube and clear adhesive tape to make a cylinder that fits over the LDR and the light emitting diode (LED).

Cut the tube into two halves of approximately 2 cm each and fit the 2 tubes over the LDR and LED, as shown in Fig. 1.1.

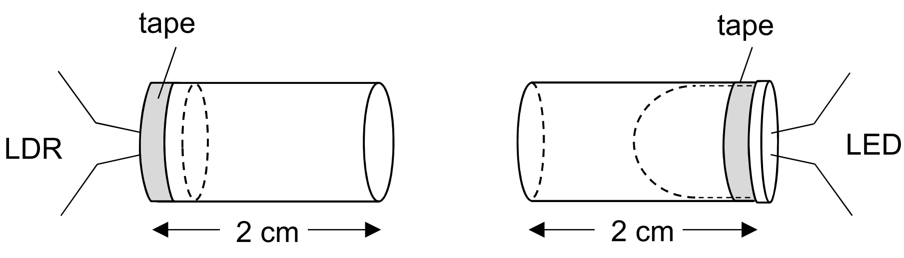


Fig. 1.1

(iii) Connect the circuit as shown in Fig. 1.2. Ensure the longer leg (red) of the LED is connected to the positive terminal of the battery.

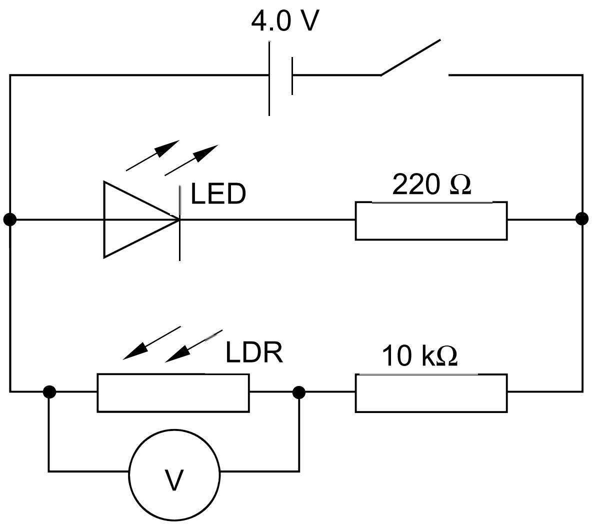


Fig. 1.2

(b) Close the switch and place the cylinders together, as shown in Fig. 1.3.

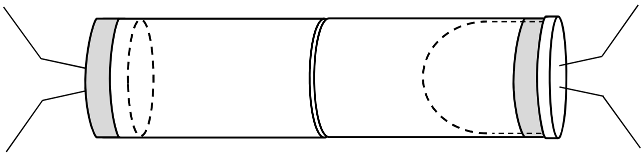


Fig. 1.3

Record the voltage V_0.

V_0 = 0.75 V
- Accept up to 3.50 V (cannot be negative)
- Correct d.p and units
- (To show repeated readings.)
- (Allow up to 3 dp in V)

V_0 = ... [1]

(c) Fold the sheet of tracing paper in half four times so that you have 16 layers.

(i) Measure and record the thickness of these 16 layers.

d_1 = 1.01 mm
d_2 = 1.04 mm, d_3 = 1.02 mm, d_4 = 1.03 mm
<*d*> = 1.03 mm
- *Repeated readings using* ***micrometer only***
- *Correct d.p and units*
- *Accepted range: 0.80 mm to 2.00 mm*

thickness of 16 layers = ... [1]

(ii) Hence, calculate the thickness *t* of one layer of tracing paper.

<*t*> = 1.03 /16 = 0.0644 mm (2 or 3 sf)

- *Correct calculation with correct sf and units*

t = ... [1]

(iii) Estimate the percentage uncertainty in your value of *t*.

Since $t = \frac{<d>}{16}$ $\qquad \therefore \frac{\Delta t}{t} = \frac{\Delta d}{d}$

- Percentage uncertainty = 0.02/1.03 x 100% = 1.9%
- *Δd >= 0.01 mm (accept up to 0.05 mm) for 16 layers (to 1 s.f.)*
- *Percentage uncertainty to 2 sf*

percentage uncertainty = ... [1]

(d) **(i)** Place four layers of tracing paper between the LED and the LDR as shown in Fig. 1.4.

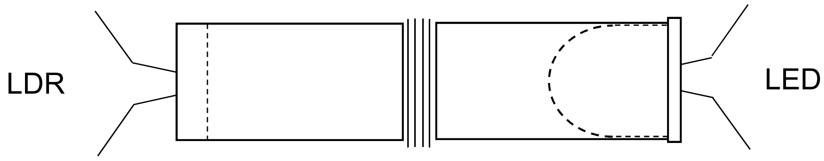


Fig. 1.4

Record the voltage V.

V = 2.03 V
Correct dp and units

V_4 = ...

(ii) Repeat **(d)(i)** using eight layers of tracing paper.

V = 2.79 V

- *Correct dp and units*
- *$V_0 < V$(di) $< V$(dii)*
- *Not marking for accuracy*
- *To allow 3dp values for voltage readings*

V_8 = ... [1]

(e) **(i)** State and explain one significant source of error or limitation of the procedures for this experiment.

....

....

.... [1]

(ii) Suggest an improvement that could be made to the experiment and explain how this addresses the error identified in **(e)(i)**. You may suggest the use of other apparatus or a different procedure.

....

....

.... [1]

Any of the following

- Alignment of LDR and LED (not just alignment of cylinder)
- Stray light coming in because the cylinders are not sealed / external light hits LDR
- Separation between LED and LDR changes as paper is added.

Corresponding improvements

- Guide used for aliignment/ line on desk / adjust LED/LDR to get max voltage / method of fixing LED/LDR in cylinder for alignment.
- Dark room / black cloth over / lights off and curtains drawn / black box
- Pre-slots in tube for tracing paper so that separation between LDR and LED is fixed.

Do not allow:

- 'varying thickness of paper, scratches on tracing paper, zero error on micrometer', paper not folded properly.
- 'repeated readings, parallax error'
- Fluctuating voltmeter reading
- Draw circles on tracing paper to align.
- 'use a computer to improve the experiment'
- Ignore separation of layers affects light getting through and squashing of paper for micrometer reading.

(f) Plan an experiment to investigate how the light detected by a LDR is affected by the angle between the polarising axes of a pair of *unmarked* polarising filters.

Your account should include:

- your experiment procedure
- how you would vary the angle between the polarising axes

- Replace the tracing paper with 2 polarising filters as with a setup as shown in Fig. 1.2 and Fig. 1.4.
- Mark the axis where the polarizing filters give the minimum V reading. Polarising axes of the 2 polarisers are parallel at this angle.
- Vary angle between polarizing axes and measure the angle with a protractor.
- Record the voltage, V across the LDR with a voltmeter.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [3]

[Total: 10 marks]

2 In this question, you will investigate the oscillation of a pendulum hung from a flexible plastic ruler.

(a) **(i)** Measure and record the mass *m* of the small metal bob.

32.30 g [allow 32 ± 4g]

- Correct dp
- Correct units

m = ...

(ii) Measure and record the diameter *d* of the small metal bob as shown in Fig. 2.1. Use a vernier calliper for your measurement.

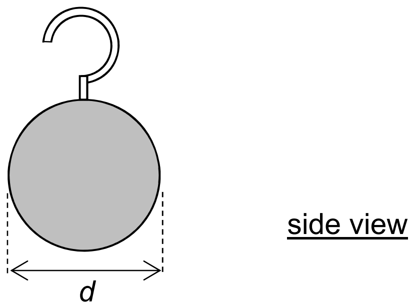


Fig. 2.1

1.87 cm [allow 1.85 to 1.90 cm]

- Correct dp
- Correct units
- Show repeated readings

d = ... [1]

(iii) Calculate the volume *V* of the small metal bob. You may assume the metal bob is spherical in shape.

Volume = $4/3\ (\pi r^3)$ = 3.42 cm^3

- Correct sf
- Correct units
- Correct calculations

V = ... [1]

(iv) Calculate the percentage uncertainty of the volume of the small metal bob.

$$\frac{\Delta V}{V} = 3\frac{\Delta d}{d}$$

$$\text{percentage uncertainty} = 3\frac{0.01}{1.87} \times 100 = 0.16\ \%$$

- Correct sf
- Correct units
- Correct calculations

percentage uncertainty = ... [1]

(b) Tie one end of the string to the small hole on the ruler. Secure the other end of the string to the small metal bob such that *L* is approximately 30 cm as shown in Fig. 2.2.

Ensure the horizontal distance *x* from the centre of the hole to the wooden cork is 25 cm. Use the retort stand to hold the wooden cork such that the ruler is horizontal.

side view

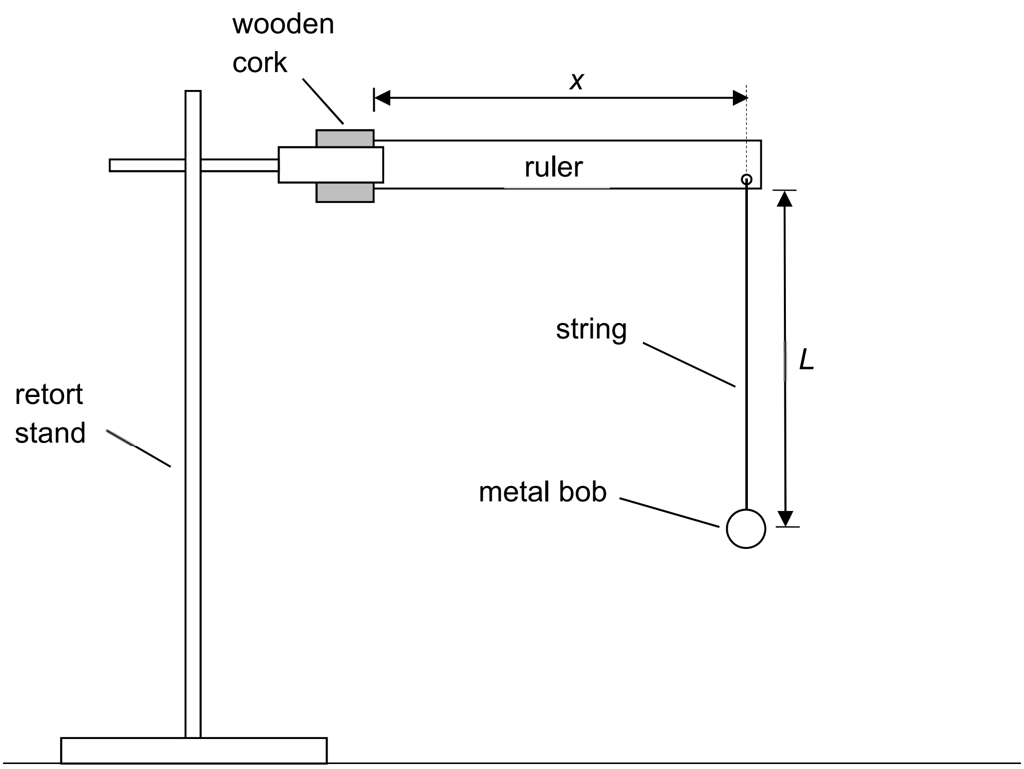


Fig. 2.2

(i) Set the metal bob oscillating by displacing and releasing it as shown in Fig. 2.3.

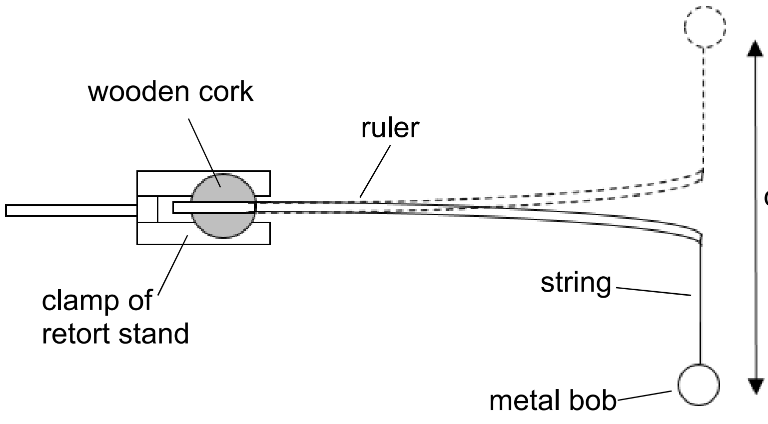


Fig. 2.3

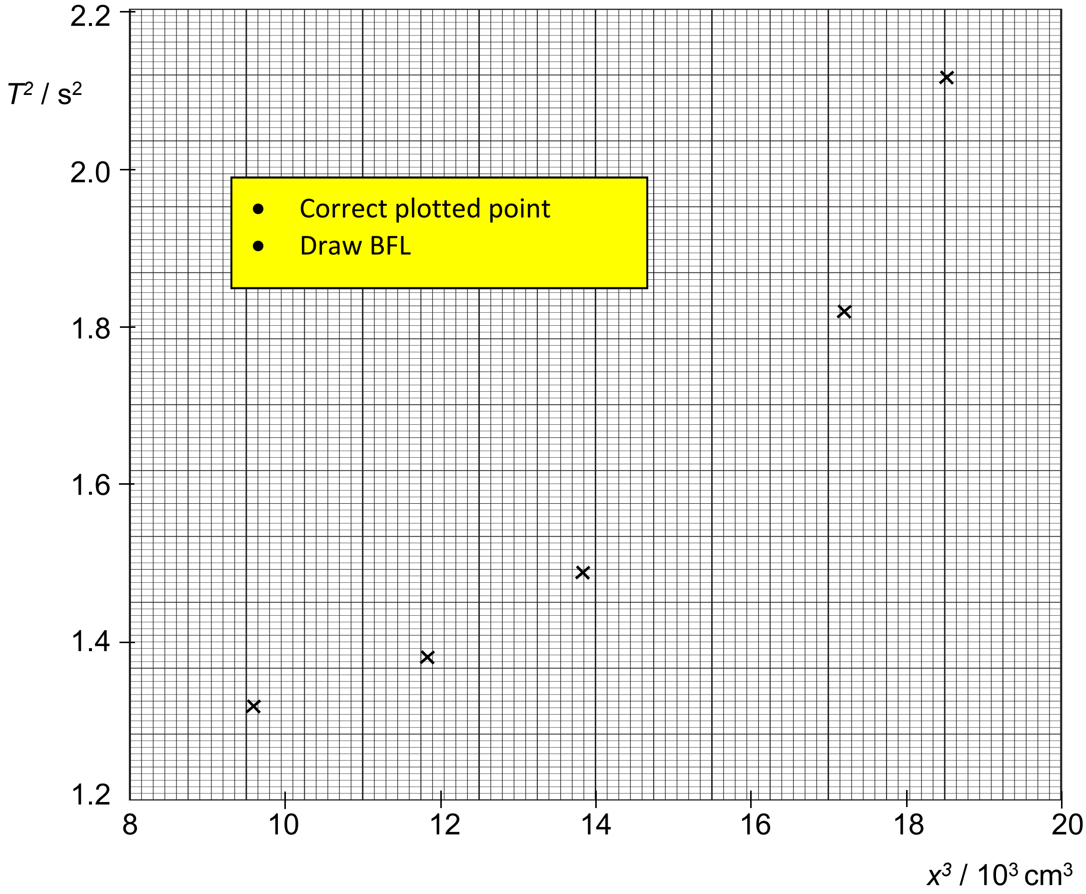
Determine the period *T* of the oscillations. Show your working clearly.

T = 1.275 s [n = 20, t = 25.52, 25.37, 25.58 s]
Allow [1.25 to 1.35]

- Correct sf/dp
- Correct units
- Correct calculations
- Show repeated readings
- t is more than 10 sec.

T = ……………………………… [1]

(ii) Plot the data obtained from **(b)(i)** on the grid and draw the line of best fit.



[2]

(c) **(i)** Remove the small metal bob in the setup and replace it with the large metal bob.

(ii) Repeat **(a)** and **(b)(i)** using the large metal bob instead.

m = 59.80 g [allow: 56.00 g to 60.00 g]

d = 2.37 cm [allow 2.35 to 2.40 cm]
V = 6.97 cm^3
T = 1.474 s [n = 20, t = 29.51, 29.40, 29.54 s]

- Correct sf/dp
- Correct units
- Correct calculations
- Show repeated readings
- t is more than 10 sec.
- show correct units in working.
- marks given for correct calculated V and T.

m = ...

d = ...

V = ...

T = ... [2]

(d) It is suggested that $\sqrt{T} = k\dfrac{m}{V}$ where *k* is a constant.

(i) Use your values from **(a), (b)(i)** and **(c)(ii)** to determine two values for *k*. Give your values for *k* to an appropriate number of significant figures.

$$For\ small\ metal\ bob: k = \frac{\sqrt{1.275}}{29.55/3.42} = 0.1307\ s^{0.5}\ cm^3\ g^{-1}$$

$$For\ large\ metal\ bob: k = \frac{\sqrt{1.474}}{59.80/6.97} = 0.1415\ s^{0.5}\ cm^3\ g^{-1}$$

- Correct sf/dp
- Correct calculations
- Show substitutions.

first value for *k* = ... $s^{0.5}$ cm^3 g^{-1}

second value for *k* = ... $s^{0.5}$ cm^3 g^{-1} [1]

(ii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your value in **(a)(iv)**.

$$\frac{0.1415 - 0.1307}{0.1415} \times 100\% = 7.6\ \%$$

- Correct sf
- Correct units
- Correct calculations

Does not support the relationship as percentage difference of k is larger than percentage uncertainty of V.

[1]

(iii) Suggest changes that could be made to the experiment to decrease the period of oscillation of the flexible plastic ruler.

- Decrease the length of string.
- Decrease the mass of the pendulum bob.
- Use a rigid ruler such that the pivot does not shift.
- Reduce distance x.
- Do not accept 'reduce in density of bob'

[2]

[Total: 12 marks]

3 In this experiment, you will investigate the equilibrium of a mass and pulley system.

(a) Set up the apparatus as shown in Fig 3.1.

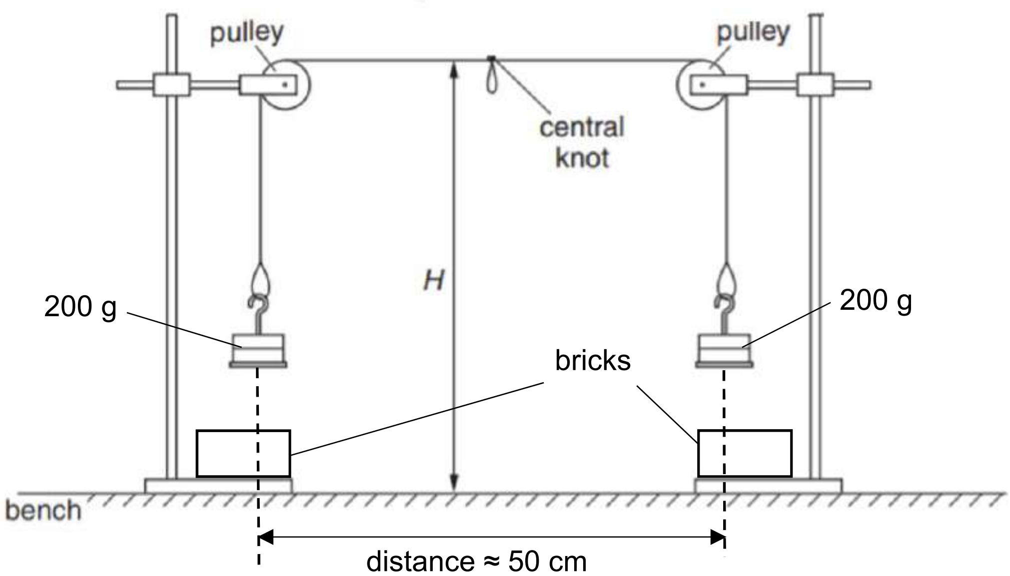


Fig. 3.1

Ensure that the distance between the masses are about 50 cm and the string with the central knot is horizontal with respect to the bench.

(b) Measure and record the height *H* of the central knot above the bench.

H between 0.200 m and 0.900 m,

Correct units of cm/m with appropriate precision, 0.1 cm / 0.001 m .... [1]

(c) **(i)** Suspend 100 g from the central loop as shown in Fig. 3.2.

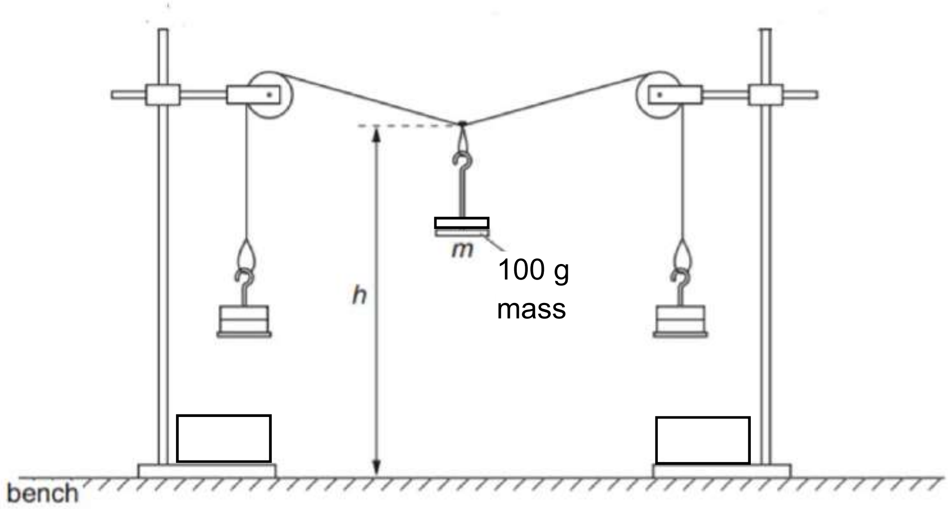


Fig. 3.2

(ii) Record the central suspended mass *m*.

m = 100 g Correct units of g/kg with appropriate precision, 1 g/ 0.001 kg

[1]

(iii) Measure and record the height *h* of the central knot above the bench, as shown in Fig. 3.2.

h = ……………………………

(iv) Calculate the deflection *y*, where $y = (H - h)$ and present it along with the associated uncertainty.

Correct calculation with appropriate uncertainty of at least 0.2 cm

y = …………………………… [2]

(d) Change *m* by adding 20 g masses to the hanger suspended from the central loop and repeat **(c)(ii)**, **(c)(iii)** and **(c)(iv)** until you have six sets of values for *m*, *h* and *y*.

Include in your table of results, values for $^1/_{y^2}$ and $^1/_{m^2}$.

Award 2 marks, if candidate has successfully collected 6 or more sets of data without assistance/intervention Award 1 marks, if candidate has successfully collected 5 sets of data without assistance/intervention Award 0 marks, if candidate has successfully collected 4 or fewer sets of data without assistance/intervention Deduct 1 mark if candidate requires some assistance/intervention but has been able to do most of the work independently. Deduct 2 marks if candidates has been unable to collect data without assistance/intenvention	2
Each column heading must contain a quantity and a unit where appropriate. There must be some distinguishing mark between the quantity and the unit. Correct units and headers, $1/y^2$ / m^{-2} and $1/m^2$ / kg^{-2}	1
All values of *h* to the nearest mm and *m* to the nearest kg.	1
For each calculated value of $1/y^2$ and $1/m^2$, the number of s.f. should be the same or one more than the number of s.f. in the raw data	1
$1/y^2$ and $1/m^2$ calculated correctly.	1

[6]

(e) Theory suggests that the relationship between y and m is

$$\frac{1}{y^2} = \frac{p}{m^2} - q$$

where p and q are constants.

Plot a suitable graph to determine the value for p and q. Include the appropriate units for p and q.

Linearisation statement – plot a graph of $1/y^2$ against $1/m^2$, if a straight line is obtained, the gradient is represented by P and the y-intercept by $-Q$.	1
Gradient triangle – larger than half the size of the graph with correct coordinates	1
P (gradient) – calculated correctly with correct units [200 g^2 cm^{-2} - 450 g^2 cm^{-2}]	1
Q (–y-intercept) - calculated correctly with correct units [cm^{-2}]	1

p = ...

q = ... [4]

Axes labelled with quantity plotted ($1/y^2$ against $1/m^2$); appropriate scale chosen such that plotted points occupy at least half the graph grid in both *x* and *y* directions	1
Straight line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line.	1
All observations must be plotted. Work to an accuracy of half small square.	1

[3]

(f) Comment on any anomalous data or result that you may have obtained.

Anomalous data/results, if any must be identified. There is no anomalous data as all points follow the trend of the best-fit line OR There is an anomalous data as there is one point that does not follow the trend of the best-fit line/ as it lies relatively far from the best fit line as compared to the other line	1

……………………………………………………………………………………...…....

…………………………………………………………………………………….. [1]

(g) **(i)** Suggest two significant sources of error in this experiment.

Hard to ensure that the metre ruler is vertically upright when measuring *h* Height h may not be accurate since the length of string on either side might not be the same. Plane of the pulley is not aligned. Friction of the pulley makes it harder for wheel to turn	2

……………………………………………………………………………………...

……………………………………………………………………………………...

………………………………………………………………………………… [2]

(ii) Suggest an improvement that could be made to the experiment to address one of the errors identified in **(g)(i)**. You may suggest the use of other apparatus or a different procedure.

Use set-square to check that the metre ruler is vertical Add markings onto the string so that it is easier to ensure that the length on either side is the same. Use spirit level to level the plane of the pulley Lubricate the pulley to make it the wheel turn better.	1

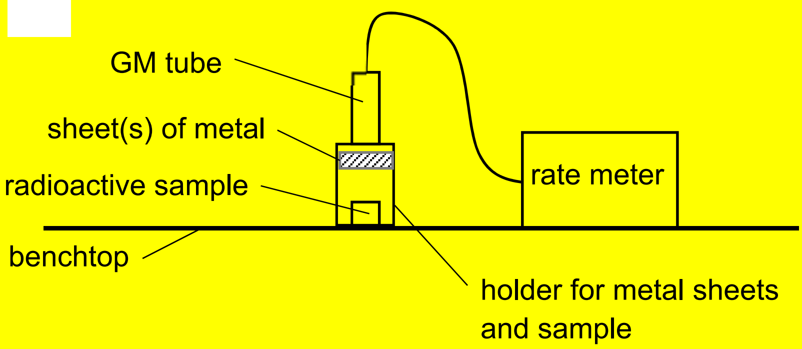
……………………………………………………………………………………...

……………………………………………………………………………………...

………………………………………………………………………………… [1]

[Total: 21 marks]

4 (b) <u>Diagram [1 mark]</u>



1 Appropriately set up with a benchtop to show orientation (axes in line), GM tube to be placed close to the radioactive sample
(can be given to accuracy marks)

2 All essential apparatus to be included, including radioactive sample, sheets of metal, GM tube and rate meter B1

(a) <u>Variables [2 marks]</u>

1 Independent variable: thickness of metal sheets, density of metal sheets; AND
Dependent variable: count rate (activity/intensity) B1

2 Control variable (allow only significant control variables):
distance between source and GM tube B1

(c) <u>Prelimary readings [1 mark]</u>

1 Check for minimum thickness of each metal that would stop all β radiation (e.g. count rate goes to background values), so all readings should be taken for thicknesses below this value. B1

(c) <u>Procedure [3 marks]</u>

1 Set up apparatus as shown

2 Starting with one type of metal, e.g. aluminium, measure density by taking volume using decanter and weighing mass on weighing scale, taking $\rho = m / V$

3 Prepare 6 sheets of aluminium of equal thicknesses, each < 1 cm thick (or depending on preliminary readings taken), and measure average thickness of each sheet using a micrometer screw gauge. B1

4 Measure count rate without any aluminium sheets (units counts/min or /s) reading off the rate meter

5 Insert one sheet of aluminium between the sample and GM tube

6 Measure count rate with the metal sheet using the rate meter (units counts/min or /s) B1

7 Repeat steps 5 and 6 for 5 more sets of readings of count rate for the increasing total number of sheets of aluminium.

8 Prepare 5 more sheets of other metals of same thickness as the aluminium sheet, and measure thicknesses using micrometer screw gauge.

9 Measure densities by measuring volume using decanter and mass using weighing scale and taking $\rho = m / V$. B1

10 Repeat experiment steps 5 and 6 for 6 sets of readings using each of the 6 different metals of same thickness.

(d) <u>Determination of values [2 marks]</u>

1	Linearise equation: $$lnI_C = lnC + mln\rho + nlnx$$ Where *Ic* is the count rate	B1
2	Plot ln *Ic* against ln *x*, if straight line is obtained, gradient will be *n*, intercept will be $lnC + mln\rho$ using data from 1st experiment	
3	Plot ln *Ic* against $ln\rho$, if a straight line is obtained, gradient will be *m*, intercept will be *lnC* + *nlnx*.	
4	Substitute values of *n* (from 1st graph) and constant *x* measure in 2nd experiment to obtain *C*.	
5	Require all 3 steps (2-4) for B1	B1
(e)	**<u>Safety precautions (any one)(max 1 mark)</u>**	
	Any of the below for up to 1 mark	B1
1	Handle radioactive material with tongs and wear gloves to prevent contact with radioactive material	
2	Wear safety goggles to prevent radiation from entering eyes	
3	Ensure hands etc are thoroughly washed after experiment to ensure	
(e)	**<u>Additional accuracy marks (max 2 marks)</u>**	
	Any of the below for up to 2 marks	B2
1	Check for background count using GM tube and rate meter without radioactive source	
2	Take three (multiple) readings on the rate meter at equal time intervals (e.g. about 10 s) and find average	
3	Set the gain setting on the rate meter to an appropriate range that gives sufficiently high counts without too much background noise	

Class	Index Number	Name
17S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2018
Preliminary Examination

PHYSICS, Higher 2 **9749/01**

Paper 1 Multiple Choice **18th September 2018**
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil..
Do not use staples, paper clips, glue or correction fluid.
Write your name, index number and Civics Group the Answer Sheet in the spaces provided.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Total	/ 30

This document consists of **14** printed pages including this page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$= (1/(36\pi)) \times 10^{-9}\ \text{F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant,	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
acceleration of free fall,	$g = 9.81\ \text{m s}^{-2}$

Formulae

uniformly accelerated motion,	$s = u t + \frac{1}{2} a t^2$
	$v^2 = u^2 + 2 a s$
work done on/by a gas,	$W = p \Delta V$
hydrostatic pressure,	$p = \rho g h$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T/\text{K} = T/^{\circ}\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$v = \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{1/2}}$

1 Which of the following correctly expresses the volt in terms of SI base units?

A kg $m^2 s^{-3} A^{-1}$ **B** kg $m^2 s^{-1} A^{-1}$

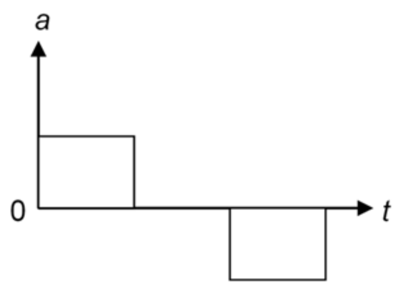
C W A^{-1} **D** A Ω

2 In a simple electrical circuit, the potential difference across a resistor is measured as (3.20 ± 0.01) V. The resistor is marked as having a value of 6.3 Ω ± 5 %.

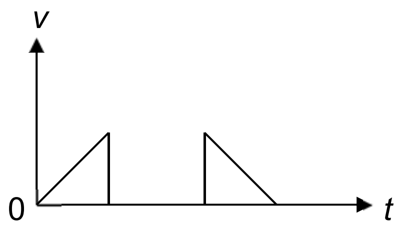
If these values were used to calculate the power dissipated in the resistor, what would be the percentage uncertainty in the value obtained?

A 5.3 % **B** 5.6 % **C** 6.0 % **D** 6.3 %

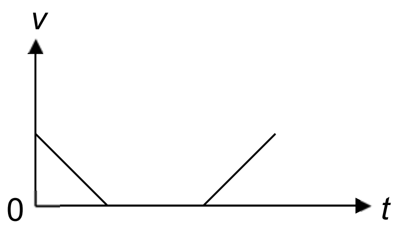
3 A car is accelerated from rest following the acceleration-time graph shown below. Which graph shows the variation of velocity of the car with time?



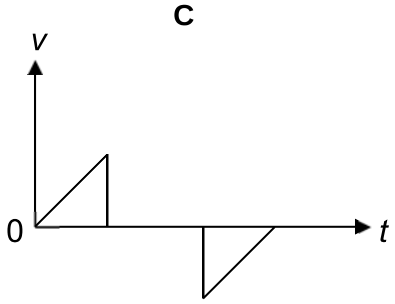
A



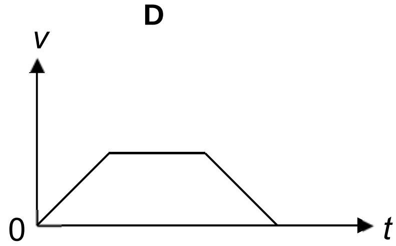
B



C

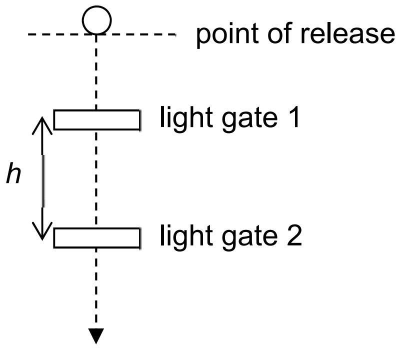


D



4 To determine the acceleration of free fall, a steel ball is dropped above two light gates as shown.

The ball passes light gate 1 and 2 at times t_1 and t_2 after release.



What is the acceleration of free fall?

A $\dfrac{2h}{(t_2 - t_1)}$

B $\dfrac{2h}{(t_2 - t_1)^2}$

C $\dfrac{2h}{(t_2^2 - t_1^2)}$

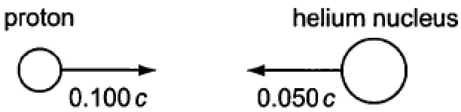
D $\dfrac{2h}{\left(\dfrac{t_2 + t_1}{2}\right)^2}$

5 A tractor of mass 3500 kg pulls a trailer of mass 1500 kg. The total resistance to motion has a constant value of 5000 N. One quarter of this resistance acts on the trailer.

When they are moving with an acceleration of 1.0 m s^{-2}, what is the force exerted on the tractor by the trailer?

A 1500 N **B** 2750 N **C** 5250 N **D** 8000 N

6 A proton (mass 1u) travelling with velocity +0.100 *c* collides elastically head-on with a helium nucleus (mass 4u) travelling with speed 0.050 *c* as shown below.



What are the velocities of each particle after the collision?

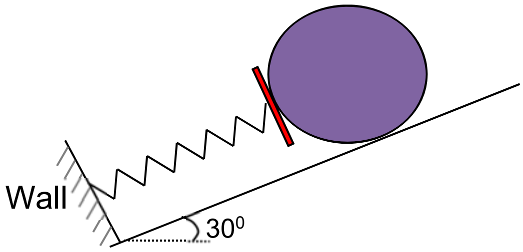
	proton	helium nucleus
A	-0.140 *c*	+0.010 *c*
B	+0.140 *c*	+0.010 *c*
C	+0.233 *c*	-0.083 *c*
D	-0.233 *c*	+0.083 *c*

7 In the Pixar movie, *Up*, an old man lifted his house using about 20000 helium balloons. Assuming that the average volume of each balloon used is 0.17 m^3, determine the maximum weight of the old man's house.

(density of air = 1.2 kg m^{-3}, density of helium = 0.18 kg m^{-3})

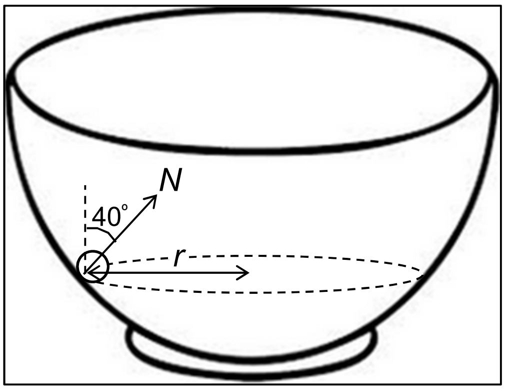
A 20000 N
B 34000 N
C 40000 N
D 46000 N

8 A sphere of mass 3.00 kg rests on a frictionless slope inclined at 30^0 above the horizontal as shown below. The spring constant is 500 N m^{-1}. Determine the compression of the spring.



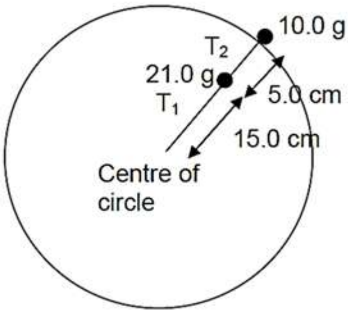
A 7.67 mm **B** 29.4 mm **C** 34.3 mm **D** 51.0 mm

9 A small glass marble is moving in a horizontal circle round the inside surface of a smooth bowl. It is observed to make 10 complete rounds in 8 s. The normal reaction *N* acting on the marble inclined at 40° to the vertical as shown. What is the radius *r* of the horizontal circle?



A 0.070 m **B** 0.090 m
C 0.11 m **D** 0.13 m

10 Two blocks of mass 10.0 g and 21.0 g are tied together and performing a uniform horizontal circular motion on a smooth table, at an angular speed of 6.28 rad s^{-1}, as shown below.



Tension T_1 is the tension in the string connecting the 21.0 g mass to the centre and T_2, the tension in the string connecting the 10.0 g mass to the 21.0 g mass. What is the ratio T_1 to T_2?

A 1.0
B 1.6
C 2.1
D 2.6

11 A kinetic theory formula relating the pressure *p* and the volume *V* of the gas to the mean-square speed $<c^2>$ of its molecules is

$$p = \frac{1}{3}\frac{Nm}{V}<c^2>.$$

In this formula, what does the product *Nm* represent?

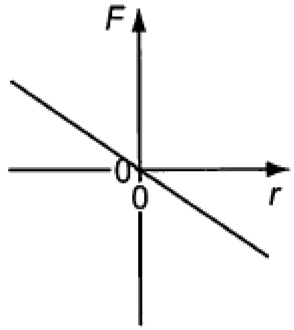
A the mass of gas present in volume *V*
B the number of molecules in unit volume of the gas
C the total number of molecules in one mole of gas
D the total number of molecules present in volume *V*

12 The temperature of a hot liquid in a container of negligible heat capacity falls at a rate of 3 K per minute just before it begins to solidify. The temperature then remains steady for 15 minutes by which time the liquid has all solidified.

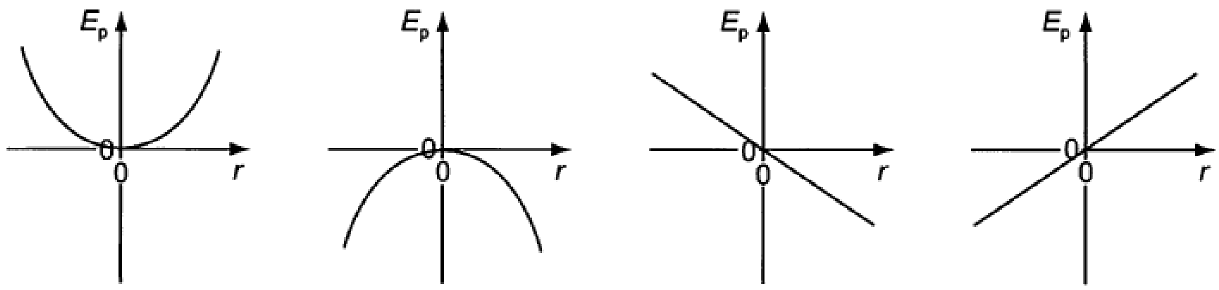
What is the value of the ratio $\dfrac{\text{specific heat capacity of liquid}}{\text{specific latent heat of fusion}}$?

A $\frac{1}{45}$ K^{-1} **B** $\frac{1}{5}$ K^{-1}
C 5 K^{-1} **D** 45 K^{-1}

13 A particle is moving such that the force F on it changes with the distance r from a fixed point as shown.



Which graph shows the relationship between the potential energy E_p of the particle and the distance r?

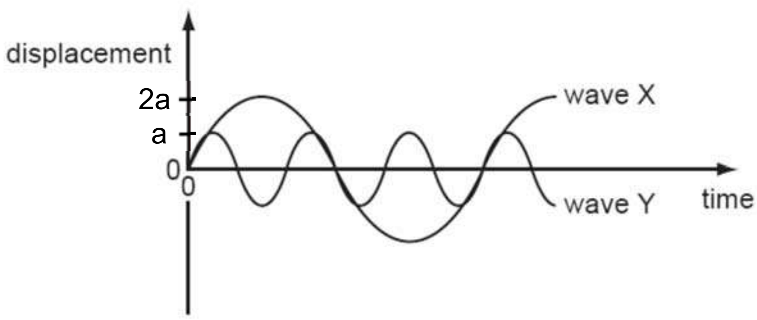


14 A particle oscillates with simple harmonic motion along a line with a maximum speed v_0.
When the displacement of the particle is half of its amplitude, its speed is

A $\frac{1}{4}v_0$ **B** $\frac{1}{2}v_0$ **C** $\frac{3}{4}v_0$ **D** $\frac{\sqrt{3}}{2}v_0$

15 The intensity of a progressive wave, besides being dependent on the amplitude of the wave, is also proportional to the square of the frequency.

The diagram shows two waves X and Y.

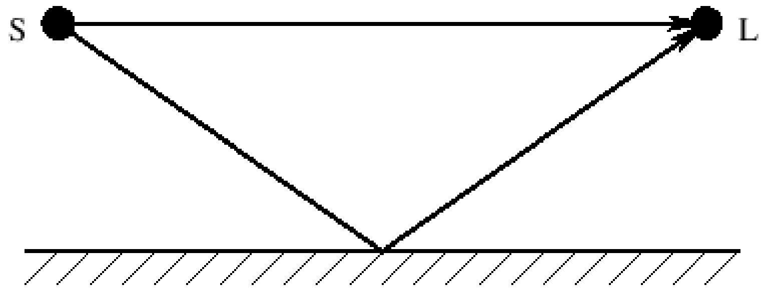


The intensity of wave X is I_0.

What is the intensity of wave Y?

A 0.028 I_0 **B** 0.11 I_0 **C** 0.44 I_0 **D** 2.25 I_0

16 A loudspeaker at position S emits sound of a single frequency. The sound travels to Leo who is at position L, both through a straight path and after reflection from a wall as shown.



As Leo walks directly towards the wall, the sound alternates between loud and soft. Which of the following changes would result in an increase in the distance between loud and soft sounds?

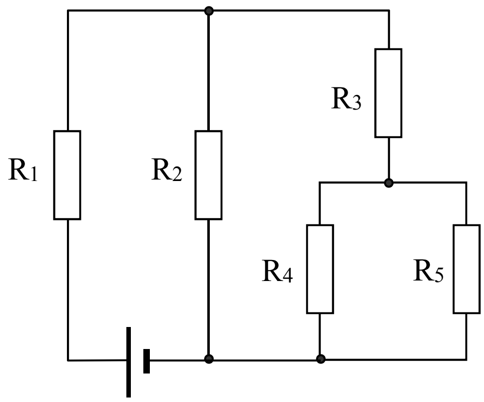
A Increase the frequency emitted by the loudspeaker.

B Move the loudspeaker closer to the wall.

C Move the loudspeaker towards L.

D Increase the loudness of the sound emitted by the loudspeaker.

17 Five identical resistors are connected to a dry cell of negligible internal resistance as shown below.



Which resistor dissipates the most power?

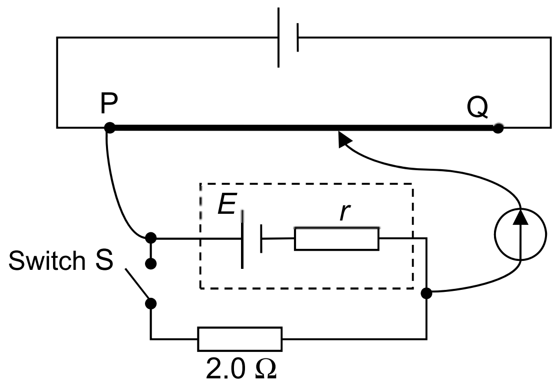
A R_1

B R_2

C R_3

D R_4

18 The diagram below shows a potentiometer circuit used to determine the internal resistance *r* of a cell of e.m.f. *E*. The driver cell has an e.m.f. of 2.0 V with negligible internal resistance and the resistance wire PQ is 1.0 m long. The cell is connected in parallel with a resistor of 2.0 Ω. When the switch is open, the balance length is 0.70 m and when the switch is closed, the balance length is 0.50 m. Determine *r*.



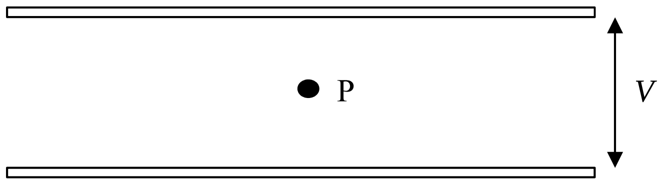
A 0.15 Ω

B 0.40 Ω

C 0.50 Ω

D 0.80 Ω

19 A small negatively charged particle P is balanced halfway between two horizontal plates where a potential difference of *V* is applied between the plates.



When *V* is increased, P rises towards the upper plate.
When *V* is decreased, P falls towards the lower plate.

Which statement is correct?

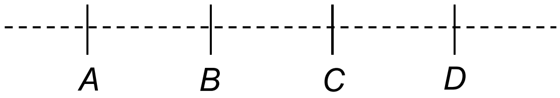
A The change of electric potential energy of the particle must equal the change in gravitational potential energy of the particle.

B Increasing *V* increases both the gravitational and electric potential energy of the particle.

C Decreasing *V* decreases both the gravitational and electric potential energy of the particle.

D Decreasing *V* decreases the gravitational potential energy and increases the electric potential energy of the particle.

20 *A*, *B*, *C*, *D* are four points on a straight line as shown below.



A point charge +*Q* is fixed at *A*. When another point charge -*Q* is moved from *B* to *C*, which of the following quantities is false?

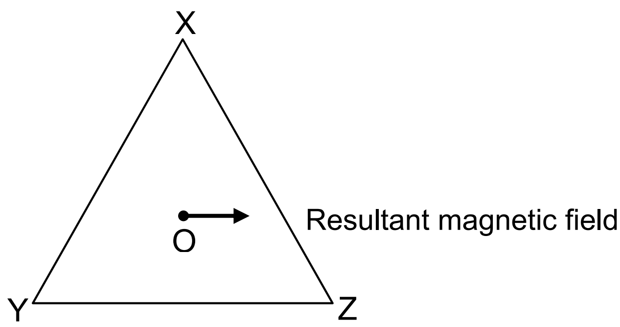
A The electric potential energy of the system of charges will increase.

B The magnitude of the electric field strength at the point *D* will increase.

C The electric potential at the point *D* will increase.

D The electric force acting on a positive charge placed at *D* will increase.

21 Three parallel conductors, carrying equal currents, pass vertically through the three corners of an equilateral triangle XYZ. It is required to produce a resultant magnetic field at O in the direction shown. What must be the directions of the currents?

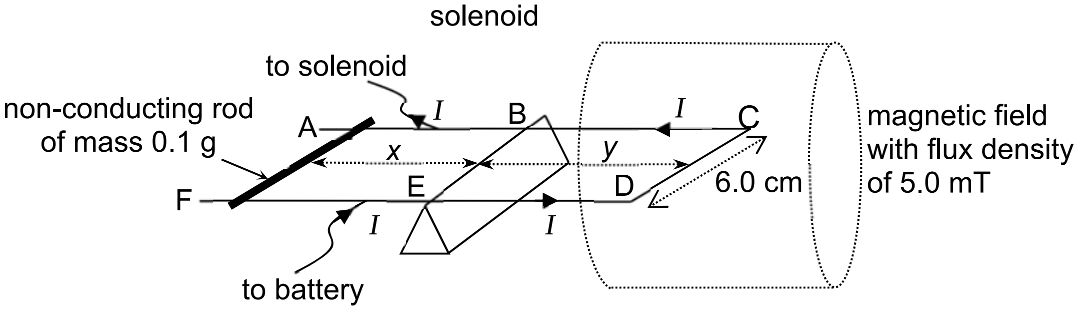


	Into page	Out of page
A	X	Y and Z
B	Z	X and Y
C	Y and Z	X
D	X, Y and Z	None

22 The figure shows a wire frame ACDF that is supported on a sharp edge at B and E such that section BCDE lies within a solenoid that provides a magnetic field of flux density 5.0 mT.

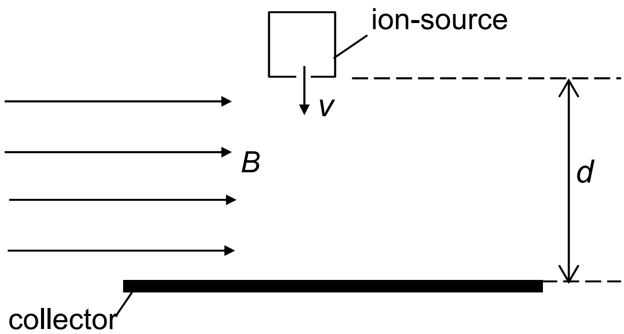
A current I of 2.0 A is then passed through the frame as shown and the position of the non-conducting rod of mass 0.10 g is adjusted so that the frame is oriented horizontally.

Given that CD = 6.0 cm, what is the ratio of the distances $\frac{x}{y}$ to ensure the frame is horizontal?



A 0.61 **B** 0.83 **C** 1.6 **D** 2.0

23 An ion-source is at distance *d* from a flat, horizontal collector at the same potential as the source. A magnetic field of flux density *B* acts horizontally as shown in the diagram. The field is uniform throughout the region between the source and the collector.



An ion of charge *q* and mass *m* is emitted vertically downwards at a speed *v*. Under what conditions will the ion reach the collector?

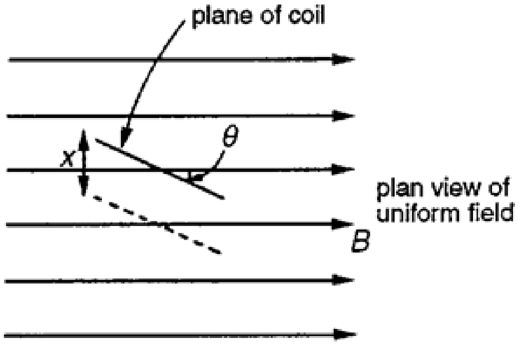
A $v > \sqrt{\frac{2Bq}{m}}$

B $v < \sqrt{\frac{2Bq}{m}}$

C $v > \frac{dBq}{m}$

D $v < \frac{dBq}{m}$

24 A plane coil of wire containing *N* turns each of area *A* is placed so that the plane of the coil makes an angle θ with the direction of the uniform magnetic field of flux density *B*. The coil is now moved through a distance *x* in time *t* to the position shown dotted.



What is the e.m.f. induced in the coil?

A zero **B** $NAB\frac{x}{t}$ **C** $NABx\frac{\cos\theta}{t}$ **D** $NABx\frac{\sin\theta}{t}$

25 A transformer steps up 120 V at the primary coil to 240 V at the secondary coil. If the current in the primary coil is 2.0 A and the power loss in the windings and core of the transformer is 48 W, what is the current in the secondary coil?

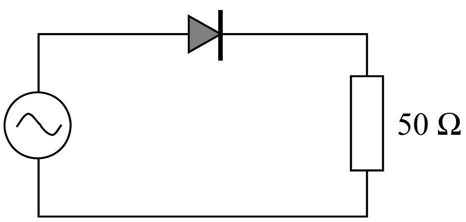
A 0.2 A

B 0.8 A

C 1.0 A

D 1.2 A

26 In the given circuit, if the sinusoidal a.c. source has a peak-to-peak voltage of 20 V, the r.m.s. current through the 50 Ω resistor is



A 0.07 A

B 0.10 A

C 0.14 A

D 0.20 A

27 Charged particles of mass *m* are accelerated from rest by a potential difference *V*.
If *V* and *m* are doubled, the de Broglie wavelength of the charged particles is

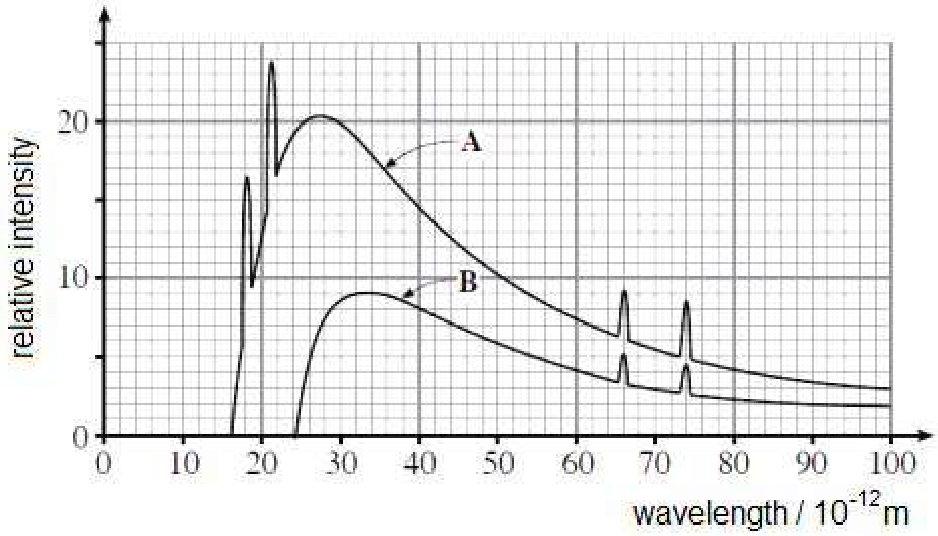
A halved.

B doubled.

C unchanged.

D decreased by a factor of $\sqrt{2}$.

28 The diagram shows two spectra of X-rays from an X-ray tube.



From the graph, it can be deduced that

A the accelerating voltage to produce spectrum B is higher than spectrum A.

B spectrum B has a continuous spectrum but no discrete spectrum.

C the target material to produce spectrum A has a higher mass number.

D the same target material is used to produce spectra A and B.

29 Alpha, beta and gamma radiations

1. are absorbed to different extents in solids,
2. behave differently in an electric field,
3. behave differently in a magnetic field.

The diagrams illustrate these behaviours.

diagram 1

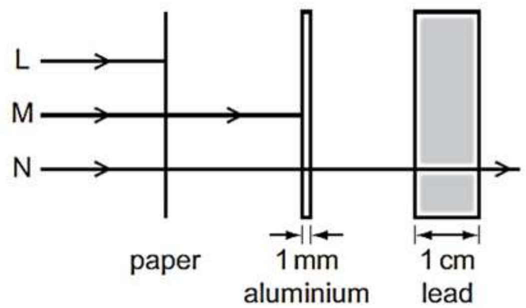


diagram 2

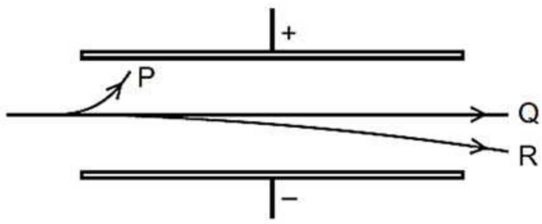
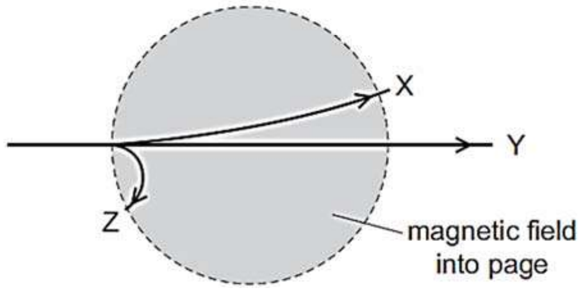


diagram 3



Which three labels on these diagrams refer to the same kind of radiation?

A L, P, X **B** L, P, Z **C** M, P, Z **D** N, Q, X

30 Each of the nuclei below is accelerated from rest through the same potential difference. Which one completes the acceleration with the lowest speed?

A ${}^{1}_{1}H$ **B** ${}^{4}_{2}He$ **C** ${}^{7}_{3}Li$ **D** ${}^{9}_{4}Be$

End of paper

JC2 Preliminary Exam 2018 (H2 Physics)

Paper 1 Solutions

Qn	1	2	3	4	5	6	7	8	9	10
Ans	A	B	D	C	B	A	B	B	D	D

Qn	11	12	13	14	15	16	17	18	19	20
Ans	A	A	A	D	D	B	A	D	D	C

Qn	21	22	23	24	25	26	27	28	29	30
Ans	C	A	C	A	B	B	A	D	C	C

Average score: /30

1 **Ans: A**

$[V] = \frac{[W]}{[q]} = \frac{[F\,s]}{[It]}$

$= \frac{kg\ m\ s^{-2}\ m}{A\ s}$

= kg m^2 s^{-3} A^{-1}

2 **Ans: B**

$$P = \frac{V^2}{R}$$

$$\frac{\Delta P}{P} \times 100\% = \left(2\frac{\Delta V}{V} + \frac{\Delta R}{R}\right) \times 100\%$$

$$= \left(2\frac{0.01}{3.20} + 0.05\right) \times 100\%$$

$$\approx 5.6\%$$

3 **Ans: D**

The gradient of the v-t graph represents the acceleration.

4 **Ans: C**

$s_1 = 0 + ½gt_1^2$ ----(1) , $s_2 = 0 + ½gt_2^2$ ----(2)

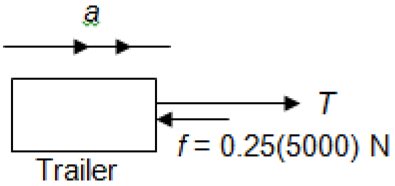
(2) – (1) $\Rightarrow$ h = $s_2 - s_1$ = ½g(t_2^2 - t_1^2)

$$g = \frac{2h}{\left(t_2^2 - t_1^2\right)}$$

5 **Ans: B**

$$T - f = ma$$

$T - 0.25(5000) = 1500(1.0)$
$T = 2750$ N



6 **Ans: A**

Do note that if rightwards is taken to be positive, u_2 = -0.050c, the negative sign is essential. In this case, it is also an elastic collision, hence, the relative speed of approach/separation equation can still be used.
PCLM : $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
$(1u)(0.100c) + (4u)(-0.050c) = (1u)\, v_1 + (4u)v_2$

Relative : $v_2 - v_1 = u_1 - u_2$
$v_2 - v_1 = 0.100c - (-0.050c)$

Solving, v_1 = -0.140c, v_2 = +0.010c

7 **Ans: B**

Upthrust = Weight of balloons + Weight of house
$\rho_{air} g V_{helium} = \rho_{helium} g V_{helium}$ + Weight of house
Weight of house
= 1.2 x 9.81 x 0.17 x 20000 – 0.18 x 9.81 x 0.17 x 20000
= 34000 N

8 **Ans: B**

By Hooke's Law, the component of the sphere's weight down the incline causes the spring to compress by a value *e*.

$$mg \sin\theta = ke$$

$$\text{or } e = \frac{(3.00)(9.81)\sin 30^0}{500} \approx 0.0294 \text{ m}$$

$$= 29.4 \text{ mm}$$

9 **Ans: D**
$\omega = 10\,(2 \times 3.14) / 8 = 7.85$ rad s^{-1}
Resolve vertically: $N\cos\theta = mg$ ----(1)
Resolve horizontally: $N\sin\theta = m\,r\,\omega^2$----(2)
(2)/(1) $\tan\theta = r\,\omega^2 / g$
$r = g\tan\theta / \omega^2 = 0.13$ m

10 **Ans: D**

Considering 10.0 g alone, T_2 provides the centripetal force for it.

$T_2 = m\,r\,\omega^2$

$= (0.010)\,(0.150 + 0.050)\,6.28^2 = 0.079$ N

Considering 21.0 g alone, $(T_1 - T_2)$ provides the centripetal force for it.

$T_1 - T_2 = (0.021)\,(0.150)\,6.28^2 = 0.124$ N

$T_1 = 0.203$ N

Ratio = 0.203 / 0.079 = 2.6

11 **Ans: A**

N is the number of molecules in the container of volume *V*. *m* is the mass of one molecule. Therefore, *Nm* is the mass of gas present in volume *V.*

12 **Ans: A**

By conservation of energy, neglecting energy losses to the surroundings,
<u>rate</u> of electrical energy supplied = <u>rate</u> of heat absorbed by the liquid

$IV = \frac{mc\Delta\theta}{t_1} = \frac{mL}{t_2}$

$c\left(\frac{3}{60}\right) = \frac{L}{15 \times 60}$

$\frac{c}{L} = \frac{1}{45}\ K^{-1}$

13 **Ans: A**

This is an SHM question and the E_p graph is **A**, lowest at the equilibrium and maximum at the amplitudes (opposite from the KE-r graph).

14 **Ans: D**

$$v = \omega\sqrt{x_0^{\ 2} - \frac{x_0^{\ 2}}{4}}$$

$$v = \frac{\sqrt{3}}{2}\omega x_0 = \frac{\sqrt{3}}{2}v_0$$

15 **Ans: D**

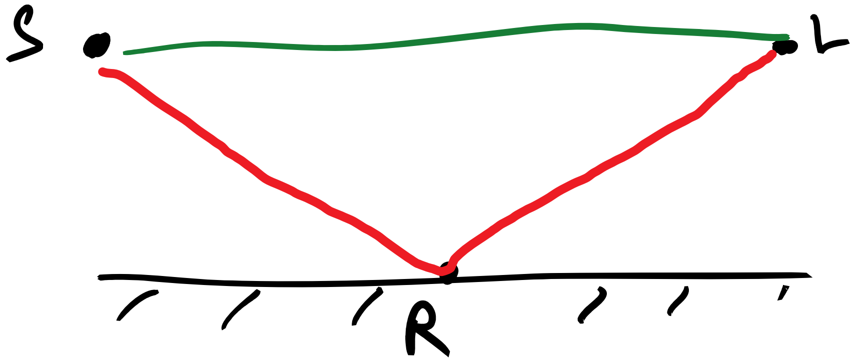
Amplitude of X = 2 x Amplitude of Y

Period of X = 3 x Period of Y ➔ Frequency of X = 1/3 Frequency of Y

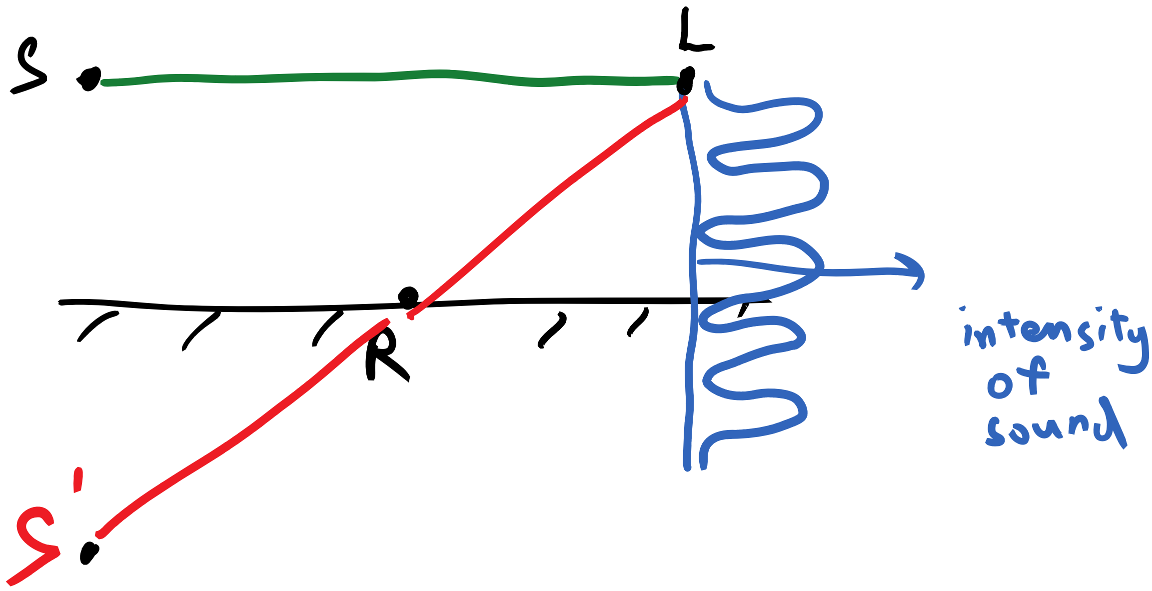
Hence, $I_X / I_Y = (2)^2(1/3)^2$

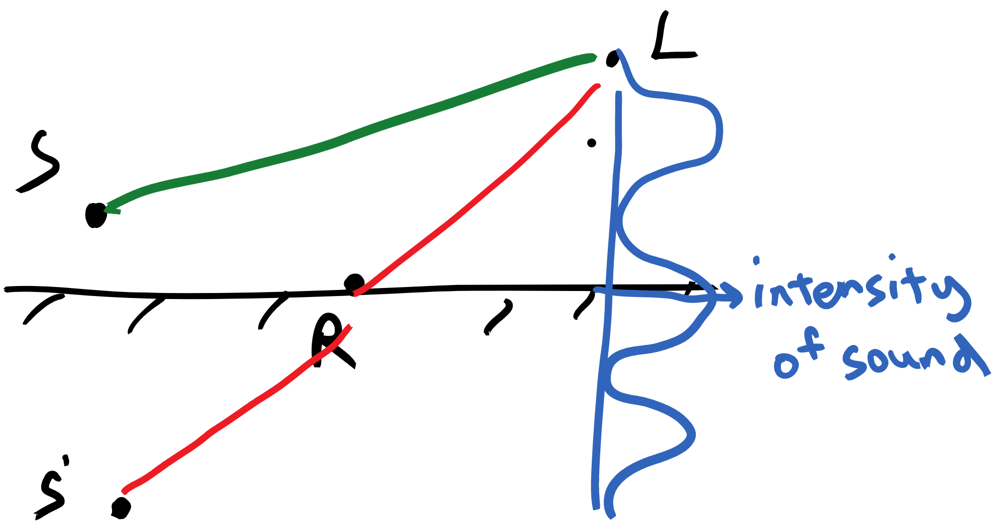
$I_Y = 9/4\ I_X = 2.25\ I_0$

16 **(L3) Ans: B**



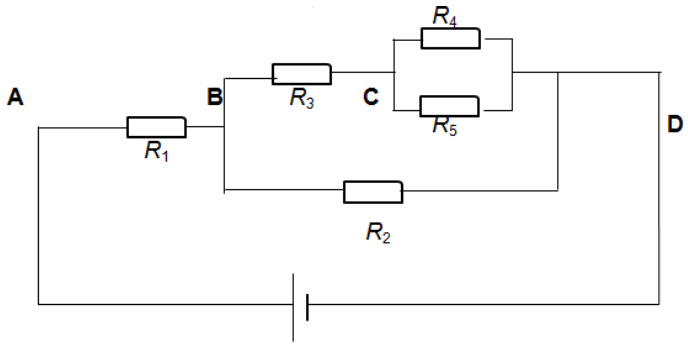
We can simplify the arrangement to look like the one below, where the reflected wave is now considered to be coming from a "virtual" source, S'. So now this looks like a "2-source" interference situation.





So if S and S' is now closer together, the distance between loud and soft sounds would be further apart ($ax = \lambda D$).

17 **Ans: A**



Redrawing:
Effective resistance across AB = R
Effective Resistance across CD = $R/2$
Effective Resistance across BD = 1/ [1/R + 1/(R + R/2)] = 3R/5
Hence p.d across AB is greater than pd across BD since resistance across AB is greater than resistance across BD. Thus p.d. is the largest across R_1. Since power is proportional to the square of the potential difference, R_1 has the largest power.

18 Ans: D

When the switch is open, at balance position, there is no current passing through the unknown emf cell.

$$E = \frac{0.70}{1.0} \times 2.0 = 1.4 \text{ V}$$

When switch is closed, at balance position, there is current flowing in the secondary circuit below.

$$E - Ir = \frac{0.50}{1.0} \times 2.0$$

$$1.4 - \left(\frac{1.4}{2.0 + r}\right) r = 1.0$$

$$r = 0.80\ \Omega$$

19 Ans: D

In order for the particle to stay balanced, the electric force must be acting upwards and the weight downwards.

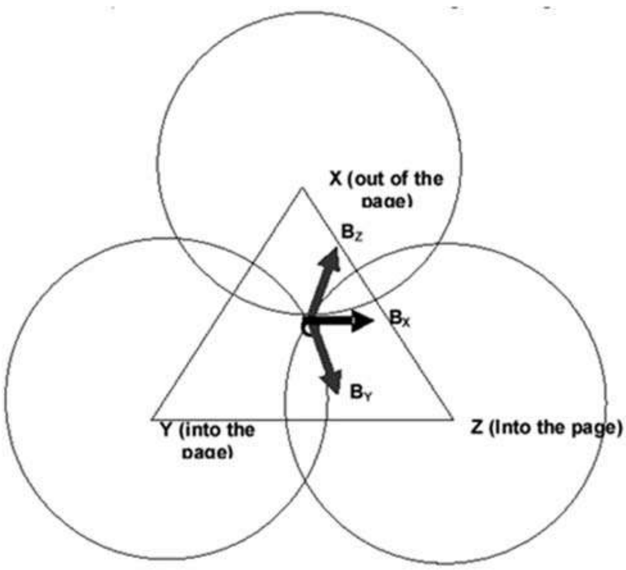
When V decreases, the particle moves downwards which is opposite to the direction of the electric force. Work done by electric force is negative and hence work done by the external force is positive. Hence the EPE increases.

20 Ans: C

As negative charge moves nearer to D, potential will become more negative and thus decrease.

21 Ans: C

Vertical components B_Y and B_Z cancel each other.
The directions of B_X, B_Y and B_Z are determined using the Right Hand Grip Rule.



22 **Ans: A**

$$mg\,(x) = BIL\,(y)$$

$$(0.10\times10^{-3})(9.81)(x) = (5.0\times10^{-3})(2.0)(6.0\times10^{-2})(y)$$

$$\frac{x}{y} = 0.61$$

23 **Ans: C**

magnetic force = centripetal force

$$Bqv = m\,\frac{v^2}{r} \quad \Rightarrow r = \frac{mv}{Bq}$$

To reach the collector, r must be greater than d.

i.e. $\frac{mv}{Bq} > \text{d} \quad \Rightarrow v > \frac{dBq}{m}$

24 **Ans: A**

There is no change of flux linkage

25 **Ans: B**

Since there is energy loss in the transformer, secondary coil current is not 1.0 A.

$P_{\text{primary}} = P_{\text{secondary}} + P_{\text{loss}}$

$120 \times 2.0 = 240I + 48$

$I = 0.8$ A

26 **Ans: B**

V_0 = 20/2 = 10 V

For half wave rectified circuit, $V_{rms} = V_0 / 2$ = 5 V

$I_{rms} = V_{rms} / R = 5 / 50 = 0.10$ A

27 Ans: A

Using loss in EPE = gain in KE,

$$\frac{1}{2}mv^2 = qV$$
$$\frac{1}{2}\frac{\rho^2}{m} = qV$$
$$\lambda = \sqrt{\frac{h^2}{2mqV}}$$

When V and m are doubled,

$$\lambda_{new} = \sqrt{\frac{h^2}{2(2m)q(2V)}} = \frac{1}{2}\lambda$$

28 Ans: D

Same target atom since the K_α and K_β have the same wavelengths showing the same set of energy levels.

29 Ans: C

L: alpha	M: beta	N: gamma
P: beta	Q: gamma	R: alpha
X: alpha	Y: gamma	Z: beta

30 Ans: C

Gain in KE = ½ m v^2 – 0 = q V
v = $(2 V q/m)^{1/2}$
Nucleus with lowest q/m will have the lowest speed. Charge is determined from the proton number while mass is determined from the mass number.

End of solutions

Class	Index Number	Name
17S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2018
Preliminary Examination

PHYSICS, Higher 2 **9749/02**

Paper 2 Structured Questions **13th September 2018**
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 6
2	/ 11
3	/ 6
4	/ 13
5	/ 15
6	/ 12
7	/ 17
Total	/ 80

This document consists of **23** printed pages including this page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho g h$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T/\text{K} = T/{}^\circ\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$v = \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{1/2}}$

1 **(a)** Explain what is meant by random error.

……………………………………………………………………………………………………..

…………………………………………………………………………………………….[1]

(b) A cylindrical thermos flask is used to store hot water. The internal diameter and depth of the thermos flask are measured to be (8.50 ± 0.01) cm and (17.0 ± 0.1) cm respectively.

(i) State the instrument used to measure its diameter and a systematic error that can occur with the use of this instrument.

....……………………………………………………………………………………

....……………………..…………………………………………………………….…[2]

(ii) Calculate the volume of the thermos flask and its associated uncertainty.

volume = ……………….………………………… cm^3 [3]

2 **(a)** State the relation between force and momentum.

……………………………………………………………………………………………………

……………………………………………………………………………………………[2]

(b) A uniform wooden bar of mass 450 g is held in position horizontally by a hinge at C, which also allows for rotation of the bar, as shown in Fig. 2.1.

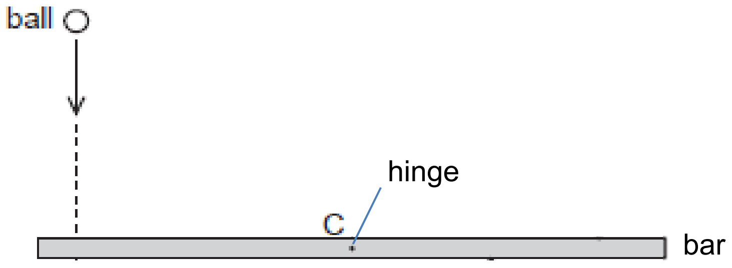


Fig. 2.1

A ball of mass 140 g falls vertically from rest onto the bar such that it hits the bar at a position to the left of C. The variation with time *t* of the velocity *v* of the ball before, during and after hitting the ball is shown in Fig. 2.2.

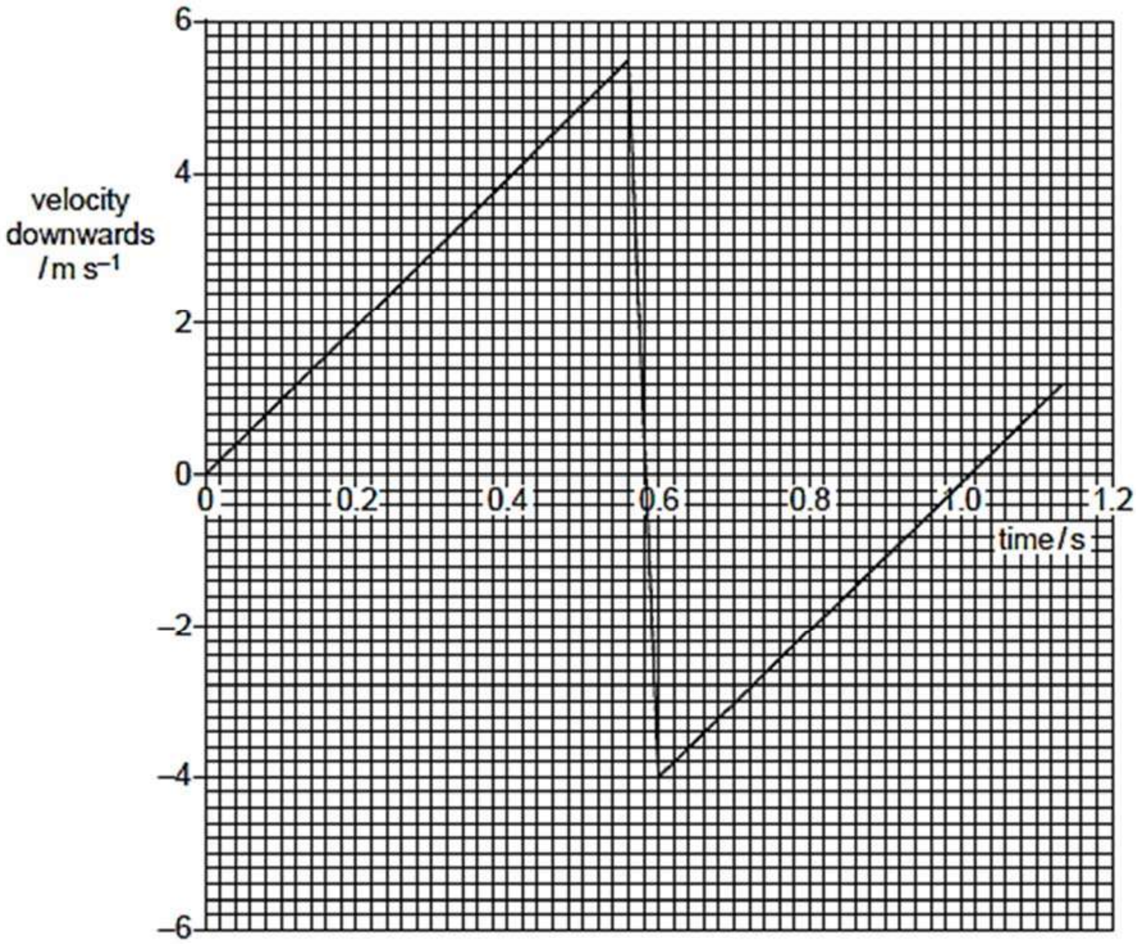


Fig. 2.2

For the time that the ball is in contact with the bar, use Fig. 2.2 to determine

(i) the change in momentum of the ball,

change = …………………… kg m s^{-1} [2]

(ii) the impulse delivered to the bar,

impulse = ………………………Ns [1]

(iii) the magnitude of the force exerted by the ball on the bar,

force = …………………… N [1]

(c) **(i)** State and explain whether the principle of conservation of momentum can be applied for the collision of the ball with the bar.

………………………………………………………………………………………...

………………………………………………………………………………………...

………………………………………………………………………………………...

……………………………………………………………………………………….[2]

(ii) Explain, using Newton's third law of motion, the relationship between the impulse experienced by the ball and the impulse experienced by the bar during impact.

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

………………………………………………………………………………………….[3]

3 Two forces, each of magnitude F, form a couple acting on the edge of a disc of radius r, as shown in Fig. 3.1.

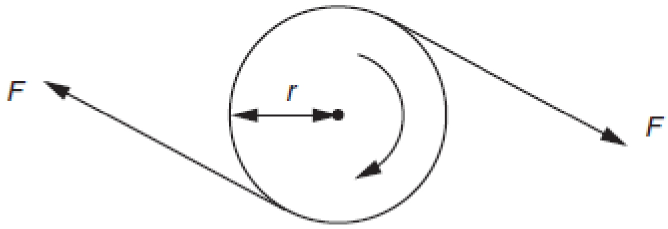


Fig 3.1

(a) The disc is made to complete n revolutions about an axis through its centre, normal to the plane of the disc. Write down an expression for

(i) The distance moved by a point on the circumference of the disc,

distance = ……………………………….. [1]

(ii) the work done by one of the two forces.

work done = ……………………………….. [1]

(b) Using your answer to **(a)**, show that the work done W by a couple producing a torque τ when it turns through n revolutions is given by

$$W = 2\pi n\tau.$$ [2]

(c) A car engine produces a torque of 450 N m at 2900 revolutions per minute. Calculate the output power of the engine.

power = ……………………………W [2]

4 A block of wood of mass *m* floats in still water, as shown in Fig. 4.1 below.

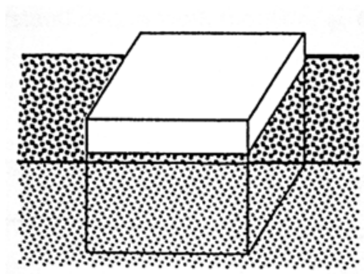


Fig. 4.1

When the block is pushed into the water, without totally submerging it, and is then released, it bobs up and down in the water in simple harmonic motion.

Surface water waves of speed 1.2 m s^{-1} and wavelength 0.35 m are then incident on the block. These cause *resonance* in the oscillation of the block.

The vertical displacement *y* of the block varies with time *t* according to the relation:

$$y = -0.015\, cos\left(\sqrt{\frac{28}{m}}\right) t\ ,$$ where *m* is measured in kg.

(a) Explain what is meant by simple harmonic motion.

……..……………………………..………………………………………………………………………

……..……………………………..………………………………………………………………………

……..……………………………..…………………………………………………………………….[2]

(b) **(i)** Calculate period of the water waves T_0 during which resonance is achieved.

T_0 = ………………………...s [1]

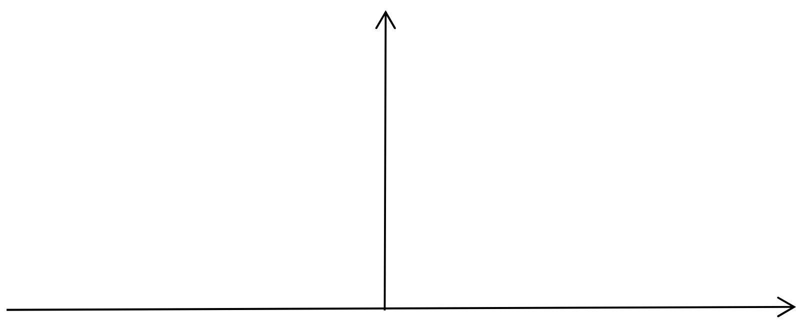
(ii) Determine the mass of the block,

mass = ………………………kg [2]

(iii) Determine the maximum acceleration during the oscillation.

maximum acceleration = ……………………….…m s^{-2} [2]

(iv) Sketch a graph of the kinetic energy of the block against displacement in the vertical direction. [2]



(c) Fig. 4.2 shows how the amplitude of oscillation of the block varies with the period of the surface water waves, while keeping the amplitude of the water waves constant.

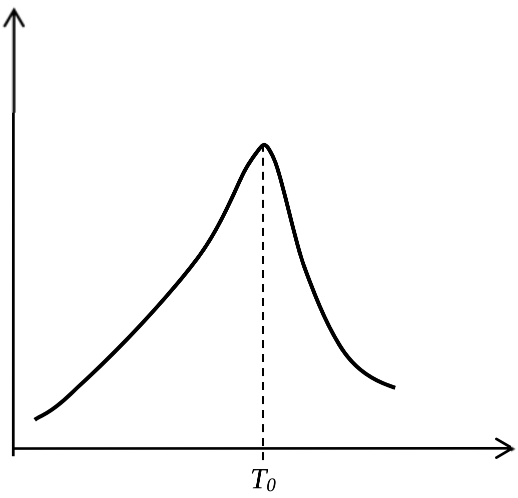


Fig. 4.2

(i) With respect to energy, explain how the peak amplitude of oscillation of the block is achieved.

…………………………………………………………………………………….………..

…………………………………………………………………………………….………..

…………………………………………………………………………………….………..

…………………………………………………………………………………………….[2]

(ii) The block is replaced with another one with a larger cross-sectional area but of the same mass. Sketch a graph on Fig. 4.2 to show how the amplitude of oscillation of the block varies with the period of the water waves. [2]

5 **(a)** Fig. 5.1 shows how the resistance of a light-dependent resistor (LDR) varies with the intensity of the light incident on it.

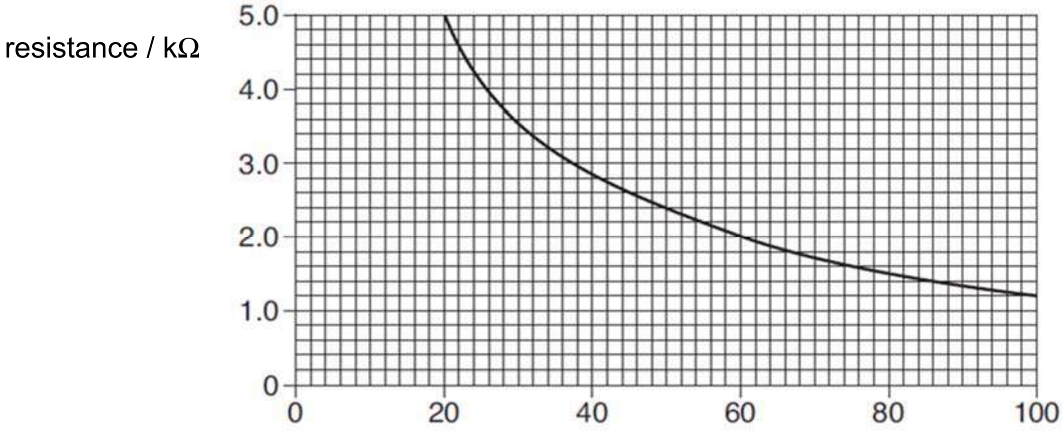


Fig 5.1

(i) State and explain *quantitatively*, if the resistance of the LDR is inversely proportional to the intensity of the light incident on it, by using the end-points of the graph.

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Complete the circuit diagram in Fig. 5.2, which should show a light-sensing circuit where the potential difference across the LDR, with characteristics shown in Fig. 5.1, can be used to control the brightness of a bulb rated 6.0 V, 1.5 W in a room.

The bulb is to be arranged in parallel with the LDR while a 1.2 kΩ resistor made of carbon is to be arranged in series with the LDR-bulb combination. The 9.0 V e.m.f. battery has negligible internal resistance.

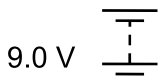


Fig. 5.2

[2]

(iii) Use Fig. 5.1 and Fig. 5.2 to show that the light intensity in the room is 24 W m^{-2} when the potential difference across the LDR is 7.0 V and the bulb is removed.

[3]

(iv) Fig. 5.3 shows a close-up of the LDR device used in the circuit in Fig. 5.2. The LDR consists of a uniform strip of an intrinsic semiconductor whose resistivity is dependent on the intensity of the light incident on it. The strip has a diameter of 8.0×10^{-4} m.

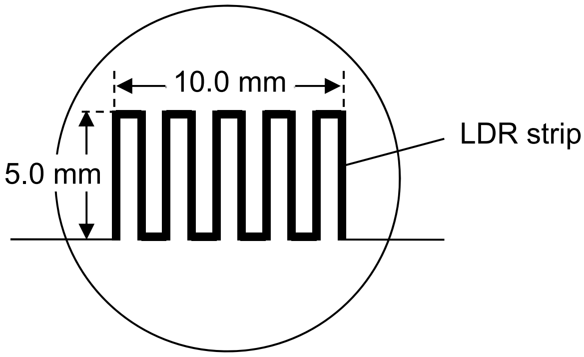


Fig. 5.3

Determine the resistivity of the LDR when it has a resistance of 4.2 kΩ.

resistivity = ……………….. Ω m [2]

(b) **(i)** Fig. 5.4 shows a circuit containing five identical lamps A, B, C, D and E. The circuit also contains three switches S_1, S_2 and S_3.

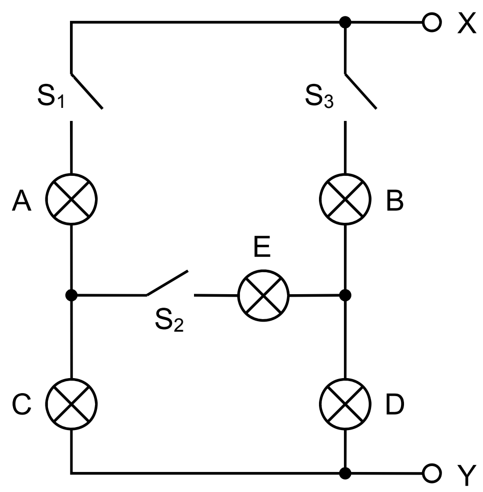


Fig. 5.4

One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 5.5 shows the readings of the ohm-meter for different switch positions.

The resistance of the non-faulty lamps can be assumed to be constant.

switch			ohm-meter reading / Ω
S_1	S_2	S_3	
open	open	open	∞
closed	open	open	30.0
closed	closed	open	30.0
closed	closed	closed	15.0

Fig. 5.5

(1) Identify the faulty lamp, and the nature of the fault.

faulty lamp = ……..……………………[1]

nature of fault = …………………………[1]

(2) Suggest why it is advisable to test the circuit using an ohm-meter that causes negligible current rather than with a power supply across terminals X and Y.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[1]

(3) State the resistance of one of the non-faulty lamps, as measured using the ohm-meter.

resistance = …………………Ω [1]

(4) After replacing the faulty lamp in the circuit in Fig. 5.4 with a similar working lamp, the ohm-meter is connected between terminals X and Y.
On Fig. 5.6, complete the readings of the ohm-meter for different switch positions.

switch			ohm-meter reading / Ω
S_1	S_2	S_3	
open	open	open	∞
closed	open	open	
closed	closed	open	
closed	closed	closed	

Fig. 5.6 [2]

6 When light illuminates a clean surface of potassium, electrons can be emitted. This is the photoelectric effect. Fig 6.1 shows a section of the surface at a microscopic scale.

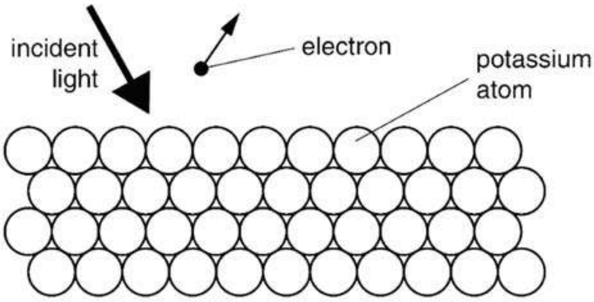


Fig. 6.1

(a) Electrons are emitted when the incident light is violet, but not when the incident light is red. Increasing the intensity of violet light causes more electrons to be emitted. Increasing the intensity of red light has no effect.
Explain how this is evidence for the quantum behaviour of light.

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……………………………………………………………………………………………………

……………………………………………………………………………………………………[4]

(b) Einstein explained the photoelectric effect by suggesting that there is a minimum energy ϕ, the work function, which must be supplied to remove an electron from the surface of a metal.

The work function for potassium is 3.7×10^{-19} J.

Show that photons of frequency less than 5.6×10^{14} Hz cannot remove electrons from a potassium surface. [2]

(c) One early device using the photoelectric effect was the photoelectric cell. This cell sets up a current in an external circuit when light falls on it.

Suggest one use for a photoelectric cell containing a potassium surface and any limitations it may have in practice.

……………………………………………………………………………………………….........

……………………………………………………………………………………………….........

……………………………………………………………………………………………….........

……………………………………………………………………………………………….......[2]

(d) The variation with frequency *f* of the maximum kinetic energy E_k of the emitted electrons is shown in Fig. 6.2.

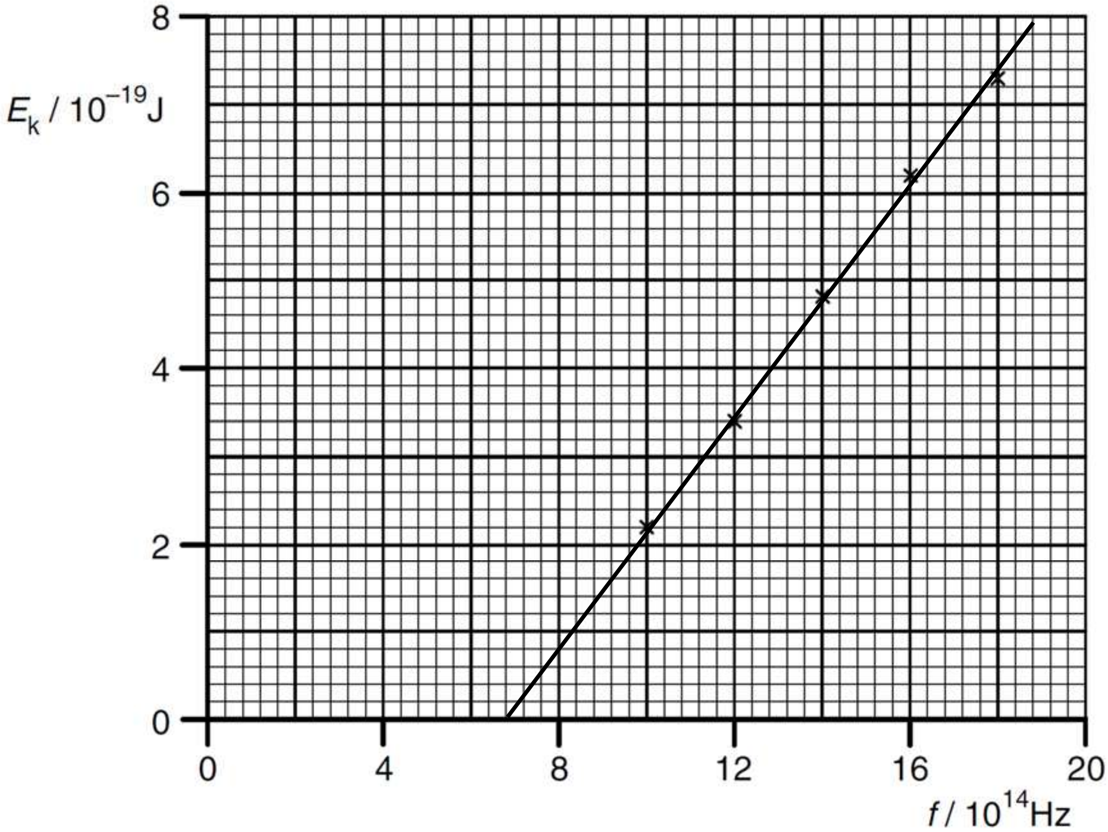

Fig. 6.2

(i) Explain the shape of the graph in Fig. 6.2.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(ii) Use Fig. 6.2 to determine a value for the Planck constant.

Planck constant = ... J s [2]

7 This question is about the performance of commercial jet aircraft.

Although much criticised for their carbon footprint, modern jet aircraft have been developed to carry the largest load they can, at the greatest speed possible, for the smallest amount of fuel. This is basic economic good sense. However, some of these factors do compete with each other: the fastest commercial jet aircraft, Concorde, proved uneconomic to run, as it could not carry enough passengers to make its journeys profitable. It was taken out of service in 2003.

More recent jet aircraft are designed to carry many more passengers and their luggage than Concorde could. They also need to travel a quarter of the way around the world without refuelling. This means that they need to carry a lot of fuel, which can be over a third of the total weight of the plane! The planes themselves are necessarily larger, which further increases the weight to be carried.

In level flight, lift is produced by pressure differences produced by airflow across the wings, with lift depending on the speed and on the surface area of the wings. Cruising speeds of many jet aircraft are all rather similar, being just less than the speed of sound, so differences in lift are likely to depend mainly on the surface area and shape of the wings.

Aircraft use fuel very rapidly at take-off, when the engines have to deliver maximum thrust. The aircraft must accelerate fast enough to reach the speed needed to take off, usually about 240 – 290 km h^{-1} in a distance well within the length of the runways available. Because take-off speeds and runway lengths are all rather similar, the acceleration of most jet aircraft down the runway is similar, whatever their mass and total engine thrust.

After take-off, jet aircraft are required to climb steeply to avoid excessive noise nuisance. If the angles of climb are similar, this also requires maximum thrust to be related to total aircraft take-off weight.

Data on six aircraft are given in the table of Fig. 7.1.

type	number of engines	maximum thrust per engine / kN	maximum take-off mass /kg	take-off distance /m	cruising speed km/h	fuel consumption litre/h	fuel capacity /litre	range /km	wing surface area /m^2
Airbus A340-300	4	152	284000	3400	876	8000	155400	13500	362
Airbus A340-600	4	276	365000	3200	902	9800	195600	13900	437
Boeing 777-200	2	343	247000	3100	900	7700	117300	9000	430
Boeing 747-400	4	264	397000	3600	925	14160	216800	13500	525
DC10-40	3	236	251700	2800	965	10800	138700	9300	339
MD-11	3	270	273900	3100	945	9000	146000	12600	339

Fig. 7.1

(a) Suggest and explain why the Concorde could not carry as many passengers as other commercial jet aircraft.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………[2]

(b) Use the data on the Airbus A340-600 in Fig. 7.1 to answer the following questions.

(i) Show that the plane takes about 15 hours to travel the range at its cruising speed. [1]

(ii) Show that the fuel consumed in travelling the range at cruising speed is less than 80% of the maximum fuel carried. [2]

(iii) Suggest and explain why the aircraft carries more fuel than that needed to travel its range at its cruising speed.

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………………………………………………………………………………………[2]

(c) Use the data on the MD-11 in Fig. 7.1 to answer the following questions.

(i) Show that the initial acceleration of the MD-11, with maximum thrust and maximum take-off mass, is approximately 3 m s^{-2}. [1]

(ii) Use your answer to **(c)(i)** to calculate the distance required for the MD-11 to reach a take-off speed of 81 ms^{-1}.

distance = …………………………….m [1]

(iii) The distance calculated in **(c)(ii)** is substantially less than the quoted take-off distance of 3100 m.
Suggest and explain a reason for this.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………[2]

(d) In level flight, the lift required is directly proportional to the *mass* of the aircraft. Explain why.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………[2]

(e) The graph of Fig. 7.2 shows the relationship between maximum take-off mass M and wing area A for all six aircraft in the table.

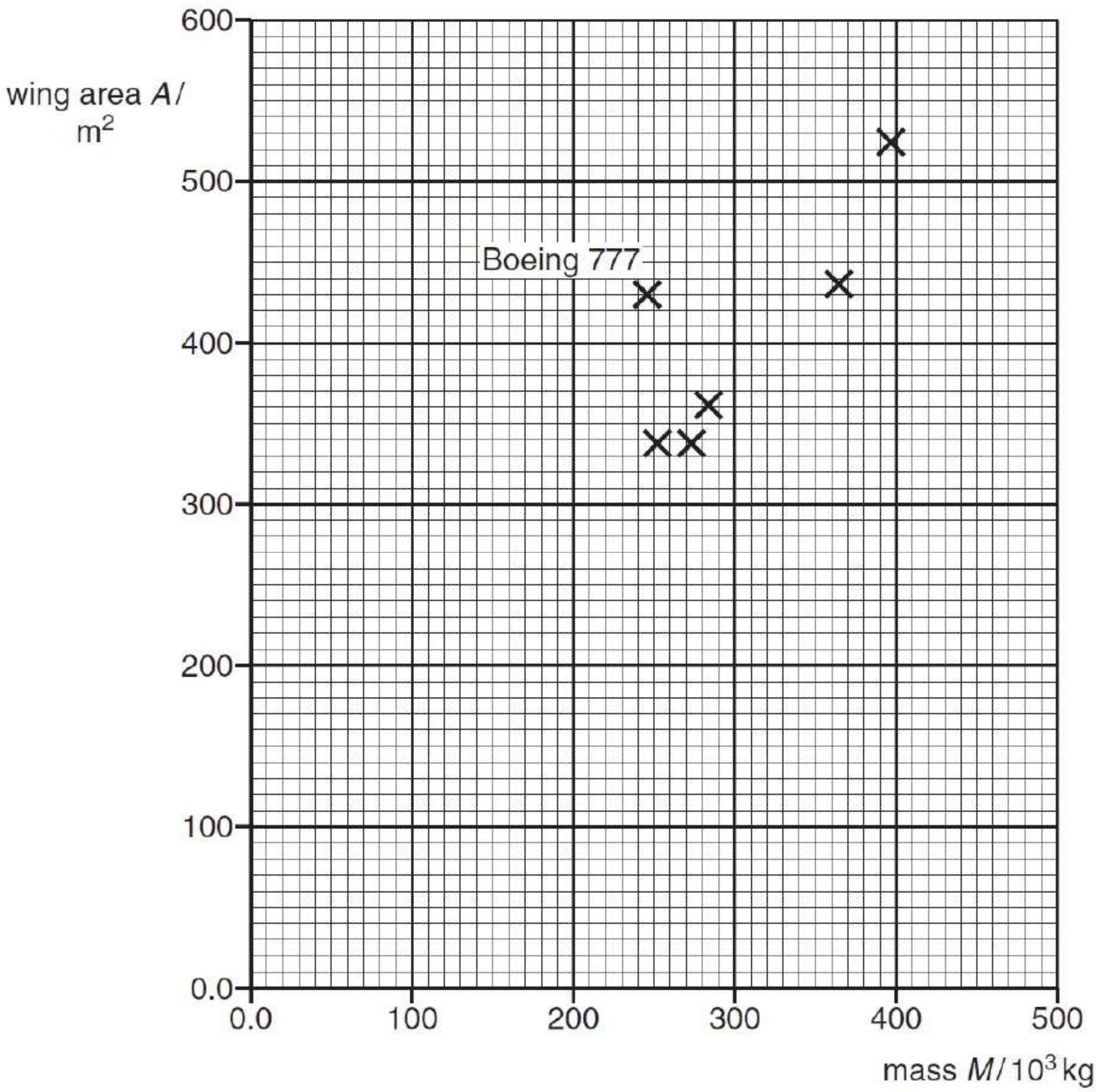


Fig. 7.2

Draw a straight line of best fit on Fig. 7.2.
Discuss what the graph suggests about the design of these six aircraft.

……

……

……

……

………………………………………………………………………………………………… [4]

End of paper

Solution for 2018 SAJC H2 Physics Prelim Paper 2

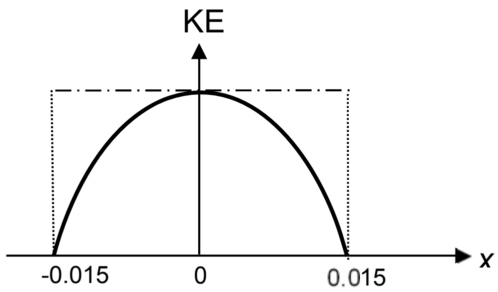
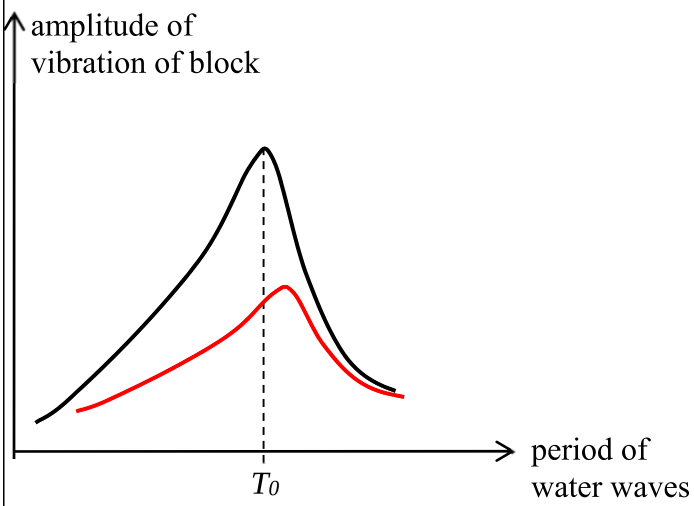
1 (a)	Random error is an error which causes measurements to be sometimes larger than the true value and sometimes smaller than the true value.	**1**
(b)(i)	vernier calipers zero error (do not accept parallax)	**1** **1**
(ii)	$V = \pi\left(\frac{d^2}{4}\right)h$ $= 964.665\ \text{cm}^3$ $\frac{\Delta V}{V} = \frac{2\Delta d}{d} + \frac{\Delta h}{h}$ $\Delta V = \left(\frac{2\times 0.01}{8.50} + \frac{0.1}{17.0}\right)\times 964.665$ $= 8\ \text{cm}^3$ $V = (965 \pm 8)\ \text{cm}^3$ {ECF for wrong V or ΔV}	**1** **1** **1**

2 (a)	Force = rate of change of momentum (allow symbols if defined) and it acts in the direction of the change in momentum. {Note: this qn appeared in N2012 P3 Q6a, 2m}	**1** **1**
(b)(i)	$\Delta p = m\,\Delta v = (0.140)(-4.0 - 5.5)$ $= $ **–1.33** kg m s^{-1} (must be –ve)	**1** **1**
(ii)	Impulse to bar = negative of the Δp of ball = + **1.33** Ns (give ecf corr to above ans)	**1**
(iii)	force = Δp / Δt = 1.33 / 0.04 = **33.3** N {give ecf for wrong impulse}	**1**
(c)(i)	If the system considered consists of only the ball, Not applicable, since there is net/resultant force acting, due to gravitational force / contact force on ball. OR If the system considered consists of both the ball and bar, Not applicable, since there is net/resultant force acting, due to the upward force by hinge on bar/ gravitational force acting on the ball & bar.	**2 or 0** **2 or 0**

(ii)	According to Newton's 3rd law, force on bar (due to ball) is equal in magnitude and opposite in direction to force on ball (due to bar) Since time (of contact) (*t*) is same for both **AND** Impulse = *Ft* Impulse on ball is equal in magnitude and opposite in direction to impulse on bar	**1** **1** **1**

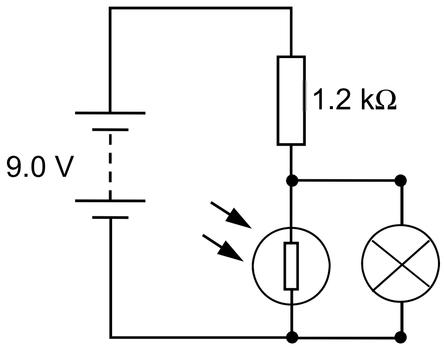
3 (a)(i)	distance = $n \times 2\pi r = 2\pi nr$	**1**
(ii)	work done = $F \times 2\pi nr$ (ecf allowed)	**1**
(b)	total work done by couple = $2 \times F \times 2\pi nr$ Since $\tau = 2Fr$ Hence work done = $\tau \times 2\pi n$	**1** **1**
(c)	Power = work done / time = $(450 \times 2\pi \times 2900) / 60$ = 1.37×10^5 W	**1** **1**

4 (a)	Simple harmonic motion is a periodic oscillation with its acceleration proportional to its displacement from the equilibrium position (“origin” not acceptable) and is always directed towards the equilibrium position/ opposite in direction to the displacement from the equilibrium position.	**1** **1**
(b)(i)	T_o = 1/ driver frequency = 1/ (speed / wavelength) = 0.35 / 1.2 = 0.292 s	**1**
(ii)	frequency of water waves = speed / wavelength = 1.2 / 0.35 = **3.43** Hz $\omega = \sqrt{\frac{28}{m}}$ $\Rightarrow 2\pi f = \sqrt{\frac{28}{m}}$ $\Rightarrow m = \frac{28}{(2\pi(3.4))^2}$ = 0.0603 kg	**1** **1**

(iii)	Max acceleration = $a_o = x_o\omega^2$ = 0.015 x $(2\pi \times 3.43)^2$ = **6.96** m s^{-2}	**1** **1**
(iv)		**1 - shape** **1- amplitude**
(c)(i)	When driver frequency (of water waves) is equal to the natural frequency (of block), there is a maximum transference of energy from the waves to the block, hence increasing the total energy of the driven oscillating system and its amplitude.	**1** **1**
(ii)	 [1] for lower overall amplitudes [1] for peak shifted to the right of T_o (note that x-axis is period, not driving frequency as in lect notes!)	**2**

<table>
<tr><td>5 (a)
(i)</td><td>If R is inversely proportional to intensity, R x intensity = constant,

$(5)(20) \neq (100)(1.2)$ or any 2 points. Products not equal. Hence, not inversely proportional.</td><td>1

1</td></tr>
<tr><td>(ii)</td><td>

[1] – correct symbols

[1] – correct diagram</td><td>1

1</td></tr>
<tr><td>(iii)</td><td>When the potential difference across the LDR is 7.0 V,
potential difference across the 1.2 kΩ resistor = 2.0 V

Using $V = IR$
$2.0 = (1.2 \times 10^3)\ I$
$I = 1.67 \times 10^{-3}$ A
$R = \frac{V}{I} = \frac{7.0}{1.67 \times 10^{-3}}$ = 4200 Ω or 4.2 kΩ

From Fig. 5.1, light intensity = 24 W m^{-2}</td><td>1

1

1</td></tr>
<tr><td>(iv)</td><td>Length of strip, $\lambda = (10 \times 5.0 \times 10^{-3}) + (10.0 \times 10^{-3}) = 0.060\ m$

Using $R = \frac{\rho \lambda}{A}$,

$\rho = \frac{RA}{l} = \frac{4200 \times \pi \times (4.0 \times 10^{-4})^2}{0.060} = 3.5 \times 10^{-2}\ \Omega\ m$
{ECF allowed for wrong length}</td><td>1

1</td></tr>
<tr><td>b(i)(1)</td><td>nature of fault: lamp fused (open circuit)

faulty lamp: lamp E</td><td>1

1</td></tr>
<tr><td>(2)</td><td>If there is a short circuit, it could cause excessive current to flow in the circuit that could cause damage to the power supply / other lamps / blow fuse in power supply.</td><td>1</td></tr>
<tr><td>(3)</td><td>Resistance of one non-faulty lamp = 30.0 / 2 = 15.0 Ω</td><td>1</td></tr>
<tr><td>(4)</td><td><table><tr><td>switch</td><td>ohm-meter reading</td></tr></table></td><td>2
-1
for</td></tr>
</table>

		S_1	S_2	S_3	/ Ω		
		open	open	open	∞		1 mistake
		closed	open	open	30.0		
		closed	closed	open	25.0		
		closed	closed	closed	15.0		

6(a)	violet photons are energetic enough to liberate electrons, while red are not OR Frequency of violet (photons) is higher than threshold frequency, while red (photons) is not	**1**
	Higher frequency/lower wavelength means higher energy photons OR E = hf greater intensity = more photons one photon liberates one electron more photons per unit time (incident on potassium leads to) more electrons produced in wave model, there will be photoelectric emission for all wavelengths/frequencies but this does not happen (so wave model is wrong)	**Any 3**
(b)	$E = hf = 6.6 \times 10^{-34}$ J s × 5.6×10^{14} Hz = 3.7×10^{-19}J comparison of calculated value with given threshold E.g. Photons with frequency less than 5.6×10^{14} Hz will have less energy than the work function, so these photons cannot remove electrons from potassium surface OR $f_o = 3.7\times10^{-19}$J/6.6×10^{-34}J s = 5.6×10^{14}Hz Photons with frequency below the threshold frequency of 5.6×10^{14} Hz will have less energy than the work function of potassium, and cannot remove electrons from potassium surface	**1** **1**
(c)	Any reasonable application/use involving detection of light or measurement of its intensity E.g. solar panel, measuring light level, automatic switch. Limitation: e.g. limited range of wavelengths detectable (not red end of spectrum), need for clean potassium surface, very low amount of power generated, very little current generated (thus requiring the need for very sensitive micro-ammeters)	**1** **1**

(di)	E_k is 0 for f below the threshold frequency 6.8×10[14] Hz (allow ±0.4×10[14] Hz) OR no electrons produced OR energy of photon is less than the work function $E_k = hf - \phi$, so a graph of constant gradient/straight line is obtained (after threshold frequency) {note: cannot say "directly proportional"}	**1** **1**
(dii)	Attempt at finding gradient (either seen from gradient triangle on graph, or calculations shown to find gradient) Working shown to give 6.6 × 10^{-34} J s (Allow ±0.2×10^{-34} J s) e.g. $h = \frac{(7.8-0)\times10^{-19}}{(18.9-6.8)\times10^{14}}$ $= 6.5 \times10^{-34}$ J s	**1** **1**

7(a)	Plausible suggestion Explains effect of suggestion on passenger capacity E.g.: Concorde travels at higher speeds so higher air resistance Need to carry more fuel (instead of carrying passengers) to do more work against air resistance E.g. Concorde travels at higher speeds so higher air resistance needs to have a small cross sectional area, so carry fewer passengers	**1** **1**
(bi)	Time = distance/ speed = 13 900 km/ 902 km h^{-1} = 15.4 h	**1**
(bii)	fuel used = 15.4 h × 9800 L h^{-1} = 151 000 L 80% of 195 600 = 156 000 L (> 151 000 L) {allow use of 15 hours: fuel used = 15 h × 9800 L h^{-1} = 147 000 L 80% of 195 600 = 156 000 L (> 147 000 L) }	**1** **1**
(biii)	Plausible suggestion Explains effect of suggestion on fuel needed – must have correct physics reasoning E.g.: head winds / diversion from route / delays in landing; so plane must stay longer in the air E.g.:	**1** **1**

	more fuel needed at take-off; work done in accelerating/overcoming turbulence/denser air at ground level	
(ci)	F = 3 × 270 000 = 810 000 N $a = F/m$ = 810 000 N/273 900 kg = 2.96 m s^{-2}	**1**
(cii)	$s = v^2/2a$ = (81 m $s^{-1})^2$/2×2.96 m s^{-2} = 1100 m	**1**
(ciii)	Plausible suggestion Explains effect of suggestion on take-off distance – must have correct physics reasoning e.g. May not reach required v due to wind / other traffic on runway / turbulence If v not reached, plane would crash /need space to slow down/brake to a halt	 **1** **1**
(d)	Lift must equal weight weight = (mass)(g) <u>so</u> Lift is proportional to mass	**1** **1**
(e)	Best-fit line excluding Boeing 777 (Line should obviously exclude Boeing 777 and should be reasonable best fit of other points by eye, i.e. have points on each side) Larger mass planes have larger wing area Identifying Boeing 777 as different from others (e.g. Boeing 777 is an anomalous plot) Suggestion for odd position of Boeing 777 on the graph e.g. Boeing 777 has a relatively low mass because of its low fuel capacity (because of its good fuel effiency)	**1** **1** **1** **1**

Class	Index Number	Name
17S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2018
Preliminary Examination

PHYSICS, Higher 2 **9749/03**

Paper 3 Longer Structured Questions **17th September 2018**
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid..

The use of an approved scientific calculator is expected, where appropriate.

Section **A**
Answer **all** questions.

Section **B**
Answer any **one** question

You are advised to spend one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	/ 17
2	/ 13
3	/ 10
4	/ 20
Section B	
5	/ 20
6	/ 20
Total	/ 80

This document consists of **21** printed pages including this page.

Data

speed of light in free space,	c = 3.00 x 10^{8} m s^{-1}
permeability of free space,	μ_o = 4 π x 10^{-7} H m^{-1}
permittivity of free space,	ε_o = 8.85 x 10^{-12} F m^{-1}
	= (1/(36π)) x 10^{-9} F m^{-1}
elementary charge,	e = 1.60 x 10^{-19} C
the Planck constant,	h = 6.63 x 10^{-34} J s
unified atomic mass constant,	u = 1.66 x 10^{-27} kg
rest mass of electron,	m_e = 9.11 x 10^{-31} kg
rest mass of proton,	m_p = 1.67 x 10^{-27} kg
molar gas constant,	R = 8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A = 6.02 x 10^{23} mol^{-1}
the Boltzmann constant,	k = 1.38 x 10^{-23} J K^{-1}
gravitational constant,	G = 6.67 x 10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g = 9.81 m s^{-2}

Formulae

uniformly accelerated motion,	$s = u t + \frac{1}{2} a t^2$
	$v^2 = u^2 + 2 a s$
work done on/by a gas,	$W = p \Delta V$
hydrostatic pressure,	$p = \rho g h$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	T / K = T / °C + 273.15
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$v = \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1 / R = 1 / R_1 + 1 / R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{1/2}}$

Section A

Answer **all** questions in the spaces provided.

1 **(a)** In the following list, underline **all** the scalar quantities.

acceleration pressure kinetic energy mass power weight

[1]

(b) Define displacement.

....[1]

(c) A ball is kicked from point A, 1.0 m above the ground with a velocity of 20.0 m s^{-1} at an angle 50° to the horizontal as shown in Fig. 1.1. It reaches the maximum height at point H and finally lands on the ground at B.

Assume air resistance is negligible.

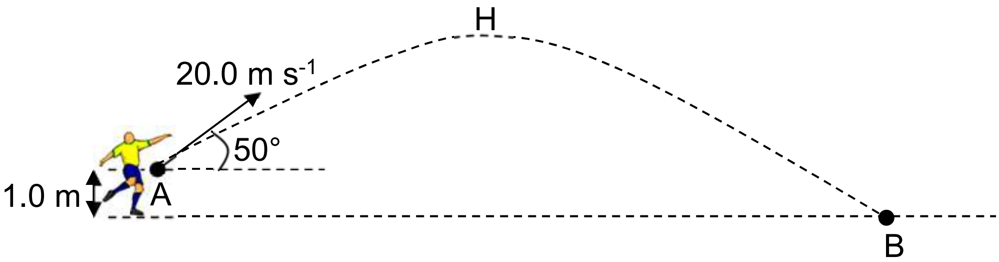


Fig. 1.1

(i) Determine the time of flight of the ball.

time = ... s [3]

(ii) Calculate the horizontal distance the ball travelled from A to B.

distance = ………………………….. m [1]

(iii) Calculate the speed of the ball when it hits the ground at B.

speed = ……………………….. m s^{-1} [2]

(iv) State the magnitude and direction of the acceleration of the ball at H.

magnitude and direction = …………………………………………… [1]

(v) **1.** On Fig. 1.2, sketch the variation with time t of the vertical component of the ball's velocity v_y.

[2]

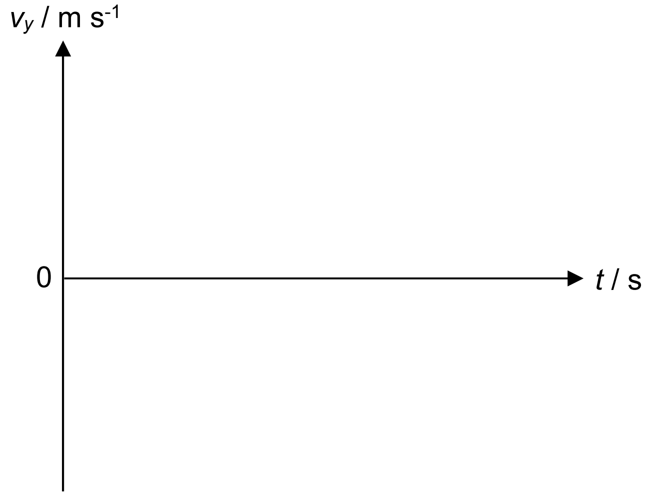


Fig. 1.2

2. On Fig. 1.3, sketch the variation with time *t* of the distance *d* travelled along its path.

[2]

Fig. 1.3

3. On Fig. 1.4, sketch the variation with time *t* of the kinetic energy E_k of the ball.

[2]

Fig. 1.4

(vi) Explain the effects on the trajectory (path) of the ball if air resistance is not negligible.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

………………………………………………………………………………………..….[2]

2 **(a)** Explain what is meant by an ideal gas.

………

…………………………………………………………………………………………………..[1]

(b) An ideal gas is enclosed in a cylinder by a gas-tight, frictionless piston as shown in Fig. 2.1.

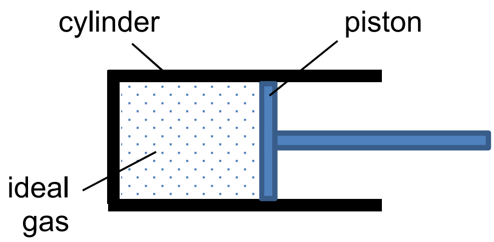


Fig. 2.1

Use the *molecular model* of a gas to explain the following phenomena.

(i) The pressure rises if the volume containing a given mass of gas is reduced, the temperature remaining constant.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………….…[2]

(ii) The temperature rises if the gas is compressed.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………….…[2]

(c) A fixed mass of monatomic ideal gas in a cylinder undergoes a cycle of changes of pressure, volume and temperature as shown in Fig. 2.2. Line **AB** and line **CD** represent two isothermal processes. The pressure at **A** and **B** are 2.7 x 10^5 Pa and 12 x 10^5 Pa respectively. The volume at **A** is 2.00 x10^{-3} m^3 and that at **B** is 0.45 x 10^{-3} m^3.

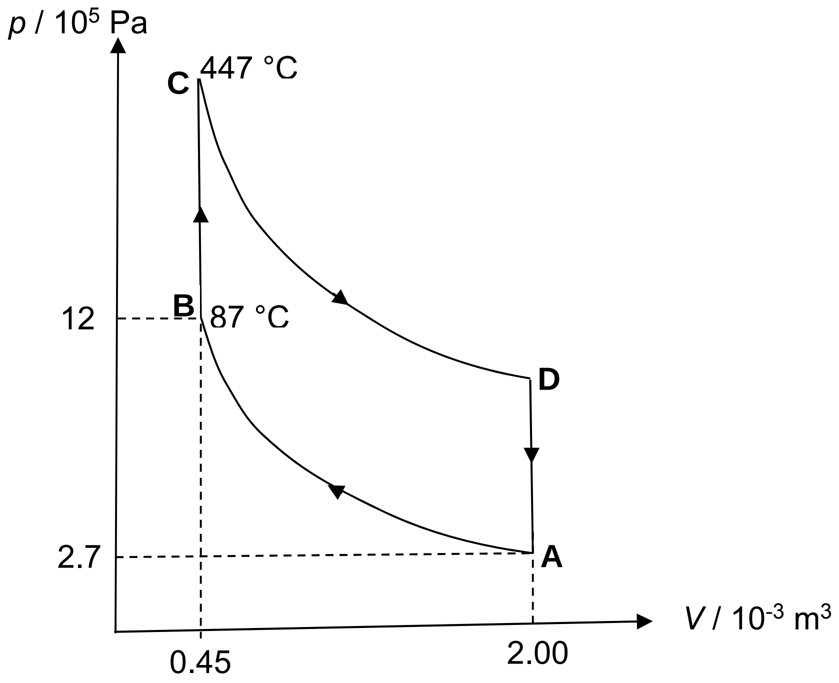


Fig. 2.2

(i) Determine the number of moles of the gas.

number of moles = ………………….. mol [1]

(ii) Calculate the heat supplied in the change from **B** to **C**, where the temperature of the gas rises from 87 °C to 447 °C.

heat supplied = ………………….. J [3]

(iii) Determine the net work done on the gas for a complete cycle. The magnitudes of heat transfer from **A** to **B** and from **C** to **D** are 8.1×10^{2} J and 1.6×10^{3} J respectively.

net work done = …….…………….. J [4]

3 Waves on water are usually produced by wind blowing across the surface.
Under certain conditions, standing waves called *seiches* can be produced on a shallow lake. Antinodes occur at opposite ends of the lake.
Fig. 3.1. shows the cross-section of a lake where a seiche is occurring, at equal intervals of time.

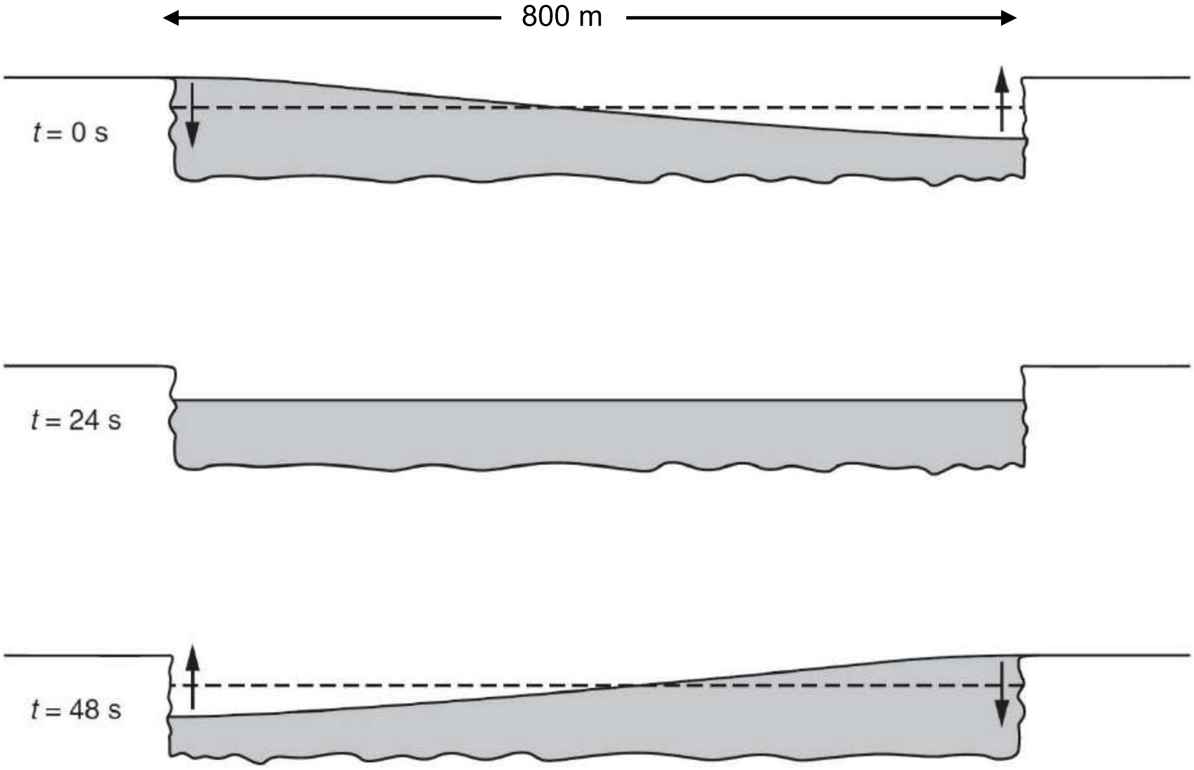


Fig. 3.1

(a) The standing waves shown in Fig. 3.1 occur in a small lake, 800 m long. They have a period of 96 s and amplitude of 1 m.

(i) Describe how someone viewing the lake might be aware that there were *standing waves* on the lake.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………...[2]

(ii) For the standing wave, label each antinode **A** and each node **N** on the bottom diagram of Fig. 3.1. With the aid of the labels, show that the wavelength of the water waves is 1600 m. [2]

(iii) Explain why Fig. 3.1 shows that the period of the waves is 96 s. Use this to calculate the speed of water waves in the lake.

speed = ……………………………m s^{-1} [2]

(b) Explain why standing waves of period 48 s might also be observed on this lake.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………[3]

(c) In another lake, the longest period of seiche standing waves observed is about 14 hours, not 96 s. Suggest and explain *one* way in which this other lake may differ from the one in Fig. 3.1.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………[1]

4 **(a)** The α-particle scattering experiment provided evidence for the existence of a nuclear atom.

State what could be deduced from the fact that

(i) most α-particles were deviated through angles of less than 10°,

....

.... [1]

(ii) a very small proportion of the α-particles was deviated through angles greater than 90°.

....

.... [2]

(b) **(i)** Define the term binding energy.

....

.... [1]

(ii) Use the data below to calculate the binding energy in MeV of a nucleus of $^{16}_{8}O$.

Data:	mass of proton	=	1.007 276 u
	mass of neutron	=	1.008 665 u
	mass of oxygen nucleus	=	15.990 527 u

binding energy = ... MeV [3]

(iii) The binding energy of $^{17}_{8}\text{O}$ is 126.43 MeV.

State and explain which of these two isotopes of oxygen would be more stable.

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(c) Scientists have worked out the age of the Moon by dating rocks brought back by the Apollo missions. They use the decay of potassium $^{40}_{19}\text{K}$ to argon $^{40}_{18}\text{Ar}$, which is stable. The decay constant of potassium-40 is 5.3 × 10^{-10} per year.

(i) Write a full nuclear equation for this decay.

……………………………………………………………………………………………… [1]

(ii) Explain what is meant by the decay constant of potassium-40 being 5.3 × 10^{-10} per year.

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(iii) On Fig. 4.1, sketch 2 labelled graphs to show how the number of $^{40}_{19}\text{K}$ nuclei and $^{40}_{18}\text{Ar}$ changes with time. Label the half-life with $t_{1/2}$.

[3]

Fig. 4.1

(iv) In one rock sample the scientists found 0.84 μg of argon-40 and 0.10 μg of potassium-40. Calculate the age of the rock sample in years.

age = ... years [2]

(v) State two assumptions that you have made for the calculation in **(iv).**

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(vi) Calculate the activity of the potassium-40 in the rock sample. Hence, explain if it is necessary for the scientists who handled the rock sample to take special safety precautions.

activity = ... Bq [1]

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

Section B

Answer **one** question from this Section in the spaces provided.

5 **(a)** State what is meant by a gravitational field.

………

…… [1]

(b) Tides are caused by the gravitational forces exerted by the Sun and the Moon on the water in the Earth's oceans. Fig. 5.1 shows the distances from the Earth to the Sun and from the Earth to the Moon. The mass of the Sun is 2.0 x 10^{30} kg and mass of the Moon is 7.0 x10^{22} kg.

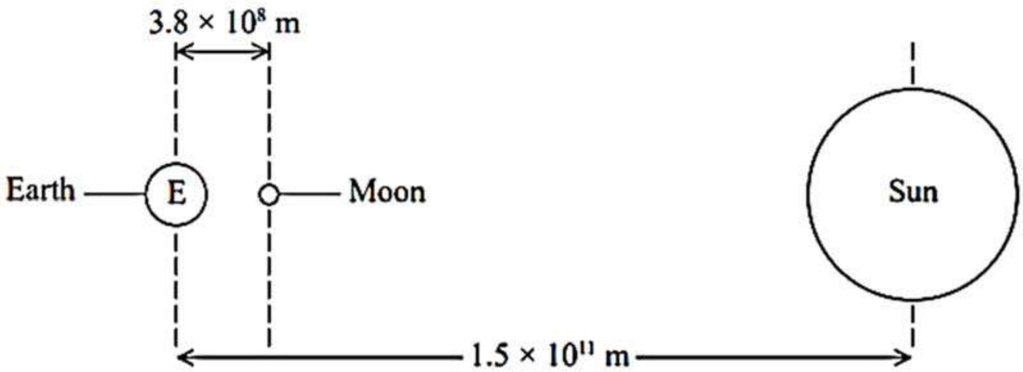


Fig. 5.1

(i) Calculate the ratio of the gravitational force acting on the Earth by the Sun to the gravitational force acting on the Earth by the Moon.

ratio = ……………………………………… [2]

(ii) Explain why, although the Earth, the Moon and the Sun are not point masses, the Newton's Law of Gravitation also applies to them.

……………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(iii) Explain why, although gravitational forces are attractive, the Moon does not accelerate and crash into the Earth.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(iv) The Moon takes 27.3 days to make one complete orbit of the Earth. Determine the mass of the Earth.

mass = ... kg [3]

(v) The Moon is gradually moving further away from the Earth because of the action of the tides. Explain how this increasing distance affects the Moon's orbital period.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(vi) In 200 years, the radius of the Moon's orbit is predicted to increase by 8 m. The rate of increase of the orbital radius is due to tidal action. However, in practice, this rate of increase is not constant.

Suggest and explain how this rate of increase might have been different in the very distant past.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(vii) The tides depend on the difference in the gravitational field strength produced by the Sun (mass M_S) and the Moon (mass M_M) on opposite sides of the Earth (mass M_E). Fig. 5.2 shows the Earth and the Sun.

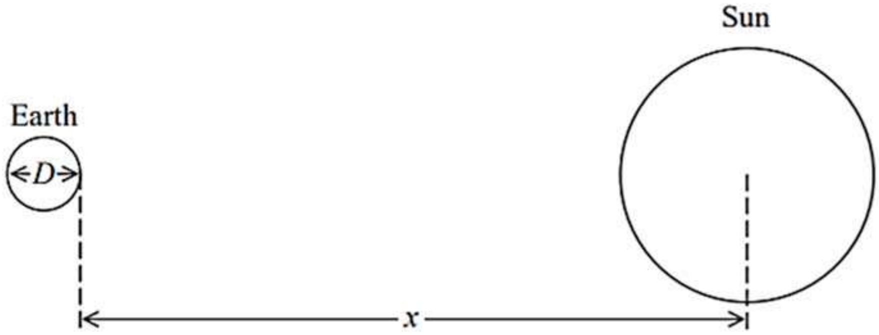


Fig. 5.2

1. State two expressions for the gravitational field strength due to the Sun at opposite sides of the Earth.

………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

2. Hence explain why the Sun has a relatively small effect on the tides.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(c) **(i)** The Earth may be assumed to be an isolated sphere of radius 6.4 x 10^3 km. A rocket is projected vertically from the surface of the Earth so that it reaches an altitude of 1.3 x 10^4 km.
With reference to **(b)(iv)**, calculate the minimum speed of projection from the Earth's surface.

minimum speed = ... m s^{-1} [3]

(ii) State the assumption made for the calculation in **(c)(i)**.

…………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(iii) State why the equation

$$v^2 = u^2 + 2as$$

is not appropriate for the calculation in **(c)(i)**.

…………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

6 **(a)** A stream of electrons, travelling at 1.0×10^{8} m s^{-1}, enters a region half-way between two parallel plates of the same length of 0.050 m and with a potential difference, as shown in Fig. 6.1.

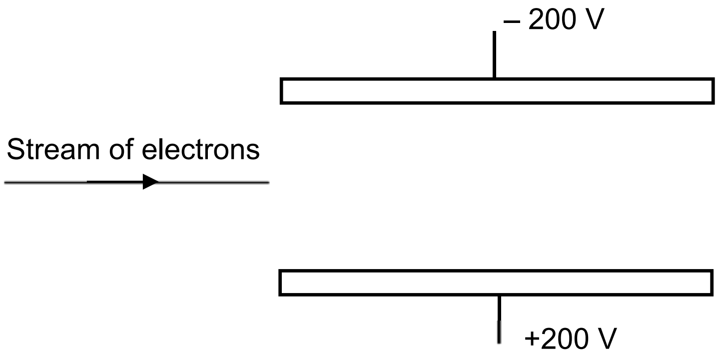


Fig. 6.1

(i) Calculate the separation between the plates given that the electric field strength between the plates is 2.0×10^{4} N C^{-1}.

separation = ... m [1]

(ii) Calculate the magnitude of the acceleration of the electrons between the plates.

acceleration = ... m s^{-2} [2]

(iii) Explain whether the stream of electrons will hit the plate.

[3]

(iv) Hence, in Fig. 6.1 draw the path of the stream of electrons between and beyond the plates. [1]

(b) The EZ-link card is a contact-less smartcard used for payment purposes in Singapore. The card has a thin wire coil with 3 turns each of area 4.00×10^{-3} m^2 printed along its edge. It also has a circuit which includes a transmitter and receiver that can communicate with external devices but it has no internal energy source.

The card obtains its energy from external devices like the card reader/writer located near the doors of the public buses and the MRT/LRT gantries. When the card reader/writer detects a card within range, it produces a changing magnetic field which affects the card thus allowing the information in the card to be read and updated. The magnetic flux density B from the card reader/writer is

$$B = B_0 \sin(2\pi ft)$$

(i) State the laws of electromagnetic induction.

………..……………………………………………………………………………

………..……………………………………………………………………………

………..……………………………………………………………………………

………..…………………………………………………………………………… [2]

(ii) Hence explain how the EZ-link card obtains its energy from the card reader/writer.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(iii) Explain whether the EZ-link card can still be used if it is bent until the embedded coil is broken.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(iv) Given that the frequency of the magnetic flux density B from the card reader/writer is 13.56×10^6 Hz, show that the magnitude of the peak e.m.f. induced in the card is $1.02 \times 10^6\ B_0$.

[2]

(v) Calculate the value of B_0 if the card needs a peak voltage of 15.0 mV to operate.

B_0 = ………………………T [2]

(vi) The Earth's magnetic field is constant at about 30 μT. Suggest whether the Earth's magnetic field will disrupt the operation of the card reader/writer.

………..…………………………………………….……………………………

………..……………………………………………………………………………

………..……………………………………………………………………………

………..…………………………………………………………………………… [2]

(vii) Calculate the root-mean-square voltage that the card needs to operate.

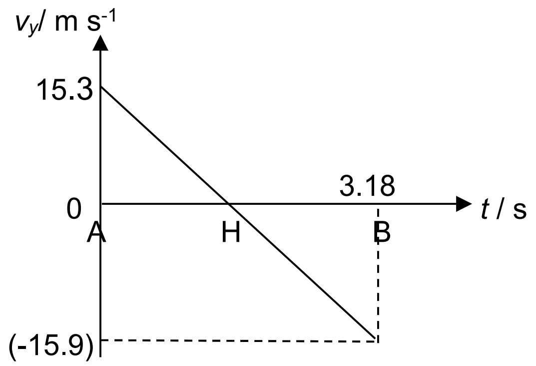
root-mean-square voltage =……………………V [1]

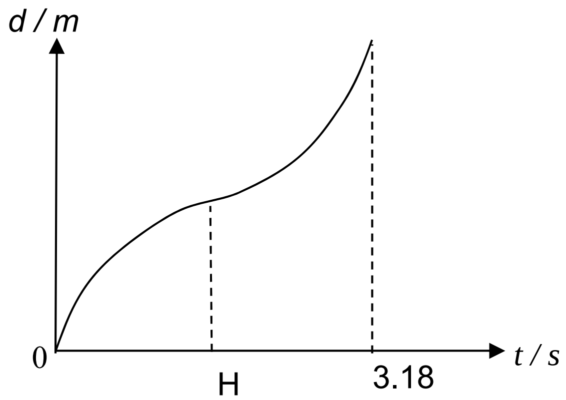
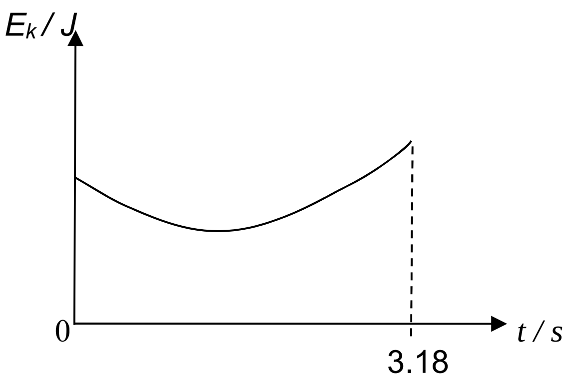
(viii) Given that the effective resistance of the circuit embedded within the card is 0.20 Ω, calculate the mean power that the card needs in order to operate.

mean power =……….………………W [1]

End of paper

Solution for 2018 SAJC H2 Physics Prelim Paper 3

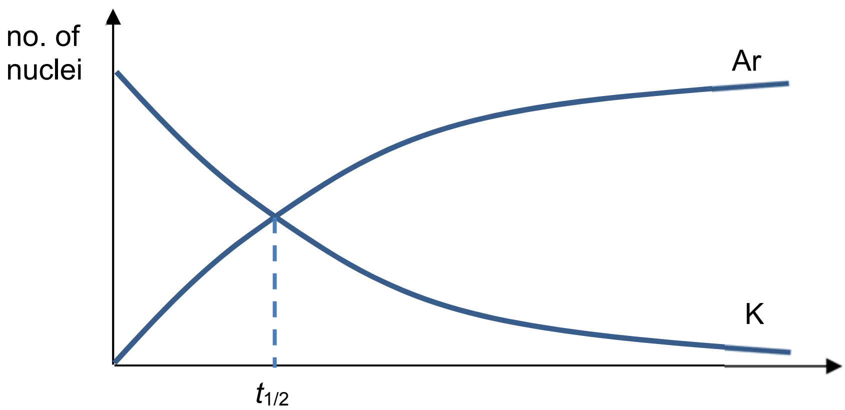
1 (a)	pressure kinetic energy mass power	**1**
(b)	distance moved in a specific direction	**1**
(c)(i)	$u_y = 20 \sin 50^o = 15.3$ taking upwards as positive, $s_y = u_y t + ½ gt^2$ $-1 = 20 \sin 50^o t + ½(-9.81)t^2$ $-1 = 15.3 t – 4.91 t^2$ $t = \frac{15.3 \pm \sqrt{15.3^2 - 4 \times 4.91 \times (-1.0)}}{2 \times 4.91}$ $= \frac{15.3 \pm 15.9}{2 \times 4.91}$ = 3.18 s	**1** **1** **1**
(ii)	$s_x = 20 \cos 50^o t$ $= 20 \cos 50^o (3.18)$ = 40.9 m {allow ecf for wrong time}	**1**
(iii)	$v_x = 20 \cos 50^o = 12.9$ m s^{-1} $v_y^2 = u_y^2 + 2as_y$ $= (20 \sin 50^o)^2 + 2(-9.81)(-1)$ $v_y = \pm 15.9$ m s^{-1} $v = \sqrt{(v_x^2 + v_y^2)} = \sqrt{[(12.9)^2 + (-15.9)^2]}$ = 20.5 m s^{-1} Alternative method: Initial KE + GPE = Final KE v = 20.5 m s^{-1}	**1** **1** **OR** **1** **1**
(iv)	9.81 m s^{-2} and downwards	**1**
(v)1.	 Correct shape: inclined straight line with + or – gradient [1]	

	{Shape must be correct before awarding the second mark.} Show: HB > AH , 15.3 and 3.18 [1]	
(v)2.	 Correct shape. [1] {Shape must be correct before awarding the second mark.} Show point of inflexion having non-zero gradient and two ends having gradient ≠ ∞ [1]	
(v)3.	 Correct "U" shape not touching t-axis. [1] {Shape must be correct before awarding the second mark.} Show the tail end higher than the start point. [1]	
(vi)	Maximum height decreases and horizontal range/distance decreases {"trajectory shorter" is not accepted} due to work done against air resistance / greater deceleration caused by air resistance.	**1** **1**

2 (a)	An ideal gas is one that obeys the equation $pV = nRT$ for <u>all values of pressure, volume and temperature.</u>	**1**
(b)(i)	As volume is reduced, <u>frequency</u> of collision between molecules and walls of container <u>increases</u>. Hence, pressure rises. As the temperature remains constant, there is <u>no increase in average KE</u> of molecules, thus having no effect on pressure. OR Change in momentum per collision remains constant. {No mark for correct answers using the 1st law.}	**1** **1**
(ii)	During the compression, the <u>piston transfers momentum</u> to the colliding molecules. Hence, the <u>velocity</u> of every molecule which bounces off the piston <u>increases</u>. <u>Average KE of molecules increases</u> (1/2mv² = 3/2kT) which means temperature rises. {No mark for correct answers using the 1st law.}	**1** **1**
(c)(i)	Applying pV = nRT to either **A** or **B**, n = <u>0.18 mol</u>	**1**
(ii)	$\Delta U = Q + W$ $w_{b\to c} = 0$ (no change in volume) OR $\Delta U = Q$ ideal gas : $U = \frac{3}{2} nRT \rightarrow \Delta U = 3/2\, nR\Delta T$ $\Delta U = \frac{3}{2}(0.18)(8.31)(447 - 87)$ $= 8.1 \times 10^2$ J {allow ecf for n} → $Q = \Delta U =$ <u>8.1×10^2 J</u>	**1** **1** **1**
(iii)	$W_{net} = W_{A\to B} + W_{B\to C} + W_{C\to D} + W_{D\to A}$ where $W_{B\to C} = 0 = W_{D\to A}$ (since $\Delta V = 0$ in these 2 processes) $\Delta U_{A\to B} = 0$ (isothermal) Thus $W_{A\to B} = -Q_{A\to B} = +8.1 \times 10^2$ J (for compression) $\Delta U_{c\to D} = 0$ (isothermal process) Thus $W_{C\to D} = -Q_{C\to D} = -1.6 \times 10^3$ J (expansion) Thus $W_{net} = (+8.1 \times 10^2) + 0 + (-1.6 \times 10^3) + 0$ = <u>-7.9×10^2 J</u> {no ecf if W_{net} is positive. Students should be able to conclude by inspection that W_{by} is more than W_{on} and hence, W_{net} is negative.} {Can accept "table method"}	**1** **1** **1** **1**

L2	3(ai)	some parts don't move at all No movement (of wave profile) along surface OR The wave does not move/advance/travel left-to-right	1 1
L2	(aii)	Labelled on Fig 3.1 : A at ends and N in centre length (of lake) = ½ wavelength {second mark can be awarded if positions of A and N are interchanged} 800 m = ½ wavelength Wavelength = 2 × 800 m = 1600 m	1 1 0
	(aiii)	From Fig. 3.1, ½ T = 48 s, so T = 2 × 48 = 96 s (as it would take another 48 s for the wave to return to the original position at t = 0 s) $v = f\lambda = (1/T)\lambda = (1/96)(1600)$ $= 16.7 \text{ m s}^{-1}$	1 1
L3	(b)	different wind speed may produce different standing wave pattern OR Stronger wind results in higher frequency Period of 48s is half of 96s OR frequency is doubled OR Frequency of wind matches one of the natural frequencies of the lake Wavelength is ½ (1600) to 800m OR Stationary/standing waves will fit (in the lake) OR Period of 48s will form a stationary wave with antinodes on both sides of the lake	1 1 1
L3	(c)	Lake (is very much) longer/bigger , so distance from antinode-node-antinode is longer, so wavelength is longer, so frequency is lower (assuming *v* unchanged), so period is longer OR Lake is different in depth, so waves travel slower	1

4(a)(i)	nucleus is small in comparison to size of atom (do not accept atom is mostly empty space)	1
(ii)	nucleus is massive/heavy/dense OR	1

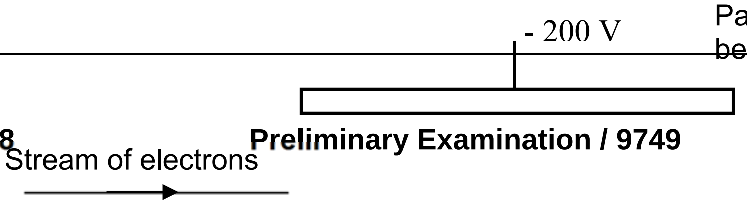
	mass is concentrated at the nucleus and (positively) charged	1
(b)(i)	Energy supplied to completely separate the nucleus (atom) into its individual nucleons (and electrons) OR Energy released when the nucleus(atom) is formed from its constituent nucleons (and electrons)	1
(ii)	Mass defect, Δm = 8(1.007276 u) + 8(1.008665 u) – 15.990527 u = 0.137001 u Binding energy, $\Delta mc^2 = (0.137001 \times 1.66 \times 10^{-27})(3.00 \times 10^8)^2$ $= 2.04 \times 10^{-11}$ J $= 127.6$ MeV $= 128$ MeV	1 1 1
(iii)	Binding energy per nucleon for ${}^{17}_{8}O = \frac{126.43}{17} = 7.43\,\text{MeV}$ Binding energy per nucleon for ${}^{16}_{8}O = \frac{127.6}{16} = 7.98\,\text{MeV}$ Since ${}^{16}_{8}O$ has a higher binding energy per nucleon, it would be more stable. {allow ECF from b(ii)}	1 for both values 1
(c)(i)	${}^{40}_{19}K \rightarrow {}^{40}_{18}Ar + {}^{0}_{1}\beta + \nu$ OR ${}^{40}_{19}K \rightarrow {}^{40}_{18}Ar + {}^{0}_{1}e + \nu$	1
(ii)	The probability that a particular potassium-40 nucleus will decay within a year is 5.3 x 10^{-10}.	1
(iii)	 [1] for K graph [1] for Ar graph intersect at half of initial no. of nuclei, mirror image of K [1] for labelling half-life at intersection point {if graphs are curving in the wrong way, do not award the third mark}	3
(iv)	Since the molar mass of the nuclides are the same, the number of nuclei is proportional to the mass of the sample.	1

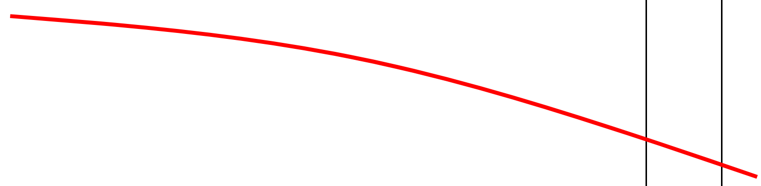
	$M = M_0 e^{-\lambda t}$ $0.1 = (0.1 + 0.84)e^{-(5.3\times10^{-10})t}$ $\Rightarrow t = 4.23\times10^{9}\ years$	1
(v)	All the argon-40 is formed from the decay of potassium-40. No argon is lost.	1 1
(vi)	$A = \lambda N = \frac{5.3\times10^{-10}}{365\times24\times60\times60}\left(\frac{0.1\times10^{-6}}{40}\times6.02\times10^{23}\right)$ $= 0.025\,Bq$ Since the activity is quite low, not necessary. {ECF given for getting very high activity}	1 1

5(a)	Region of space in which a mass experiences a force	1
(b)(i)	F = GMm / r^2 $\frac{F_{sun}}{F_{moon}} = \frac{\frac{2.0\times10^{30}}{(1.5\times10^{11})^2}}{\frac{7.0\times10^{22}}{(3.8\times10^{8})^2}}$ = 183	1 1
(b)(ii)	The separation is much greater than the diameter/radius of the Moon and the Earth and the Sun.	1
(b)(iii)	Since the Moon has a linear/tangential velocity perpendicular to gravitational force, the gravitational force is just sufficient to provide the centripetal acceleration for the Moon to orbit about the Earth.	1 1
(b)(iv)	ω = 2π / T = 2π / (27.3 x 24 x 60 x 60) = 2.66 x 10^{-6} rad s^{-1} m$r\omega^2$ = GMm / r^2 M = (3.8 x $10^8)^3$ (2.66 x $10^{-6})^2$ / (6.67 x 10^{-11}) = 5.8 x 10^{24} kg	 1 1 1
(b)(v)	As orbital radius increases, angular velocity decreases (GM = $r^3\omega^2$) Since ω = 2π / T, orbital period increases OR By T^2 proportional to r^3, orbital period increases	1 1 1 1
(b)(vi)	In the past, since orbital radius is small, gravitational force is stronger. As tidal action is due to gravitational force, tidal action is stronger. Hence there is greater rate of increase in the past.	1
(b)(vii)1	$g_1 = GM_s / x^2$ $g_2 = GM_s / (x + D)^2$	1 for both
(b)(vii)2	Since x is much greater than D, Difference between gravitational field strength on opposite sides is very small / zero.	1 1

(c)(i)	Total Initial energy = Total Final energy $\frac{1}{2} m v_{min}^2 + (- GMm / (6.4 \times 10^6)) = 0 + (- GMm / (6.4 \times 10^6 + 1.3 \times 10^7))$ v_{min} = 9000.6 m s^{-1} OR use loss in KE = gain in GPE Note: Use M from (b)(iv)	**1** **1** **1**
(c)(ii)	Negligible air resistance	**1**
(c)(iii)	Acceleration (due to gravity) is not constant	**1**

6(a)(i)	$E = \frac{V}{d}$ $\Rightarrow d = \frac{V}{E}$ $= \frac{400}{2.0 \times 10^4}$ = 0.02 m	**1**
(ii)	F = qE $= (1.6 \times 10^{-19})(2.0 \times 10^4)$ = 3.2 x 10^{-15} N $a = \frac{F}{m_e}$ $= \frac{3.2 \times 10^{-15}}{9.11 \times 10^{-31}}$ =3.51 x 10^{15} m s^{-2} (downwards)	**1** **1**
(iii)	Time interval that the electron is inside the electric field = $\frac{s_x}{u_x}$ $= \frac{0.05}{1.0 \times 10^8}$ = 5.0 x 10^{-10} s Vertical distance travelled by the stream of electrons is given by $s_y = \frac{1}{2} a_y t^2$ $= \frac{1}{2}(3.51 \times 10^{15})(5.0 \times 10^{-10})^2$ = 4.39 x 10^{-4} m Since the vertical distance travelled by the stream of electrons in the region between the parallel plates is <u>shorter than half the distance (< 0.01 m) between the two plates, the stream of electrons will NOT hit any of the parallel plates.</u>	**1** **1** **1**
(iv)	Parabolic path between plates	**1**



	 Straight path after plates	
(b)(i)	Faraday's law of electromagnetic induction states that the <u>magnitude of induced electromotive force in a coil is directly proportional to the rate of change of magnetic flux linkage through the coil.</u> Lenz's law states that the <u>direction of induced e.m.f. opposes the change causing it</u>	1 1
(ii)	When the card is brought close enough to the card reader/writer, the <u>**changing** magnetic field causes a **changing** magnetic flux linkage</u> through the thin wire loops inside the card. Using Faraday's law, <u>e.m.f. is induced in the loop, which results in a current due to a closed circuit</u>**.** Thus the card obtains electrical energy which can be used to operate its transmitter and receiver.	1 1
(iii)	It <u>cannot</u> be used anymore since the breakage in the coil will cause an <u>open circuit</u>**.**	1
(iv)	Magnitude of e.m.f. induced $=\frac{d\Phi}{dt}=\frac{d(NBA)}{dt}=NA\frac{dB}{dt}=NA\frac{d(B_0\sin 2\pi ft)}{dt}=NAB_0\frac{d(\sin 2\pi ft)}{dt}$ $=2\pi fNAB_0\cos(2\pi ft)$ Magnitude of peak e.m.f. induced $= 2\pi(13.56 \times 10^6)(3)(4.00 \times 10^{-3})B_0$ $= 1.02 \times 10^6\ B_0$	 1 1
(v)	Peak e.m.f. induced in card = peak voltage supplied to card $1.02 \times 10^6\ B_0 = 15.0 \times 10^{-3}$ $B_0 = 1.47 \times 10^{-8}$ T	1 1
(vi)	The Earth's magnetic field <u>will not</u> disrupt the operation of the card reader/writer since <u>it is not a changing field</u>.	2 or 0
(vii)	$V_{rms}=\frac{V_0}{\sqrt{2}}=\frac{15.0\times10^{-3}}{\sqrt{2}}=1.06\times10^{-2}$ V	1
(viii)	$\text{Power}=\frac{V_{rms}{}^2}{R}=\frac{(10.6\times10^{-3})^2}{0.20}$ = 5.62×10^{-4} W	1

Civics Group 17S	Index Number	Name

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2018
Preliminary Examination

PHYSICS **9749/04**

Paper 4 Practical

20th August 2018 **2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed on the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
4	
Total	**/55**

This question paper consists of **18** printed pages including this page.

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1 In this experiment, you will stretch a rubber band by suspending a mass m from it.

(a) **(i)** Set up the apparatus as shown in Fig. 1.1.

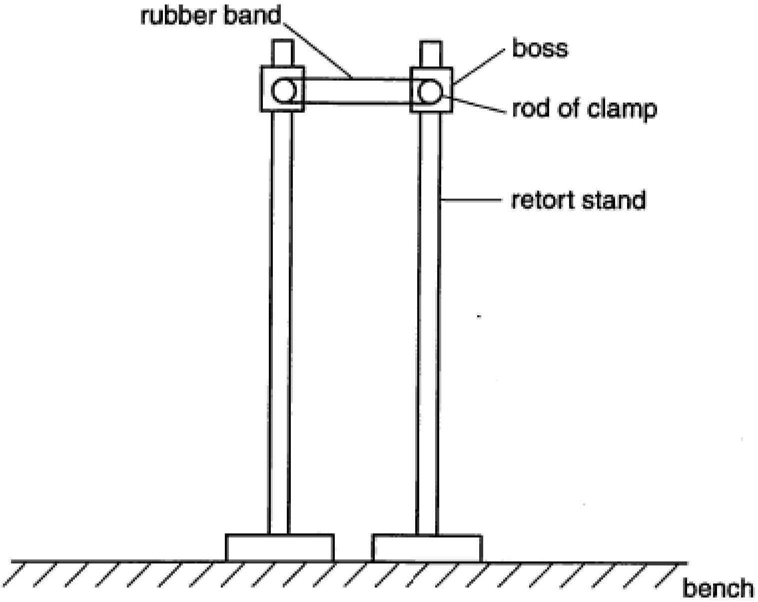

Fig. 1.1

The rods of the two clamps should be at the same height above the bench.

Position the two stands so that the rubber band has no slack.

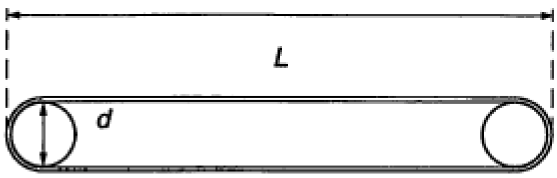

Fig. 1.2

(ii) Measure and record the length *L* as shown in Fig. 1.2.

L =……………………………..[1]

(iii) Measure and record the diameter *d* of the rod as shown in Fig. 1.2.

d = ……………………………[1]

(b) **(i)** Suspend the 100 g mass hanger from the centre of the lower part of the rubber band as shown in Fig. 1.3.

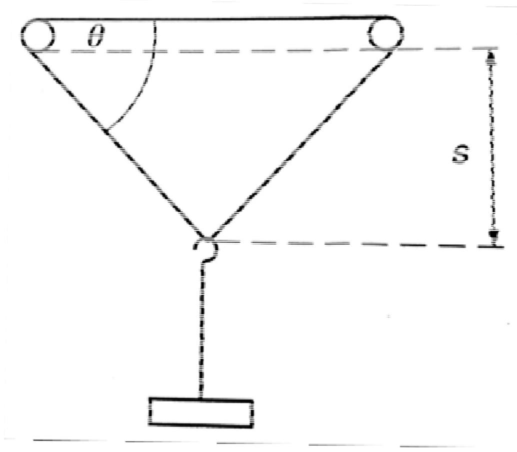

Fig. 1.3

(ii) Determine and record the displacement *s* of the rubber band as shown in Fig. 1.3.

s = ……………………………[2]

(iii) Measure and record the angle θ as shown in Fig.1.3.

θ =……………………………..[1]

(iv) Determine the percentage uncertainty in your value of θ.

percentage uncertainty in θ =……………………………[1]

(c) Repeat **(b)(i), (ii)** and **(iii)** for a 200 g mass.

s = ……………………………[1]

θ = ……………..……………..[1]

(d) Put your values of *m*, *s* and θ into a table.

[1]

(e) A student suggested that *m, s* and θ are related by the expression

$$m = k\,[s - \frac{L \sin\theta}{2}]$$

where *k* is a constant.

(i) Use your values from **(d)** to determine two values of *k*.

first value of *k* = …………………………………..

second value of *k* = …………………………………..

[1]

(ii) Do the results of your experiment support the suggested relationship?
Justify your answer by referring to your value in **(b)(iv)**.

....

....

....

....

.... [1]

(part (f) continues on next page)

(f) Hooke's law states that the extension is proportional to the force or tension in the spring if the proportional limit is not exceeded.

Using the given apparatus or any additional apparatus found in the College laboratory, plan an investigation to determine whether the rubber band obeys Hooke's law.

Your account should include:

- your experimental procedure,
- details of the measurements, and
- the type of results if Hooke's law is obeyed.

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....[4]

[**Total 15 marks**]

2 In this experiment, you will investigate the torsional oscillations of a metre rule.

(a) **(i)** Set up the apparatus as shown in **Fig. 2.1.**

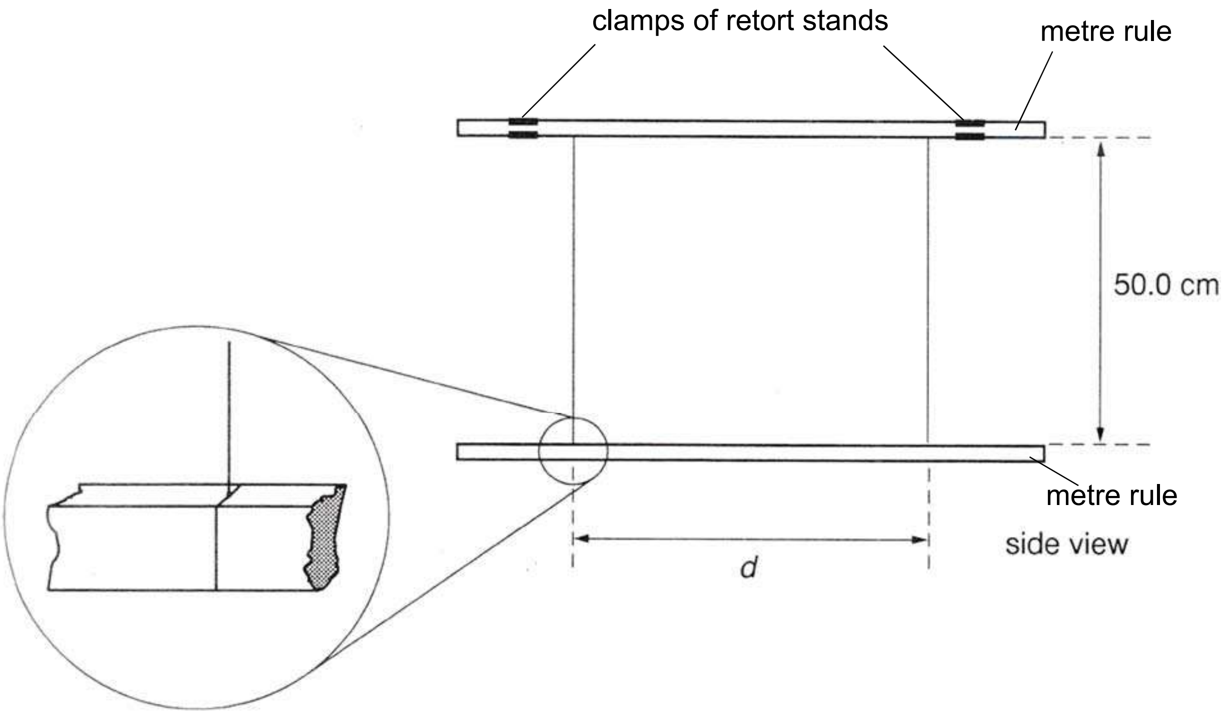

Fig. 2.1

A metre rule is suspended horizontally from another metre rule using two vertical threads. The length of each of the threads should be 50.0 cm.

Adjust the separation *d* of the threads to a value of about 60.0 cm, and at the same time ensure that the threads are at equal distances from the ends of the rules.

(ii) Displace the ends of the lower rule slightly, so that it performs small torsional oscillations about a vertical axis through the centre of the rule, as shown in Fig. 2.2.

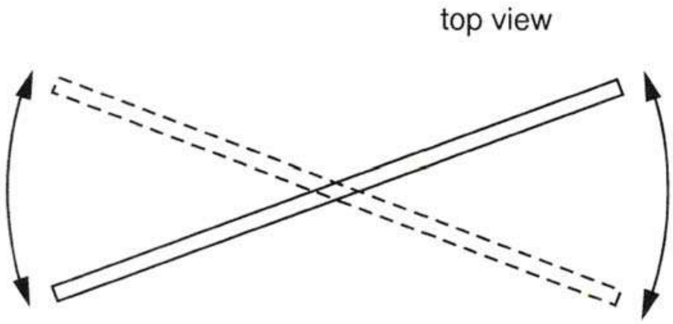

Fig. 2.2

(iii) Take measurements to determine the period *T* of these oscillations.

T = ... [1]

(iv) Move the threads to new positions on the rules and measure and record **two further** sets of values of *d* and *T* for *d* in the range 60 cm to 20 cm. In each case, the threads must be vertical and equidistant from the ends of the rules.

[4]

(b) Theory predicts that d and T are related by the expression

$$T^2 = \frac{4\pi^2 P}{3gd^2} ,$$

where P is a constant and g = 9.81 m s^{-2}.

(i) Using one set of readings you obtained in **(a)(iv)**, determine the value of P.

P = ... [1]

(ii) Justify the number of significant figures which you have given for P.

....

....

....[1]

[Total 7 marks]

Question 3 begins on the next page

3 In this experiment, you will measure the e.m.f. *E* and internal resistance *r* of a dry cell by changing the resistance *R* in the circuit and measuring the current *I*.

Connect the circuit shown in Fig. 3.1 using one of the 10 Ω resistors as resistance *R*.

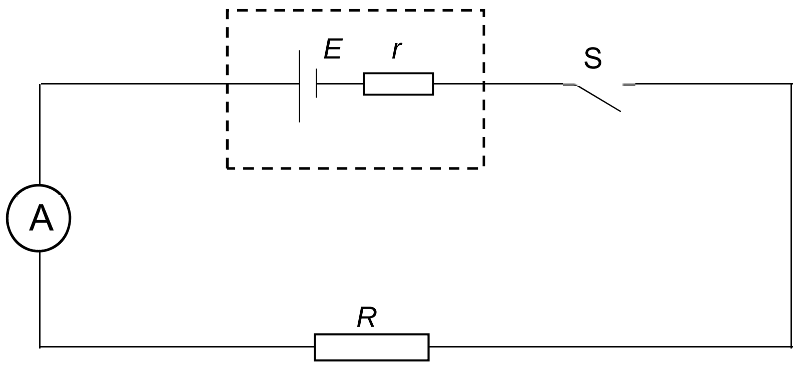

Fig. 3.1

(a) Close switch S.

Record the value of the current *I* and the resistance *R*.

I = ... [1]

R = ... [1]

Open switch S.

(b) The combined resistance of resistors in series is given by $R = R_1 + R_2 + \dots$

The combined resistance of resistors in parallel is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

Change the value of R by using different combinations of the resistors and repeat **(a)** until you have six sets of readings for I and R.

[7]

(c) **(i)** The quantities I and R are related by the equation

$$\frac{1}{I} = \frac{1}{E}R + \frac{r}{E}$$

Plot a suitable graph to determine the values of E and r.

E = ... [2]

r = ... [2]

[3]

(d) Comment on any anomalous data or results you may have obtained.
Explain your answer.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………..…..[1]

(e) **(i)** State one significant source of error in the experiment.

………………………………………………………………………………………..

……………………………………………………………………………………….….[1]

(ii) Suggest one improvement that could be made to the experiment to address the error identified in **(e)(i)**.

………………………………………………………………………………………..

……………………………………………………………………………………….….[1]

(f) On the graph grid on page 13, sketch a second line to show your prediction of the results if two dry cells are used in series instead of one dry cell as the power source.

Label this line Z.

[1]

[**Total 20 marks**]

Question 4 begins on the next page

4 Creep is the name given to the slow deformation of solid materials over an extended period of time when the material experiences stresses, which are below that required to reach the elastic limit. An example of a situation where creep occurs is in the blades of a high temperature gas turbine. The operating temperature of the turbine is fairly close to the melting point of the material from which the blades are made. Therefore the blades are subject to creep and gradually become elongated as the turbine is used. This is illustrated in Fig. 4.1.

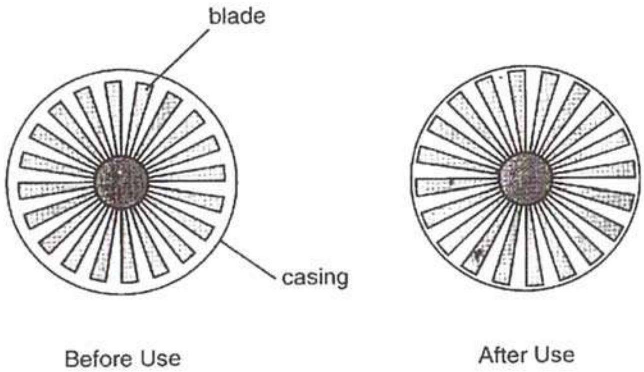

Fig. 4.1

The clearance between the blades and the casing is very small. This clearance decreases during the life of the turbine due to the creep in the blades. Therefore, it is important to engineers to have information about the creep process so that the life expectancy of the blades can be determined and damage to the engine can be prevented.

The length of a wire made of lead changes with time (i.e. creeps) as the temperature, T, of the wire and the load, m, which it supports are changed. The change in length, ΔL, is related to the temperature, T, of the wire and the load, m by the relationship

$$\Delta L = k\, T^{p}\, m^{q}$$

where k and p and q are constants.

You are provided with lead wires, a long box with toughened glass sides, some masses and an electrical heater.

Design an experiment to determine the values of p and q.

You should draw a diagram showing the arrangement of your apparatus and you should pay particular attention to

(a) the equipment you would use
(b) the procedure to be followed
(c) the control of variables
(d) how the values of p and q are determined from your readings
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

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……………………………………………………………………………………………………[13]

END OF PAPER

Question 1 Apparatus List (2012 9646/05 Q1, 2 different masses suspended on a rubber band)

1. Suitable rubber band
2. 2 Stands, 2 bosses and 2 clamps
3. 100 g mass hanger
4. 100 g slotted mass
5. Metre rule with mm scale
6. Vernier calipers (to be shared)
7. Protractor

Question 2 Apparatus List (N95Q1 (modified

1. Three metre rules
2. Two retort stands, bosses and clamps
3. Stopwatch
4. Two 70 cm strings

Question 3 Apparatus List

1. Four 10.0 Ω resistors {each labelled as 10.0 Ω}
2. 1.5 V dry cell with holder and a resistor in series. See Note 1.
3. Digital multimeter
4. Switch
5. Eight connecting wires

Note 1:
The dry cell is placed in series with a 10.0 Ω resistor which is unknown to the candidates. Candidates must not be able to make connections to the cell without including the 10 Ω resistor. The 10.0 Ω resistor is an integral part of the power supply.

H2 Physics Preliminary Practical Exam (Paper 4) Mark schemes

Q1 (2012 Q1, Justification of Suggested Relation)

No.	Marking Point	Marks
1(a)(ii)	Record two readings and average of L to nearest mm, if rule is used; nearest 0.1 mm, if vernier caliper is used	1
(iii)	Record two readings and average of d to nearest 0.1 mm (i.e. 0.01 cm). {Accept answer without reference to zero error of vernier caliper.}	1
(b)(ii)	• Should be calculated using s = distance between horizontal portion of rubber band & top of hanger – diameter d of rod • Record two readings and average of s to nearest mm.	1 1
(iii)	Record two readings and average of θ to nearest degree.	1
(iv)	Percentage uncertainty in θ: • correctly calculated with $2^0 \leq \Delta\theta \leq 4^0$ {challenging case} • recorded to 1 or 2 sf (not 3 sf).	1
(c)	• Record two readings and average of s to nearest mm. {No need to show the first bullet point of (b)(ii).} • Record two readings and average of θ to nearest degree.	1 1
(d)	Tabulated m, s & θ for the 2 sets of readings, with each column heading with correct unit & values recorded to correct precision. {No ECF for precision.}	1
(e)(i)	Calculated the 2 values of k correctly & recorded them to the correct no. of sf {2 or 3 sf as θ has 2 sf} & unit {kg m^{-1}}	1
(ii)	The criterion here is, whether or not, $\frac{\Delta k}{k_{ave}}$ x 100% > Percentage Error of the expt given by (b)(iv) If yes, ⇒ results do not support suggested relationship. • Δk = difference between the 2 k values. • k_{ave} = average of the 2 values of k	1
(f)	• A diagram showing a workable set-up / a clear description of set-up. {Force meter with vertical rubber band can award this mark.}	4

	x-variable: • Suitable method of varying force and instrument used e.g. using either slotted masses with equation F = mg or using a force meter in a horizontal set-up. (For vertical set-up, the effect of weight of spring balance on rubber band must be accounted for). y-variable: • Clear method of measuring extension and instrument used i.e. metre rule or vernier callipers. • Plotting force-extension graph, state whether a straight line passing through origin is obtained and make the correct conclusion. {Any safety precautions / experimental details will not be awarded marks for such mini planning question.}	
	Total:	15

Q2 (N95Q1 modified)

No.	Marking point	Mark
2(a) (iii)	• Repeated timings for n oscillations, *t* to 1 d.p. • Timings for oscillations must be such that *t* > 20 s. • Correct s.f. for calculated value of period *T* & with correct unit.	1
(iv)	• Collect at least 2 sets of data without assistance • Repeated timings for n oscillations • Value of *d* should include 20.0 cm. d = 60.0 cm is optional.	1
	Each column heading must contain a quantity and a unit.	1
	Raw data: • Both values of *d* recorded to the nearest mm {i.e. 3 dp in m} • All stopwatch timings to the nearest 0.1 s.	1

	Calculated data: All values of *T* recorded to the same number of s.f. {or one more} as the corresponding raw data {which is *t*} {If no oscillation time is recorded, award a max of 1 mark out of 4.}	1
(b)(i)	Correct calculation of P with unit {i.e. m^3}.	1
(ii)	State e.g. "P should be recorded to the same sf or one more as the least accurate raw data. Since *d* and *t* are in 3 sf, hence P is recorded to 3 or 4 sf." {No ECF due to wrong dp in raw data.}	1
	Total:	7

Q3

No.	Marking Point	Mark
3(a)	Record one value of current I to 1 dp in mA with unit. Allow up to 100 mA.	1
	Record resistance *R* to 10 Ω	1
(b)	Tabulation Collect 6 sets of *R* & I without assistance. (1 mark for 5 sets, zero mark for 4 or less sets) {-1 for minor help from Supervisor, -2 for major help. -1 for incorrect trend, -1 for split table.}	2
	Range of *R* should be at least 30 Ω.	1
	Column Heading: • Each column heading (*R*, I, $1/I$) must contain a quantity and a unit.	1
	Raw data: • All values of *R* must be recorded to 2 or 3 sf {as R may be calculated} • All values of I must be recorded with consistent dp, to the nearest 0.1 mA.	1
	Calculated quantities: Precision of Recording & Consistency	

	• <u>All</u> values of $1/I$ recorded to *either* the same number of sf or one more as the corresponding raw data {which is I } AND • Candidate is consistent with his/her choice of sf for $1/I$.	1
	<u>Calculated quantities</u>: <u>Accuracy of Calculation</u> • All values of $1/I$ correctly calculated.	1
(c) (i)	<u>Graph: scale, size & axes</u> • Sensible scales, no awkward scales (eg 3:10) • Plotted pts occupy at least ½ the graph grid in both x & y directions • Axes labelled with the quantity & unit. {ECF for units} • Scale markings: no more than 20 small squares apart.	1
	<u>Plotting</u> • ALL observations in table must be plotted. • Accuracy of plots must be within half a small square in both x and y directions.	1
	<u>Best fit line</u>: • Drawn with approx. equal number of points on either side of line (anomalous pts not considered). Minimum number is 5 non-anomalous pts. • Line must not be kinked/disjointed or thicker than half a small square	1
	<u>Gradient:</u> • Recording of the 4 coordinates. • Hypotenuse of triangle must be greater than half length of line drawn • No obscurity of coordinates used for gradient calculation. • State explicitly, gradient = 1/E • <u>Correct calculation</u>	1
	<u>y-intercept:</u> y-intercept calculated using read-off from a <u>point on the line</u> {not from the table} & value of gradient. Or Read-off of the y- intercept directly from the graph (if x-axis starts from zero). • State explicitly, y-intercept = r/E	1
	Value of *E* = 1/(candidate's gradient) with unit {i.e. V}.	1
	Value of *r* = *E* × (candidate's intercept) with unit {i.e. Ω} Or Value of *r* = (candidate's intercept) / (candidate's gradient) with unit {i.e. Ω}	1

(d)	Case 1: No anomalous data From the graph plotted, it can be observed that there are no anomalous results as all the plots lie very close to the best fit line. Case 2: Anomalous plot From the graph plotted, it can be observed that there is an anomaly as the plot (xxx, yyy) lies far from the best fit line.	1
(e)(i)	The presence of contact resistance {which is inevitable & variable}	1
(ii)	Use connecting wires with new crocodile clips / use as few connecting wires as possible.	1
(f)	Line Z drawn with half the original gradient (±10%) and same *y*-intercept. {If the horizontal axis does not start from zero, then both the gradient and the false intercept of Z must be smaller than that of the original graph.}	1
	Total:	20

Q4 Planning

Defining the Problem *T* and *m* are the independent variables and Δ*L* is the dependent variable. Constant length / diameter of wire	 [1] [1]
Procedure Labelled diagram of workable experiment including wire, masses, long box, electrical heater and thermometer. Thermostat connected in series with electrical heater. Measure mass *m* using electronic balance (do not accept mass balance or lever balance. If slotted masses are used, no measuring instrument is required.) Measure temperature *T* using thermocouple / thermometer. Measure extension of wire Δ*L* using a travelling microscope. Keeping mass *m* constant, vary temperature *T* by changing the thermostat setting. Keeping temperature *T* constant, vary mass *m* by changing the number of slotted masses.	 [1] [1] [1] [1] [1] [1]
Analysis For constant *m*, plot a graph of lg Δ*L* against lg *T* where *p* = gradient For constant *T*, plot a graph of lg Δ*L* against lg *m* where *q* = gradient	 [1] [1]
Safety Consideration Use goggles to protect the eyes (in case wire were to snap). Use tongs or heatproof gloves to handle the wires (e.g. when there is a need to keep the wire from small oscillations). Set up apparatus vertically above a bucket of sand (to reduce impact on the ground if wire snaps).	Max [1]
Additional Details Perform a preliminary experiment to gauge the range of load that can be used to produce a measurable change in length without causing wire to snap. Use a kink-free wire OR use a new wire after each reading Use a long wire to obtain measurable extensions. Perform the experiment over a sufficiently long period of time to obtain measurable extensions. Ensure that the point of suspension of wire at the ceiling does not sag (due to excessive weight of the suspended masses). (Accept repeated measurements only if quantities are identified clearly)	Max [2]

Note: Do not allow vague computer methods. Total: / 13

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME			
CG		**INDEX NO.**	

PHYSICS 9749/01

Preliminary Examination — **21st Sep 2018**
Paper 1 Multiple Choice — **1 hour**

Additional Materials: OMS.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in soft pencil on the OMS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

For Examiners' Use	
MCQ	/ 30

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T /K	=	T /ºC + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\,\omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{ln2}{t_{\frac{1}{2}}}$

Answer all questions.

1 The rate of heat flow, R, can be found using the equation

$$R = k\,A\,\frac{(T_2 - T_1)}{L}$$

where k is the thermal conductivity, A is the total cross sectional area of the conducting surface, and L is the thickness of conducting surface separating the 2 temperatures T_1 and T_2.

What is the SI base units for k?

A kg m s^{-3} K^{-1} **B** kg m s^{-2} K^{-1} **C** kg m s^{-3} **D** kg s^{-2} K^{-1}

2 With reference to Question 1, a student collected the following measurements to determine the rate of heat flow R of the object

L = (0.35± 0.05) mm
T_1 = (32.0 ± 0.5) °C
T_2 = (4.0 ± 0.5) °C

What is the fractional uncertainty in R?

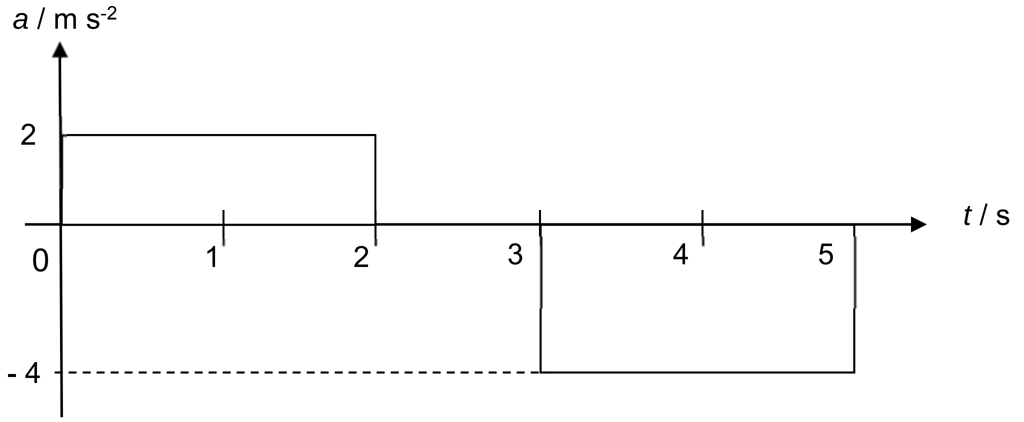
A 0.11 **B** 0.14 **C** 0.16 **D** 0.18

3 A value for the acceleration of free fall on Earth is given as (10 ± 2) m s^{-2}.

Which statement is correct?

A The value is accurate but not precise.
B The value is both precise and accurate.
C The value is neither precise nor accurate.
D The value is precise but not accurate.

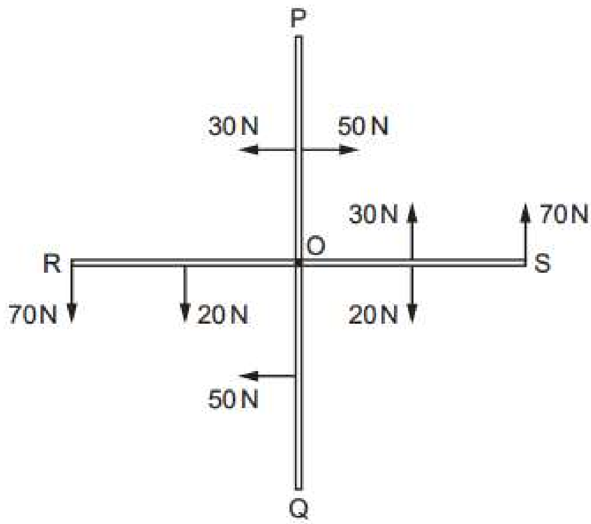
4 The graph below represents the variation with time *t* of the acceleration *a* of a car starting from rest.



What is the total displacement of the car from the starting point at the end of 5 s?

A -4 m **B** 4 m **C** 8 m **D** 12 m

5 A rigid cross-shaped structure having four arms PO, SO, QO and RO, each 1.80 m long, is pivoted at O. Forces act on the ends of the arms and on the midpoints of the arms as shown.



What is the net moment about O?

A 54 N m **B** 108 N m **C** 216 N m **D** 432 N m

6 Forces 5 N, 12 N and 13 N act at a point which is in equilibrium.

What is the angle between the 5 N and 13 N force?

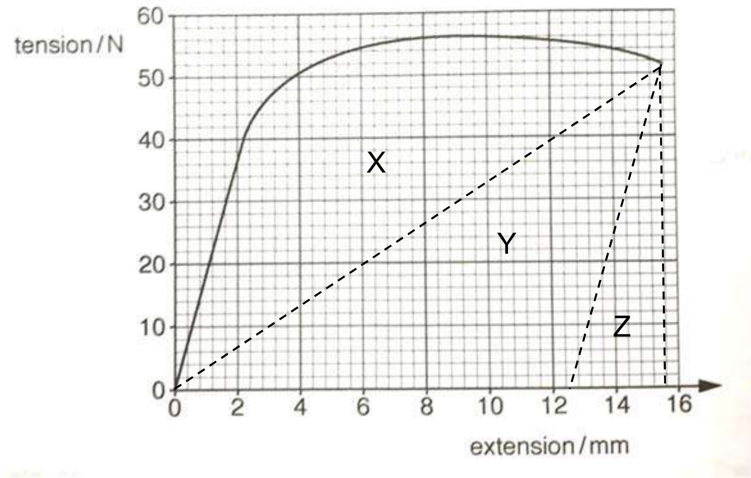
A 23° **B** 67° **C** 90° **D** 113°

7 A cube of sides 10 cm has a density of 7.8 g cm^{-3}. It floats vertically with one-eighth of its side exposed above the liquid surface.

What is the density of the liquid?

A 6.8 g cm^{-3} **B** 8.9 g cm^{-3} **C** 11.6 g cm^{-3} **D** 62.4 g cm^{-3}

8 The tension in a sample of wire varies with extension as shown in the diagram below.



The graph shows that the wire undergoes two types of deformation as it is extended to 15.6 mm. In the region where Hooke's law applies, the deformation is elastic and the wire will lose this deformation when the tension is released. In the region where Hooke's law does not apply, the deformation is plastic and the wire retains this deformation when the tension is released.

Which area represents the elastic potential energy that is stored in the wire when it is extended to 15.6 mm?

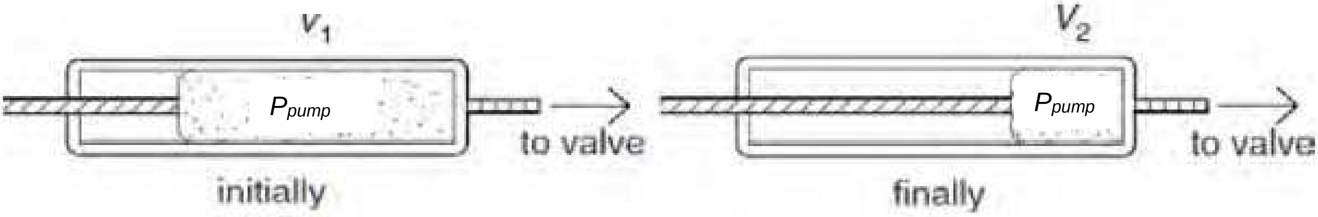
A Area Z

B Area X + Area Y

C Area Y + Area Z

D Area X + Area Y + Area Z

9 Air in a bicycle pump is forced through a valve at a constant pressure P_{pump}, to supply air to a tyre which is initially at a pressure P_{tyre}. In one stroke of the pump, the volume of air in the pump chamber is reduced from V_1 to V_2.



What is the work done on this air in one stroke of pump ?

A $P_{pump}\,V_1$ **B** $P_{pump}\,(V_2 - V_1)$ **C** $P_{tyre}\,V_1$ **D** $P_{tyre}\,(V_2 - V_1)$

10 Which one of the following statements is true about gravitational potential energy, electric potential energy and elastic potential energy?

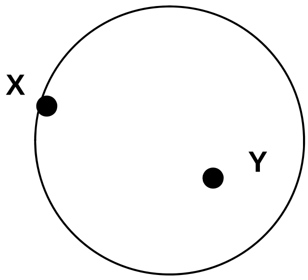
A Gravitational force and elastic force always points in the direction of decreasing potential energy but whether electric force will point towards increasing or decreasing potential energy depends on whether it is a positive or negative charge.

B Zero gravitational potential energy and zero electric potential energy is the smallest possible potential energy in a given system of 2 masses and 2 negative charges respectively.

C The magnitude of the potential energy can be found using the gradient of the force-displacement graph.

D These potential energies are energies stored in the body due to its position or the arrangement of its component parts.

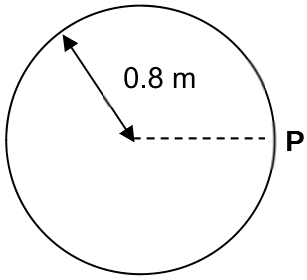
11 Sand is sprinkled on a turntable on points X and Y. The turntable is rotating with increasing speed.



Which one of the following comparing sand at points X and Y is true?

	angular speed	linear speed	which will fly off first?
A	X = Y	X > Y	X
B	X = Y	X > Y	Y
C	X > Y	X = Y	Y
D	X > Y	X > Y	Y

12 A model car moves in a circular path of radius 0.8 m at an angular speed of 0.5π rad s^{-1}.



What is its displacement from point P, 4 s after passing P?

A zero **B** 1.6 m **C** 0.8π m **D** 1.6π m

13 Which of the following is a correct description of a geostationary orbit?

The mass of Earth is 6.0 x 10^{24} kg.

A The moon is an example of a geostationary satellite of Earth.

B A geostationary satellite has an orbital circumference of 2.7 x 10^{8} m.

C A geostationary satellite moves from North pole to South pole then back to North pole in 24 hours.

D A geostationary satellite experiences zero net force as it orbits around Earth.

14 Which of the following statements about the internal energy of a monatomic ideal gas is correct?

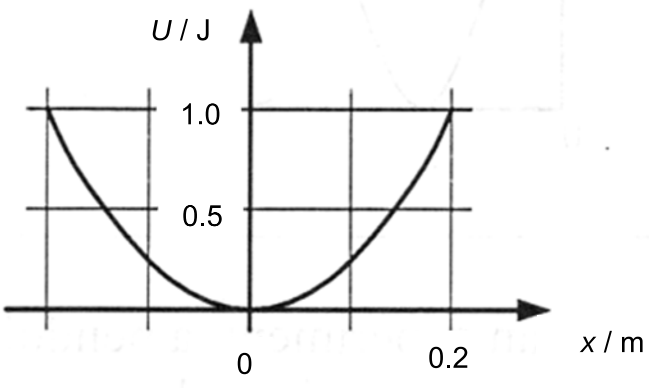
A It will increase when heat is supplied to the gas.
B It is proportional to the root-mean-square speed of the gas.
C It increases when the temperature of the gas increases.
D It is dependent on the potential energy of the gas.

15 In a mixture of two monatomic ideal gaseous X and Y, the molecules of Y have thrice the mass of those of X. The mixture is in thermal equilibrium and the molecules of Y have a mean translational kinetic energy of E_K.

What is the mean translational kinetic energy of the molecules of X?

A 1/3 E_K **B** 1/2 E_K **C** E_K **D** 3 E_K

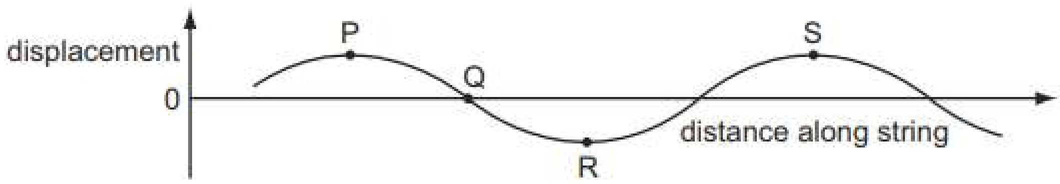
16 The given graph shows the variation with displacement *x* of the potential energy *U* of a particle of mass 4 kg moving in simple harmonic motion.



Which of the following is the period of oscillation of the mass?

A 0.3 s **B** 0.9 s **C** 1.1 s **D** 1.8 s

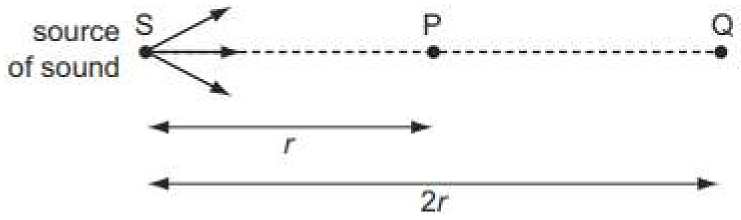
17 The string shows the shape at a particular instant of part of a progressive wave travelling along a string.



Which statement about the motion of the points along the string is correct?

A The speed at point P is maximum.
B The displacement at point Q is always zero.
C The energy at point R is entirely kinetic.
D The acceleration at point S is maximum.

18 A point source of sound is placed at point S.

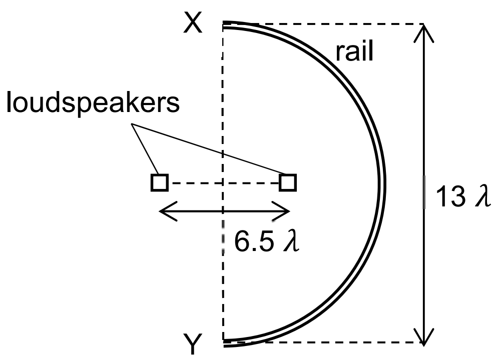


The air molecules at P, a distance *r* from S, oscillate with an amplitude of 8.0 μm. Point Q is situated at a distance 2*r* from S.

What is the amplitude of oscillation of air molecules at point Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

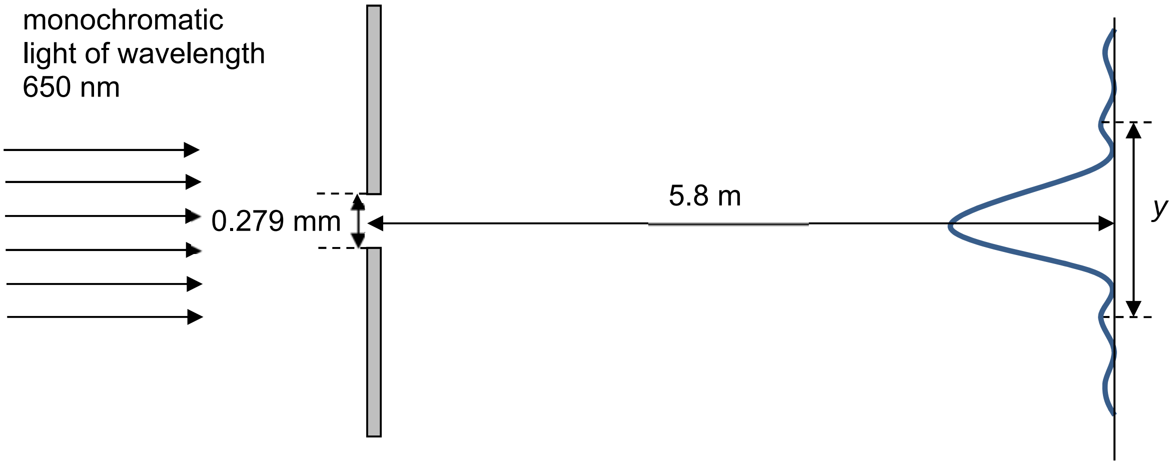
19 Two loudspeakers are emitting sound of wavelength λ in all directions. They are in phase with each other and are placed a distance 6.5 λ apart in the middle of a semicircular rail of diameter 13 λ, as shown below. Moveable microphones along the rail are used to detect the sound intensity along the rail. The midpoint of the line joining the 2 speakers coincides with the centre of line XY.



How many minima will the microphones detect?

A 7 **B** 12 **C** 13 **D** 14

20 A laser light of wavelength 650 nm is passed normally through a narrow slit. A screen is placed parallel to the slit 5.8 m away from the slit. An interference pattern is formed on the screen. The width of the slit is 0.279 mm. The distance *y* is the distance between the two first maximas.



What is the value of *y*?

A 13.5 mm **B** 27.0 mm **C** 40.5 mm **D** 54.0 mm

21 A negatively-charged sphere P is balanced halfway between two horizontal plates when a potential difference *V* is applied between the plates.

Which statement is correct?

A Increasing *V* increases both the electric and the gravitational potential energy of the sphere.

B Increasing *V* decreases the electric potential energy and increases the gravitational potential energy of the sphere.

C Decreasing *V* decreases both the electric and the gravitational potential energy of the sphere.

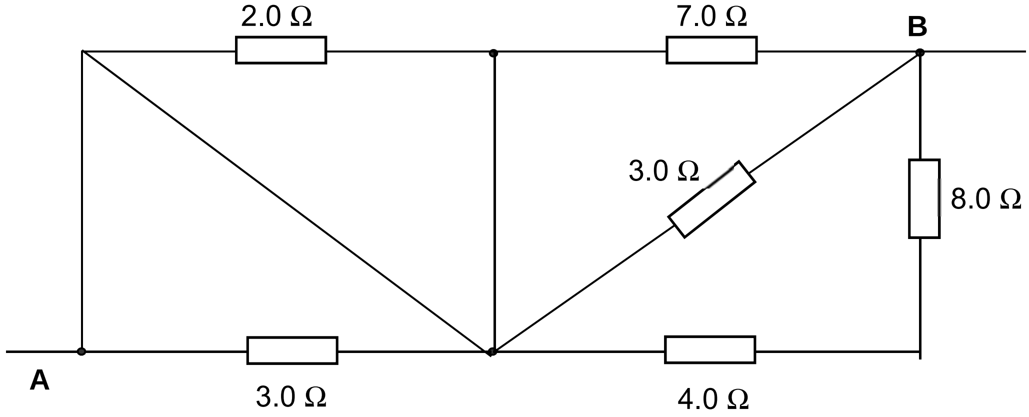
D Decreasing *V* increases both the electric and gravitational potential energy of the sphere.

22 A 8.0 A current passes through a cylindrical copper wire with a diameter of 8.0 mm. The density of copper is 8960 kg m^{-3} and the mass of a single copper atom is 1 x 10^{-25} kg.

Assuming that there is one conduction electron for each copper atom, what is the drift velocity of the electrons in the wire?

A 2.8 x 10^{-6} m s^{-1} **B** 3.4 x 10^{-6} m s^{-1} **C** 1.1 x 10^{-5} m s^{-1} **D** 5.8 x 10^{-5} m s^{-1}

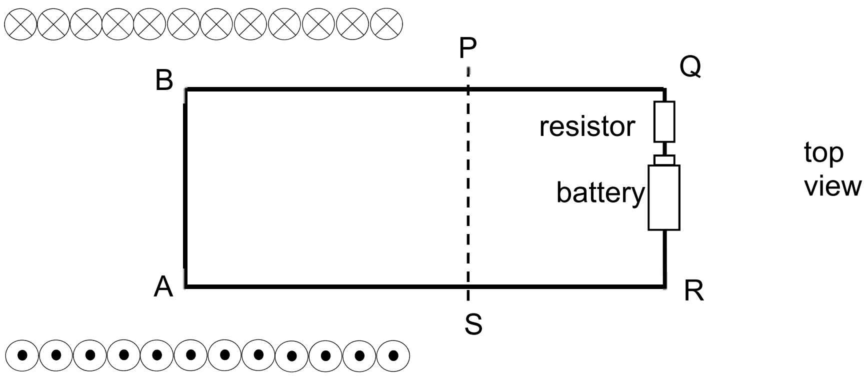
23 Six resistors are connected in a circuit as shown below.



What is the effective resistance of the circuit between terminals AB?

A 1.2 Ω **B** 1.8 Ω **C** 3.0 Ω **D** 3.4 Ω

24 The figure below shows the top view of a current balance where the rigid rectangular wire loop ABQR pivoted at PS is in equilibrium. It is connected in series with an ideal 2.0 V battery and a 0.025 Ω resistor of a total mass of 300 g. Part of the wire loop is placed inside a solenoid. The mass of the loop can be taken to be negligible and the wire has no resistance.



The length of the side AB is 6.0 cm and $SR = \frac{2}{5}ASR$.

What is the magnitude of the magnetic flux density in the solenoid?

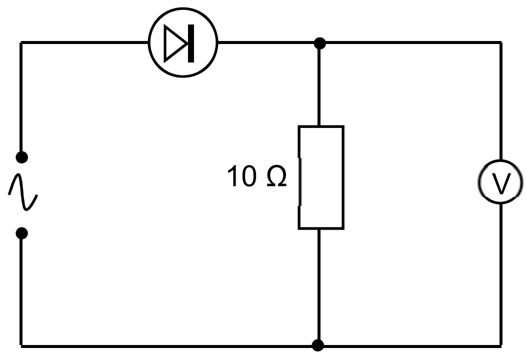
A 0.37 T **B** 0.41 T **C** 3.7 T **D** 4.1 T

25 When a light bulb is connected across an a.c. source of peak voltage 150 V, the mean power dissipated is 13 W. Two such light bulbs are now connected in series to the electrical mains of 240 V r.m.s.

What is the peak voltage across each light bulb and the total power dissipated in the light bulbs?

	peak voltage across each light bulb / V	total power dissipated in the light bulbs / W
A	120	17
B	170	33
C	120	67
D	170	17

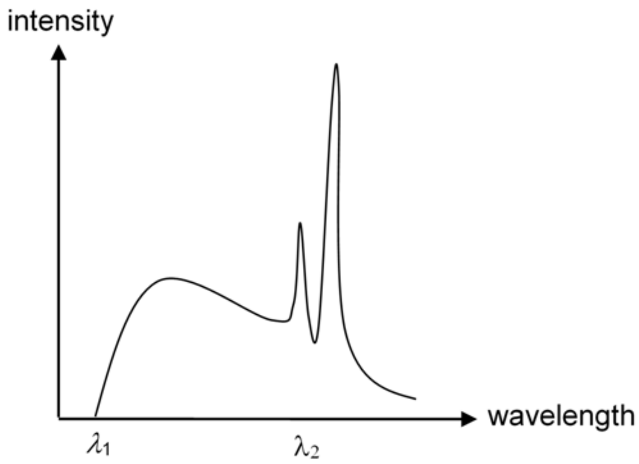
26 A voltmeter reads 80 V when measuring the potential difference across a load of 10 Ω connected to a sinusoidal power source with frequency 888 Hz.



What is the peak power dissipated by the load when the frequency is 1/3 of its original?

A 640 W **B** 850 W **C** 1280 W **D** 2560 W

27 The graph below shows the variation of X-ray intensity with wavelength emitted from an X-ray tube.



What are the factors that will affect λ_1 and λ_2?

	λ_1	λ_2
A	target metal	target metal
B	target metal	accelerating voltage
C	accelerating voltage	target metal
D	accelerating voltage	accelerating voltage

28 The momentum of an alpha particle is measured with an uncertainty of 2.0%.

Given that it has a kinetic energy of 1.00 MeV, what is the minimum uncertainty in its position?

A 2.1×10^{-19} m **B** 7.2×10^{-13} **C** 1.6×10^{-12} **D** 7.2×10^{-10}

29 Which of the following is a correct description of mass defect?

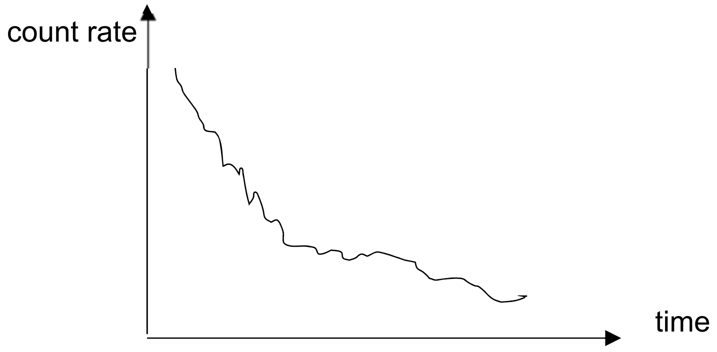
A The difference between the mass of the nucleus of the products and reactants in a nuclear reaction.

B It is the difference between the total mass of the neutrons and the mass of the nucleus.

C It is equal to the energy gained when individual nucleons comes together to form a nucleus.

D It is the binding energy of a nucleus divided by square of the speed of light.

30 The graph below shows the variation of count rate from a particular radioactive sample with time.



What does the jagged feature of the graph indicate?

A It indicates the presence of background radiation.
B It indicates that the decay obeys radioactive decay law.
C It indicates the spontaneous nature of the radioactive decay.
D It indicates the random nature of the radioactive decay.

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME

CG | **INDEX NO.**

PHYSICS 9749/02

Preliminary Examination **14th September 2018**
Paper 2 Structured Questions **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 10
Q2	/ 7
Q3	/ 14
Q4	/ 8
Q5	/ 8
Q6	/ 14
Q7	/ 19
Total marks	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T/K	=	T/ºC + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 A raindrop falls vertically from rest.

(a) Assume that air resistance is negligible.

On Fig. 1.1, sketch a graph to show the variation with time *t* of the velocity *v* of the raindrop for the first 1.0 s of the motion. [1]

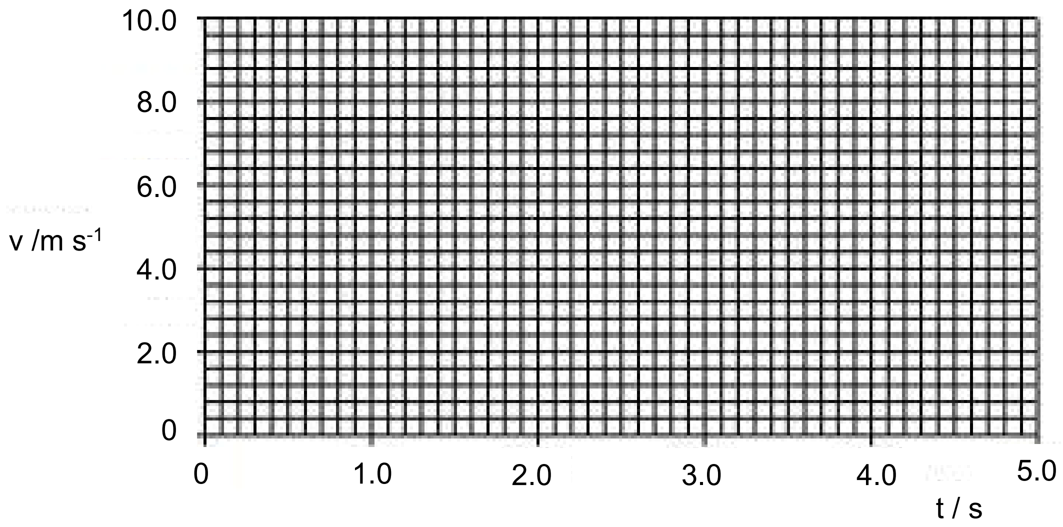

Fig. 1.1

(b) In practice, air resistance *D* on the raindrop is not negligible.

D is given by the expression

$$D = k\,v^2$$

where *k* is a constant and *v* is the speed.

(i) The raindrop has mass 1.38×10^{-5} kg and *k* is 2.76×10^{-6} N m^{-2} s^2.

Calculate the terminal velocity of the raindrop.

terminal velocity = ………….. m s^{-1} [2]

(ii) The raindrop reaches terminal velocity at *t* = 3.0 s.

On Fig. 1.1, sketch the variation with time *t* of velocity *v* for the raindrop. The sketch should include the first 5.0 seconds of the motion. [2]

For Examiner's Use

(c) A raindrop falls on a roof and rebounds off with a velocity of 5.5 m s^{-1} at an angle 60^o with respect to the horizontal as shown in Fig. 1.2.

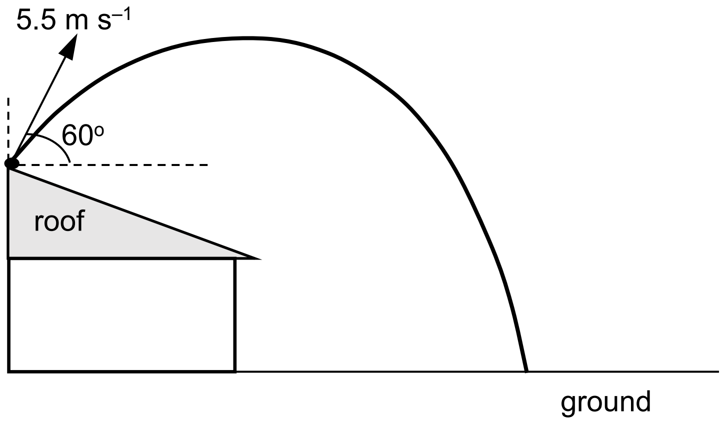

Fig. 1.2

Assume air resistance is negligible. The maximum horizontal distance travelled by the raindrop is 3.8 m.

(i) Calculate the time taken for the raindrop to hit the ground.

time = …………………. s [1]

(ii) Determine the speed of the raindrop as it hits the ground.

speed = …………………...m s^{-1} [2]

(iii) Discuss quantitatively whether the assumption that air resistance is negligible is justified by considering the vertical component of the initial velocity of the raindrop.

The raindrop has the same mass and dimension as in **(b)(i)**.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

For Examiner's Use

2 A uniform rectangular card is suspended from a wooden rod. The card is held at one of its ends as shown in Fig. 2.1. The force by the hand on the card acts horizontally to the right.

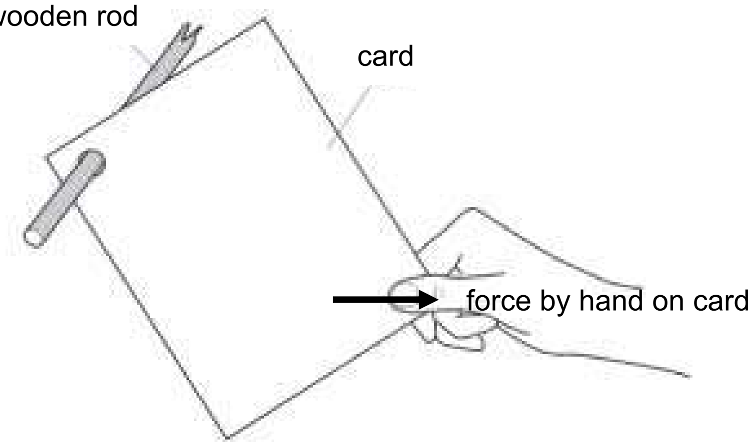

Fig. 2.1

(a) On Fig. 2.1,

(i) mark with an 'X' the position of the centre of gravity of the card. [1]

(ii) draw an arrow labelled with *W* to represent the weight of the card. [1]

(b) State the conditions for the card to be in equilibrium.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(c) Draw an arrow labelled with *R* on Fig. 2.1 to represent the force exerted by the wooden rod on the card.

Show your construction clearly. [2]

(d) The card is now released. It swings on the wooden rod and eventually comes to a rest.

By reference to the completed diagram in Fig. 2.1, describe the final position in which the card comes to a rest.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

For Examiner's Use

3 **(a)** An object is placed on a smooth horizontal surface and is connected to a light spring, as shown in Fig. 3.1.

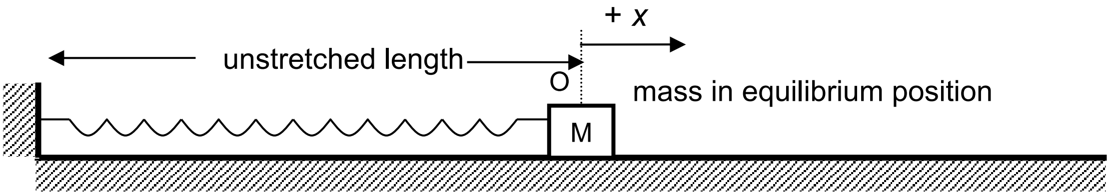

Fig. 3.1

The object is displaced to the right by 0.60 m and then released. Fig. 3.2 shows the variation with displacement *x* of acceleration *a* of the object.

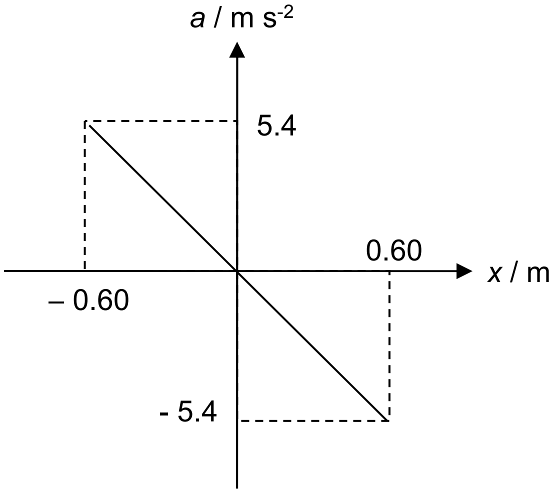

Fig. 3.2

(i) Use two features of the graph in Fig 3.2 to explain why the motion of the object is simple harmonic.

…………………………………………………………………………………………………

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…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(ii) Calculate

1. the angular frequency,

angular frequency = ………………….. rad s^{-1} [1]

2. maximum speed of the object.

maximum speed = …………………. m s^{-1} [1]

(iii) Sketch on Fig. 3.3 the variation with time of the kinetic energy of the object for one complete oscillation. The mass of the object is 0.0020 kg.

Assume that the object just passes by the equilibrium position at time = 0 s. [2]

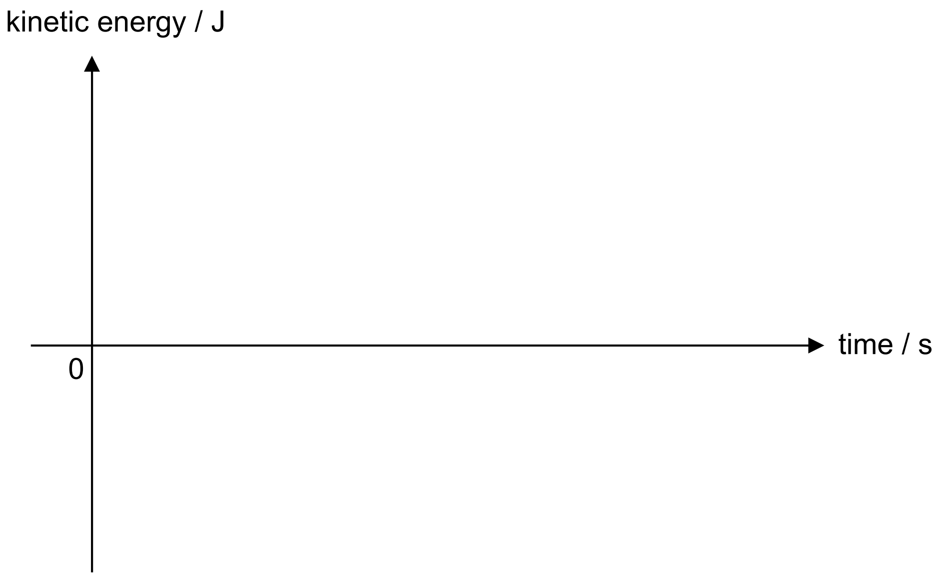

Fig. 3.3

(iv) Calculate the shortest time taken for the object to move from a point 0.30 m to the left of the equilibrium point to a point 0.30 m to the right of the equilibrium point.

time = ………………….. s [3]

For Examiner's Use

(b) A car component of mass 0.0460 kg rattles at a resonant frequency of 35.5 Hz. Fig. 3.4 shows how the amplitude of the vertical oscillation varies with frequency.

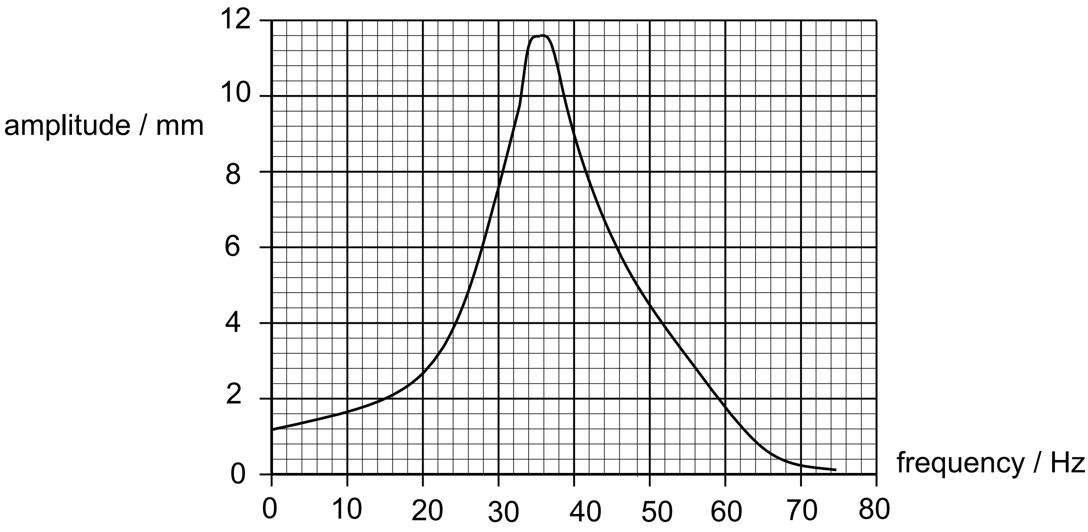

Fig. 3.4

(i) When oscillating at the resonant frequency, calculate

1. the angular frequency of the oscillation,

angular frequency = ………………………….. rad s^{-1} [1]

2. the total energy stored in the oscillation of the component.

energy = ... J [2]

(ii) Draw on Fig 3.4 to show how the amplitude of the oscillation varies with frequency if the component is supported on a rubber mounting. [2]

For Examiner's Use

4 **(a)** Fig.4.1 shows a string stretched between two fixed points P and Q.

Fig. 4.1

An oscillator is attached near end P of the string. End Q is fixed to a wall. The oscillator has a frequency of 50.0 Hz.

The stationary wave produced on PQ at an instant time *t* is shown in Fig. 4.2. Each point on the string is at its maximum displacement.

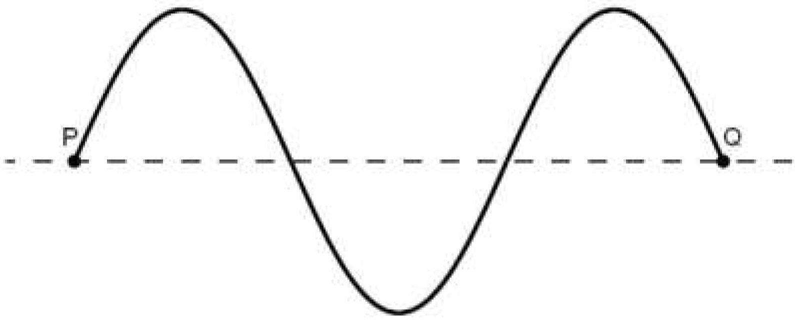

Fig. 4.2

(i) On Fig. 4.2, label all the nodes with the letter **N** and the antinodes with the letter **A** along the dotted line PQ. [1]

(ii) On Fig 4.2, draw the stationary wave at (t + 5.0 ms). [1]

(b) Sound waves is directed from a loudspeaker towards a metal plate. A microphone, connected to a cathode ray oscilloscope (CRO), is placed in between the loudspeaker and the metal plate as shown in Fig. 4.3.

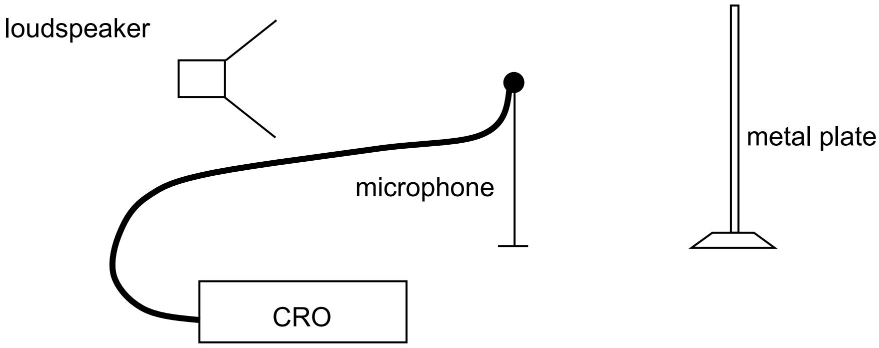

Fig. 4.3

(i) Explain how stationary waves are formed in between the loudspeaker and the metal phase.

……………………………………………………………………………………………………

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……………………………………………………………………………………………………[3]

(ii) The trace on the CRO in Fig. 4.4 shows the variation of signal with time at an antinode.

The time-base setting on the CRO is 0.10 ms cm^{-1}.

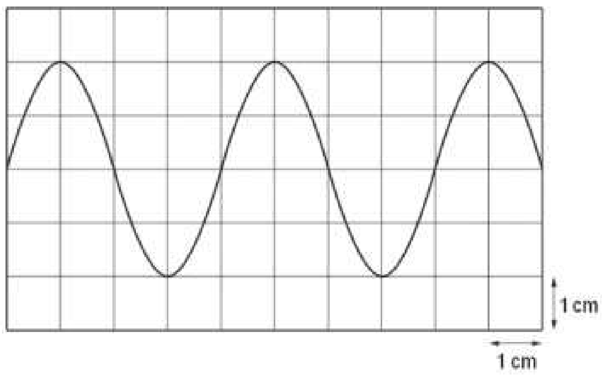

Fig. 4.4

The microphone is then moved by 3.3 cm and the trace on the CRO now records zero amplitude.

1. Determine the frequency of the sound.

frequency = …………………….. Hz [1]

2. Calculate the speed of sound.

speed = …………………….. m s^{-1} [2]

For Examiner's Use

5 **(a)** For a particular gas, the emission and absorption spectra are obtained for the visible light spectrum.

Discuss one similarity and one difference between the discrete lines of the absorption and emission spectra of this gas.

……

……

……

……

…… [2]

(b) Fig. 5.1 gives information on three lines observed in the emission spectrum of hydrogen atoms.

wavelength / nm	**energy of photon / eV**
486	2.56
656	
1880	0.66

Fig. 5.1

(i) Complete Fig. 5.1 by calculating the energy of the photon with wavelength 656 nm. [1]

(ii) Fig. 5.2 is a partially completed diagram to show energy levels of a hydrogen atom.

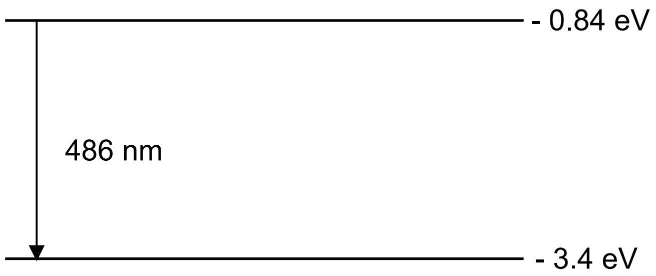

Fig. 5.2

On Fig. 5.2, draw an additional labelled energy level which will account for the emission of the photons in Fig. 5.1. [1]

(c) Three of the energy levels of a lithium atom are shown in Fig. 5.3.

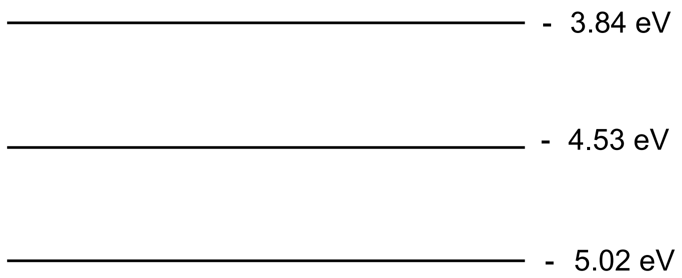

Fig. 5.3

One way to study the energy levels of an atom is to bombard the atom with electrons and measure the kinetic energies of the bombarding electrons before and after the collision. If a lithium atom which is originally in the – 5.02 eV level is bombarded with an electron of kinetic energy 0.92 eV, the scattered electron can have only two possible kinetic energies.

States these two kinetic energy values, and state what happens to the lithium atom in each case.

1st possible kinetic energy value: ………………………. eV [1]

……………………………………………………………………………………………………

…………………………………………………………………………………………………….. [1]

2nd possible kinetic energy value: ………………………. eV [1]

……………………………………………………………………………………………………

…………………………………………………………………………………………………….. [1]

For Examiner's Use

6 **(a)** A stationary nucleus of a radioactive nuclide, ${}^{218}_{84}Po$, underwent a chain of decays by the emission of an α and β–particles. The decay is represented by the two equations:

$$ {}^{218}_{84}Po \rightarrow D + \alpha $$
$$ D \rightarrow E + \beta $$

where D and E are the nuclides formed after the decay.

(i) State the nuclear notation for E. [1]

$${}^{\cdots\cdots\cdots}_{\cdots\cdots\cdots}E$$

(ii) Determine the ratio of the kinetic energy of the α–particle to the total kinetic energy of D and α–particle.

ratio = ……………………… [3]

For Examiner's Use

(iii) In reality, the β–particles have a range of kinetic energies, instead of a fixed value. Explain why this is so.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

………………………………………………………………………………………………….[1]

(iv) A sample of $^{218}_{84}Po$ is placed on a weighing balance and a reading of 4.05 g is obtained. After 243 s, the reading drops to 4.02 g.

1. Determine the number of particles $^{218}_{84}Po$ in the initial sample.

number of particles = ………………….. [1]

2. Show that the total number of particles D and E after 243 s is 4.52 x 10^{21}. [1]

3. Determine the half life of $^{218}_{84}Po$.

half life = …………………. s [2]

For Examiner's Use

(b) For many unstable parent nuclei, the daughter nuclei is itself radioactive. This may give rise to a radioactive series where there may be ten or more different radioactive daughter products.

A radioactive parent nucleus X has a radioactive daughter nucleus Y and, in turn, this daughter produces a further stable daughter Z. The variation with time *t* of the percentage number *P* of the different nuclei X, Y and Z in a radioactive sample is illustrated in Fig. 6.1

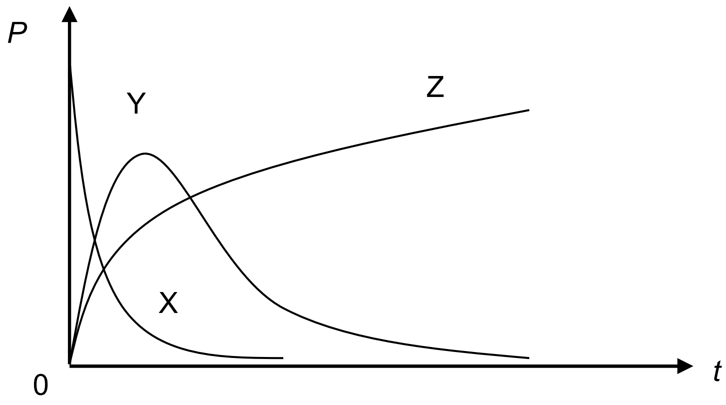

Fig 6.1

(i) X has a half life of 5 hours. The count rate at t = 0 and t = 5 hours were measured. Suggest three possible reasons why the count rate is not exactly halved after 5 hours.

1. …………………………………………………………………………………………………

…………………………………………………………………………………………………

2. …………………………………………………………………………………………………

…………………………………………………………………………………………………

3. …………………………………………………………………………………………………

…………………………………………………………………………………………………[3]

(ii) Explain why graph of Y increases to a maximum and then decreases.

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…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

7 Many devices are designed to create a spray of tiny droplets. The effectiveness of these devices usually depends on droplet size. One example is an agriculture pesticide spray in which a few large droplets do not coat the leaves of plants as well as many small droplets. Another example is a fuel injection system for an engine.

Measuring the size of droplets present in a spray is difficult to do by direct means but instruments called droplet sizers can be purchased which make droplet sizing a fast routine operation.

The principle of operation of one such sizer is shown in Fig. 7.1, in which light from a helium/neon laser is passed through a spray of droplets of uniform diameter and forms a circular diffraction ring of radius *x*. The diameter *d* of the droplets is related to *x* by the equation

$$d = k\frac{\lambda}{x}$$

In this equation λ, the wavelength of the light, is 6.33 x 10^{-7} m. *k* is a constant equal to 0.474 m, and *d* and *x* are both in metres.

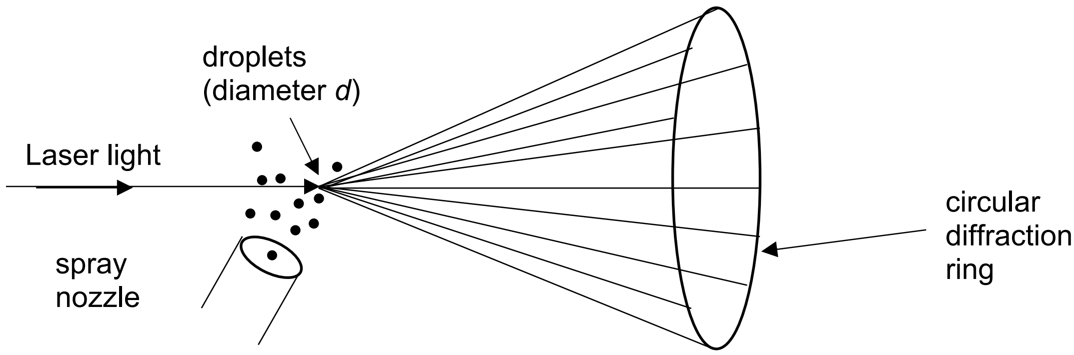
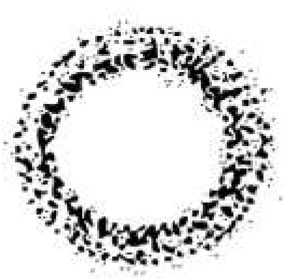


Fig. 7.1

In practice, a spray will consist of droplets of different sizes, so many rings of diffracted light will be caused. The diffraction pattern in Fig. 7.2a is projected on a flat surface containing many light sensitive detectors. The output from the detectors can be analysed by a computer and be shown in the form of a graph in Fig. 7.2b.



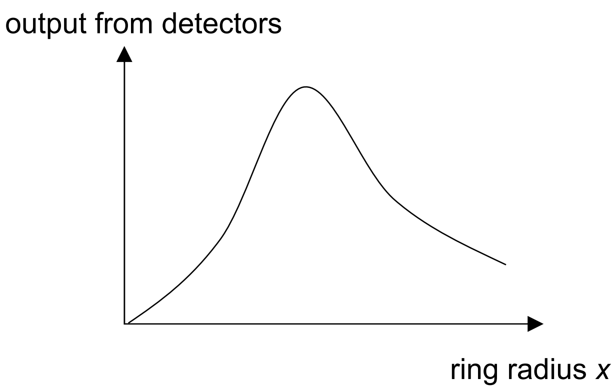


Fig. 7.2b

Fig. 7.2a

For Examiner's Use

(a) Suggest two devices, other than those mentioned in the first paragraph of the passage, where droplet size is important.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………[2]

(b) Outline a direct method for measuring droplet diameter.
Apparatus available includes: high speed camera, stroboscope, stopwatch, rulers.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

(c) Give two reasons why direct methods are likely to be difficult for measuring droplets of small diameter.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………[2]

(d) Calculate the value of *x* for a droplet of diameter

(i) 10 μm

x = ……………………….. m [1]

(ii) 200 μm

x = ……………………….. m [1]

For Examiner's Use

(e) State whether a small value of x corresponds to large or to small droplets.

…… [1]

(f) Suggest, with reference to the equation given, how the radius of the circular diffraction ring can be increased for the same diameter of water droplets.

…… [1]

(g) Sketch on the axes in Fig. 7.3 curves to show the general shape of graphs that would be obtained if

(i) droplets with a wide range of diameters were used. Label as **(i)**. [1]

(ii) very small droplets with a narrow range of diameters were used. Label as **(ii)** [1]

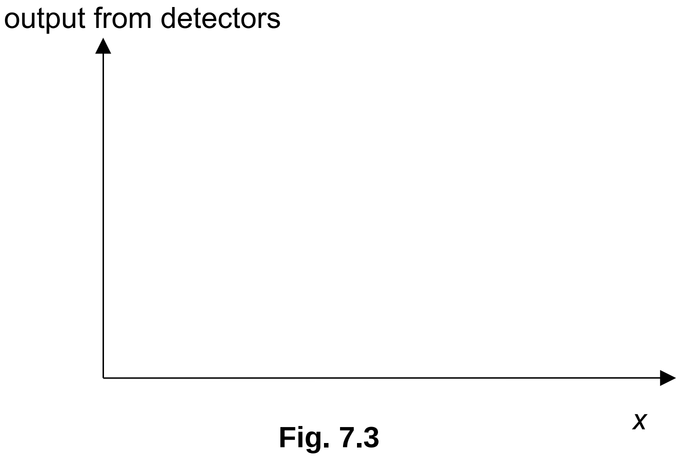


Fig. 7.3

For Examiner's Use

(h) In practice, a cloud of spray droplets moves through the laser beam as shown at intervals in Fig. 7.4. The output from the detectors varies with time in the way shown in Fig. 7.5.

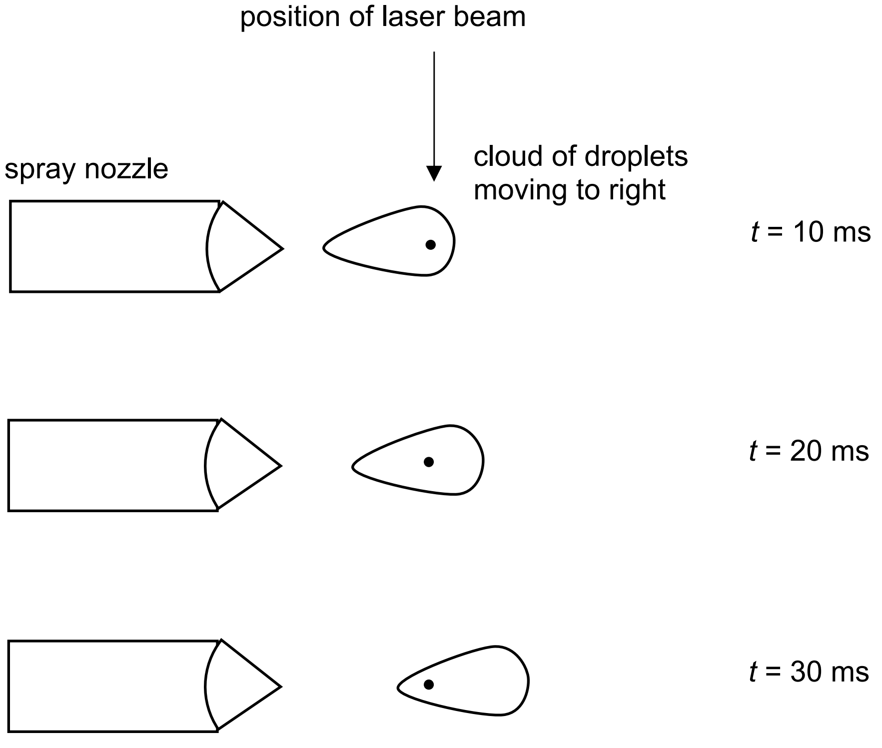


Fig. 7.4

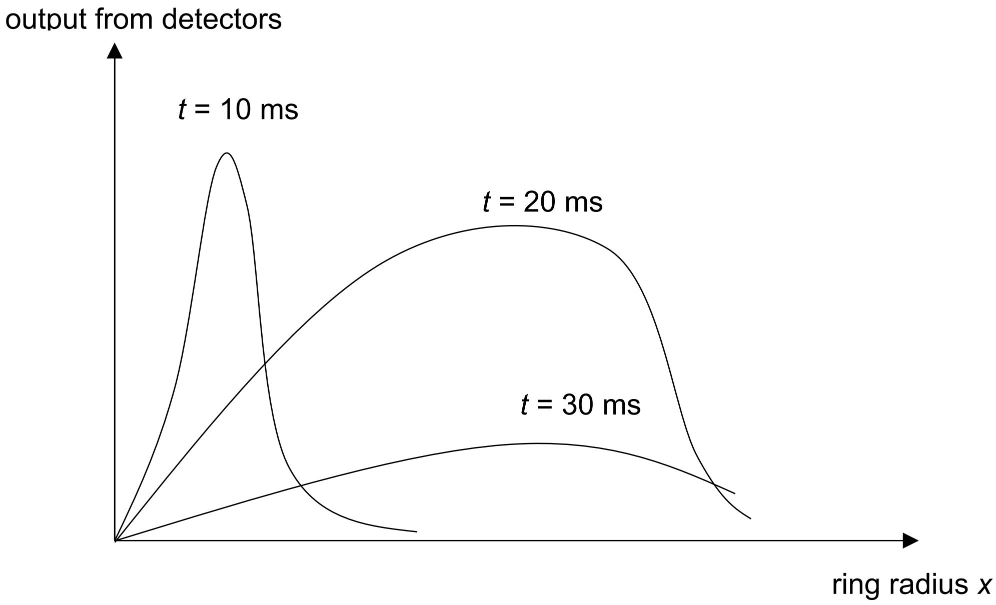


Fig. 7.5

For Examiner's Use

With reference to Fig. 7.6, describe the distribution of droplets in the cloud according to their size and concentration (i.e. amount of droplets).

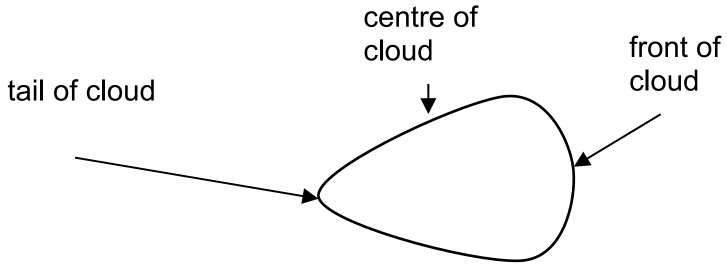


Fig. 7.6

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....[6]

END OF PAPER

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General Certificate of Education Advanced Level
Higher 2

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INDEX NO.	

PHYSICS 9749/03

Preliminary Examination — **20th September 2018**
Paper 3 Longer Structured Questions — **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions in Section A, and **one** of the two questions in Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 8
Q2	/ 7
Q3	/ 10
Q4	/ 8
Q5	/ 10
Q6	/ 10
Q7	/ 7
Q8	/ 20
Q9	/ 20
Total marks	/ 80

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T /K	=	T /ºC + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided.

1 **(a)** Define *impulse*.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………… [1]

(b) In a car test, a car with a dummy driver and passenger, moving at a speed of 6.9 m s^{-1}, collides head-on into a wall. The mass of the car is 1250 kg, the mass of the driver is 85 kg and the mass of the front passenger is 65 kg. The average deceleration of the car as it comes to a stop is 48 m s^{-2}. Both passenger and driver have their seat belts tightly fastened.

For the impact,

(i) determine the magnitude of the average force exerted on the car and its occupants.

average force = ……………..………. N [1]

(ii) determine the magnitude of the impulse caused by the force.

impulse = ……………..………. N s [2]

(iii) Hence, calculate the time taken for the car to come to a stop.

time = ……………..………. s [2]

(iv) Assuming that the average deceleration remains the same, state and explain how your answer in **(b) (iii)** will change (if any) when the total mass of car and occupants is doubled.

…………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

For Examiner's Use

2 A fixed mass of an ideal monatomic gas undergoes a cycle **ABCA** of changes, as shown in Fig. 2.1.

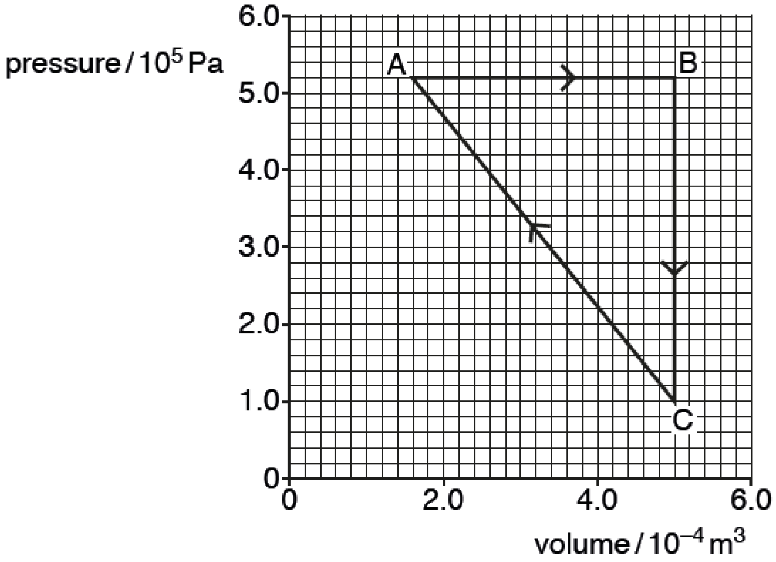

Fig. 2.1

(a) During the change from **B** to **C**, the internal energy of the gas decreases by 315 J.

By considering molecular energy, state and explain qualitatively the change, if any, in the temperature of the gas.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………… [2]

(b) During the change from **A** to **B**, the energy supplied to the gas by heating is 442 J.

Fig. 2.2 is a table of energy changes during one cycle. Complete Fig. 2.2.

section of cycle	heat supplied to gas / J	work done on gas / J	increase in internal energy of gas / J
A to B	442		
B to C			-315
C to A			

Fig. 2.2

[3]

For Examiner's Use

(c) Calculate the root-mean-square speed of the gas atoms at point **B** if the root-mean-square speed at point **A** is 350 m s^{-1}.

root-mean-square speed = ……………..……….. m s^{-1} [2]

For Examiner's Use

3 **(a)** As seen in Fig 3.1, a monochromatic light of wavelength 580 nm is used to produce an interference pattern on screen AB. The separation between the slits is 0.41 mm and the perpendicular distance between the double slit and the screen is *D*. Point Y is at a distance *x* = 2 mm from point O and it is the position of the first dark fringe. The intensities of the light passing through the two slits are the same.

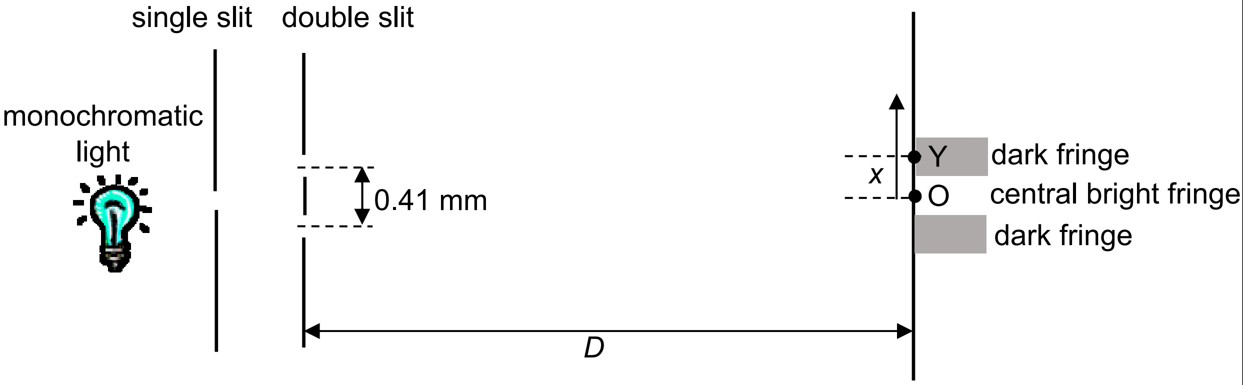

Fig 3.1

(i) Calculate the path difference between the 2 waves arriving at point Y from the slits.

distance = ……………….. nm [1]

(ii) Calculate the distance *D*.

D = ……………………… m [2]

(iii) The width of both slits is reduced by the same amount without altering their separation. The original variation with distance *x* from point O of the intensity is as shown in Fig. 3.2. Sketch the new variation of intensity on Fig. 3.2. [3]

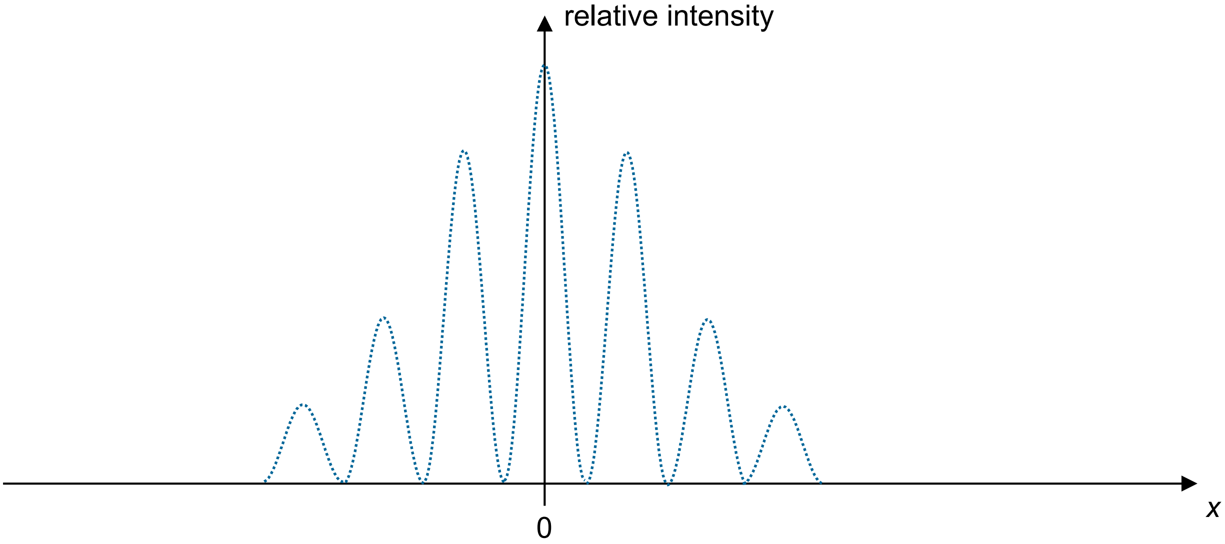

Fig. 3.2

For Examiner's Use

(b) A diffraction grating is used to measure the wavelengths of light. The angle θ of the second order maximum is measured for each wavelength. The variation with wavelength λ of sin θ is shown in Fig 3.3.

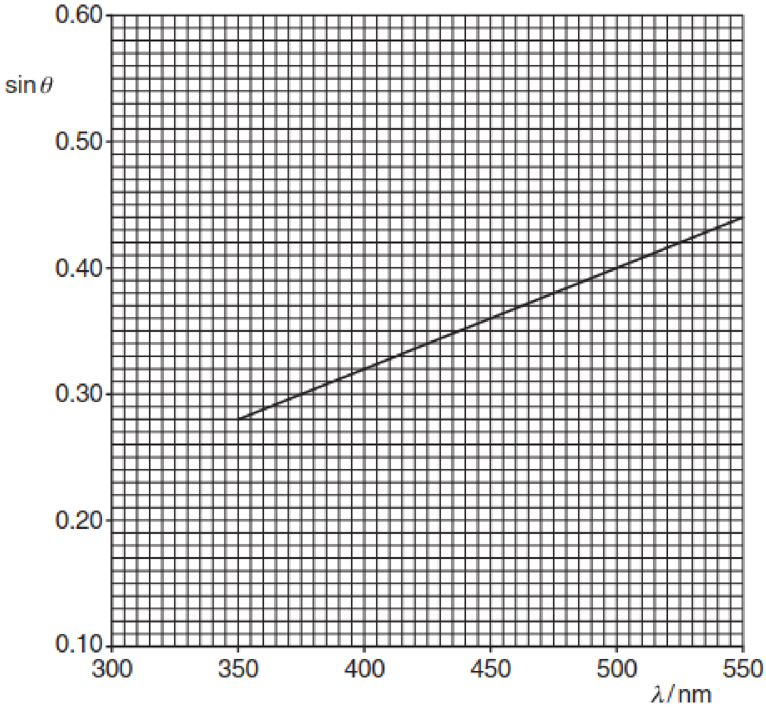

Fig. 3.3

(i) Calculate the slit separation d of the diffraction grating.

d = ……………………….m [3]

(ii) On Fig. 3.3, sketch a line to show the results that would be obtained for the first order maxima. [1]

4 **(a)** Define *electric potential* at a point.

....

....

.... [2]

(b) Two charged solid spheres A and B are situated in a vacuum. Their centres are separated by a distance of 30.0 cm, as shown in Fig. 4.1. The diagram is not drawn to scale.

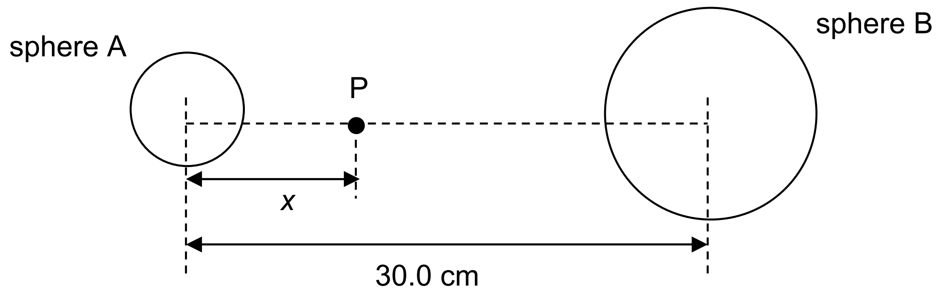

Fig. 4.1

The variation with distance x of the electric potential V_A and V_B due to sphere A and B independently is shown in Fig. 4.2.

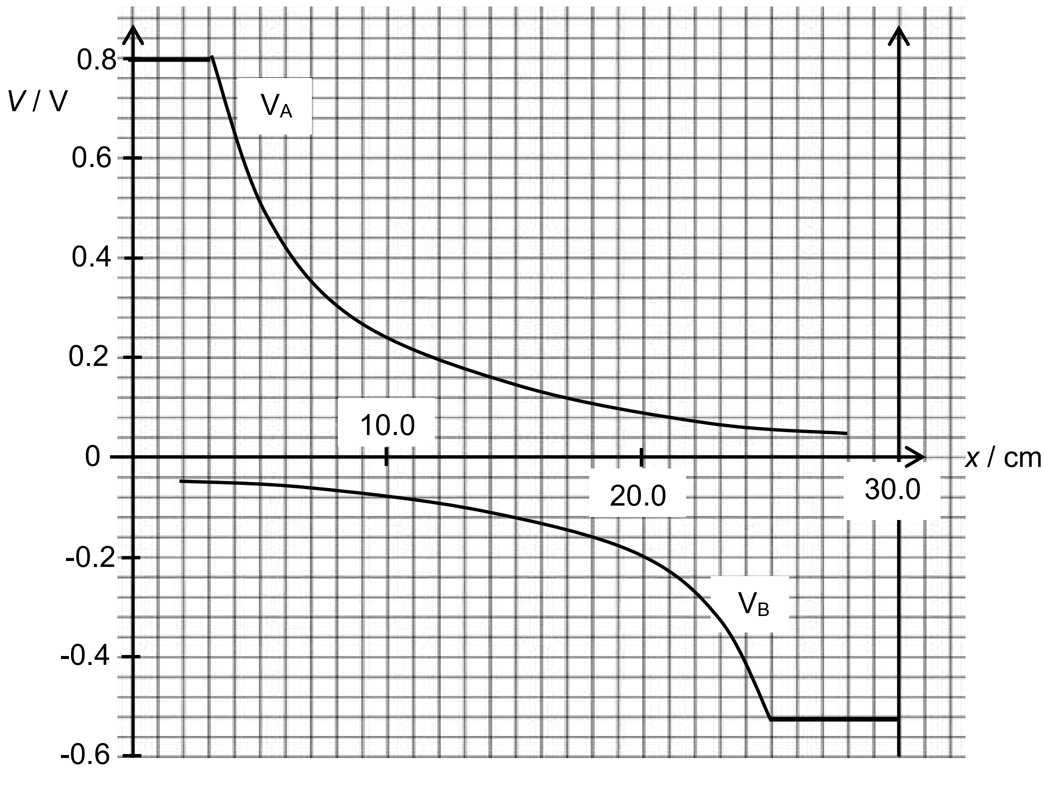

Fig. 4.2

For Examiner's Use

(i) Using Fig. 4.2, state the radius of both spheres.

radius of sphere A = ……………… cm

radius of sphere B = ………………. cm [1]

(ii) State and explain the signs of both spheres.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………... [2]

(iii) Point P is at a distance x = 10.0 cm.
An alpha particle has kinetic energy E_K when at infinity.

Use Fig. 4.2 to determine the minimum value of E_K such that the alpha particle may travel from infinity to point P.

E_K = ………………………….. J [3]

For Examiner's Use

5 An ideal transformer is connected to a sinusoidal a.c. supply, as shown in Fig. 5.1. The primary coil has a r.m.s. current of 0.85 A.

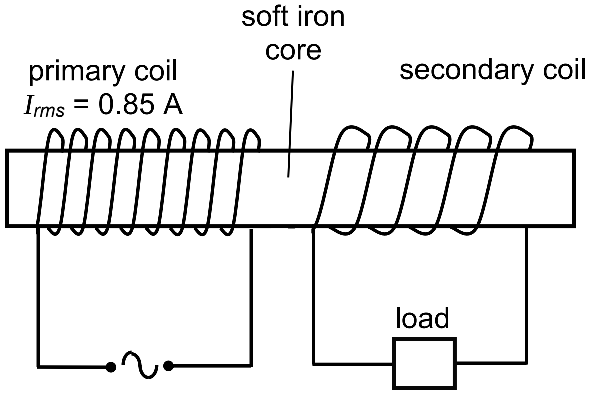

Fig. 5.1

(a) Use the laws of electromagnetic induction to explain how a potential difference can be developed across the secondary coil.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………………………………………………. [3]

(b) **(i)** The primary coil contains 9 turns per cm, calculate the maximum magnetic field strength at its centre.

maximum magnetic field strength = …………………. T [2]

For Examiner's Use

(ii) The ratio of the number of turns in the primary to secondary coil is 16 : 1.

Calculate the peak current in the load.

peak current = …………………… A [2]

(iii) The variation with time t of current I_p in the primary coil is shown in Fig. 5.2.

On Fig. 5.3, sketch the variation with time t of current I_s in the secondary coil. [1]

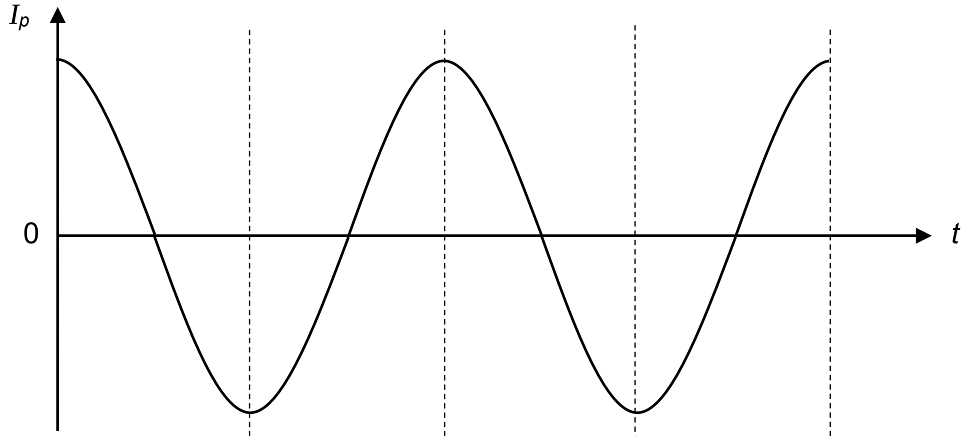

Fig. 5.2

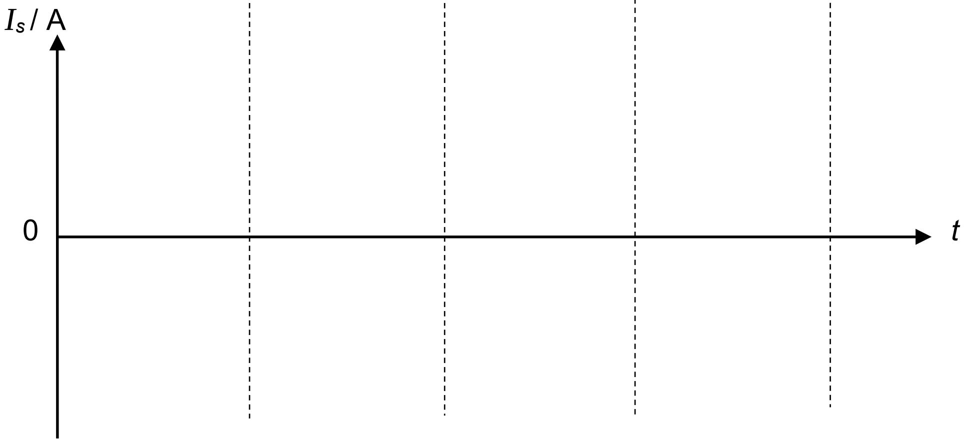

Fig. 5.3

(iv) State and explain how the answer to **b (iii)** will change if the iron core is removed from the transformer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

For Examiner's Use

6 Ultraviolet radiation of wavelength 122 nm is used to illuminate the cathode in the vacuum tube as shown in Fig. 6.1.

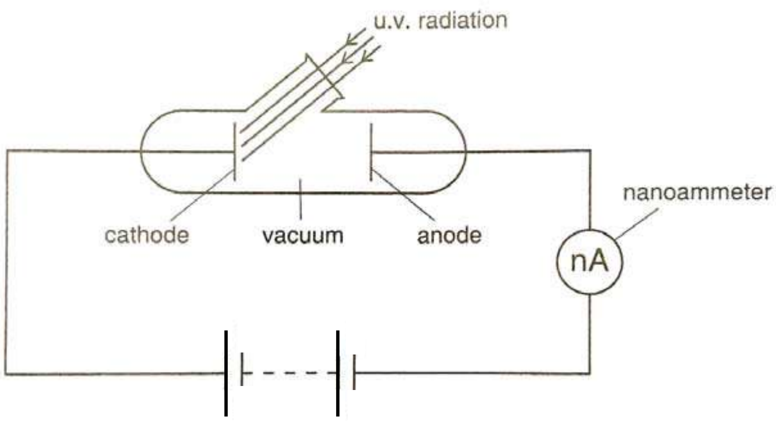

Fig. 6.1

(a) Photoelectrons are emitted from the cathode and collected at the anode. With the anode made negative and the cathode positive, some photoelectrons can still reach the anode, and by varying the battery's e.m.f, a graph of current against e.m.f. can be plotted as shown in Fig. 6.2.

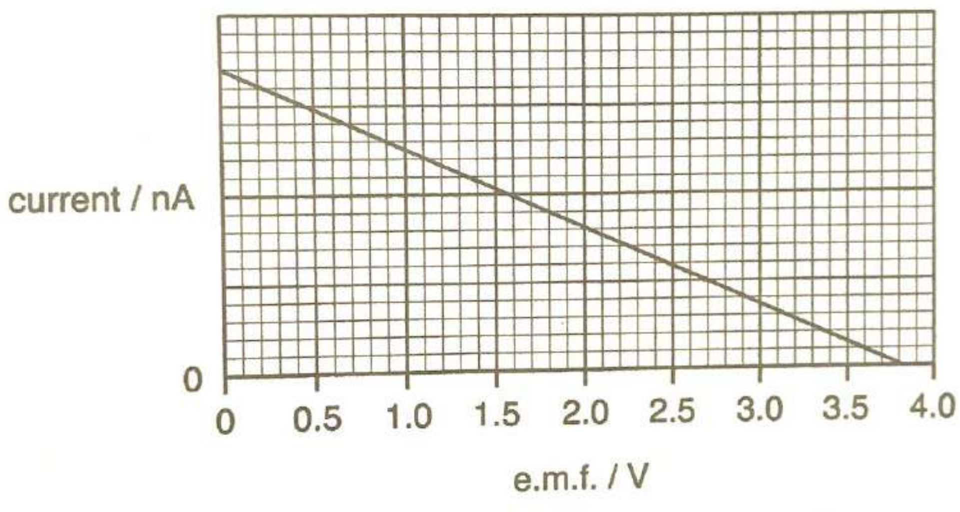

Fig. 6.2

(i) Explain why some photoelectrons are still able to reach the negative anode.

....

....

....

.... [1]

For Examiner's Use

(ii) Calculate the maximum speed the photoelectrons can have when they leave the cathode.

maximum speed = …………………………………… m s^{-1} [2]

(iii) Calculate the work function of the metal used in the cathode.

work function = ………………………………… J [2]

(b) The photocurrent I for different potential difference V between the cathode and the anode was measured. The experiment was then repeated using ultraviolet radiation of the same wavelength but of different intensity.

The series of graphs of I against V are shown in Fig. 6.3.

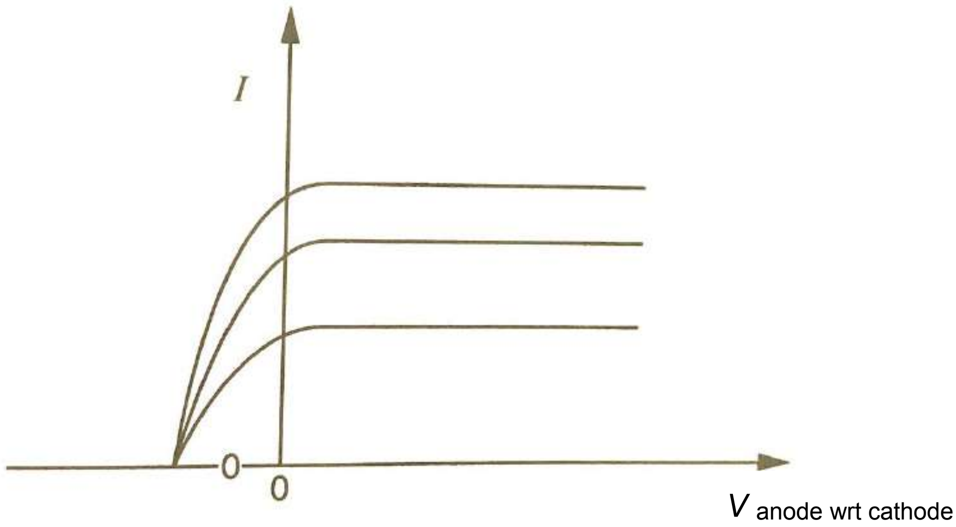

Fig. 6.3

(i) State and explain which feature of this graph could not be explained using the wave theory of light.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

……………………………………………………………………………………………………[2]

(ii) Explain why the maximum kinetic energy of photoelectrons is independent of intensity whereas the photoelectric current is proportional to intensity of the light.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

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……………………………………………………………………………………………………[3]

7 An induced nuclear fission reaction may be represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$$

(a) Sketch the variation with nucleon number of the binding energy per nucleon in Fig 7.1. [2]

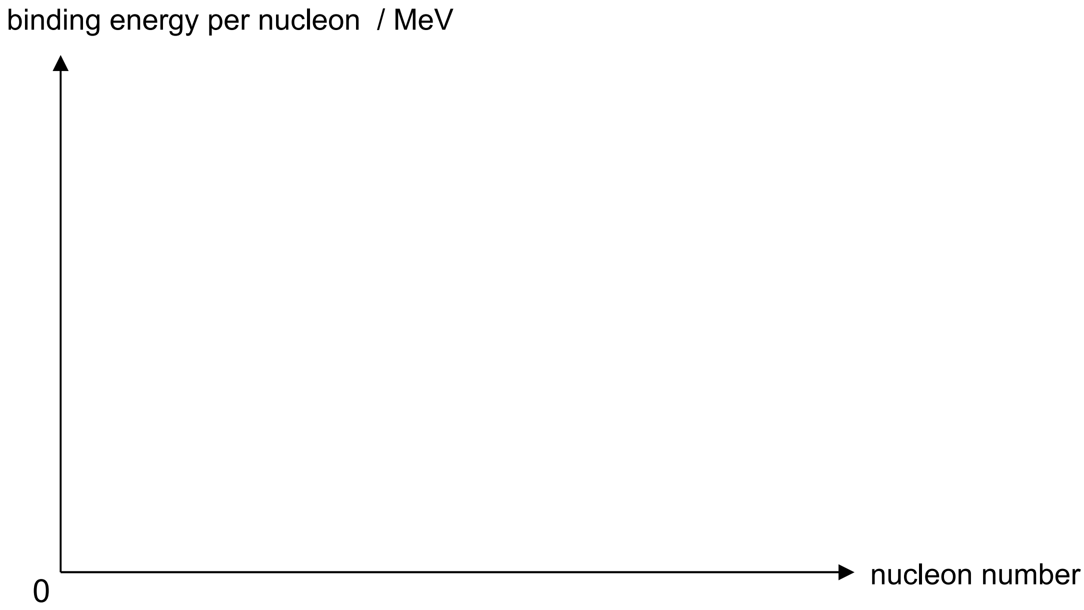

Fig 7.1

(b) Hence, explain why Uranium – 235 is more likely to undergo fission than fusion.

………

………

………

………

………

………

……[3]

For Examiner's Use

(c) The masses of the various nuclides are as listed below:

nuclide	mass / *u*
Uranium - 235	235.04393
Barium – 141	140.91441
Krypton - 92	91.92616
neutron	1.00867

Determine the energy released in the reaction.

energy released = …………………………… J [2]

For Examiner's Use

Section B

Answer **one** question from this section in the spaces provided**.**

8 **(a)** **(i)** Define *gravitational field strength*.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(ii) Derive, from Newton's Law of Gravitation and **(a)(i)**, the equation for the gravitational field strength of a point mass of mass M_1, placed in a gravitational field generated by a mass M_2 and at a distance of r from M_1. [2]

(b) Information related to the Earth and the Moon is given below:

$$\frac{\text{Radius of Earth}}{\text{Radius of Moon}} = 3.7$$

$$\frac{\text{Mass of Earth}}{\text{Mass of Moon}} = 81$$

The center-to-center distance of the Moon from the Earth is 3.84×10^8 m and the gravitational field strength due to the Earth at its surface is 9.8 N kg^{-1}.

(i) Using these data, calculate the gravitational field strength due to the Moon at its surface.

gravitational field strength = …………………. N kg^{-1} [3]

For Examiner's Use

(ii) There is a point on the line between the Earth and the Moon at which their combined gravitational field strength is zero.

Calculate the distance between this point and the centre of the Earth.

distance = ……………………………… m [2]

(iii) The Moon orbits around the Earth with a period of 27.3 days.

1. Calculate the angular speed of the Moon.

angular speed = ……………….. rad s^{-1} [1]

2. Calculate the mass of the Earth.

mass = ………………………………… kg [2]

3. Determine the gravitational force between the Earth and the Moon.

gravitational force = ……………………………….. N [2]

For Examiner's Use

4. Tidal action on the Earth's surface causes the radius of the orbit of the Moon to increase by 4.0 cm each year. Using your answer in **(b)(iii)(3)**, determine the change, in one year, of the gravitational potential energy of the Moon.

change in potential energy = ………………………….. J [2]

(c) **(i)** Explain, by considering the respective field forces, why gravitational potential energy is negative whereas electric potential energy can be positive or negative.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………..[1]

(ii) The Earth may be assumed to be an isolated sphere of radius 6.4×10^3 km with its mass of 6.0×10^{24} kg concentrated at its centre. A 2.0 kg mass is projected vertically from the surface of the Earth so that it reaches a maximum altitude of 1.3×10^4 km.

Calculate, for this mass,

1. the change in gravitational potential energy

change in gravitational potential energy = …………………….. J [2]

2. the speed of projection from the Earth's surface, assuming air resistance is negligible.

speed = …………………………….. m s^{-1} [2]

9 **(a)** By reference to energy transfers, distinguish between electromotive force (e.m.f.) and potential difference (p.d.).

e.m.f. ……………………………………………………………………………………………

……………………………………………………………………………………………..

p.d. ……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

(b) A circuit is set up as shown in Fig. 9.1.

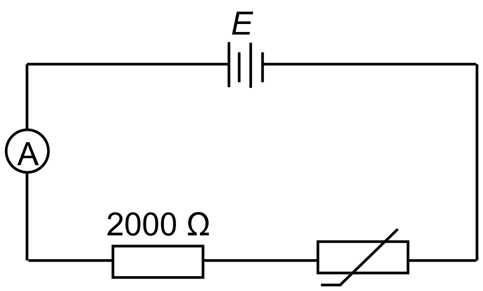

Fig. 9.1

The battery source of emf *E* is found to provide 2.4 x 10^5 J of electrical energy to the 2000 Ω resistor and thermistor when a charge of 2.2 x 10^4 C passes through the ammeter. At room temperature, the thermistor has a resistance of 1800 Ω.

(i) Sketch on Fig. 9.2 the variation with temperature *θ* of resistance *R* in a thermistor. [1]

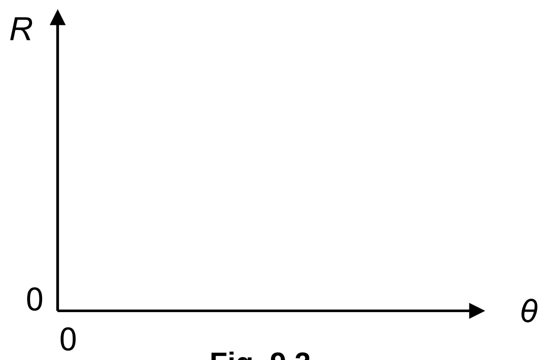

Fig. 9.2

(ii) For the thermistor at room temperature,

1. show that *E* is 11 V. [1]

2. determine the time taken for a charge of 2.2 x 10^4 C to pass through the ammeter.

time = ………………… s [2]

3. show that the fraction of power dissipated in the thermistor is 0.47. [1]

(c) A uniform resistance wire PQ of length 1.2 m is subsequently connected across the resistor and thermistor, as shown in Fig. 9.3. A sensitive voltmeter is connected between point Y and a moveable contact M on the wire.

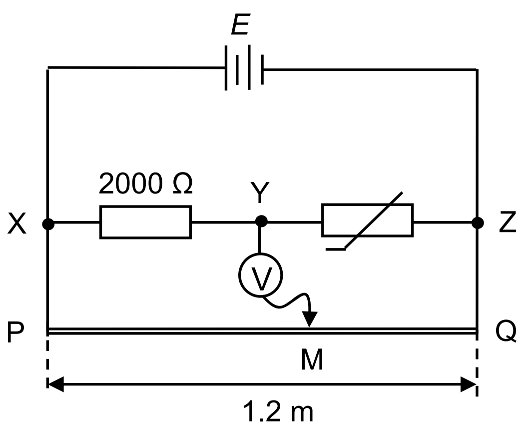

Fig. 9.3

(i) At room temperature, the contact M is moved along PQ until the voltmeter shows zero reading.

Calculate the length of wire between M and Q.

length of wire = …………………… m [2]

(ii) State and explain the effect, if any, on the length of the wire between M and Q for the voltmeter to remain at zero deflection if each of the following changes takes place independently.

1. The thermistor is warmed slightly.

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……………………………………………………………………………………….. [2]

2. A uniform wire with a bigger cross sectional area is used to replace PQ.

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…………………………………………………………………………………………….... [2]

(d) The circuit shown in Fig. 9.4 is used to compare potential differences.

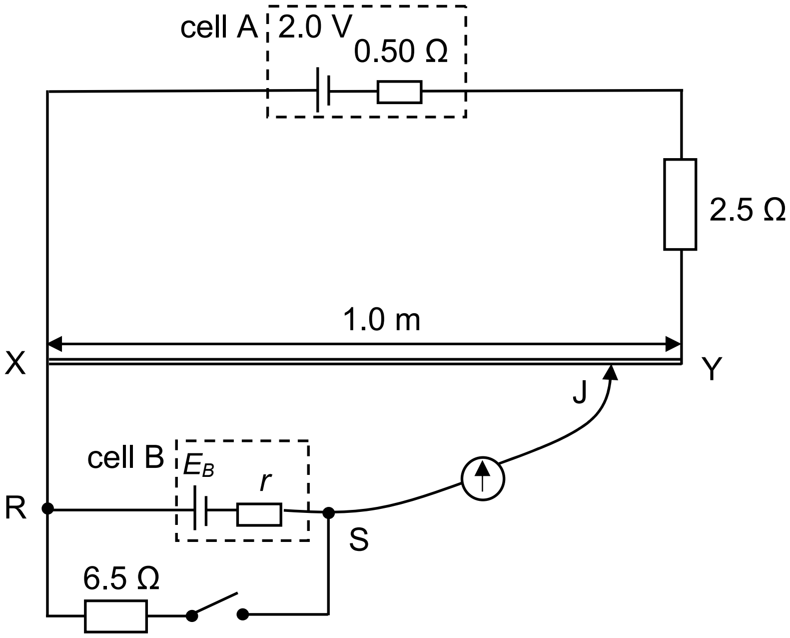

Fig. 9.4

The uniform resistance wire XY has length 1.0 m and resistance 8.0 Ω. Cell A has e.m.f. 2.0 V and internal resistance 0.50 Ω. Cell B has e.m.f. E_B and internal resistance r.

(i) The switch is opened. The galvanometer shows no deflection when the moveable contact J is adjusted so that the length XJ is 0.90 m.

Show that the e.m.f. E_B of cell B is 1.3 V. [2]

(ii) The switch is now closed.

1. For the galvanometer to show no deflection, contact J has to be adjusted so that length XJ is 0.75 m.

Determine the internal resistance *r* of cell B.

r = …………………….. Ω [3]

2. A resistor is connected in parallel with the 6.5 Ω resistor.

Deduce how the balanced length XJ would be affected.

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END OF PAPER

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME			
CG		**INDEX NO.**	

PHYSICS 9749 / 04

Preliminary Examination **28th August 2018**
Paper 4 Practical **2 hour 30 minutes**

Question Booklet for Question 4

Candidates to answer all questions in the Question Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

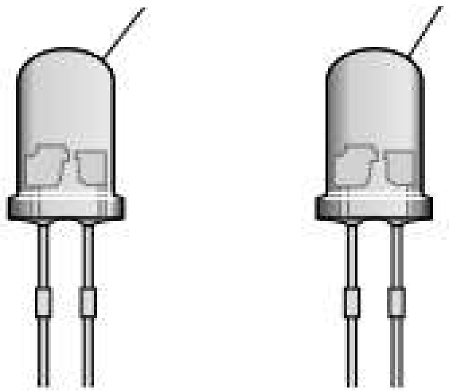
Shift
Laboratory

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
4	/ 11
Total	/ 11

For Examiner's Use

4 A student is investigating the characteristics of different light-emitting diodes (LEDs). Fig. 4.1 shows examples of LEDs and the circuit symbol for an LED.



Circuit symbol:

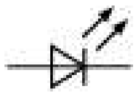


Fig. 4.1

Each LED needs a minimum potential difference *V* across it to emit light. The student is investigating the relationship between *V* and the wavelength *λ* of the light emitted by the LED for several different LEDs.

Design an experiment to investigate the relationship between *V* and *λ*.

You are provided with the following equipment:

Power supply	Metre rule
Resistors	Ammeter
Diffraction grating	Voltmeter
Double slit	Different LEDs
Micrometer screw gauge	Vernier callipers

You may also use any of the other equipment usually found in a Physics laboratory.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the equipment you would use,
(b) the procedure to be followed,
(c) the control of variables,
(d) the analysis of the data,
(e) any precautions that would be taken to improve the accuracy of the experiment.

For Examiner's Use

Diagram

[Total: 11 marks]

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For Examiner's Use

END OF PAPER

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME			
CG		**INDEX NO.**	

PHYSICS — 9749 / 04

Preliminary Examination — **28th August 2018**
Paper 4 Practical — **2 hour 30 minutes**

Candidates to answer all questions in the Question Booklet.

Additional Material: Question Booklet for Question 4

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/ 10
2	/ 12
3 (a) to (d)	/ 17
subtotal	/ 39
3 (e)	/ 5
4	/ 11
Planning subtotal	/ 16

1 In this experiment, you are provided with a ball suspended by a thread so that it is next to a wooden block. You will investigate how the rebound distance is related to the release distance when it swings against the wooden block.

(a) Assemble the apparatus as shown in Fig. 1.1, with the thread clamped between the two small wooden blocks so that l is about 50 cm, and with the big wooden block positioned so that it is just touching the stationary ball.

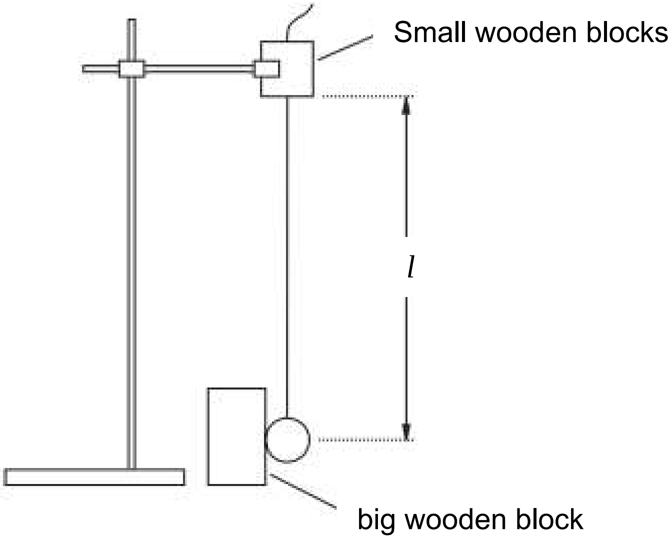

Fig. 1.1

Measure and record l.

l = …………………………….. [1]

(b) **(i)** Pull back the ball as shown in Fig. 1.2.

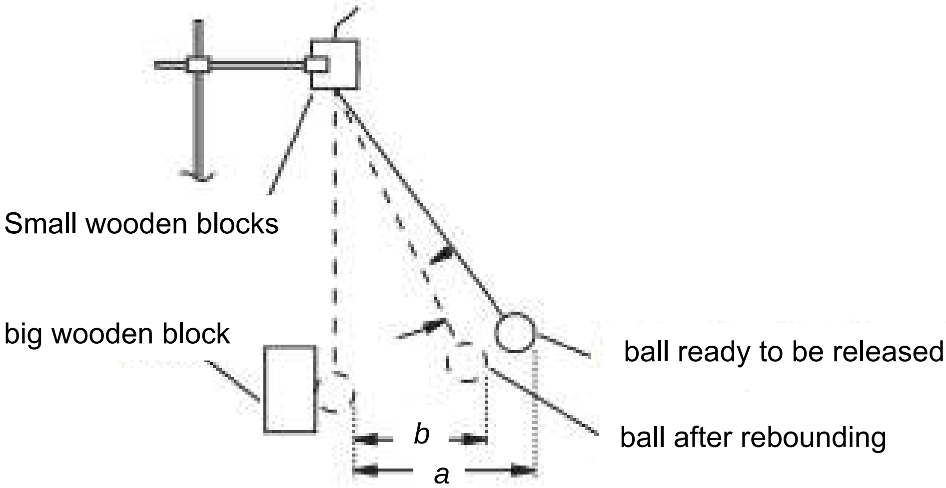

Fig. 1.2

Measure the distance *a.* Do not exceed *a* = 25 cm.

a = …………………………….. [1]

For Examiner's Use

(ii) Release the ball and make measurements to determine the rebound distance b as shown in Fig. 1.2.

b = …………………………….. [2]

(c) **(i)** Explain how you used the apparatus to ensure that the rebound distance b was measured as accurately as possible.

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…………………………………………………………………………………..…………… [1]

(ii) Estimate the percentage uncertainty in the value of b.

percentage uncertainty = …………………………….. [1]

(d) For values of a less than 25 cm, theory predicts that

$$k = \frac{l - \sqrt{l^2 - b^2}}{l - \sqrt{l^2 - a^2}}$$

where k is a constant. Calculate k.

k = ……………………………..[1]

For Examiner's Use

(e) Repeat **(b)(i)**, **(b)(ii)** and **(d)** using a different value of *a*.

a = ……………………………..

b = ……………………………..

k = ……………………………..

[1]

(f) State whether the results of your experiment indicates that *k* is a constant.
Justify your conclusion by referring to **(c)(ii)**.

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…………………………………………………………………………………………….…………… [2]

[Total : 10 marks]

2 In this experiment, you will calculate the amount of charge that flows through a resistor.

(a) **(i)** Set up the circuit as shown in Fig. 2.1, taking care to connect component Y the right way round.

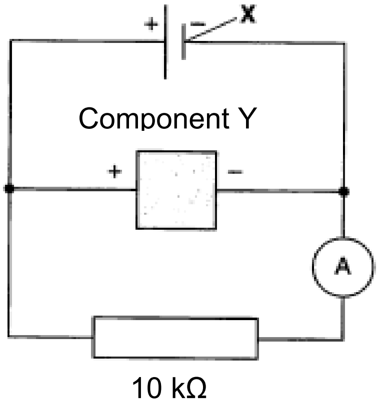

Fig. 2.1

(ii) Read and record the reading I on the ammeter.

I = ...[1]

(b) When the wire at X is disconnected, the current in the resistor gradually decreases to zero.

(i) Disconnect the wire at X and start the stopwatch.

(ii) Take at least five more sets of I and time t up to a value of t = 50 s. Tabulate your results.
(You may need several attempts. Reconnect wire at X for one minute before making another attempt.)

[2]

For Examiner's Use

(iii) **1.** Plot your values from **(b)(ii)** on Fig. 2.2. and draw a curve through your points.

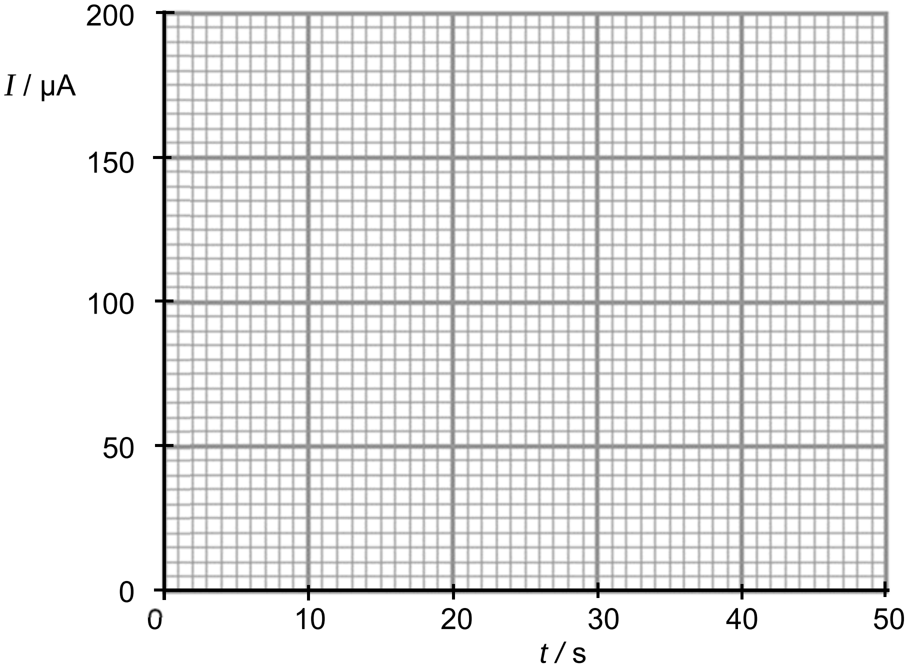

Fig. 2.2

[2]

2. The area under the graph represents the charge *Q* that has flowed through the resistor during 50 s. Estimate *Q*.

Q = ………………………………….[1]

(c) It is suggested that the time taken for the current in the 10 kΩ resistor to decrease to zero is shorter when the total effective resistance of the circuit is lower.

With an aid of circuit diagram(s), suggest how you can verify this.

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.... [4]

(d) Theory suggests that $Q = kV$ where V is the potential difference across the resistor and k is a constant equal to 1.0×10^{-3} C V^{-1}.

(i) Use the analogue voltmeter to measure V.

V = ...[1]

(ii) Use your answer to **(d)(i)** to determine Q.

Q = ...[1]

[Total : 12 marks]

For Examiner's Use

3 In this experiment, you will investigate how the motion of two pendulums depends on the tension in the string connecting them.

(a) Measure and record the unstretched length l_0 of the coiled part of the spring as shown in Fig. 3.1.

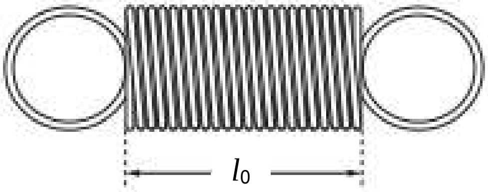

Fig. 3.1

l_0 = ...[1]

(b) (i) Set up the apparatus as shown in Fig. 3.2. Tie strings X and Y such that the spring is horizontal.

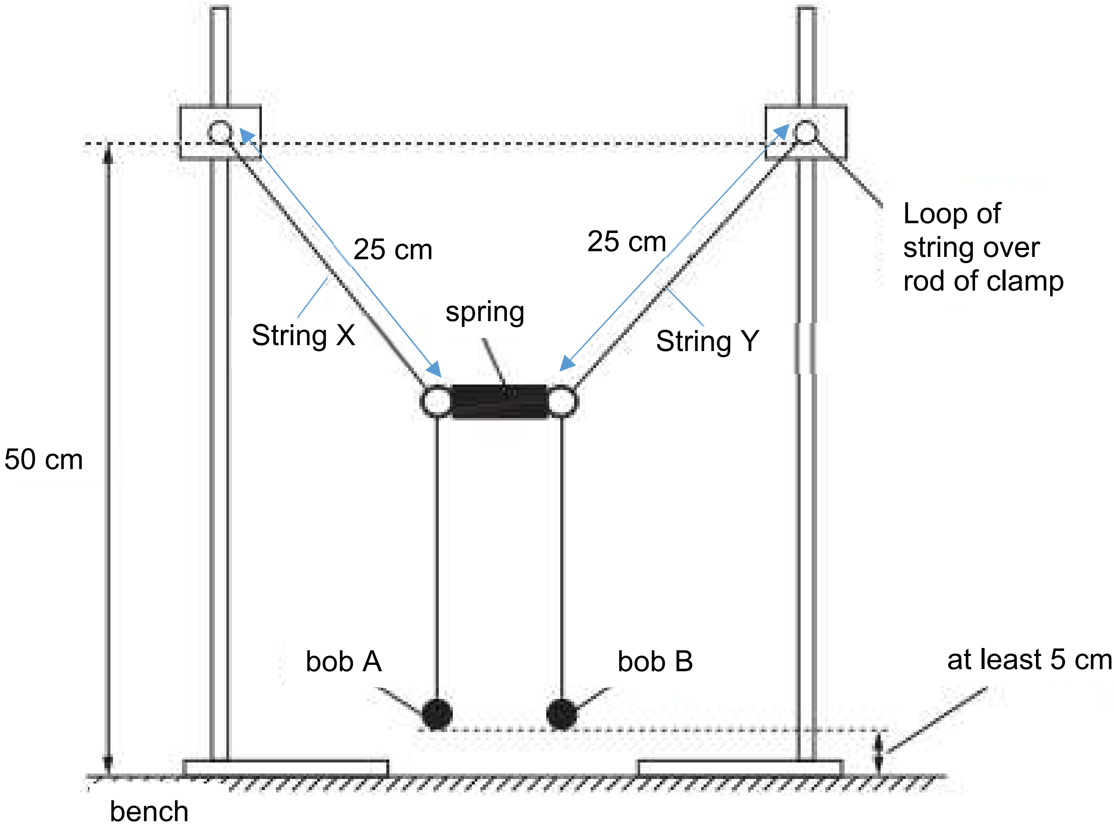

Fig. 3.2

(ii) Position the stands so that the coiled part of the spring has approximate length l_0 + 2 cm (so that the spring is extended by approximately 2 cm).

For Examiner's Use

(iii) Measure and record the length l of the coiled part of the spring. Calculate the extension x of the spring where $x = l - l_0$.

l = ……………………………..

x = …………………………. [1]

(iv) Gently pull bob A towards you. Release the bob and watch the movement of the two bobs.

Bob A will eventually stop and start moving again. It will then stop for a second time.

Determine and record the time T between these two stops.

T = …………………………. [1]

(c) By moving the stands further apart, repeat **(b)(iii)** and **(b)(iv)** until you have further readings of l, x and T, with x in the range 2 cm ≤ x ≤ 10 cm.

[4]

For Examiner's Use

(d) It is suggested that T and x are related by the expression

$$T = p\,x + q$$

where p and q are constants.

(i) Plot a suitable graph to determine p and q.

p = ……………………………..

q = ……………………………..

[5]

(ii) Hence determine the extension x that would be expected to give a value of T = 75 s.

x = …………………………. [1]

For Examiner's Use

For Examiner's Use

(iii) Comment on any anomalous data or results you may have obtained. Explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(iv) On your graph on page 11, draw a new graph when *q* is increased. Label this graph Z. [1]

(v) Suggest a significant source of error in this experiment.

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…………………………………………………………………………………………………… [1]

(vi) Suggest an improvement that could be made to the experiment to address the error identified in **(d)(v)**. You may suggest the use of other apparatus or a different procedure.

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……………………………………………………………………………………………………[1]

For Examiner's Use

(e) It is suggested that the mass of the identical pendulums A and B will affect the time *T* between the two stops of pendulum A such that the mass *m* of a pendulum is directly proportional to the time *T* between the two stops of pendulum A.
Plan an investigation to verify this.

Your account should include:

- your experimental procedure
- details of the table of measurements with appropriate units

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....[5]

[Total: 22 marks]

Question 4:

Write your answer in the Question Booklet for Question 4.

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME	

CG		**INDEX NO.**	**SOLUTIONS**

PHYSICS **9749/01**

Preliminary Examination **21st Sep 2018**
Paper 1 Multiple Choice **1 hour**

Additional Materials: OMS.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in soft pencil on the OMS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

For Examiners' Use	
MCQ	/ 30

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T /K	=	T /°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{ln2}{t_{\frac{1}{2}}}$

Answer all questions.

1 The rate of heat flow, R, can be found using the equation

$$R = k\,A\,\frac{(T_2 - T_1)}{L}$$

where k is the thermal conductivity, A is the total cross sectional area of the conducting surface, and L is the thickness of conducting surface separating the 2 temperatures T_1 and T_2.

What is the SI base units for k?

A kg m s^{-3} K^{-1} **B** kg m s^{-2} K^{-1} **C** kg m s^{-3} **D** kg s^{-2} K^{-1}

Ans: A

$$\lfloor k \rfloor = \left[\frac{R}{A}\frac{L}{(T_2 - T_1)}\right]$$
$$= \frac{W}{m^2}\frac{m}{K}$$
$$= W\ m^{-1}\ K^{-1} = J\ s^{-1}\ m^{-1}\ K^{-1} = kg\ m\ s^{-3}\ K^{-1}$$

2 With reference to Question 1, a student collected the following measurements to determine the rate of heat flow R of the object

L = (0.35± 0.05) mm
T_1 = (32.0 ± 0.5) °C
T_2 = (4.0 ± 0.5) °C

What is the fractional uncertainty in R?

A 0.11 **B** 0.14 **C** 0.16 **D** 0.18

Ans: D

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + \left|\frac{\Delta(T_2 - T_1)}{(T_2 - T_1)}\right|$$
$$= \frac{0.05}{0.35} + \left|\frac{\Delta T_2 + \Delta T_1}{(T_2 - T_1)}\right|$$
$$= \frac{0.05}{0.35} + \left|\frac{0.5 + 0.5}{(4.0 - 32.0)}\right| = 0.18$$

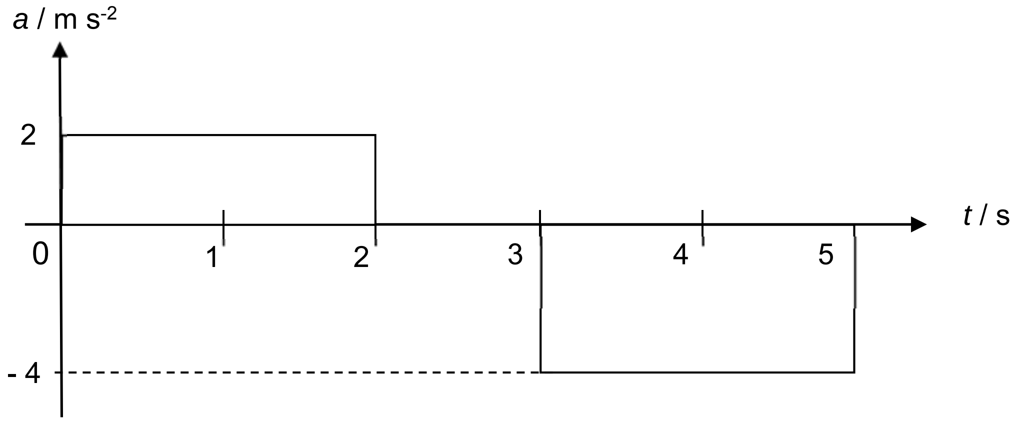
3 A value for the acceleration of free fall on Earth is given as (10 ± 2) m s^{-2}.

Which statement is correct?

A The value is accurate but not precise.
B The value is both precise and accurate.
C The value is neither precise nor accurate.
D The value is precise but not accurate.

Ans: A value is not precise but still accurate to 1 sf

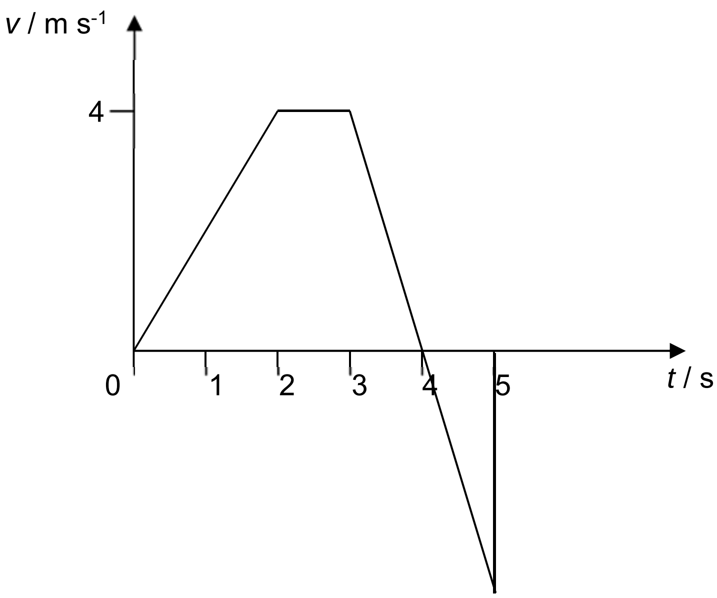
4 The graph below represents the variation with time t of the acceleration a of a car starting from rest.



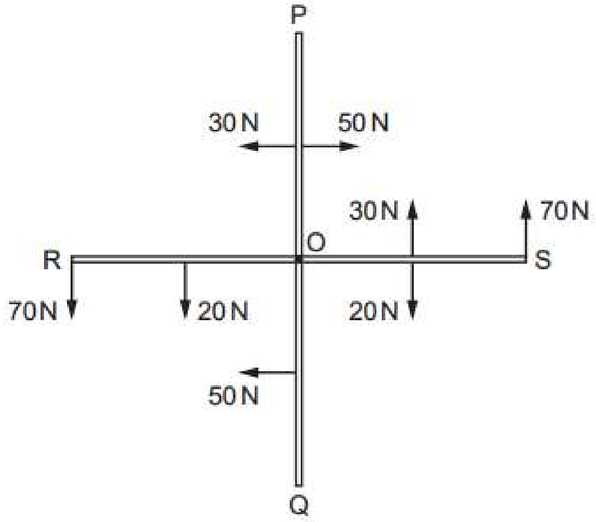
What is the total displacement of the car from the starting point at the end of 5 s?

A -4 m **B** 4 m **C** 8 m **D** 12 m

Ans: C
change in displacement
= Area under the v-t graph
= ½ (1+4)(4) – ½ (1)(4)
= 8 m



5 A rigid cross-shaped structure having four arms PO, SO, QO and RO, each 1.80 m long, is pivoted at O. Forces act on the ends of the arms and on the midpoints of the arms as shown.



What is the net moment about O?

A 54 N m **B** 108 N m **C** 216 N m **D** 432 N m

Ans: C
sacw = (20+30+30) x 0.9 + (70+70) x1.8 = 324 N m
scw = (20+50+50) x 0.9 = 108 N m
Net moments = 216 N m

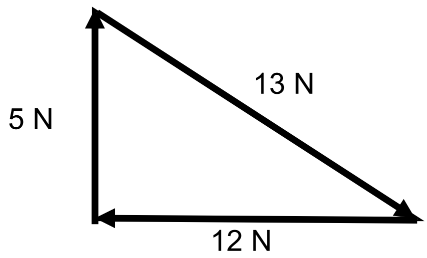
6 Forces 5 N, 12 N and 13 N act at a point which is in equilibrium.

What is the angle between the 5 N and 13 N force?

A 23° **B** 67° **C** 90° **D** 113°

Ans: D

Angle = 180 - $\tan^{-1}$ (12/5)
= 180 – 67
= 113



7 A cube of sides 10 cm has a density of 7.8 g cm^{-3}. It floats vertically with one-eighth of its side exposed above the liquid surface.

What is the density of the liquid?

A 6.8 g cm^{-3} **B** 8.9 g cm^{-3} **C** 11.6 g cm^{-3} **D** 62.4 g cm^{-3}

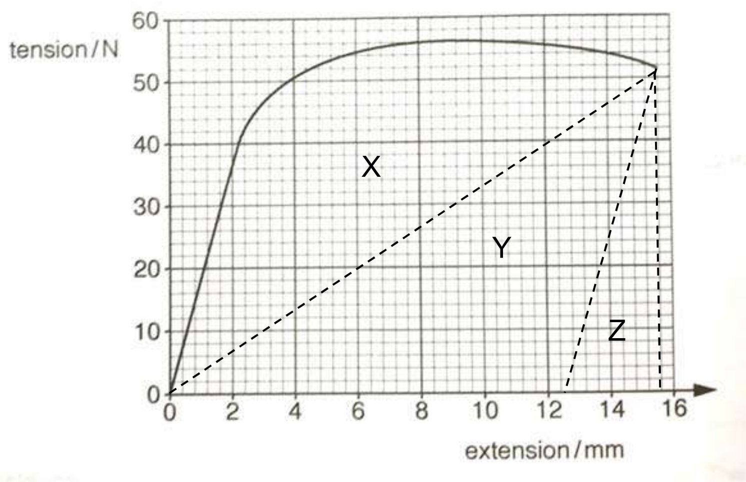
Ans: B

As object is floating, Weight of object = Upthrust

$$\rho_b V_b g = \rho_l V_{submerged} g$$

$$\rho_l = \frac{\rho_b V_b}{V_{submerged}} = \frac{(7.8)(l^3)}{\left(l^2 \times \frac{7}{8} l\right)} = 8.9 \text{ g cm}^{-3}$$

8 The tension in a sample of wire varies with extension as shown in the diagram below.



The graph shows that the wire undergoes two types of deformation as it is extended to 15.6 mm. In the region where Hooke's law applies, the deformation is elastic and the wire will lose this deformation when the tension is released. In the region where Hooke's law does not apply, the deformation is plastic and the wire retains this deformation when the tension is released.

Which area represents the elastic potential energy that is stored in the wire when it is extended to 15.6 mm?

A Area Z

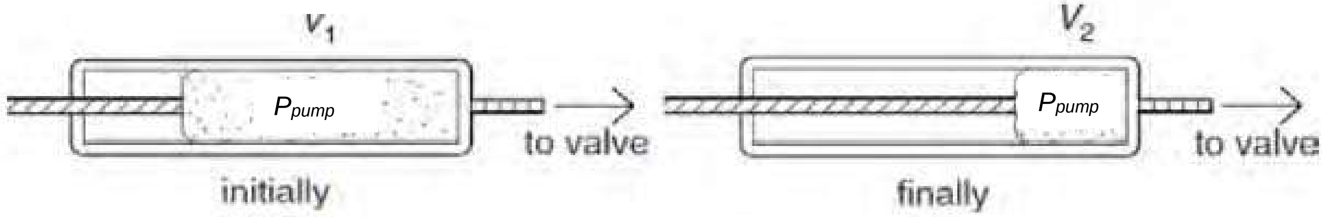
B Area X + Area Y

C Area Y + Area Z

D Area X + Area Y + Area Z

Ans : A

9 Air in a bicycle pump is forced through a valve at a constant pressure P_{pump}, to supply air to a tyre which is initially at a pressure P_{tyre}. In one stroke of the pump, the volume of air in the pump chamber is reduced from V_1 to V_2.



What is the work done on this air in one stroke of pump ?

A $P_{pump} V_1$

B $P_{pump} (V_2 – V_1)$

C $P_{tyre} V_1$

D $P_{tyre} (V_2 – V_1)$

Ans : B

10 Which one of the following statements is true about gravitational potential energy, electric potential energy and elastic potential energy?

A Gravitational force and elastic force always points in the direction of decreasing potential energy but whether electric force will point towards increasing or decreasing potential energy depends on whether it is a positive or negative charge.

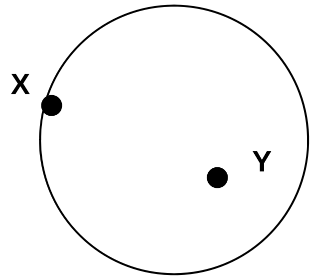
B Zero gravitational potential energy and zero electric potential energy is the smallest possible potential energy in a given system of 2 masses and 2 negative charges respectively.

C The magnitude of the potential energy can be found using the gradient of the force-displacement graph.

D These potential energies are energies stored in the body due to its position or the arrangement of its component parts.

Ans : D
By definition of potential energy.

11 Sand is sprinkled on a turntable on points X and Y. The turntable is rotating with increasing speed.

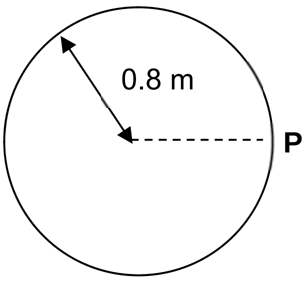


Which one of the following comparing sand at points X and Y is true?

	angular speed	linear speed	which will fly off first?
A	X = Y	X > Y	X
B	X = Y	X > Y	Y
C	X > Y	X = Y	Y
D	X > Y	X > Y	Y

Ans: A
ω on the same turntable is the same for both points.
$v = r\omega$, since $r_x > r_y$, therefore $v_x > v_y$
Centripetal force $F = mr\omega^2$ required for Sand at X is higher, so the sand at X will have a tendency to fly off 1st as the frictional force is unable to provide the higher centripetal force.

12 A model car moves in a circular path of radius 0.8 m at an angular speed of 0.5π rad s^{-1}.



What is its displacement from point P, 4 s after passing P?

A zero **B** 1.6 m **C** 0.8π m **D** 1.6π m

Ans: A
$v = r\omega = 0.8 \times \pi/2 = 0.4\pi$,
$s = vt = 0.4\pi \times 4 = 1.6\pi$
Circumference of circle $= 2\pi(0.8) = 1.6\pi$
Therefore, displacement = 0

13 Which of the following is a correct description of a geostationary orbit?

The mass of Earth is 6.0×10^{24} kg.

A The moon is an example of a geostationary satellite of Earth.

B A geostationary satellite has an orbital circumference of 2.7×10^{8} m.

C A geostationary satellite moves from North pole to South pole then back to North pole in 24 hours.

D A geostationary satellite experiences zero net force as it orbits around Earth.

Ans: B

14 Which of the following statements about the internal energy of a monatomic ideal gas is correct?

A It will increase when heat is supplied to the gas.
B It is proportional to the root-mean-square speed of the gas.
C It increases when the temperature of the gas increases.
D It is dependent on the potential energy of the gas.

Ans: C
Since for an ideal gas, internal energy is purely kinetic energy, internal energy is proportional to the temperature of the gas.

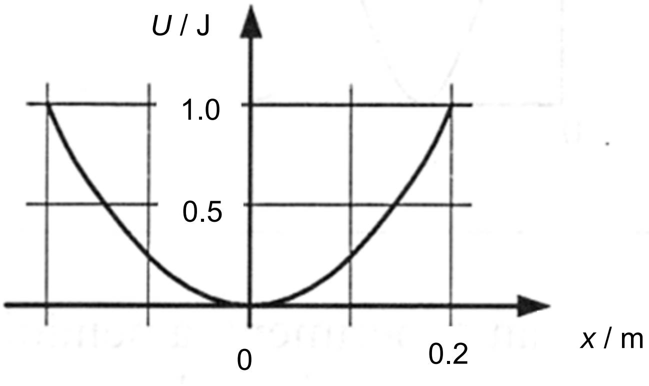
15 In a mixture of two monatomic ideal gaseous X and Y, the molecules of Y have thrice the mass of those of X. The mixture is in thermal equilibrium and the molecules of Y have a mean translational kinetic energy of E_K.

What is the mean translational kinetic energy of the molecules of X?

A 1/3 E_K **B** 1/2 E_K **C** E_K **D** 3 E_K

$T_X = T_Y$
$<KE>_X = <KE>_Y$
since $T \propto <KE>$
Ans: C

16 The given graph shows the variation with displacement *x* of the potential energy *U* of a particle of mass 4 kg moving in simple harmonic motion.



Which of the following is the period of oscillation of the mass?

A 0.3 s **B** 0.9 s **C** 1.1 s **D** 1.8 s

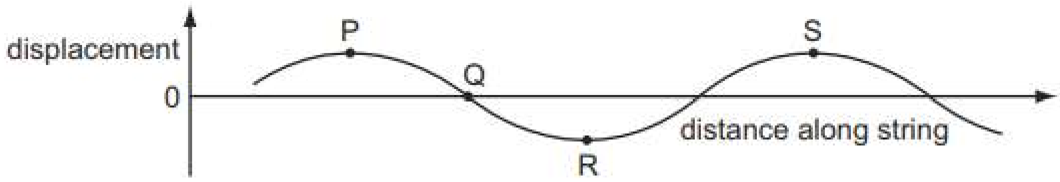
$$TE = KE_{\max} = \frac{1}{2}mv_o^{\ 2} = \frac{1}{2}m\left(\omega x_o\right)^2 = \frac{1}{2}m\frac{4\pi^2}{T^2}x_o^{\ 2}$$

$$1 = \frac{1}{2}(4)\frac{4\pi^2}{T^2}(0.2)^2$$

$$T = \frac{2\pi\sqrt{2}}{5}s$$

Ans: D

17 The string shows the shape at a particular instant of part of a progressive wave travelling along a string.



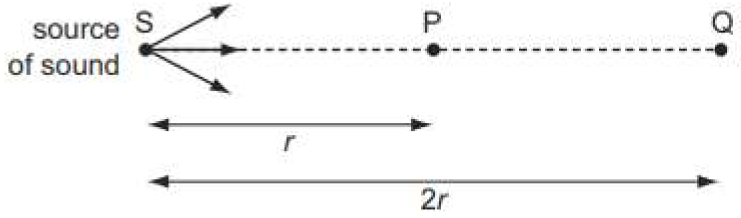
Which statement about the motion of the points along the string is correct?

A The speed at point P is maximum.
B The displacement at point Q is always zero.
C The energy at point R is entirely kinetic.
D The acceleration at point S is maximum.

Ans: D

At Point S, the displacement of the particle is maximum. Hence, by using a =- ω^2x, the acceleration will also be at a maximum.

18 A point source of sound is placed at point S.



Ans: D

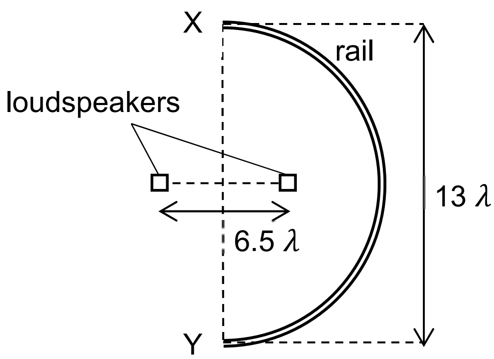
Amplitude is inversely proportional to the distance from the source.

The air molecules at P, a distance *r* from S, oscillate with an amplitude of 8.0 μm. Point Q is situated at a distance 2*r* from S.

What is the amplitude of oscillation of air molecules at point Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

19 Two loudspeakers are emitting sound of wavelength λ in all directions. They are in phase with each other and are placed a distance 6.5 λ apart in the middle of a semicircular rail of diameter 13 λ, as shown below. Moveable microphones along the rail are used to detect the sound intensity along the rail. The midpoint of the line joining the 2 speakers coincides with the centre of line XY.



Ans : C

At the centre of the rail, the path difference is 6.5 λ.
At the start and end of the rail, the path difference is 0 λ.

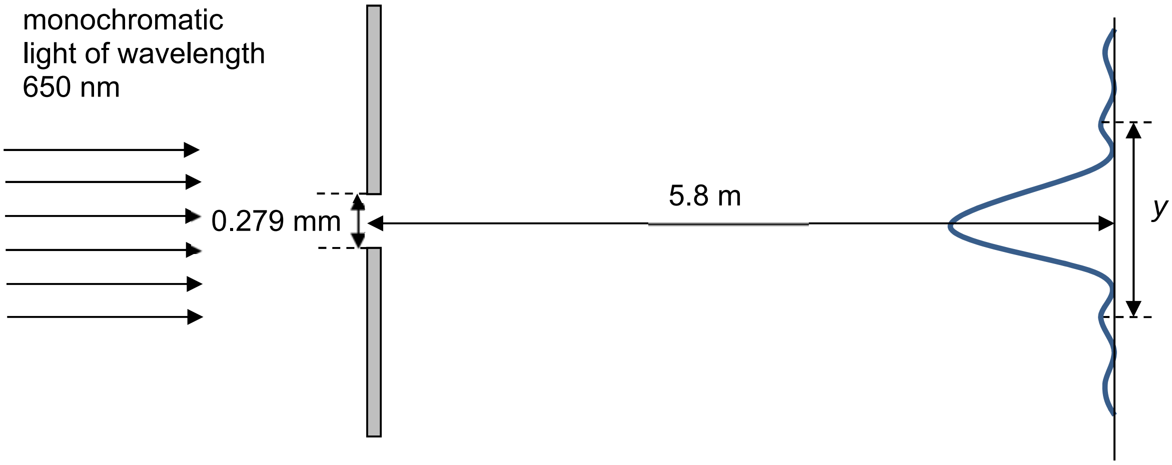
Hence, the magnitude of path difference increases from 0 to 6.5 λ and then decreases to 0

Since waves are in phase, minima will be detected at locations where path differences are (n+1/2)λ and this occurs at path differences = 0.5 λ, 1.5 λ, 2.5 λ, 3.5 λ, 4.5 λ, 5.5 λ, 6.5 λ.

How many minima will the microphones detect?

A 7 **B** 12 **C** 13 **D** 14

20 A laser light of wavelength 650 nm is passed normally through a narrow slit. A screen is placed parallel to the slit 5.8 m away from the slit. An interference pattern is formed on the screen. The width of the slit is 0.279 mm. The distance *y* is the distance between the two first maximas.



What is the value of *y*?

A 13.5 mm **B** 27.0 mm **C** 40.5 mm **D** 54.0 mm

Ans: C
Since sinθ = λ/b
θ = 0.1333°
Distance from central maxima to first minima = 13.5 mm
y = 27 + 13.5 = 40.5 mm
(since width of subsequent maxima is half the width of central maxima)

21 A negatively-charged sphere P is balanced halfway between two horizontal plates when a potential difference *V* is applied between the plates.

Which statement is correct?

A Increasing *V* increases both the electric and the gravitational potential energy of the sphere.

B Increasing *V* decreases the electric potential energy and increases the gravitational potential energy of the sphere.

C Decreasing *V* decreases both the electric and the gravitational potential energy of the sphere.

D Decreasing *V* increases both the electric and gravitational potential energy of the sphere.

Ans: B
When the potential difference is increased, the sphere will experienced a greater upward electric force. Therefore, the electric force is bigger than the weight of the sphere. Net force will be upwards and hence sphere will accelerate upwards, and thus experiencing a decreasing EPE and increasing GPE.
(Answer will be the same even when the sphere is positive charged)

22 A 8.0 A current passes through a cylindrical copper wire with a diameter of 8.0 mm. The density of copper is 8960 kg m^{-3} and the mass of a single copper atom is 1 x 10^{-25} kg.

Assuming that there is one conduction electron for each copper atom, what is the drift velocity of the electrons in the wire?

A 2.8 x 10^{-6} m s^{-1} **B** 3.4 x 10^{-6} m s^{-1} **C** 1.1 x 10^{-5} m s^{-1} **D** 5.8 x 10^{-5} m s^{-1}

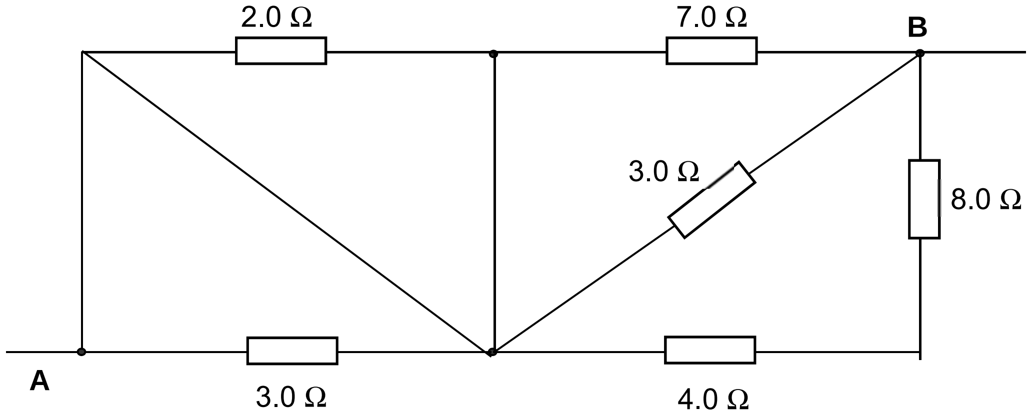
Ans:C

$I = nAvq$

$$v = \frac{I}{nAq} = \frac{8.0}{8960/(1\times10^{-25})\times\pi(4.0\times10^{-3})^2\times1.6\times10^{-19}} = 1.1\times10^{-5}\text{ m s}^{-1}$$

Distractors:
2.8 x 10^{-6}: Never convert diameter to radius.

23 Six resistors are connected in a circuit as shown below.



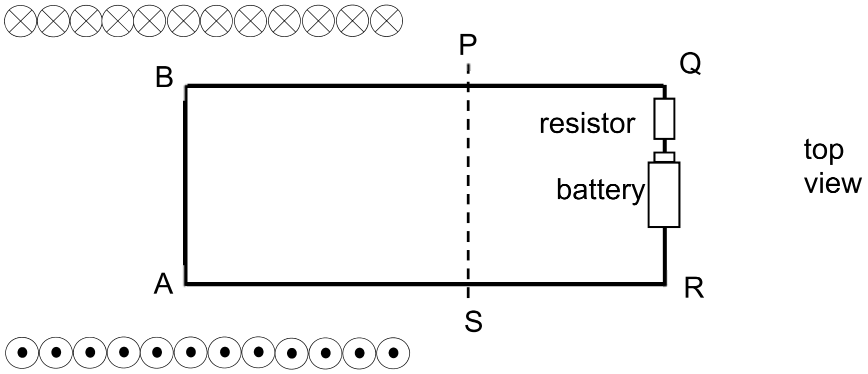
What is the effective resistance of the circuit between terminals AB?

A 1.2 Ω **B** 1.8 Ω **C** 3.0 Ω **D** 3.4 Ω

Ans: B

Distractors:
A: 7//3//8//4
Options C and D both consider the 2.0 and 3.0 resistor.
C: 2//3 + 7//3//12
D: 9 // [3 + 3// (8 and 4)]

24 The figure below shows the top view of a current balance where the rigid rectangular wire loop ABQR pivoted at PS is in equilibrium. It is connected in series with an ideal 2.0 V battery and a 0.025 Ω resistor of a total mass of 300 g. Part of the wire loop is placed inside a solenoid. The mass of the loop can be taken to be negligible and the wire has no resistance.



The length of the side AB is 6.0 cm and $SR = \frac{2}{5}ASR$.

What is the magnitude of the magnetic flux density in the solenoid?

A 0.37 T **B** 0.41 T **C** 3.7 T **D** 4.1 T

Ans: B

By principle of moments,

$$F_B \times AS = mg \times SR$$

$$B \times \frac{2}{0.025} \times 0.060 \times 3L = 0.300 \times 9.81 \times 2L$$

$$B = 0.41\text{T}$$

Distractors:
Never convert units – 4.1 T
Use wrong distance – AS = 5L and SR = 3L – 0.37 T
Use wrong distance and never convert units = 3.7 T

25 When a light bulb is connected across an a.c. source of peak voltage 150 V, the mean power dissipated is 13 W. Two such light bulbs are now connected in series to the electrical mains of 240 V r.m.s.

What is the peak voltage across each light bulb and the total power dissipated in the light bulbs?

	peak voltage across each light bulb / V	total power dissipated in the light bulbs / W
A	120	17
B	170	33
C	120	67
D	170	17

Ans: B

$V_{rms} = \frac{150}{\sqrt{2}}$

$P = \frac{V_{rms}^2}{R} \Rightarrow R = 865\Omega$

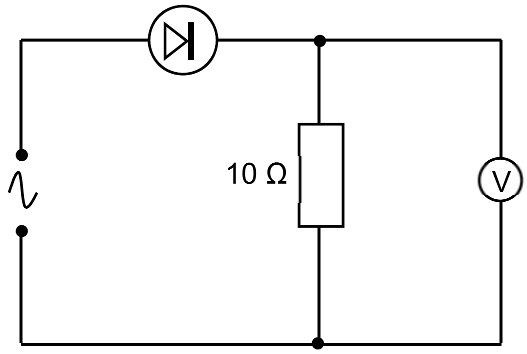
$R_{total} = 865 \times 2$

$P_{total} = \frac{240^2}{865 \times 2} = 33$

V_0 across each bulb $= 120\sqrt{2} = 170$

Distractors:
For 17 W, take peak voltage as $V_{r.m.s.}$
For 67 W, assume only one bulb connected to 240 V rms source.

26 A voltmeter reads 80 V when measuring the potential difference across a load of 10 Ω connected to a sinusoidal power source with frequency 888 Hz.



What is the peak power dissipated by the load when the frequency is 1/3 of its original?

A 640 W **B** 850 W **C** 1280 W **D** 2560 W

Ans: D

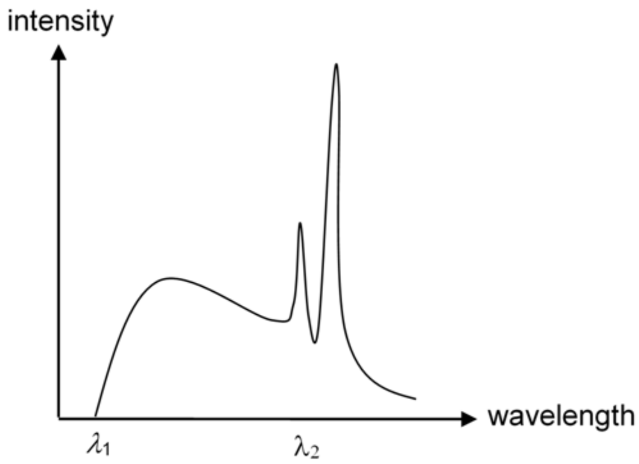
$$\frac{(V_{rms}\times 2)^2}{R} = (80\times 2)^2 / 10 = 2560$$

A: $\frac{V_{rms}^2}{R}$

B: $\frac{(V_{rms}\times 2)^2}{3R}$

C: $\frac{(V_{rms}\sqrt{2})^2}{R}$

27 The graph below shows the variation of X-ray intensity with wavelength emitted from an X-ray tube.



What are the factors that will affect λ_1 and λ_2?

	λ_1	λ_2
A	target metal	target metal
B	target metal	accelerating voltage
C	accelerating voltage	target metal
D	accelerating voltage	accelerating voltage

Ans: C

28 The momentum of an alpha particle is measured with an uncertainty of 2.0%.

Given that it has a kinetic energy of 1.00 MeV, what is the minimum uncertainty in its position?

A 2.1×10^{-19} m **B** 7.2×10^{-13} **C** 1.6×10^{-12} **D** 7.2×10^{-10}

Ans: B

29 Which of the following is a correct description of mass defect?

A The difference between the mass of the nucleus of the products and reactants in a nuclear reaction.

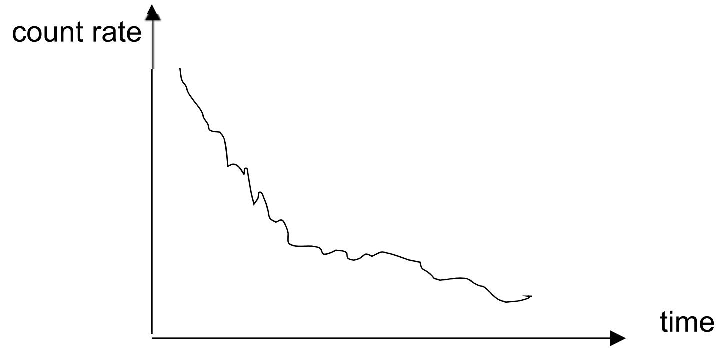
B It is the difference between the total mass of the neutrons and the mass of the nucleus.

C It is equal to the energy gained when individual nucleons comes together to form a nucleus.

D It is the binding energy of a nucleus divided by square of the speed of light.

Ans: D

30 The graph below shows the variation of count rate from a particular radioactive sample with time.



What does the jagged feature of the graph indicate?

A It indicates the presence of background radiation.
B It indicates that the decay obeys radioactive decay law.
C It indicates the spontaneous nature of the radioactive decay.
D It indicates the random nature of the radioactive decay.

Ans: D

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

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PHYSICS 9749/02

Preliminary Examination **14th September 2018**
Paper 2 Structured Questions **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.
.

For Examiners' Use	
Q1	/ 10
Q2	/ 7
Q3	/ 14
Q4	/ 8
Q5	/ 8
Q6	/ 14
Q7	/ 19
Total marks	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

Formulae

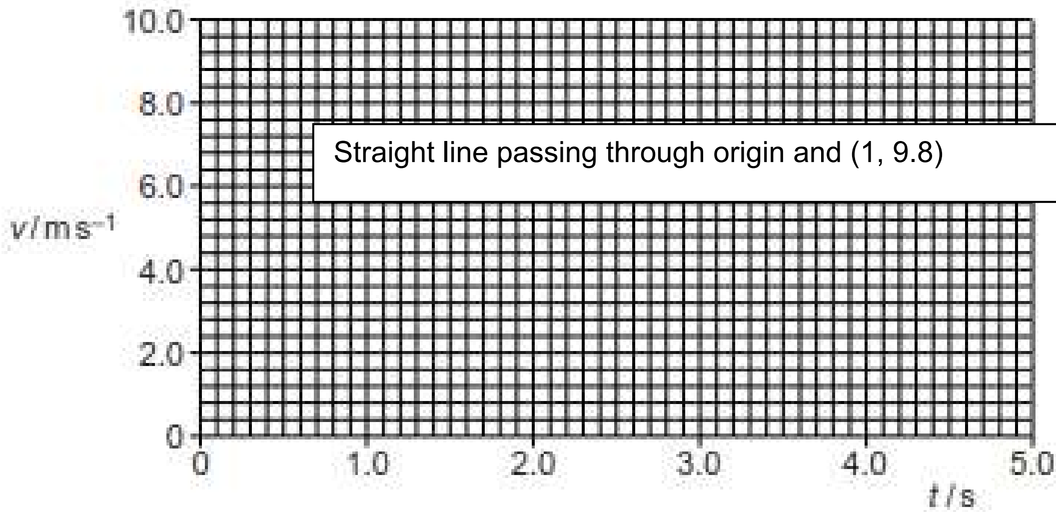
uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 A raindrop falls vertically from rest.

(a) Assume that air resistance is negligible.

On Fig. 1.1, sketch a graph to show the variation with time t of the velocity v of the raindrop for the first 1.0 s of the motion. [1]



Straight line passing through origin and (1, 9.8)

Fig. 1.1

(b) In practice, air resistance D on raindrops is not negligible.

D is given by the expression

$$D = k\, v^2$$

where k is a constant and
v is the speed

(i) The raindrop has mass 1.38×10^{-5} kg and k is 2.76×10^{-6} N m^{-2} s^2.

Calculate the terminal velocity of the raindrop.

At terminal velocity, acceleration is zero.
By Newton's Law,
Fnet = 0
Weight = D (+ upthrust)
$1.38 \times 10^{-5} \times 9.81 = \frac{1}{2}\,(0.63 \times 1.2 \times 7.3 \times 10^{-6})v^2$ [1]
v = 7.0 m s^{-1} [1]

terminal velocity = …………… m s^{-1} [2]

(ii) The raindrop reaches terminal velocity at t = 3.0 s.

On Fig. 1.1, sketch the variation with time t of velocity v for the raindrop. The sketch should include the first 5.0 seconds of the motion. [2]

Same initial gradient [1]
Curve passing through origin and tends towards a horizontal line <u>and</u>
should reach terminal velocity at 3 seconds [1]

For Examiner's Use

(c) A raindrop falls on a roof and rebounds off with a velocity of 5.5 m s^{-1} at an angle 60^o with respect to the horizontal as shown in Fig. 1.2.

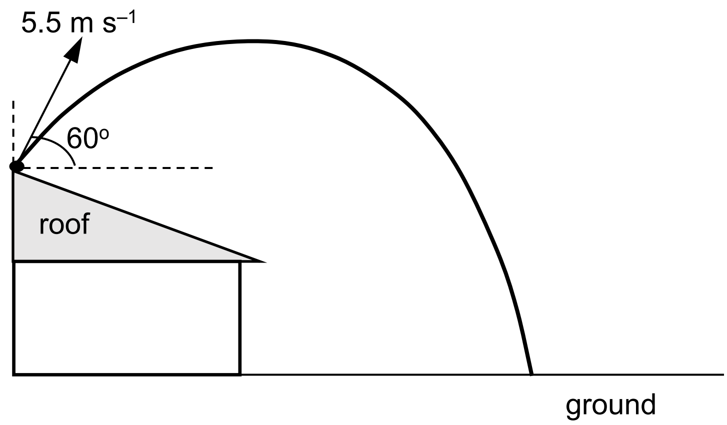


Fig. 1.2

Assume air resistance is negligible. The maximum horizontal distance travelled by the raindrop is 3.8 m.

(i) Calculate the time taken for the raindrop to hit the ground.

$S_x = u_x t$
$3.8 = (5.5 \cos 60^o)\, t$
$t = 1.38$ s

time = …………………. s [1]

(ii) Determine the speed of the raindrop as it hits the ground.

$v_x = u_x = 5.5 \cos 60^o = 2.75$ m s^{-1}
$v_y = (-5.5 \sin 60^o) + (9.81)(1.38) = 8.77$ m s^{-1} [M1]
$v = \sqrt{2.75^2 + 8.77^2} = 9.19$ m s^{-1} [A1]

speed = …………………...m s^{-1} [2]

(iii) Discuss quantitatively whether the assumption that air resistance is negligible is justified by considering the vertical component of the initial velocity of the raindrop.

The raindrop has the same mass and dimension as in **(b)(i)**.

Drag force = 2.76×10^{-6} $(5.5 \sin 60)^2$ = 6.26×10^{-5} N [1]

this is 0.4 times of the weight of raindrop [1]
so assumption is not justified

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

For Examiner's Use

2 A uniform rectangular card is suspended from a wooden rod. The card is held at one of its ends as shown in Fig. 2.1. The force by the hand on the card acts horizontally to the right.

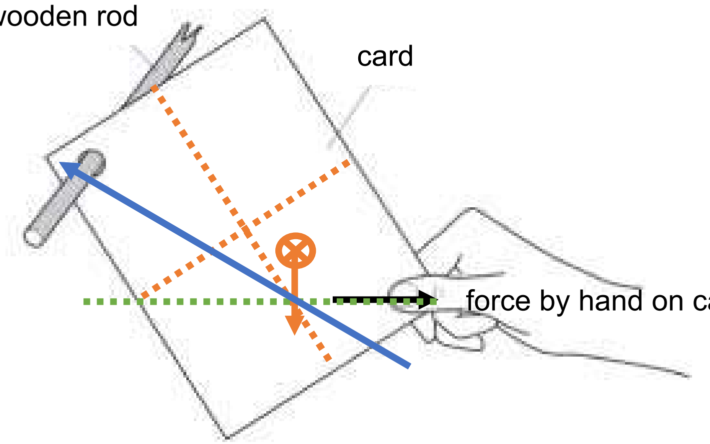


Fig. 2.1

(a) On Fig. 2.1,

(i) mark with an 'X' the position of the centre of gravity of the card. [1]

Accept answers that off-centre (below and towards the right) [1]

(ii) draw an arrow labelled with *W* to represent the weight of the card. [1]

arrow points downwards starting from X [1]

(b) State the conditions for the card to be in equilibrium.

Net force is zero [B1]
Net torque is zero [B1] <u>or</u> the sum of clockwise moments about any point is equal to the sum of anticlockwise moments about that same point <u>or</u> the lines of action of the 3 forces (weight, force by hand on card and force by rod on card) passes through a common point

[2]

(c) Draw an arrow labelled with *R* on Fig. 2.1 to represent the force exerted by the wooden rod on the card.

Show your construction clearly. [2]

Concurrent forces, 3 forces passes through same point. [B1]
Correct direction of arrow [B1]

(d) The card is now released. It swings on the wooden rod and eventually comes to a rest.

By reference to the completed diagram in Fig. 2.1, describe the final position in which the card comes to a rest.

Position of X directly below point of contact of card with rod/ line of action of W passing through the point of contact of card with rod [1]
Such that there is no resultant moment
Correct diagrams are accepted as part of the working.

[1]

For Examiner's Use

3 **(a)** An object is placed on a smooth horizontal surface and is connected to a light spring, as shown in Fig. 3.1.

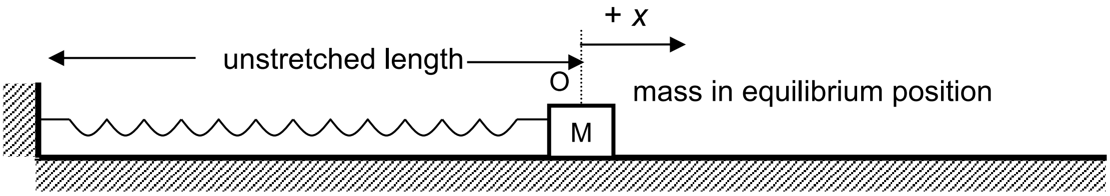


Fig. 3.1

The object is displaced to the right by 0.60 m and then released. Fig. 3.2 shows the variation with displacement *x* of acceleration *a* of the object.

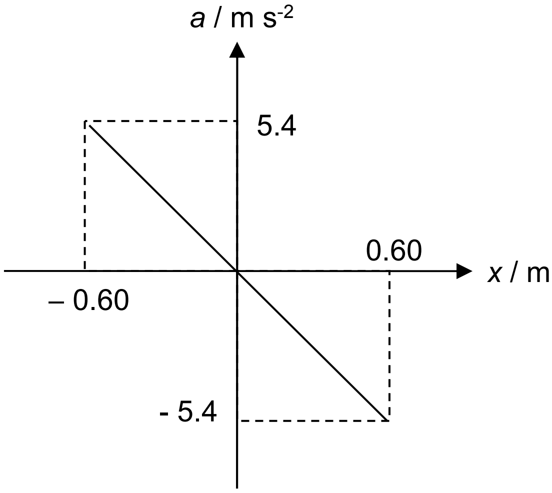


Fig. 3.2

(i) Use two features of the graph in Fig 3.2 to explain why the motion of the object is simple harmonic.

Negative gradient shows that the acceleration and displacement in opposite directions. [1]

Straight line through the origin shows that acceleration is proportional to displacement from equilibrium [1]

………………………………………………………………………………………………… [2]

(ii) Calculate

1. the angular frequency,

$| a_0 | = | \omega^2 x_0 |$
$5.4 = \omega^2 (0.6)$
$\omega = 3.0$ rad s^{-1}

angular frequency = ………………….. rad s^{-1} [1]

2. maximum speed of the object.

Since $v_0 = \omega x_0$
$v_0 = 3 (0.6) = 1.8$ m s^{-1} [1]

maximum speed = ………………… m s^{-1} [1]

(iii) Sketch on Fig. 3.3 the variation with time of the kinetic energy of the object for one complete oscillation. The mass of the object is 0.0020 kg.

Assume that the object just passes by the equilibrium position at time = 0 s. [2]

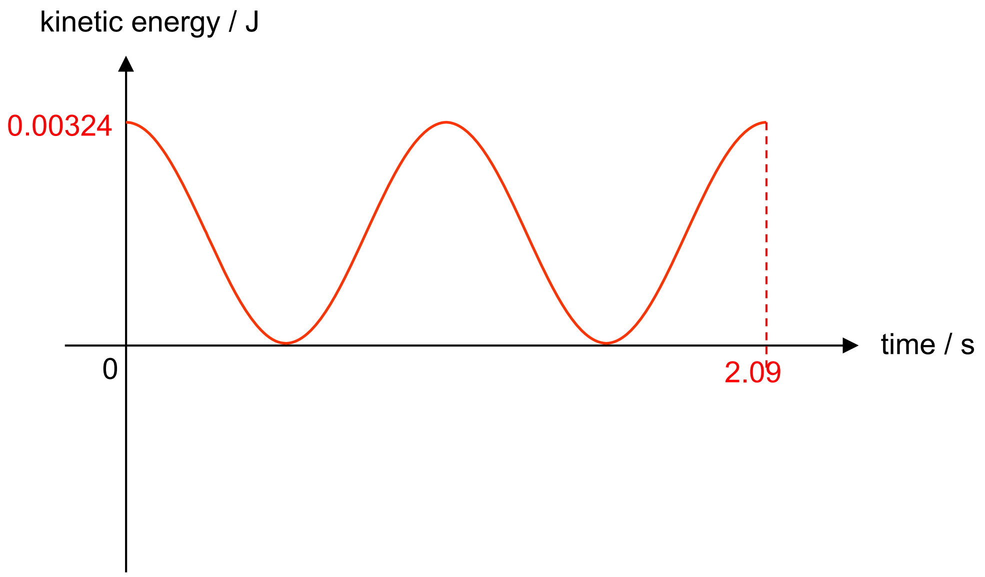


Fig. 3.3

(iv) Calculate the shortest time taken for the object to move from a point 0.30 m to the left of the equilibrium point to a point 0.30 m to the right of the equilibrium point.

At x = -0.30 m, 0.3 = 0.6 sin ($3t_1$) [1]
$t_1 = 0.174$ s [1]
Time taken = 0.174 x 2 = 0.349 s [1]

time = ………………….. s [3]

For Examiner's Use

(b) A car component of mass 0.0460 kg rattles at a resonant frequency of 35.5 Hz. Fig. 3.4 shows how the amplitude of the vertical oscillation varies with frequency.

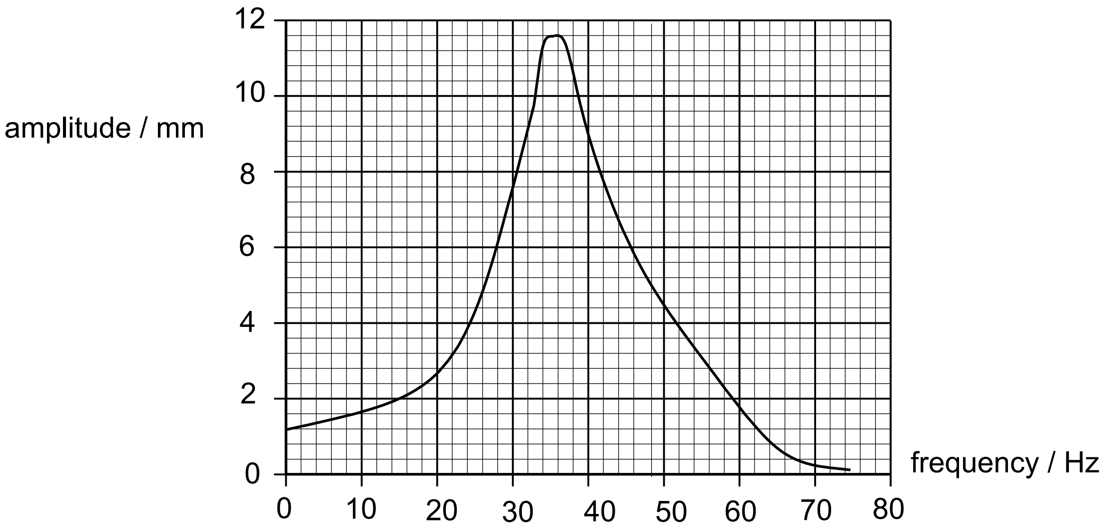


Fig. 3.4

(i) When oscillating at the resonant frequency, calculate

1. the angular frequency of the oscillation,

$\omega = 2\pi f = 2\pi \times 35.5 = 223$ rad s^{-1}

angular frequency = ………………………….. rad s^{-1} [1]

2. the total energy stored in the oscillation of the component.

total energy $= \frac{1}{2} m (\omega)^2 (x_0)^2$
$= \frac{1}{2} \times 0.046 \times 0.0116^2 \times 223^2$ [1]
$= 0.154$ J [1]

energy = ... J [2]

(ii) Draw on Fig 3.4 to show how the amplitude of the oscillation varies with frequency if the component is supported on a rubber mounting. [2]

maximum amplitude at <u>lower frequency</u> [1]
<u>same starting point</u> and <u>lower graph within original shape</u> [1]

For Examiner's Use

4 **(a)** Fig.4.1 shows a string stretched between two fixed points P and Q.

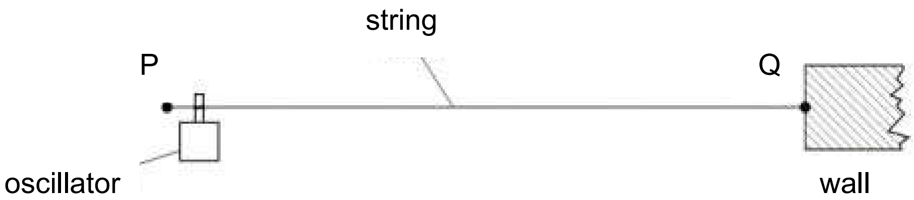


Fig. 4.1

An oscillator is attached near end P of the string. End Q is fixed to a wall. The oscillator has a frequency of 50.0 Hz.

The stationary wave produced on PQ at an instant time *t* is shown in Fig. 4.2. Each point on the string is at its maximum displacement.

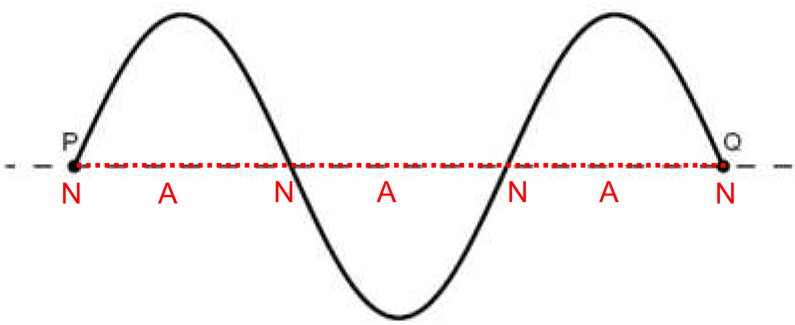


Fig. 4.2

(i) On Fig. 4.2, label all the nodes with the letter **N** and the antinodes with the letter **A** along the dotted line PQ. [1]

(ii) On Fig 4.2, draw the stationary wave at (*t* + 5.0 ms). [1]

Since T = 1/f = 1/50 = 20 ms, 5 ms is ¼ of a period. Correct diagram [1]

(b) Sound waves is directed from a loudspeaker towards a metal plate. A microphone, connected to a cathode ray oscilloscope (CRO), is placed in between the loudspeaker and the metal plate as shown in Fig. 4.3.

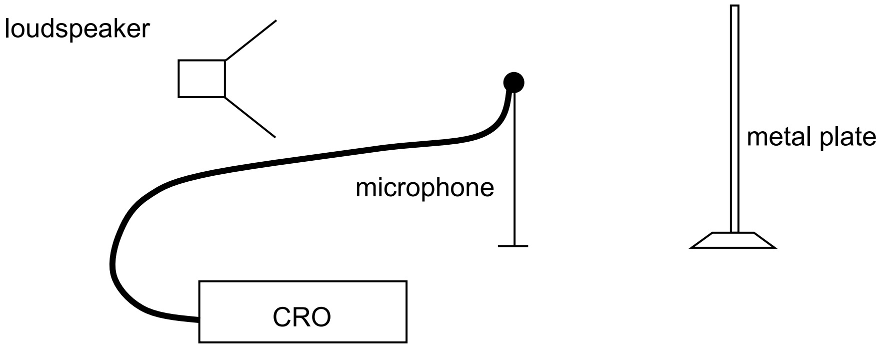


Fig. 4.3

(i) Explain how stationary waves are formed in between the loudspeaker and the metal phase.

As the sound waves reflects off the metal plate, the incident and reflected waves have the same amplitude, wavelength and frequency [B1] move in opposite direction and overlap/superpose/meet [B1].

When they experience constructive interference, they form regions of high intensity and when they experience destructive interference, they forms regions of low intensity. [B1]

…………………………………………………………………………………………………

…………………………………………………………………………………………………[3]

(ii) The trace on the CRO in Fig. 4.4 shows the variation of signal with time at an antinode.

The time-base setting on the CRO is 0.10 ms cm^{-1}.

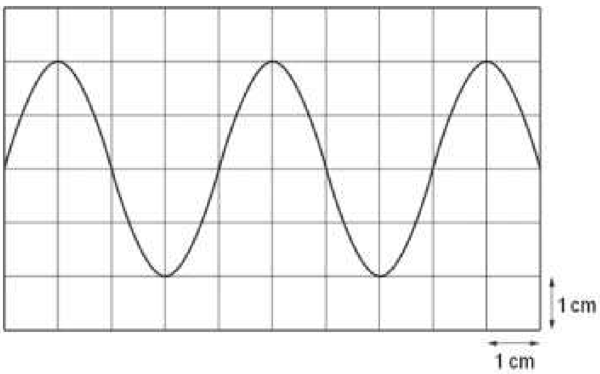


Fig. 4.4

The microphone is then moved by 3.3 cm and the trace on the CRO now records zero amplitude.

For Examiner's Use

1. Determine the frequency of the sound.

Frequency = 1/ period = 1 / 4 x 10^{-3} = 2500 Hz [A1]

frequency = …………………….. Hz [1]

2. Calculate the speed of sound.

Distance between node and antinode = ¼ wavelength.

Wavelength = 4 x 3.3 = 13.2 m [M1]

$v = f\lambda$ = 2500 x 13.2 = 330 m s^{-1} [A1]

speed = …………………….. m s^{-1} [2]

For Examiner's Use

5 (a) For a particular gas, the emission and absorption spectra are obtained for the visible light spectrum.

Discuss one similarity and one difference between the discrete lines of the absorption and emission spectra of this gas.

{Similarity} The discrete lines of both absorption and emission spectrum occur at same frequencies [1], but {Difference} the absorption has dark lines against a continuous spectrum whereas the emission spectrum has coloured lines against a black background [1].

.... [2]

(b) Fig. 5.1 gives information on three lines observed in the emission spectrum of hydrogen atoms.

wavelength / nm	**energy of photon / eV**
486	2.56
656	1.90
1880	0.66

Fig. 5.1

(i) Complete Fig. 5.1 by calculating the energy of the photon with wavelength 656 nm. [1]

(ii) Fig. 5.2 is a partially completed diagram to show energy levels of a hydrogen atom.

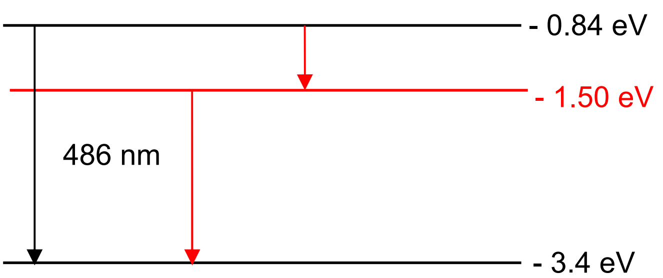


Fig. 5.2

On Fig. 5.2, draw an additional labelled energy level which will account for the emission of the photons in Fig. 5.1. [1]

(c) Three of the energy levels of a lithium atom are shown in Fig. 5.3.

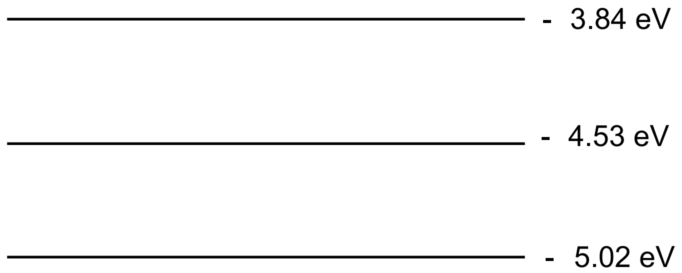


Fig. 5.3

One way to study the energy levels of an atom is to bombard the atom with electrons and measure the kinetic energies of the bombarding electrons before and after the collision. If a lithium atom which is originally in the – 5.02 eV level is bombarded with an electron of kinetic energy 0.92 eV, the scattered electron can have only two possible kinetic energies.

States these two kinetic energy values, and state what happens to the lithium atom in each case.

1st possible kinetic energy value: ………………………. eV [1]

0.92 eV [1]
Nothing happens to the lithium atom (ie. it stays in the -5.02 eV level) [1]

[1]

2nd possible kinetic energy value: ………………………. eV [1]

0.92 – (5.02 – 4.53) = 0.43 eV [1]
Atom will be excited to the -4.53 eV level [1]

[1]

For Examiner's Use

6 **(a)** A stationary nucleus of a radioactive nuclide, ${}^{218}_{84}Po$, underwent a chain of decays by the emission of an α and β–particles. The decay is represented by the two equations:

$${}^{218}_{84}Po \rightarrow D + \alpha$$
$$D \rightarrow E + \beta$$

where D and E are the nuclides formed after the decay.

(i) State the nuclear notation for E. [1]

$\cdots\cdots\cdots E$
$\cdots\cdots\cdots$

${}^{214}_{83}E$

(ii) Determine the ratio of the kinetic energy of the α–particle to the total kinetic energy of D and α–particle.

By conservation of linear momentum,

$0 = p_D + p_\alpha$

$|p_D| = |p_\alpha|$ [M1]

$$\frac{\text{KE of } \alpha\text{-particle}}{\text{total KE}}$$

$$= \frac{\frac{p_\alpha^2}{m_\alpha}}{\frac{p_\alpha^2}{m_\alpha} + \frac{p_D^2}{m_D}} \quad [\text{M1}]$$

$$= \frac{\frac{1}{m_\alpha}}{\frac{1}{m_\alpha} + \frac{1}{m_D}}$$

$$= \frac{\frac{1}{4u}}{\frac{1}{4u} + \frac{1}{214u}}$$

$= 0.982$ [A1]

ratio = ……………………… [3]

(iii) In reality, the β–particles have a range of kinetic energies, instead of a fixed value. Explain why this is so.

Because there are neutrinos emitted together with the beta particles and kinetic energy is shared between the beta particles and neutrino. [A1]

……………………………………………………………………………………………[1]

(iv) A sample of ${}^{218}_{84}Po$ is placed on a weighing balance and a reading of 4.05 g is obtained. After 243 s, the reading drops to 4.02 g.

1. Determine the number of particles ${}^{218}_{84}Po$ in the initial sample.

$$\text{No. of } {}^{218}_{84}Po \text{ particles } N_{218} = \frac{4.05\times10^{-3}}{218u} = 1.12\times10^{22} \quad [A1]$$

number of particles = ………………….. [1]

2. Show that the total number of particles D and E after 243 s is 4.52 x 10^{21}. [1]

$$\text{Total mass after time } t = (N_{Po} - N_{D+E})m_{Po} + (N_{D+E})m_D$$
$$(1.119\times10^{22} - N_{D+E})218u + (N_{D+E})214u = 4.02\times10^{-3} \quad [M1]$$
$$(1.119\times10^{22} - N_{D+E})218u + (N_{D+E})214u = 4.02\times10^{-3}$$
$$4.05\times10^{-3} - 4.02\times10^{-3} = (N_{D+E})4u$$
$$N_{D+E} = 4.518\times10^{21}$$

3. Determine the half life of ${}^{218}_{84}Po$.

$$N = N_0(\frac{1}{2})^{\frac{t}{t_{\frac{1}{2}}}}$$
$$(1.12\times10^{22} - 4.52\times10^{21}) = 1.12\times10^{22}(\frac{1}{2})^{\frac{243}{t_{\frac{1}{2}}}} \quad [M1]$$
$$t_{\frac{1}{2}} = 326 \text{ s } [A1]$$

half life = …………………. s [2]

(b) For many unstable parent nuclei, the daughter nuclei is itself radioactive. This may give rise to a radioactive series where there may be ten or more different radioactive daughter products.

A radioactive parent nucleus X has a radioactive daughter nucleus Y and, in turn, this daughter produces a further stable daughter Z. The variation with time *t* of the percentage number *P* of the different nuclei X, Y and Z in a radioactive sample is illustrated in Fig. 6.1

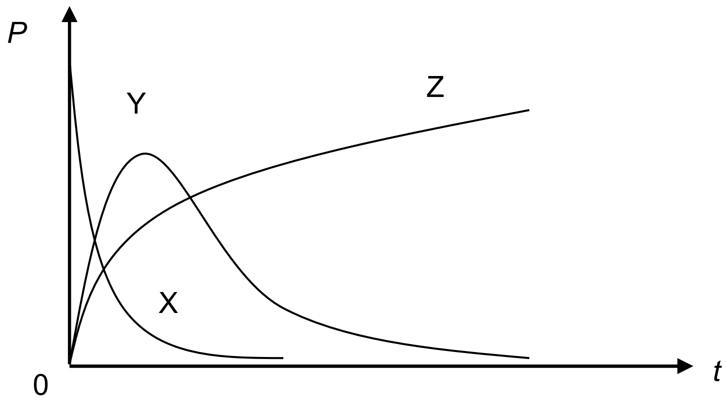


Fig 6.1

(i) X has a half life of 5 hours. The count rate at t = 0 and t = 5 hours were measured. Suggest three possible reasons why the count rate is not exactly halved after 5 hours.

1. ……………………………………………………………………………………………

1. Existence of background count. [B1]
2. Product Y is also giving off radiation that adds to count rate. [B1]
3. Random nature of radioactive decay. [B1]

2. ……………………………………………………………………………………………

3. ……………………………………………………………………………………………

……………………………………………………………………………………………[3]

(ii) Explain why graph of Y increases to a maximum and then decreases.

It happens because initially, there are more number of X than Y and hence, Y is being formed faster than it is decaying. [B1] As number of X decreases, there will be a point where Y decays faster than it is being formed. Hence, this will lead to a decrease in number of Y. [B1]

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

For Examiner's Use

7 Many devices are designed to create a spray of tiny droplets. The effectiveness of these devices usually depends on droplet size. One example is an agriculture pesticide spray in which a few large droplets do not coat the leaves of plants as well as many small droplets. Another example is a fuel injection system for an engine.

Measuring the size of droplets present in a spray is difficult to do by direct means but instruments called droplet sizers can be purchased which make droplet sizing a fast routine operation.

The principle of operation of one such sizer is shown in Fig. 7.1, in which light from a helium/neon laser is passed through a spray of droplets of uniform diameter and forms a circular diffraction ring of radius *x*. The diameter *d* of the droplets is related to *x* by the equation

$$d = k\frac{\lambda}{x}$$

In this equation λ, the wavelength of the light, is 6.33×10^{-7} m. *k* is a constant equal to 0.474 m, and *d* and *x* are both in metres.

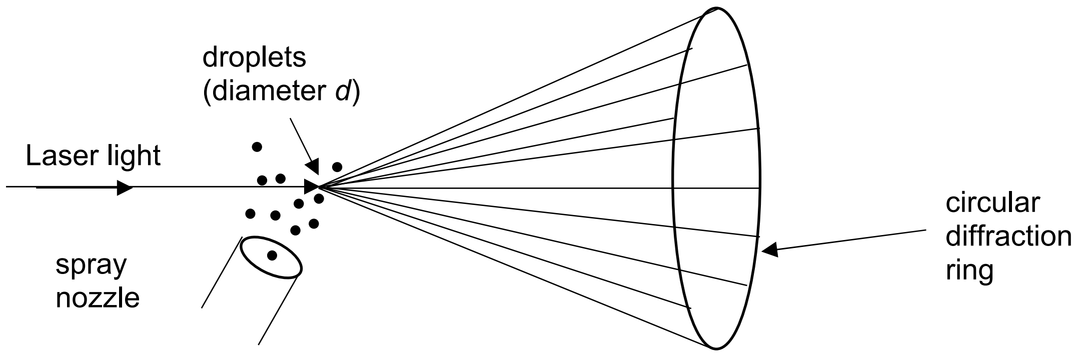


Fig. 7.1

In practice, a spray will consist of droplets of different sizes, so many rings of diffracted light will be caused. The diffraction pattern in Fig. 7.2a is projected on a flat surface containing many light sensitive detectors. The output from the detectors can be analysed by a computer and be shown in the form of a graph in Fig. 7.2b.

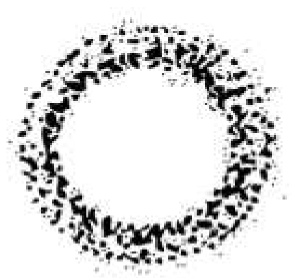


Fig. 7.2a

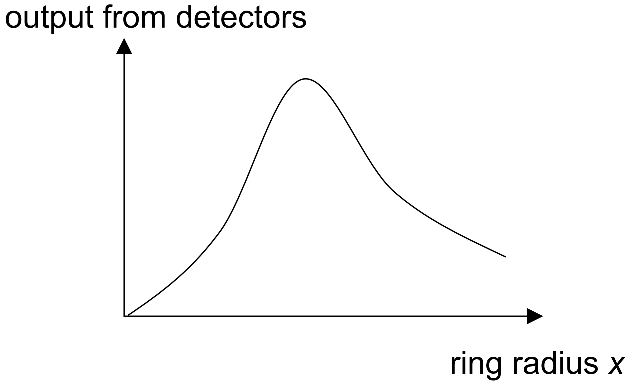


Fig. 7.2b

For Examiner's Use

(a) Suggest two devices, other than those mentioned in the first paragraph of the passage, where droplet size is important.

Spray paint [B1], Hair spray [B1]

....[2]

(b) Outline a direct method for measuring droplet diameter.
Apparatus available includes: high speed camera, stroboscope, stopwatch, rulers.

Use high speed camera to capture still image of droplets. [1]
Have a backdrop of grid squares in the background to estimate size of each droplet. [1]
Use an object of known diameter at same distance from background to compare with size of droplet and thus use scaling to determine droplet diameter. [1]

....[3]

(c) Give two reasons why direct methods are likely to be difficult for measuring droplets of small diameter.

1. Measurement devices may lack sufficient precision for measurement. [B1]
2. The droplets may be too packed to give a distinct image [B1]

....[2]

(d) Calculate the value of *x* for a droplet of diameter

(i) 10 μm

$$d = k\frac{\lambda}{x}$$

$$x = k\frac{\lambda}{d} = 0.474\left(\frac{6.33\times10^{-7}}{10\times10^{-6}}\right) = 0.0300 \text{ m} \quad [\text{A1}]$$

x = ... m [1]

(ii) 200 μm

$$d = k\frac{\lambda}{x}$$

$$x = k\frac{\lambda}{d} = 0.474\left(\frac{6.33\times10^{-7}}{200\times10^{-6}}\right) = 0.00150 \text{ m} \quad [\text{A1}]$$

x = ... m [1]

For Examiner's Use

(e) State whether a small value of x corresponds to large or to small droplets.

Small x corresponds with large droplets [1]

.... [1]

(f) Suggest, with reference to the equation given, how the radius of the circular diffraction ring can be increased for the same diameter of water droplets.

.... Increase wavelength of laser light. [1] .... [1]

(g) Sketch on the axes in Fig. 7.3 curves to show the general shape of graphs that would be obtained if

(i) droplets with a wide range of diameter were used. Label as **(i)**. [1]

(ii) very small droplets with a narrow range of diameters were used. Label as **(ii)** [1]

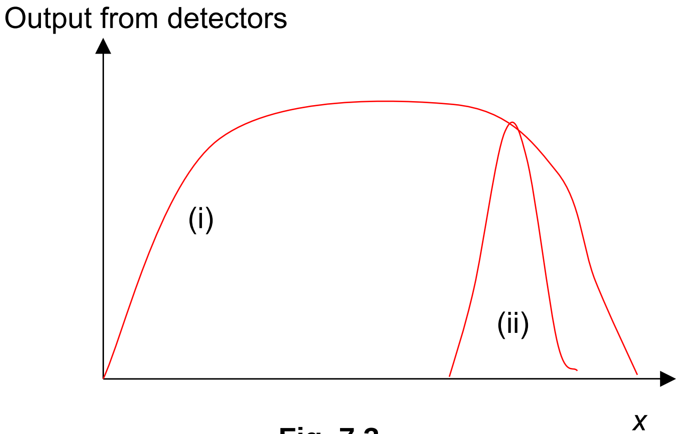


Fig. 7.3

For Examiner's Use

(h) In practice, a cloud of spray droplets moves through the laser beam as shown at intervals in Fig. 7.4. The output from the detectors varies with time in the way shown in Fig. 7.5.

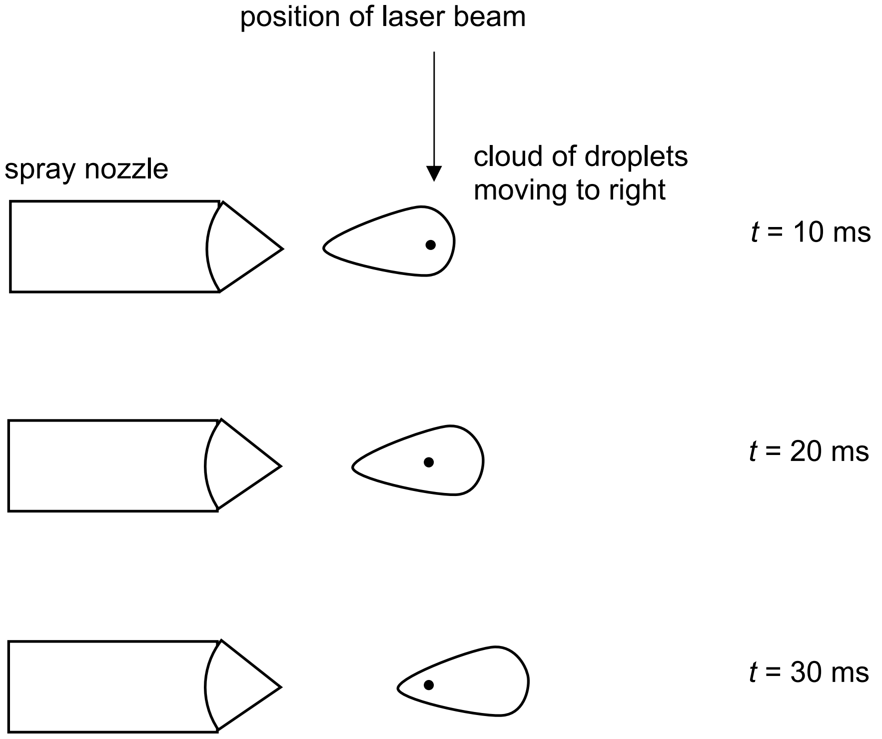


Fig. 7.4

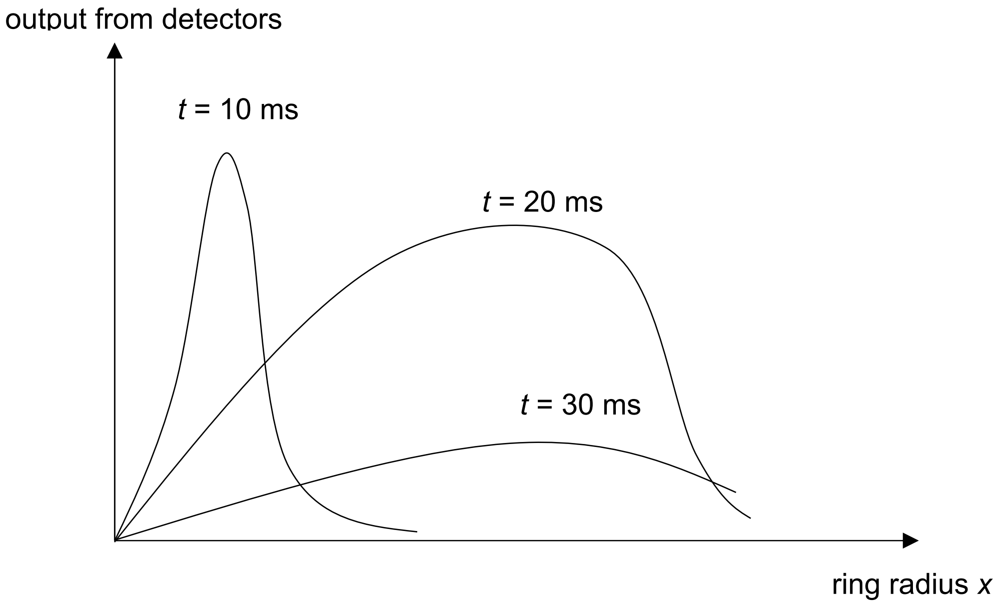


Fig. 7.5

For Examiner's Use

With reference to Fig. 7.6, describe the distribution of droplets in the cloud according to their size and concentration (i.e. amount of droplets)..

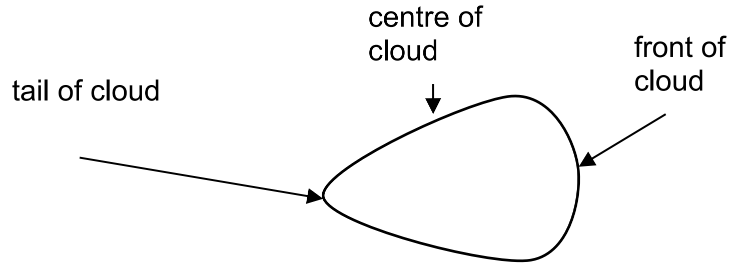


Fig. 7.6

At the front tip of the cloud,
Droplets are of uniform sizes and with a large diameter. [1] fewer droplets as compared to centre [1]

At the centre of cloud,
Droplets are of a range of sizes [1] and are large number of droplets as compared to front and tail of cloud. [1]

At tail of cloud, detected with a range of different diameters. [1] fewer droplets as compared to centre [1]

Concentration – amount of water droplets
Size – diameter + range of diameters

[6]

END OF PAPER

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Higher 2

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PHYSICS 9749/03

Preliminary Examination **20th September 2018**
Paper 3 Longer Structured Questions **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions in Section A, and **one** of the two questions in Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 8
Q2	/ 7
Q3	/ 10
Q4	/ 8
Q5	/ 10
Q6	/ 10
Q7	/ 7
Q8	/ 20
Q9	/ 20
Total marks	/ 80

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_0^2 - x^2}$
electric current	I	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{ln2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided.

1 **(a)** Define *impulse*.

Product of (average) force and the time that the (average) force acts on the body [1] (or time of impact)

.... [1]

(b) In a car test, a car with a dummy driver and passenger, moving at a speed of 6.9 m s^{-1}, collides head-on into a wall. The mass of the car is 1250 kg, the mass of the driver is 85 kg and the mass of the front passenger is 65 kg. The average deceleration of the car as it comes to a stop is 48 m s^{-2}. Both passenger and driver have their seat belts tightly fastened.

For the impact,

(i) determine the magnitude of the average force exerted on the car and its occupants.

average force = ma = (1250+85+65) (48) = 67200 N

average force = ... N [1]

(ii) determine the magnitude of the impulse caused by the force.

Impulse = change in momentum
= mv – mu
= 0 – (1250+85+65) (6.9) [1]
= - 9660 Ns
Ans: 9660 [1]

impulse = ... N s [2]

(iii) Hence, calculate the time taken for the car to come to a stop.

By Impulse - momentum theorem,
Ft = mv – mu
t = 9660/67200 [1]
= 0.144 s [1]

time = ... s [2]

(iv) Assuming that the average deceleration remains the same, state and explain how your answer in **(b)iii)** will change (if any) when the total mass of car and occupants has doubled.

No change [A1].
Since the change in velocity and the deceleration remains unchanged (a = Δv/Δt) [M1]
Or since the impulse (the change in momentum) and the average force both doubled, the time taken remains unchanged [M1]

[2]

For Examiner's Use

2 A fixed mass of an ideal monatomic gas undergoes a cycle **ABCA** of changes, as shown in Fig. 2.1.

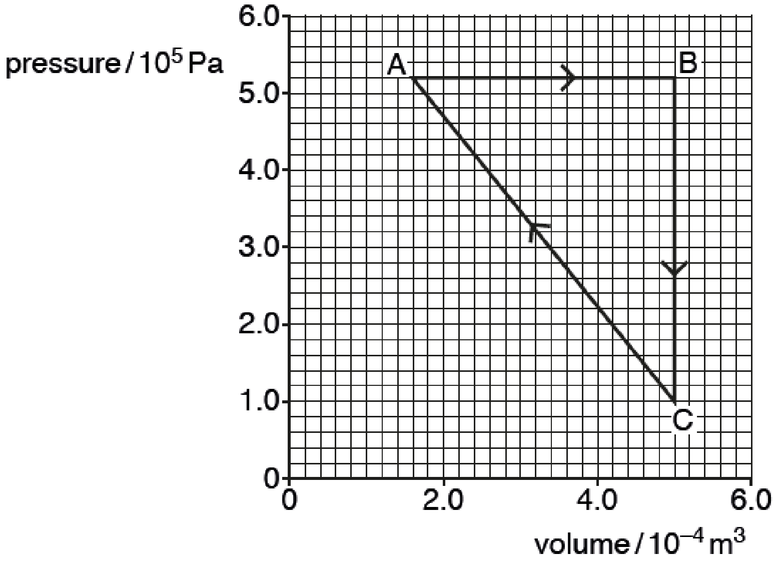


Fig. 2.1

(a) During the change from **B** to **C**, the internal energy of the gas decreases by 315 J.

By considering molecular energy, state and explain qualitatively the change, if any, in the temperature of the gas.

There is negligible potential energy PE. As such, a decrease in internal is equivalent to a decrease in kinetic energy. [B1]

Since KE is proportional to thermodynamic T, a decrease in kinetic energy will lead to a decrease in the temperature of the gas. [B1]

[2]

(b) During the change from **A** to **B**, the energy supplied to the gas by heating is 442 J.

Fig. 2.2 is a table of energy changes during one cycle. Complete Fig. 2.2.

section of cycle	heat supplied to gas / J	work done on gas / J	increase in internal energy of gas / J
A to B	442	-177	265
B to C	-315	0	-315
C to A	-55	105	50

Fig. 2.2

[3]

For Examiner's Use

Since ΔU = 0 for the entire cycle **ABCA,**
ΔU (for process C to A) = 315 – 265.2 = 49.8

Work done on gas (from C to A) = area under graph
= (5 - 1.6) x 10^{-4} x (5.2 + 1) / 2
= 105.4 J
By First Law of Thermodynamics,
ΔU = Q + W
ΔQ = 49.8 – 105.4
ΔQ = - 55.6 J

All W correct – 1 mark
Last column correct (add up to 0) – 1 mark
First Law correct – 1 mark

(c) Calculate the root-mean-square speed of the gas atoms at point **B** if the root-mean-square speed at point **A** is 350 m s^{-1}.

Since ½ $<c^2>$ = 3/2 kT
$\sqrt{<c^2>}$ proportional to $\sqrt{T}$ or $\sqrt{V}$ when P is constant

$$\frac{\sqrt{<c^2>}}{350} = \sqrt{\frac{5}{1.6}}$$

$\sqrt{<c^2>}$ = 619 m s^{-1}

root-mean-square speed = ……………..……… m s^{-1} [2]

For Examiner's Use

3 **(a)** As seen in Fig 3.1, a monochromatic light of wavelength 580 nm is used to produce an interference pattern on screen AB. The separation between the slits is 0.41 mm and the perpendicular distance between the double slit and the screen is *D*. Point Y is at a distance *x* = 2 mm from point O and it is the position of the first dark fringe. The intensity of the light passing through the two slits is the same.

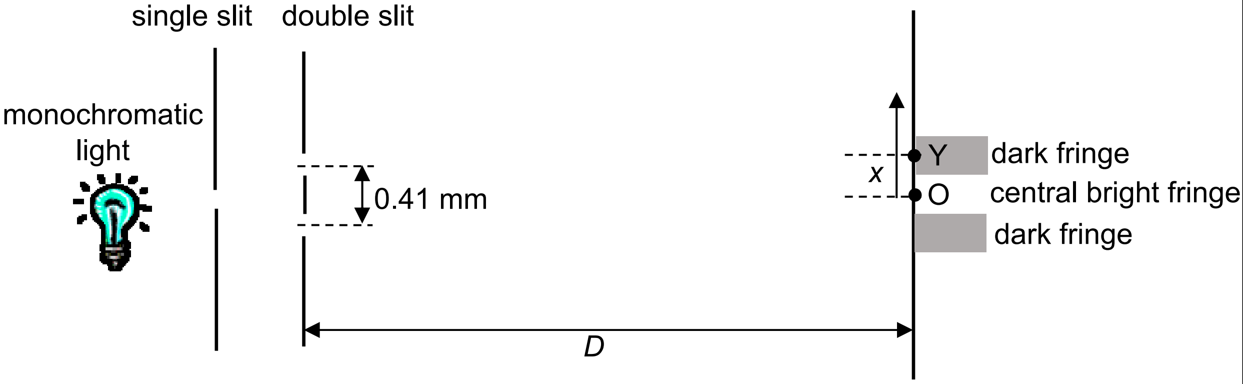


Fig 3.1

(i) Calculate the path difference between the 2 waves arriving at point Y from the slits.

Path difference = λ/2 = 580 /2 = 290 nm

distance = ……………….. nm [1]

(ii) Calculate the distance *D*.

By using x = λD/a

$D = 0.41 \times 10^{-3} (2 \times 2 \times 10^{-3}) / 580 \times 10^{-9}$ [M1]

= 2.8 m [A1]

D = ……………………… m [2]

For Examiner's Use

(ii) The width of both slits is reduced by the same amount without altering their separation. The original variation with distance *x* from point O of the intensity is as shown in Fig. 3.2. Sketch the new variation of intensity on Fig. 3.2. [3]

Peaks at same location [1] (YDS)
More peaks & and wider envelope (minima shift outwards) [1]
Lower peaks [1]

Not marking for first maxima details.

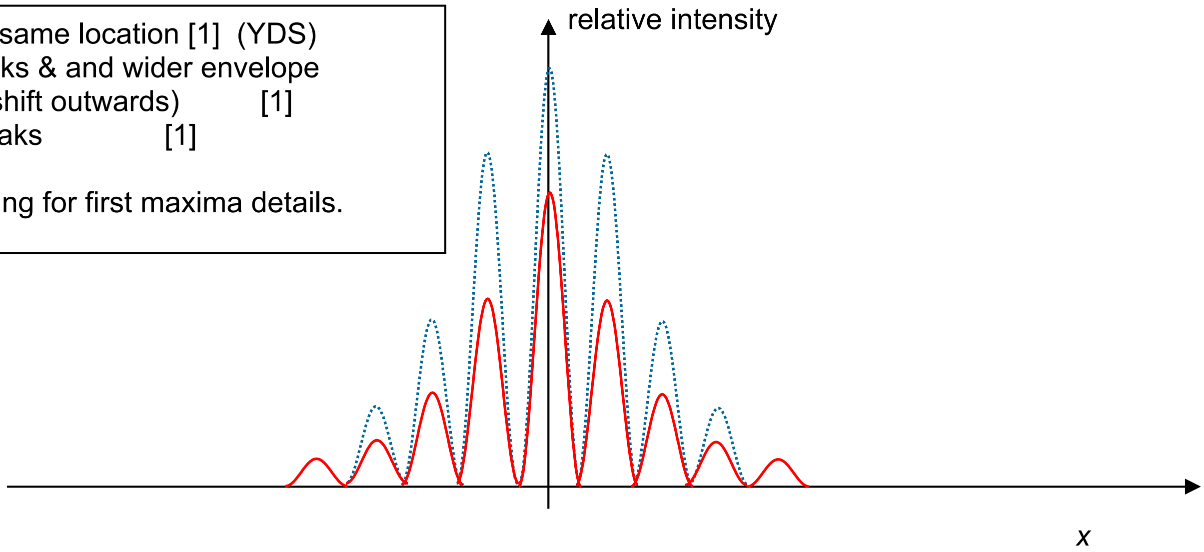


Fig. 3.2

(b) A diffraction grating is used to measure the wavelengths of light. The angle θ of the second order maximum is measured for each wavelength. The variation with wavelength λ of sin θ is shown in Fig 3.3.

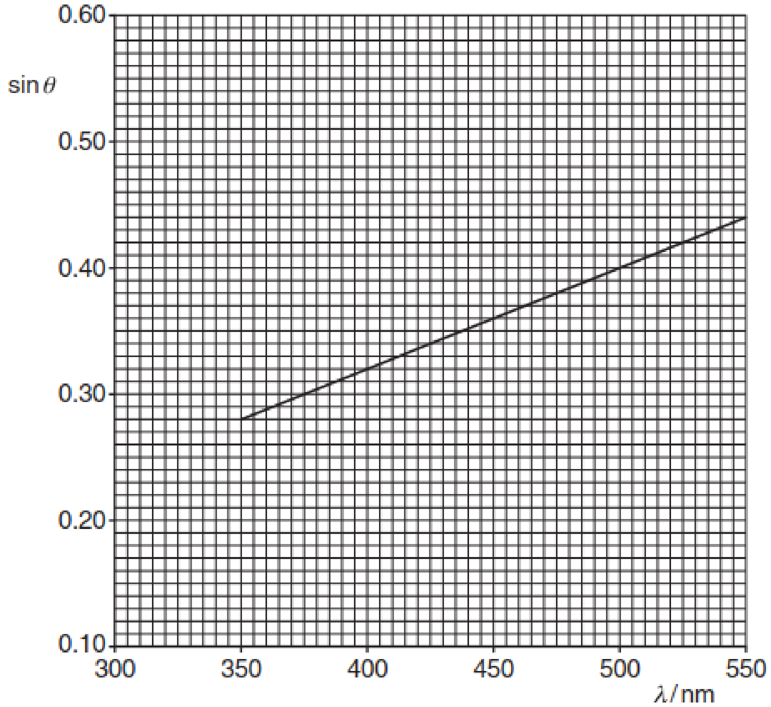


Fig. 3.3

(i) Calculate the slit separation d of the diffraction grating.

Gradient = 8.0×10^5	[B1]
d = n / gradient = $2 / 8.0 \times 10^5$	[M1]
= 2.5×10^{-6} m	[A1]

d = ……………………….m [3]

(ii) On Fig. 3.3, sketch a line to show the results that would be obtained for the first order maxima. [1]

straight line drawn with lower gradient (½) and all new y coordinates are ½ of the original y values

4 **(a)** Define *electric potential* at a point.

<u>work done per unit positive charge by an external force</u> [B1] in moving a <u>small test charge</u> from infinity to that point in the electric field [B1] (without a change in its kinetic energy).

.... [2]

(b) Two charged solid spheres A and B are situated in a vacuum. Their centres are separated by a distance of 30.0 cm, as shown in Fig. 4.1. The diagram is not drawn to scale.

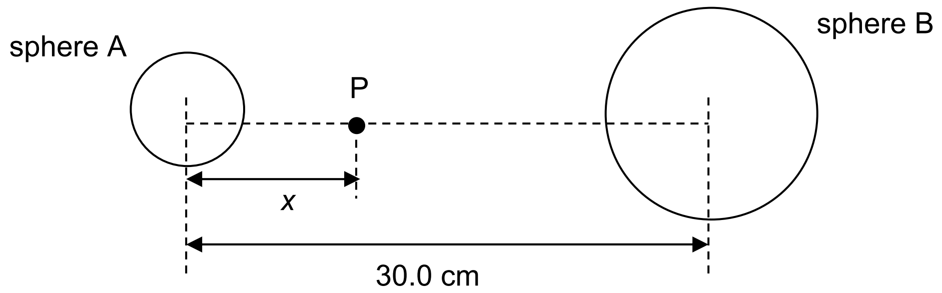


Fig. 4.1

The variation with distance x of the electric potential V_A and V_B due to sphere A and B independently is shown in Fig. 4.2.

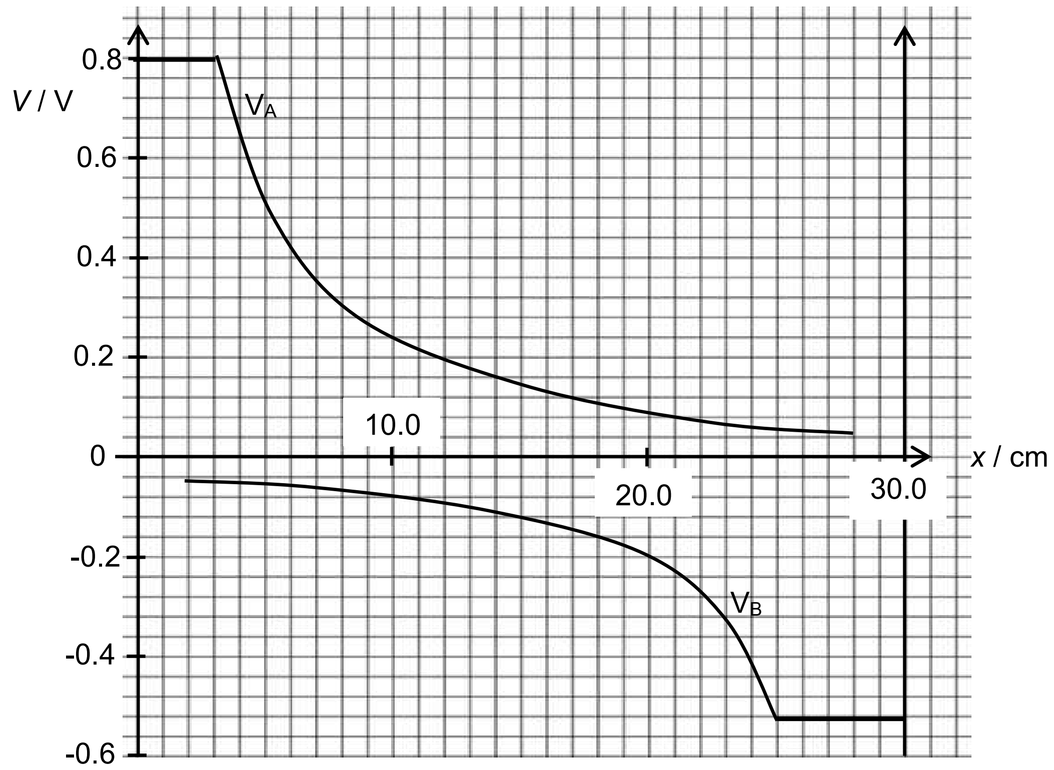


Fig. 4.2

For Examiner's Use

(i) Using Fig. 4.2, state the radius of both spheres.

Sphere A: 3.0 cm
Sphere B: 5.0 cm

radius of sphere A = ……………… cm

radius of sphere B = ………………. cm [1]

(ii) State and explain the signs of both spheres.

Since the potential of sphere A is positive and that of sphere B is negative, sphere A is positively charged while sphere B is negatively charged.

1 mark – opposite charges

(Cannot accept using gradient to determine direction of E field since no indication of which direction of *x* is positive.)

…… [2]

(iii) Point P is at a distance x = 10.0 cm.
An alpha particle has kinetic energy E_K when at infinity.

Use Fig. 4.2 to determine the minimum value of E_K such that the alpha particle may travel from infinity to point P.

Resultant potential (10 cm from sphere A) = 0.24 + (-0.08) = 0.16 V [B1]

By COE,

Loss in KE = Gain in EPE

$E_K - 0 = 0.16 (2 \times 1.6 \times 10^{-19}) - 0$ [M1 – 2q, q∆V, COE]

$E_K = 5.12 \times 10^{-20}$ J [A1]

If B1 correct and M1 wrong, 1 mark.
If B1 wrong and M1 correct, 1 mark.

E_K = ………………………….. J [3]

For Examiner's Use

5 An ideal transformer is connected to a sinusoidal a.c. supply, as shown in Fig. 5.1. The primary coil has a r.m.s. current of 0.85 A.

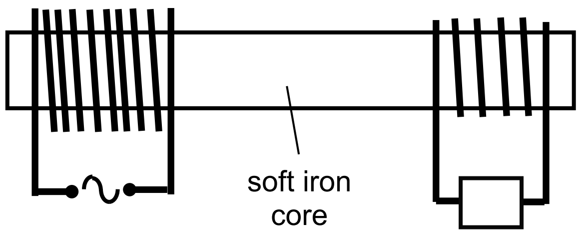


Fig. 5.1

(a) Use the laws of electromagnetic induction to explain how a potential difference can be developed across the secondary coil.

Alternating current in the primary coil results in an alternating magnetic field strength generated. [M1]
Magnetic field strength generated by primary coil linked to secondary coil (via the soft iron core).
Secondary coil experiences alternating magnetic flux linkage due to alternating magnetic field strength [M1]. By Faraday's law, an e.m.f. will be induced across the secondary coil. [A1]
Without 1st M1, max 1 mark.

………………………………………………………………………………………………….. [3]

(b) **(i)** The primary coil contains 9 turns per cm, calculate the maximum magnetic field strength at its centre.

$B = \mu_0 n I = 4\pi \times 10^{-7} \times 9 \times 100 \times 0.85\sqrt{2} = 1.36 \times 10^{-3}$ T [2]

maximum magnetic field strength = …………………. T [2]

For Examiner's Use

(ii) The ratio of the number of turns in the primary to secondary coil is 16 : 1.

Calculate the peak current in the load.

$$\frac{I_S}{I_P} = \frac{N_p}{N_S} = 16$$

I_s = $16 \times 0.85\sqrt{2}$ [M1]
= 19.2 A [A1]

peak current = ... A [2]

(iii) The variation with time t of current I_p in the primary coil is shown in Fig. 5.2.

On Fig. 5.3, sketch the variation with time t of current I_s in the secondary coil. [1]

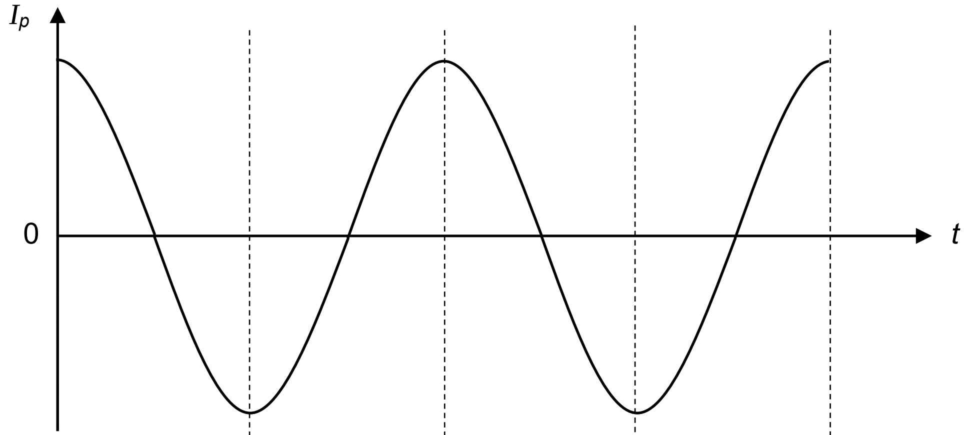


Fig. 5.2

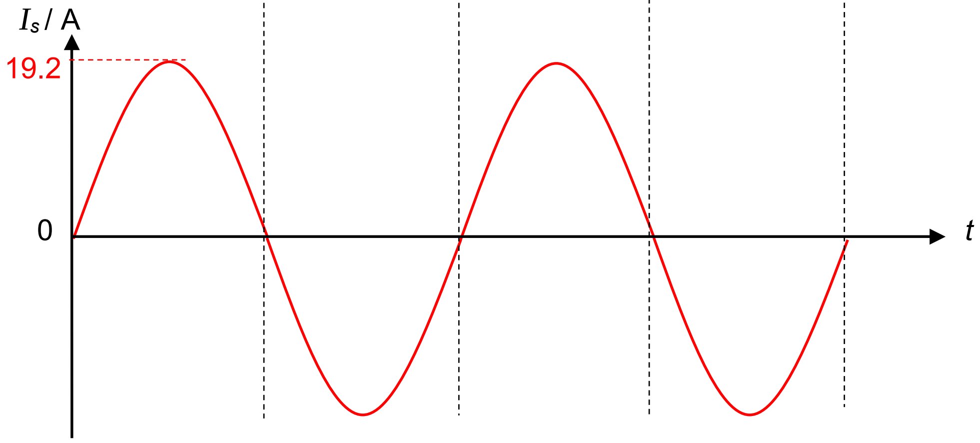


Fig. 5.3

(iv) State and explain how the answer to **b (iii)** will change if the iron core is removed from the transformer.

Magnetic flux linking secondary coil will decrease. [M1]
Hence rate of change of flux linkage will decrease. (By Faraday's law, induced e.m.f. and) hence magnitude of induced current will decrease. [A1]

.... [2]

For Examiner's Use

6 Ultraviolet radiation of wavelength 122 nm is used to illuminate the cathode in the vacuum tube as shown in Fig. 6.1.

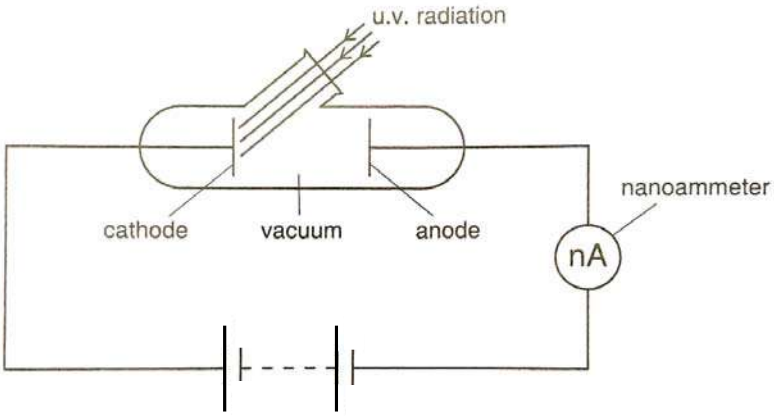


Fig. 6.1

(a) Photoelectrons are emitted from the cathode and collected at the anode. With the anode made negative and the cathode positive, some photoelectrons can still reach the anode, and by varying the battery's e.m.f, a graph of current against e.m.f. can be plotted as shown in Fig. 6.2.

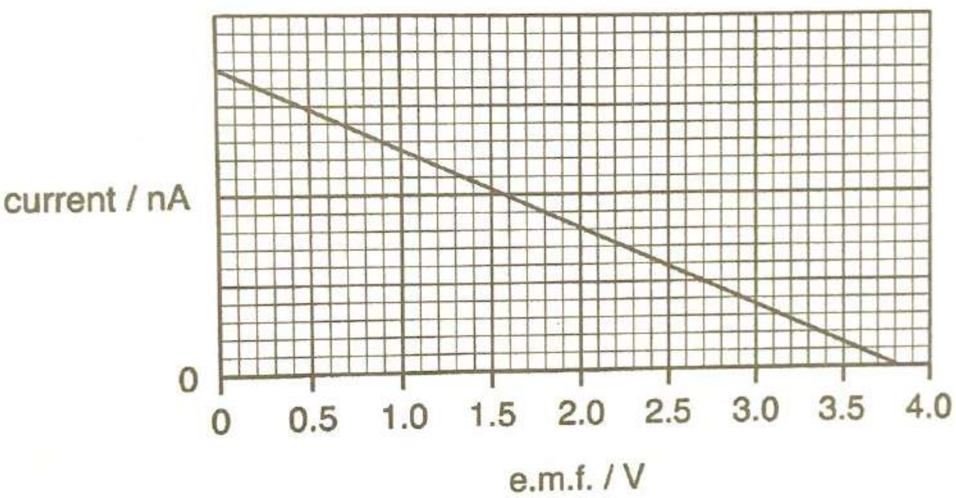


Fig. 6.2

(i) Explain why some photoelectrons are still able to reach the negative anode.

Photoelectrons emitted have kinetic energies ranging from zero to a maximum values. Those photoelectrons that **have enough energy to do work against the electric field** will be able to reach the anode.

.... [1]

For Examiner's Use

(ii) Calculate the maximum speed the photoelectrons can have when they leave the cathode.

Loss in KE = Gain in EPE
$\frac{1}{2} m v_{max}^2 = eV_s$
$\frac{1}{2} (9.11 \times 10^{-31}) V_{max}^2 = (1.6 \times 10^{-19})(3.8)$ [1]
$V_{max} = 1.16 \times 10^6$ m s^{-1} [1]

maximum speed = ………………………………… m s^{-1} [2]

(iii) Calculate the work function of the metal used in the cathode.

$hf = \phi + eV_s$
$\phi = (6.63 \times 10^{-34})(3 \times 10^8)/(122 \times 10^{-9}) - 1.6 \times 10^{-19} (3.8)$ [1]
$= 1.02 \times 10^{-18}$ J [1]

work function = ………………………………… J [2]

(b) The photocurrent I for different potential difference V between the cathode and the anode was measured. The experiment was then repeated using ultraviolet radiation of the same wavelength but of different intensity.

The series of graphs of I against V are shown in Fig. 6.3.

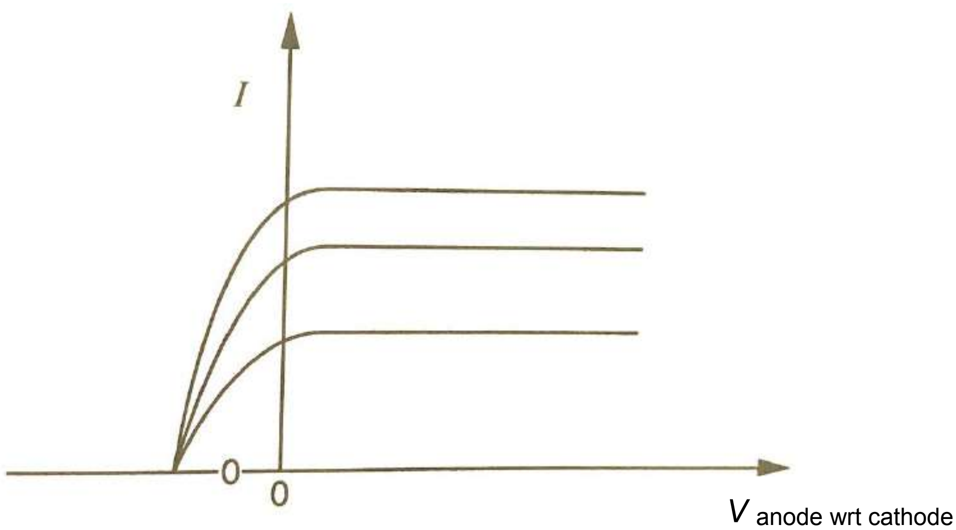


Fig. 6.3

For Examiner's Use

(i) State and explain which feature of this graph could not be explained using the wave theory of light.

The stopping potential is independent of the intensity of the radiation [1]. According to wave theory, the higher the intensity, the more energy the light would possess which would cause the **photoelectrons emitted to have higher kinetic energy**, and hence **a higher stopping potential to bring them to rest** [1].

[2]

(ii) Explain why the maximum kinetic energy of photoelectrons is independent of intensity whereas the photoelectric current is proportional to intensity of the light.

When electromagnetic radiation is irradiated on the metal surface, the energy is delivered in packets known as photons. The energy of each photon energy is *hf* (where h is Planck's constant and f is the frequency of radiation.) [B1]

Photons interact with the electrons on a 1-to-1 basis such that the maximum kinetic energy of the emitted photoelectron, $KE_{max} = hf - \phi$ is dependent only on the frequency of the radiation and ϕ, the work function of the metal. [B1]

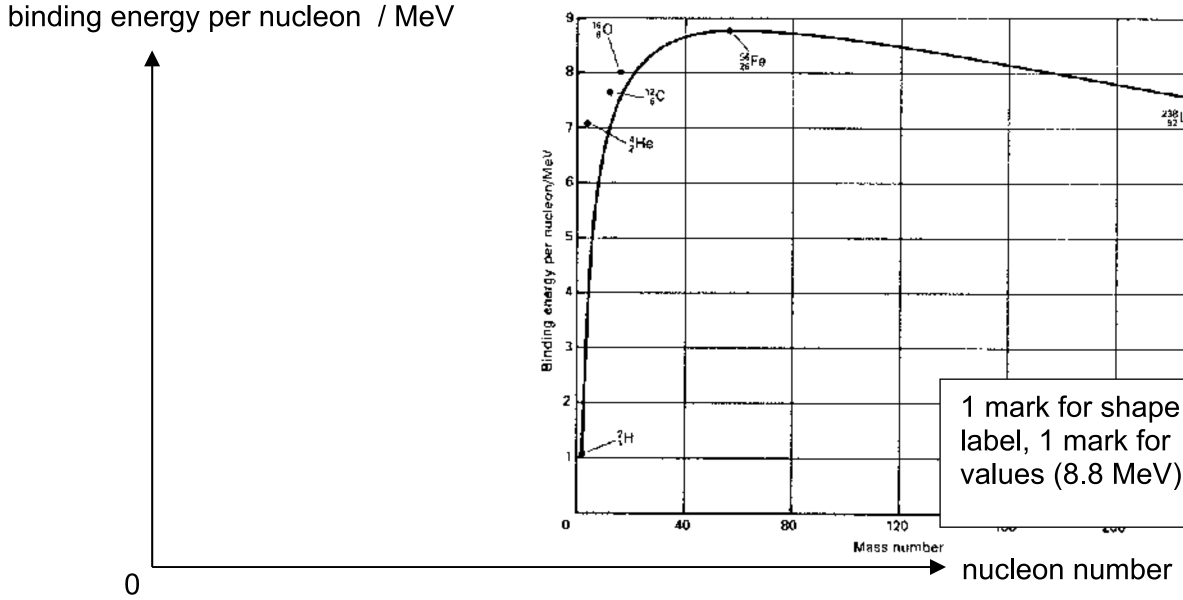
For light of a constant frequency, intensity is directly proportional to the rate of incidence of photons which is in turn directly proportional to the rate of photoelectrons emitted, and hence the photoelectric current. [B1]

[3]

7 An induced nuclear fission reaction maybe represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$$

(a) Sketch the variation with nucleon number of the binding energy per nucleon. [2]



1 mark for shape and label, 1 mark for values (8.8 MeV)

Fig. 7.1

(b) Hence, explain why Uranium – 235 is more likely to undergo fission than fusion.

Uranium-235 is on the right hand side of graph, beyond Fe-56.

BE is the BE per nucleon multiply by the number of nucleons. [B1]

Fission involves breaking a larger nucleus into smaller nuclei [B1].

Fission will involve products with higher BE per nucleon, hence more stable products and more likely to occur. [B1] or Fission implies increase of total BE and hence release of energy, hence more likely to occur. [B1]

..[3]

(c) The masses of the various nuclides are as listed below:

nuclide	mass / *u*
Uranium - 235	235.04393
Barium – 141	140.91441
Krypton - 92	91.92616
neutron	1.00867

Determine the energy released in the reaction.

Energy released = mass of reactants - mass of products

$=(235.04393+1.00867)-[140.91441+91.92616+3(1.00867)]uc^2$ [M1]

$=0.18602uc^2$

$=2.78\times10^{-11}$ J [A1]

energy released = …………………………… J [2]

Section B

Answer **one** question from this section in the spaces provided**.**

8 (a)(i) Define *gravitational field strength*.

The gravitational field strength at a point is the gravitational force exerted per unit mass when a small test mass is placed at that point in a gravitational field.

…………………………………………………………………………………………………… [1]

(ii) Derive, from Newton's Law of Gravitation and **(a)(i)** above, the equation for the gravitational field strength of a point mass of mass M_1, placed in a gravitational field generated by a mass M_2 and at a distance of r from M_1. [2]

Since $g = F/M_1$
and $F = GM_1M_2/r^2$ [Both equations to get 1]

Therefore, $g = GM_1M_2/r^2 / M_1$
$= GM_2/r^2$ [1]

(b) Information related to the Earth and the Moon is given below:

$$\frac{\text{Radius of Earth}}{\text{Radius of Moon}} = 3.7$$

$$\frac{\text{Mass of Earth}}{\text{Mass of Moon}} = 81$$

The center-to-center distance of the Moon from the Earth is 3.84×10^8 m and the gravitational field strength due to the Earth at its surface is 9.8 N kg^{-1}.

(i) Using these data, calculate the gravitational field strength due to the Moon at its surface.

Since $g \propto M/r$,
$\frac{g_M}{g_E} = \left(\frac{M_M}{M_E}\right)\left(\frac{r_E}{r_M}\right)^2$ [M1]
$= (1/81)(3.7)^2$
$= 0.169$

Therefore, g due to Moon = 0.169 X 9.81
= 1.66 N kg^{-1} [A1]

gravitational field strength = ………………… N kg^{-1} [3]

(ii) There is a point on the line between the Earth and the Moon at which their combined gravitational field strength is zero.

Calculate the distance between this point and the centre of the Earth.

$$\frac{GM_E}{r^2} = \frac{GM_M}{(3.84 \times 10^8 - r)^2}$$

$$81 = \frac{r^2}{(3.84 \times 10^8 - r)^2} \text{ [1]}$$

r = 3.46 x 10^8 m [1]

distance = ……………………………… m [2]

(iii) The Moon orbits around the Earth with a period of 27.3 days.

1. Calculate the angular speed of the Moon.

$\omega = 2\pi/T$
$= 2\pi/(27.3 \times 24 \times 60 \times 60)$
= 2.66 x 10^{-6} rad s^{-1} [1]

angular speed = ……………….. rad s^{-1} [1]

2. Calculate the mass of the Earth.

Gravitational acceleration provides centripetal acceleration.

$GM/r^2 = r\omega^2$
$M = r^3\omega^2/G$ [M1]
$= (3.84 \times 10^8)^3 \times (2.66 \times 10^{-6})^2 / 6.67 \times 10^{-11}$
$= 6.0 \times 10^{24}$ [A1]

……… kg [2]

3. Determine the gravitational force between the Earth and the Moon.

Mass of Moon = 1/81 Mass of Earth

$F = GM_EM_M/r^2$
$= [6.67 \times 10^{-11} (6.0 \times 10^{24})^2 / 81] / (3.84 \times 10^8)^2$ [1]
$= 2.01 \times 10^{20}$ [1]

gravitational force = ………………………………. N [2]

For Examiner's Use

4. Tidal action on the Earth's surface causes the radius of the orbit of the Moon to increase by 4.0 cm each year. Using your answer in **(b)(iii)(3)**, determine the change, in one year, of the gravitational potential energy of the Moon.

Change in potential energy
= Work done by external force
= $2.01 \times 10^{20} \times 0.04$ [1]
= 8.04×10^{18} J [1]

change in potential energy = ………………………….. J [2]

(c) **(i)** Explain, by considering the respective field force, why gravitational potential energy is negative whereas electric potential energy can be positive or negative.

Gravitational forces are **always attractive**, whereas electric forces **can be attractive or repulsive**. [1]

…………………………………………………………………………………………..[1]

(ii) The Earth may be assumed to be an isolated sphere of radius 6.4×10^3 km with its mass of 6.0×10^{24} kg concentrated at its centre. A 2.0 kg mass is projected vertically from the surface of the Earth so that it reaches a maximum altitude of 1.3×10^4 km.

Calculate, for this mass,

1. the change in gravitational potential energy

Change in GPE
= $-GMm/r_2 - (-GMm/r_1)$
= $GMm (1/r_1 - 1/r_2)$
= $6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 2.0 (1/6.4 \times 10^6 - 1/(6.4 \times 10^6 + 1.3 \times 10^7)$ [M1]
= 8.38×10^7 J [A1]

change in gravitational potential energy = …………………….. J [2]

2. the speed of projection from the Earth's surface, assuming air resistance is negligible.

By COE, Loss in KE = Gain in GPE
$\frac{1}{2} m v^2 = 8.38 \times 10^7$
$\frac{1}{2} (2) v^2 = 8.38 \times 10^7$ [M1]
$v = 9150 \text{ m s}^{-1}$ [A1]

speed = …………………………….. m s^{-1} [2]

For Examiner's Use

9 **(a)** By reference to energy transfers, distinguish between electromotive force (e.m.f.) and potential difference (p.d.).

e.m.f. ……

Emf: electrical energy converted from other forms of energy per unit charge delivered round a complete circuit.

Pd: The potential difference between two points in a circuit is the amount of energy converted from electrical to other forms of energy per unit charge passing from one point to the other

p.d. …… [2]

(b) A circuit is set up as shown in Fig. 9.1.

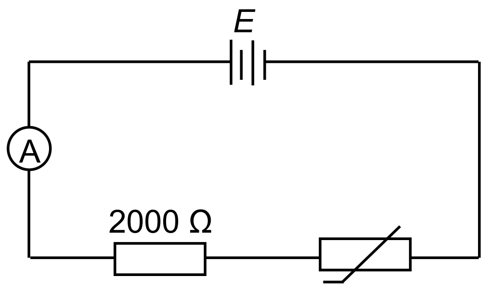


Fig. 9.1

The source of e.m.f. *E* is found to provide 2.4 x 10^5 J of electrical energy to the 2000 Ω resistor and thermistor when a charge of 2.2 x 10^4 C passes through the ammeter. At room temperature, the thermistor has a resistance of 1800 Ω.

(i) Sketch on Fig. 9.2 the variation with temperature *θ* of resistance *R* in a thermistor. [1]

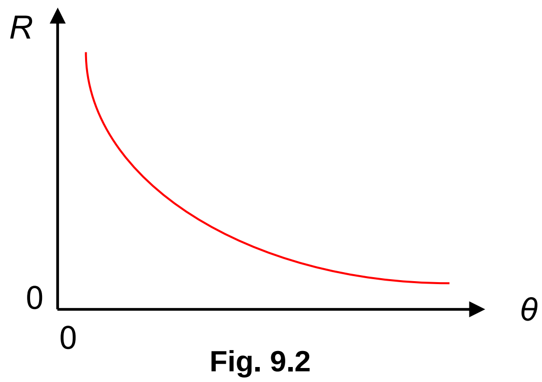


Fig. 9.2

(ii) For the thermistor at room temperature,

1. show that *E* is 11 V. [1]

$$E = \frac{W}{Q} = \frac{2.4\times10^5}{2.2\times10^4} = 11\text{V}$$ [M1]

For Examiner's Use

2. determine the time taken for a charge of 2.2 x 10^4 C to pass through the ammeter.

$$Q = It = \frac{E}{R}t$$

$$\Rightarrow t = \frac{QR}{E} = \frac{2.2\times10^4 \times 3800}{11} \quad \text{[M1]}$$

$$= 7.6\times10^6 \text{ s} \quad \text{[A1]}$$

time = ………………… s [2]

3. show that the fraction of power dissipated in the thermistor is 0.47. [1]

$$\text{fraction} = \frac{I^2R_T}{I^2R_T + I^2R} = \frac{R_T}{R_T + R} = \frac{1800}{1800+2000} \quad \text{[M1]}$$

$$= 0.474$$

(c) A uniform resistance wire PQ of length 1.2 m is subsequently connected across the resistor and thermistor, as shown in Fig. 9.3. A sensitive voltmeter is connected between point Y and a moveable contact M on the wire.

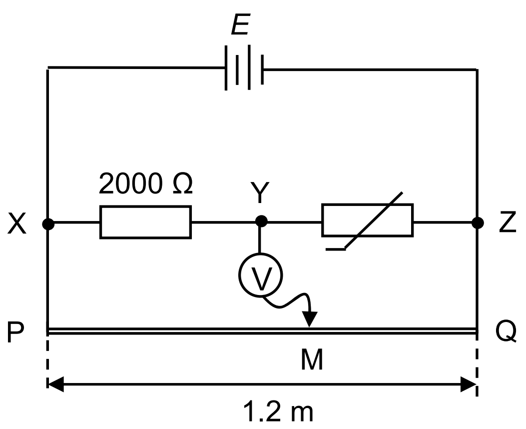


Fig. 9.3

(i) At room temperature, the contact M is moved along PQ until the voltmeter shows zero reading.

Calculate the length of wire between M and Q.

Potential difference between MQ and YZ has to be the same for voltmeter to register zero reading.

$$\frac{L}{1.2} = \frac{1800}{3800} \quad \text{[M1]}$$

L = 0.568 m [A1]

length of wire = …………………… m [2]

For Examiner's Use

(ii) State and explain the effect, if any, on the length of the wire between M and Q for the voltmeter to remain at zero deflection if each of the following changes takes place independently.

1. The thermistor is warmed slightly.

(As temperature rises), resistance of thermistor decreases and by Potential Divider Principle, the potential difference across the thermistor drops.

For zero deflection, the potential difference across the thermistor and across MQ have to be the same. Since the pd across MQ is proportional to its length, MQ is shorter. [2]

2. A uniform wire with a bigger cross sectional area is used to replace PQ.

While the bigger cross-sectional area will result in a lower resistance in the wire PQ, as the potential difference across PQ did not change, the potential difference per unit length remains the same.

Since potential difference across thermistor (and resistor) did not change, the length of wire will not need to change. [2]

For Examiner's Use

(d) The circuit shown in Fig. 9.4 is used to compare potential differences.

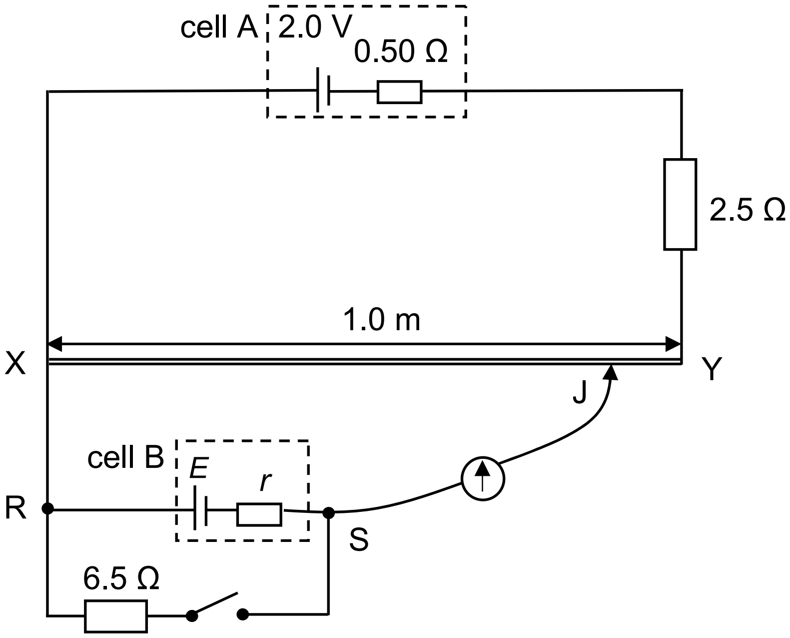


Fig. 9.4

The uniform resistance wire XY has length 1.0 m and resistance 8.0 Ω. Cell A has e.m.f. 2.0 V and internal resistance 0.50 Ω. Cell B has e.m.f. *E* and internal resistance *r*.

(i) The switch is opened. The galvanometer shows no deflection when the moveable contact J is adjusted so that the length XJ is 0.90 m.

Show that the e.m.f. *E* of cell B is 1.3 V. [2]

$$V_{XY} = \frac{8.0}{8.0 + 0.50 + 2.5} \times 2.0 = 1.455 \text{ V}$$ [M1]

At null deflection, V_{XJ} = e.m.f. of cell B.

$$E = \frac{0.90}{1.0} \times 1.455 = 1.31 \text{ V}$$ [M1]

For Examiner's Use

(ii) The switch is now closed.

1. For the galvanometer to show no deflection, contact J has to be adjusted so that length XJ is 0.75 m.

Determine the internal resistance *r* of cell B.

At null deflection, $V_{XJ} = V_{RS}$

$$V_{XJ} = \frac{0.75}{1.0} \times 1.455 = 1.091 \text{ V} \qquad \text{[M1]}$$

$$I = \frac{V}{R} = \frac{1.091}{6.5} = 0.1679 \text{ A} \qquad \text{[M1]}$$

$$E = V + Ir \Rightarrow r = \frac{E - V}{I} = \frac{1.3 - 1.091}{0.1679} = 1.25 \ \Omega \qquad \text{[A1]}$$

r = …………………….. Ω [3]

2. A resistor is connected in parallel with the 6.5 Ω resistor.

Deduce how the balanced length XJ would be affected.

With resistor connected in parallel, load resistance of cell B would decrease.
This would cause terminal p.d. of cell B to decrease. [1]
Since no change in potential difference per unit length along wire XY,
Balance length XJ would decrease. [A1]

……. [2]

END OF PAPER

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

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PHYSICS 9749 / 04

PRELIMINARY Examination **28th August 2018**
Paper 4 Practical **2 hour 30 minutes**

Candidates to answer all questions in the Question Booklet.

Additional Material: Question Booklet for Question 4

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/ 10
2	/ 12
3 (a) to (d)	/ 17
subtotal	/ 39
3 (e)	/ 5
4	/ 11
Planning subtotal	/ 16

For Examiner's Use

1 In this experiment, you are provided with a ball suspended by a thread so that it is next to a solid vertical surface. You will investigate how the rebound distance is related to the release distance when it swings against the solid surface.

(a) Assemble the apparatus as shown in Fig. 1.1, with the thread clamped between the two small wooden blocks so that l is about 50 cm, and with the big wooden block positioned so that it is just touching the stationary ball.

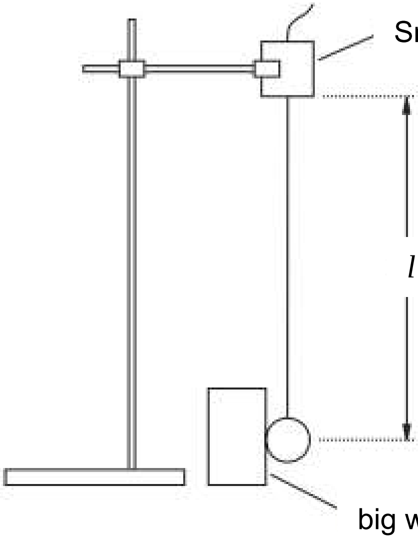


Fig. 1.1

(ii) Measure and record l.

3 d.p in m
Correct precision and within range (48.0 cm to 52.0 cm) with units

……………………… [1]

(b) **(i)** Pull back the ball as shown in Fig. 1.2.

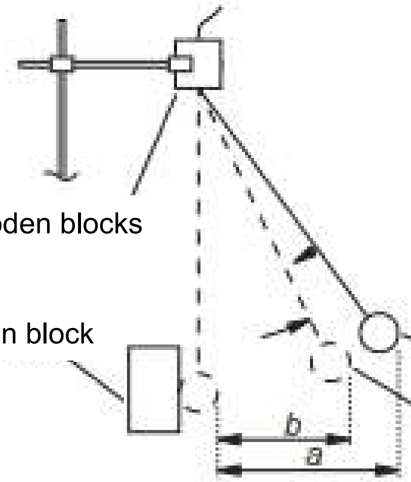


Fig. 1.2

Measure the distance *a*. Do not exceed *a* = 25 cm.

Part (b)(i) and (b)(ii) marked together for:
1) Correct precision
2) Correct units
$a \leq 25.0$ cm

a = ……………………………… [1]

For Examiner's Use

(ii) Release the ball and make measurements to determine the rebound distance *b* as shown in Fig. 1.2.

3 d.p in m
within range (< a)
Measurements for *b* must be repeated.

b = ………………………………. [2]

(c) **(i)** Explain how you used the apparatus to ensure that the rebound distance *b* was measured as accurately as possible.

Place ruler under path and view directly from above OR
Use protractor to determine angle of release and use *Lsinθ* to calculate.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………. [1]

(ii) Estimate the percentage uncertainty in your value of *b*.

Δ*b* between 0.2 cm and 0.5 cm
with 1 or 2 sf as final answer [1]

percentage uncertainty = ………………………………. [1]

For Examiner's Use

(d) For values of a less than 25 cm, theory predicts that

$$k = \frac{l - \sqrt{l^2 - b^2}}{l - \sqrt{l^2 - a^2}}$$

where *k* is a constant.
Calculate *k*.

Correct calculation of k with no units [1]

k = ……………………………….[1]

(e) Repeat **(b)(i)**, **(b)(ii)** and **(d)** using a different of *a*.

Value of b shows correct trend with *a* within range (*a* ≤ 25.0 cm). [1]

a = ……………………………….

b = ……………………………….

k = ……………………………….
[1]

(f) State whether the results of your experiment indicates *k* is a constant.
Justify your conclusion by referring to **(c)(ii)**.

show calculation of percentage difference = $\frac{k_2 - k_1}{k_1} \times 100\%$

(1 or 2 sf) [1 correct calculation & sf]

If the percentage difference is large as compared to the percentage uncertainty of b, k is not a constant . [1 for conclusion]

…………………………………………………………………………………………………… [2]

[Total : 10 marks]

For Examiner's Use

2 In this experiment, you calculate the amount of charge that flows through a resistor.

(a) **(i)** Set up the circuit as shown in Fig. 2.1, taking care to connect Y the right way round.

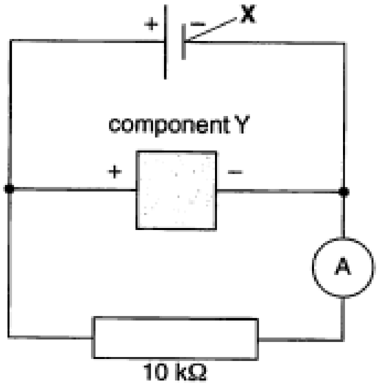


Fig. 2.1

(ii) Read and record the reading I on the ammeter.

correct precision of I at least 3 dp and units [1]
0.100 mA - 0.250 mA

I = ...[1]

(b) When the wire at X is disconnected, the current in the resistor gradually decreases to zero.

(i) Disconnect the wire at X and start the stopwatch.

(ii) Take at least five more sets of I and time up to a value of t = 50 s. Tabulate your results.
(You may need several attempts. Reconnect wire at X for one minute before making another attempt.)

Successfully collected 6 sets data including correct trend [1]
Repeated readings &
Processed data of average *I, calculation & precision [1]*

[2]

For Examiner's Use

(iii) **1.** Plot your values from **(b)(ii)** on Fig. 2.2. and draw a curve through your points.

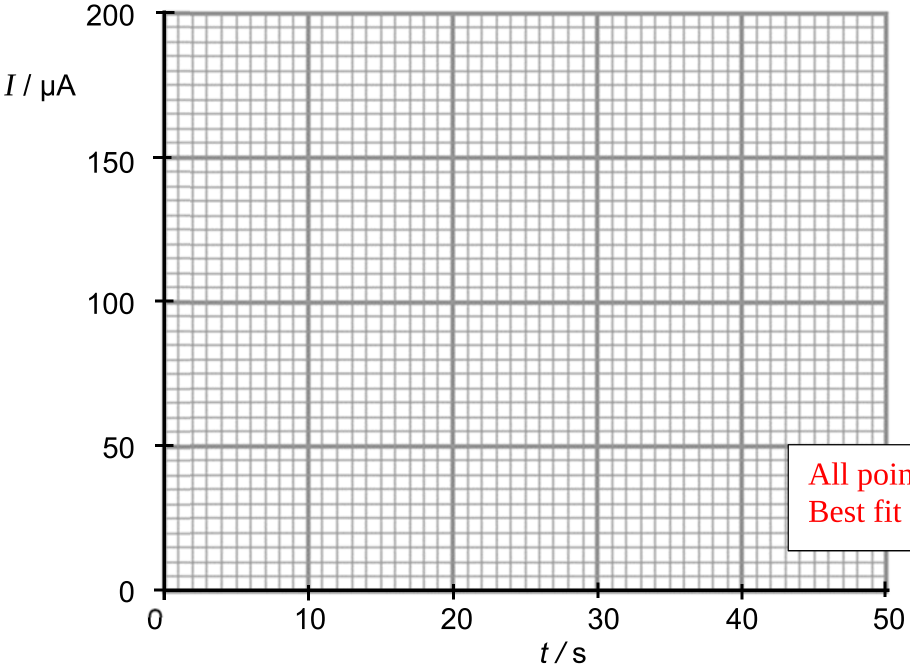


Fig. 2.2

All points correctly plotted [1]
Best fit curve [1]

[2]

2. The area under the graph represents the charge *Q* that has flowed through the resistor during 50 s. Estimate *Q*.

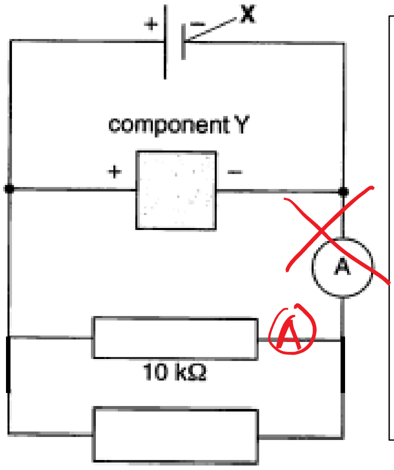
Correct method to estimate area under graph with correct units [1]

Q = ...[1]

For Examiner's Use

(c) It is suggested that the time taken for the current in the 10 kΩ resistor to decrease to zero is shorter when the total effective resistance of the circuit is lower.

With an aid of circuit diagram(s), suggest how you can verify this.



Ammeter placed at correct position [1], method to change resistor with indication of whether effective R increases when R is added. [1]
Charge the capacitor
Disconnect wire at X and start stopwatch
Stop the stopwatch when the reading in ammeter becomes zero and record as T1.
Repeat the experiment with additional resistor removed [1] and record the time taken for ammeter reading to be zero as T2.
If T1>T2, verified [A1]

....

....

....

....

....

....

.... [4]

(d) Theory suggests that $Q = kV$ where V is the potential difference across the resistor and k is a constant equal to 1.0×10^{-3} C V^{-1}.

(i) Use the analogue voltmeter to determine V.

correct precision of V to 2 dp and units [1]

V = ...[1]

(ii) Use your answer to **(d)(i)** to determine Q.

correct calculations and units [1]

Q = ...[1]

[Total : 12 marks]

For Examiner's Use

3 In this experiment, you will investigate how the motion of two pendulum depends on the tension in the string connecting them.

(a) Measure and record the unstretched length l_0 of the coiled part of the spring as shown in Fig. 3.1.

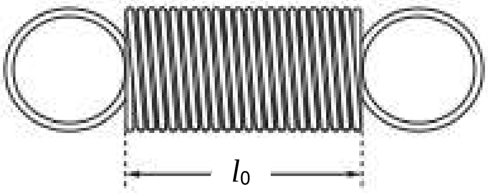


Fig. 3.1

correct precision at least 1 dp in cm and units for both (a) & (b)(iii)
range :1.8 - 2.2 cm

l_0 = ... [ ]

(b) **(i)** Set up the apparatus as shown in Fig. 3.2. Tie strings X and Y such that the spring is horizontal.

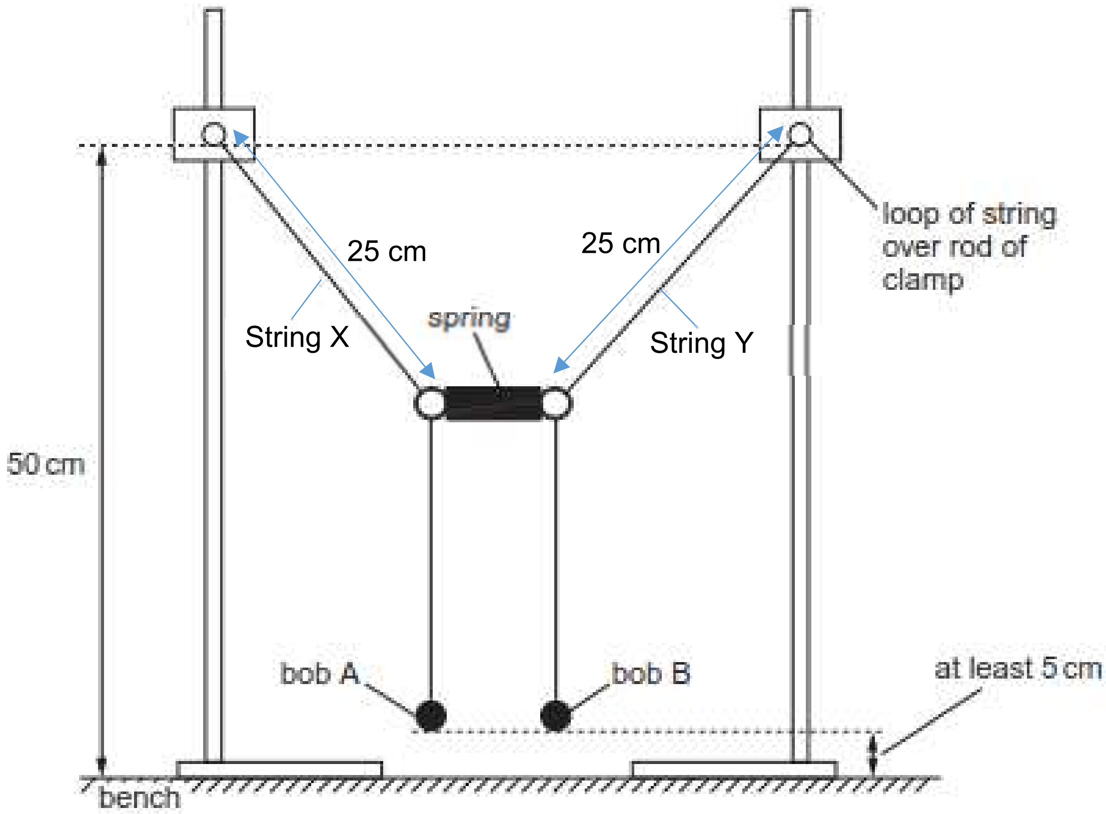


Fig. 3.2

(ii) Position the stands so that the coiled part of the spring has approximate length l_0 + 2 cm (so that the spring is extended by approximately 2 cm).

For Examiner's Use

(iii) Measure and record the length l of the coiled part of the spring. Calculate the extension x of the spring where $x = l - l_0$.

correct calculation of x of 3 dp and units range of x :1.5 cm - 2.5 cm

l = ………………………………..

x = …………………………… [1]

(iv) Gently pull bob A towards you. Release the bob and watch the movement of the two bobs.

Bob A will eventually stop and start moving again. It will then stop for a second time.

Determine and record the time T between these two stops.

correct precision of 1 dp and units [1]

T = …………………………… [1]

(c) By moving the stands further apart, repeat **(b)(iii)** and **(b)(iv)** until you have further readings of l, x and T, with x in the range 2 cm ≤ x ≤ 10 cm.

[2] successfully collected data of at least 6 sets - [-1] if 1 of set T < 6.0 s - [0] if more than 1 set of T < 6.0 s - [0] wrong trend - [-1] if spread of x (2.5cm to 9.5 cm) - [-1] for 5 sets only, [0] for less than 5 sets [1] for correct table headings/units (l, x, T) [1] repeated reading, correct calculation for T_{ave}

[4]

For Examiner's Use

(d) It is suggested that T and x are related by the expression

$$T = p\,x + q$$

where p and q are constants.

(i) Plot a suitable graph to determine p and q.

[1] for appropriate scale with labelling of axes
[1] for best fit line
[1] for correct plotting of ALL points
[-1] if no big gradient triangle with coordinates read to the half a small square
[1] correct calculation of P with units
[1] correct calculation of q with units

p = ...

q = ...

[5]

(ii) Hence determine the extension x that would be expected to give a value of T = 75 s.

correct calculation 3 sf and units [1]

x = ... [1]

For Examiner's Use

For Examiner's Use

(iii) Comment on any anomalous data or results you may have obtained. Explain your answer.

There is no anomalous data as all points are fairly scattered about the best fit line. *OR*
There is a anomalous points at (_ , _) as it lies further away from the best fit line as **compared to all the other points**.

[0] if more than 1 anomalous points

......[1]

(iv) On your graph on page 11, draw new graph when *q* is increased. Label this graph Z. [1]

Graph Z is above and parallel to the plotted graph.

(v) Suggest a significant source of error in this experiment.

1) Difficult to determine the exact time when the ball stops and hence affecting T
2) Difficult to determine the length of the spring due to shaky hands and hence affects x
3) Difficult to ensure the spring is horizontal, hence affecting T
4) Oscillation is wobbly, hence affecting T

[1]

(vi) Suggest an improvement that could be made to the experiment to address the error identified in **(d)(v)**. You may suggest the use of other apparatus or a different procedure.

1) Placed light gates connected with a datalogger and a computer such that pendulum A is between the light gates at its equilibrium position. The time between the 2 stops of pendulum A can be analysed from the signal on the computer.
2) Clamp the ruler such that it is parallel to the spring.
3) Use spirit level/ measure height from 2 points and ensure it is equal/ use teacher's bench/cupboard as the plane for reference

[1]

For Examiner's Use

(f) It is suggested that the mass of the identical pendulums A and B will affect the time T between the two stops of pendulum A such that the mass m of a pendulums is directly proportional to the time T between the two stops of pendulum A.
Plan an investigation to verify this.

Your account should include:

- your experimental procedure
- details of the table of measurements with appropriate units

1. **Weigh the mass *m* of the sphere using a top pan balance [1]**
2. **Set up the apparatus as shown in Fig. 3.1**
3. Position the stands so that the spring is extended by approximately 2 cm.
4. Gently pull bob A towards you. Release the bob and watch the movement of the two bobs. Bob A will eventually stop and start moving again. It will then stop for a second time.
5. Determine and record the time T between these two stops.
6. **Repeat steps 3 and 4 for reliability to obtain the average time *T*.**
7. **Repeat the steps 1 to 5 by replacing with <u>6 different spherical pendulums of the different masses</u> [1] <u>but same dimension</u> and extension [1]**
8. **Record the readings in the following table [1]**

m / g	T_1 / s	T_2 / s	T_{ave} / s

9. **Plot a graph of T_{ave} vs m**
10. **If the graph is a straight line passing through the origin, the relationship is verified. [1 for 9 & 10]**
[-1 for incorrect procedure]

..........[5]

[Total: 22 marks]

Question 4:

Write your answer in the Question Booklet for Question 4.

For Examiner's Use

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For Examiner's Use

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME			
CG		**INDEX NO.**	

PHYSICS **9749 / 04**

PRELIMINARY Examination **28th August 2018**
Paper 4 Practical **2 hour 30 minutes**

Question Booklet for Question 4

Candidates to answer all questions in the Question Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
4	/ 11
Total	/ 11

4 A student is investigating the characteristics of different light-emitting diodes (LEDs). Fig. 4.1 shows examples of LEDs and the circuit symbol for an LED.

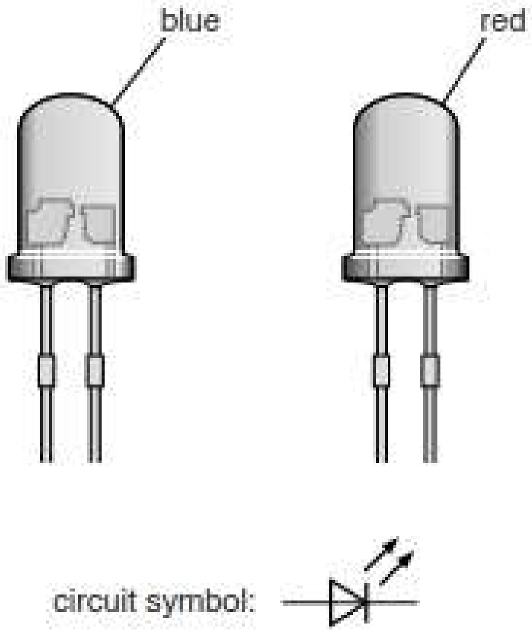

Fig. 4.1

Each LED needs a minimum potential difference V across it to emit light. The student is investigating the relationship between V and the wavelength λof the light emitted by the LED for several different LEDs.

Design an experiment to testinvestigate the relationship between *V* and *λ*.

You are provided with the following equipment:

Power supply	Metre rule
resistors	Ammeter
Diffraction grating	Voltmeter
Double slit	Different LEDs
Micrometer screw gauge	Vernier callipers

You may also use any of the other equipment usually found in a Physics laboratory.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the equipment you would use,
(b) the procedure to be followed,
(c) the control of variables,
(d) the analysis of the data,
(e) any precautions that would be taken to improve the accuracy of the experiment.

Diagram

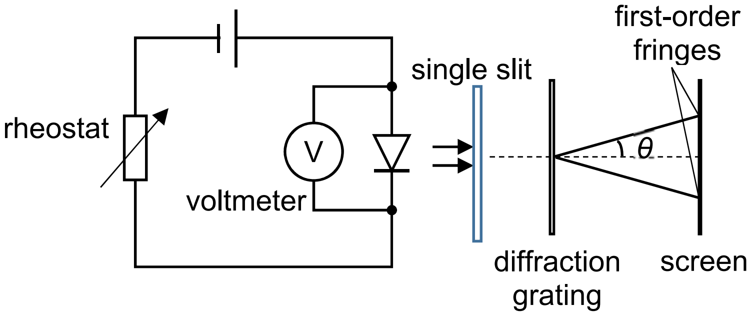

Fig. 4a

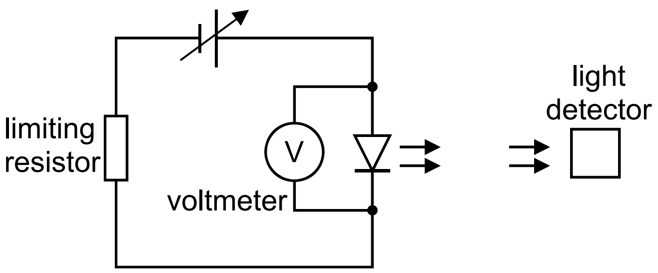

Fig. 4b

For Examiner's Use

[Total: 11 marks]

Diagram (max 2 marks):
Correct positioning of voltmeter and rheostat [D1]
Correct labelling of the various lengths to be measured for determining wavelength (e.g. slit to screen distance, distance between two slits and fringe separation for double slit interference method. [D1]
Measurement (max 2 marks):
Correctly identify means of measuring potential difference as voltmeter. [M1]
Correctly describe means of determining wavelength. For example, when using double slit, correctly identify apparatus for measuring slit to screen distance, distance between two slits and fringe separation and stating the correct equation for calculating wavelength. [M1]
Procedure (max 3 marks):
Correct identification of potential difference across LED as dependent variable and wavelength of light as independent variable. [P1]
Correctly state that to change wavelength, must use LED that gives light of different wavelengths. [P1]
Correctly describe when to record voltmeter reading as when the resistance of rheostat is slowly decreased from maximum till the LED light <u>first</u> lights up. [P1]
Analysis (max 2 marks):
Correctly states a hypothesis that relates potential difference across LED and wavelength. [D1]
Correctly state the graph to be plotted and that <u>a straight line graph will be obtained if the hypothesis is true</u> and how the constants can be determined. [D1]
Accuracy (max 1 mark):
States that experiment should be conducted in a dark room. [A1]
States that the intensity meter at a fixed distance from LED should be used to determine when first light is observed. [A1]
States that instead of measuring fringe separation between 0^{th} and first order maxima, measure distance across multiple maxima and take average. [A1]
Control variable (max 1 mark):
Distance between LED and intensity meter for detecting first light. [C1]

For Examiner's Use

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END OF PAPER

TEMASEK JUNIOR COLLEGE

2018 Preliminary Examination
Higher 2

PHYSICS

9749/01

Paper 1 Multiple Choice

14 September 2018
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Civics Group and Index Number on the Answer Sheet in the spaces provided.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers, **A**, **B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/{}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$
	$= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = Q/(4\pi\varepsilon_0 r)$
alternating current / voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ the liquid. The speed is given by the equation

$$v = k\left(\frac{\Delta P}{\rho}\right)^n$$

where k is a constant that has no unit.

What is the value of n?

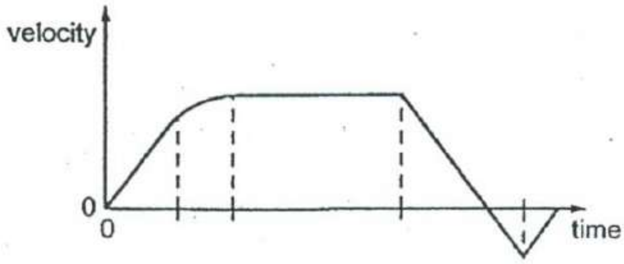
A 0.5 **B** 1 **C** 1.5 **D** 2

2 The diameter D of a sphere is measured to be 5.0 cm with a fractional uncertainty of 0.02.

What is the absolute uncertainty and fractional uncertainty of the radius R of the sphere?

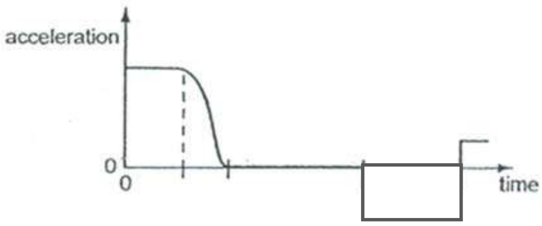
	absolute uncertainty of R	fractional uncertainty of R
A	0.05 cm	0.01
B	0.1 cm	0.01
C	0.05 cm	0.02
D	0.1 cm	0.02

3 A velocity-time graph of a journey is shown in the diagram.

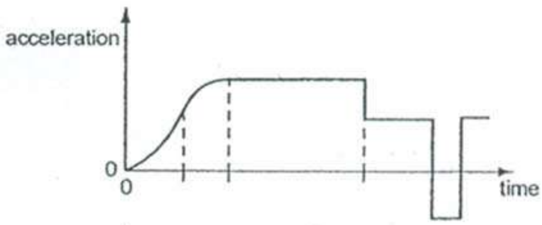


What is the shape of the acceleration-time graph for the same journey?

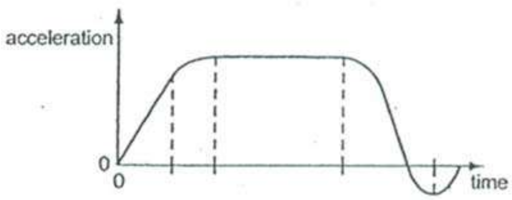
A



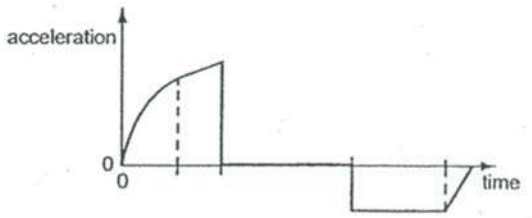
B



C



D

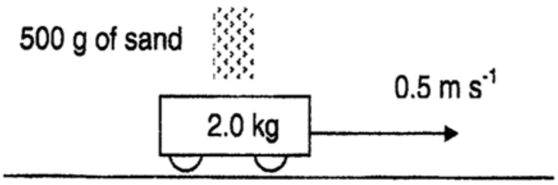


4 A hot-air balloon is moving vertically upwards with a constant speed of 3.00 m s^{-1}. A sandbag is dropped from the balloon. It takes 5.00 s for the sandbag to fall to the ground.

What was the height of the balloon when the sandbag was released?

A 29 m **B** 108 m **C** 123 m **D** 138 m

5 The diagram shows a 2.0 kg trolley moving on a frictionless horizontal table at a speed of 0.5 m s^{-1} and 500 g of sand is then released onto the trolley.

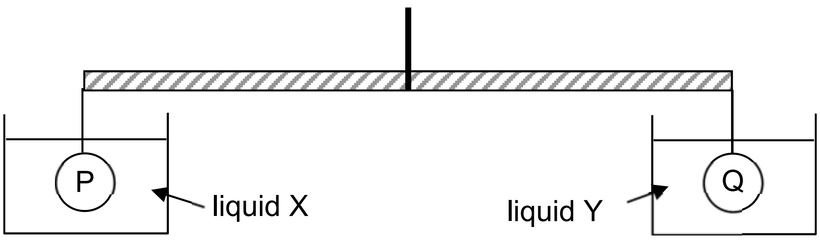


What is the change in the momentum of the trolley?

A zero **B** 0.15 N s

C 0.20 N s **D** 1.80 N s

6 Two objects P and Q having the same volume are hung at either ends of a light uniform rod and subsequently submerged in two different liquids X and Y respectively. The density of liquid X is less than that of liquid Y. The system is balanced when a string is hung right at the centre of the rod as shown in the figure below.



Which of the following statements is correct?

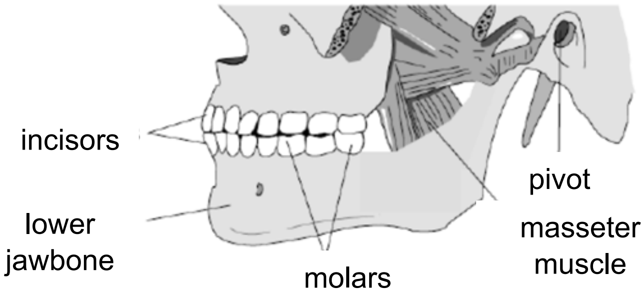
A Mass of P is larger than mass of Q.

B Mass of P is smaller than mass of Q.

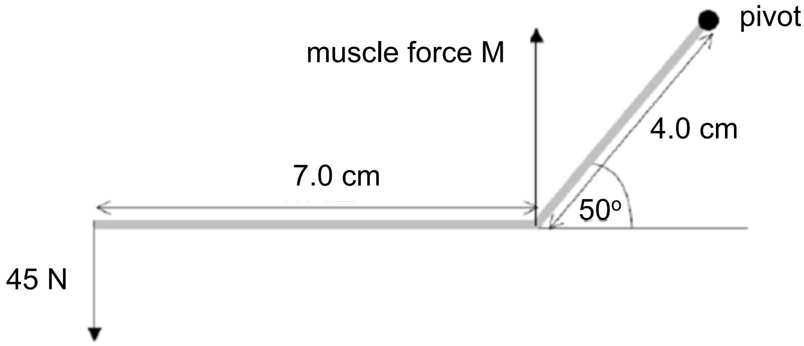
C P and Q experience the same magnitudes of upthrust.

D Upthrust acting on P is larger than the upthrust acting on Q.

7 The diagram below shows the position of a person's lower jawbone.



The lower jaw may be represented by the diagram below.

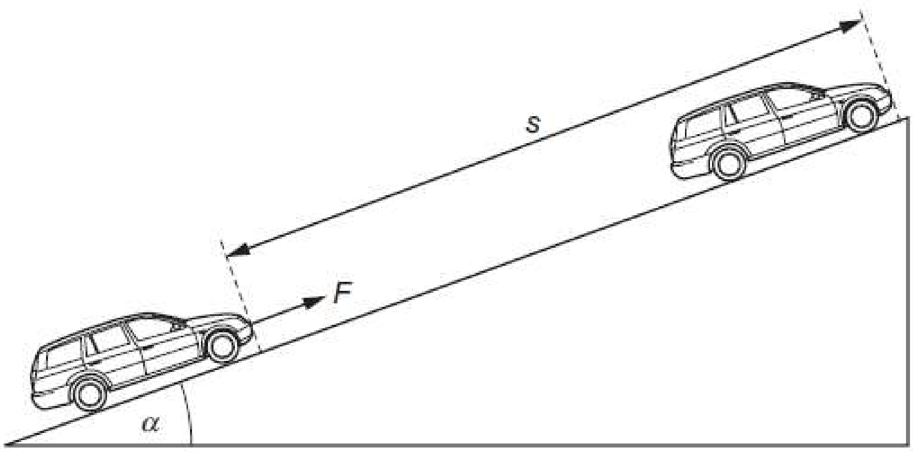


The jawbone has negligible mass. It consists of two straight parts of length 7.0 cm and 4.0 cm making an angle of 130° with each other. During one particular bite, a force of 45 N is applied by the teeth at the front of the jawbone.

What is the magnitude of muscle force M?

A 120 N **B** 140 N **C** 150 N **D** 170 N

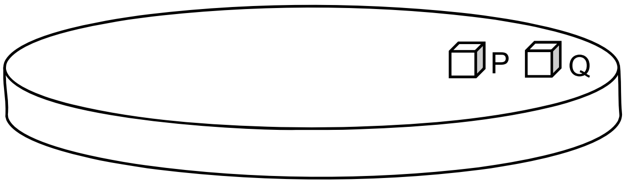
8 A constant force *F*, acting on a car of mass *m*, moves the car up a slope through a distance *s* at constant velocity *v*. The angle of the slope to the horizontal is α.



What is the ratio $\dfrac{\text{gravitational potential energy gained by car}}{\text{work done by force } F}$?

A $\dfrac{mgs\sin\alpha}{Fv}$ **B** $\dfrac{mv}{Fs}$ **C** $\dfrac{mv^2}{2Fs}$ **D** $\dfrac{mg\sin\alpha}{F}$

9 Two identical objects rest on a flat rough circular disc.



The disc starts from rest and starts spinning about its central axis with increasing rate. When the disc spins at a certain rate, one of the objects slides off the disc.

Which of the following statements is correct?

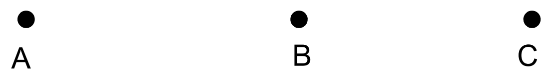
A The friction experienced by P and Q are always equal.

B P experiences larger friction than Q.

C Q will start to slide first due to larger angular velocity.

D Q will start to slide first due to larger radius.

10 Two points in space, A and B, have gravitational potentials of -7.0 J kg^{-1} and -3.0 J kg^{-1} respectively as shown below.



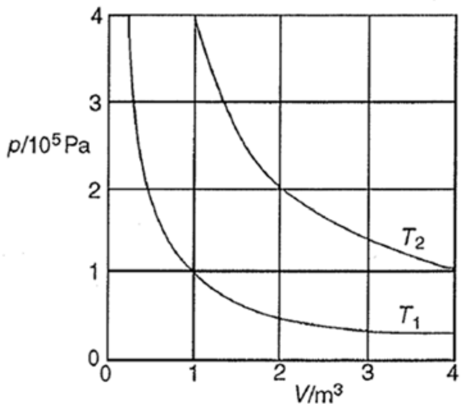
ϕ_A = -7.0 J kg^{-1} ϕ_B = -3.0 J kg^{-1} ϕ_C = ?

When a mass is moved from A to B, it gains gravitational potential energy of 20 J. When it is moved from B to C, it loses gravitational potential energy of 5.0 J.

What is the gravitational potential at C?

A - 8.0 J kg^{-1} **B** - 4.0 J kg^{-1} **C** - 2.0 J kg^{-1} **D** 2.0 J kg^{-1}

11 The two curves shown below are for a fixed mass of an ideal gas.



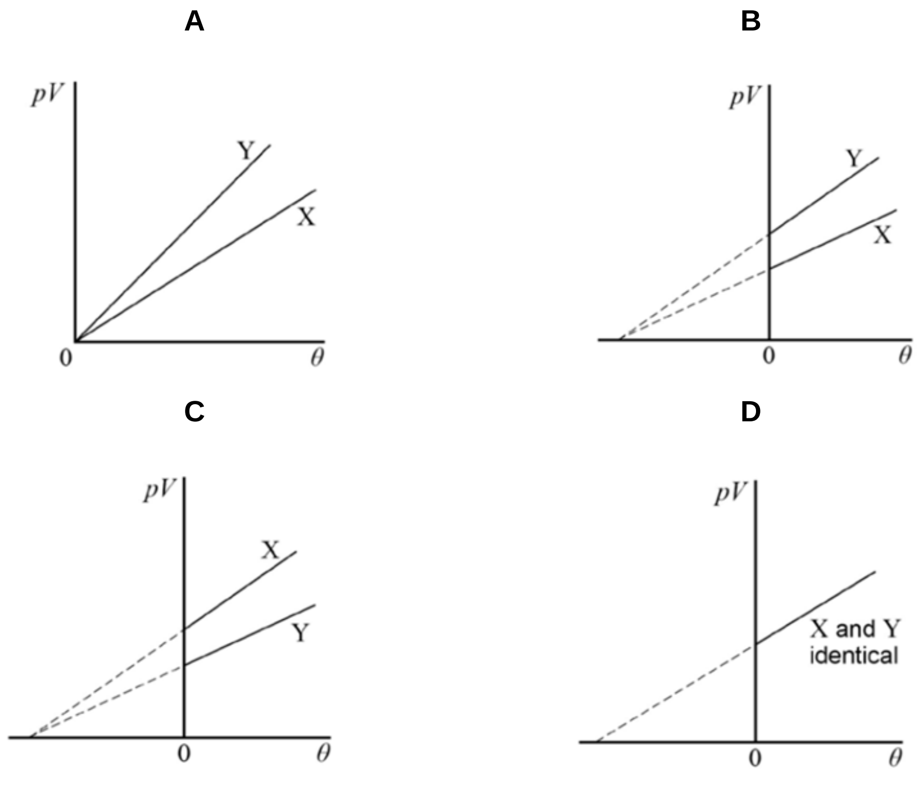
What is the ratio $\frac{\text{r.m.s. speed of the molecules at temperature } T_2}{\text{r.m.s. speed of the molecules at temperature } T_1}$?

A $\sqrt{2}$ **B** 2 **C** $2\sqrt{2}$ **D** 4

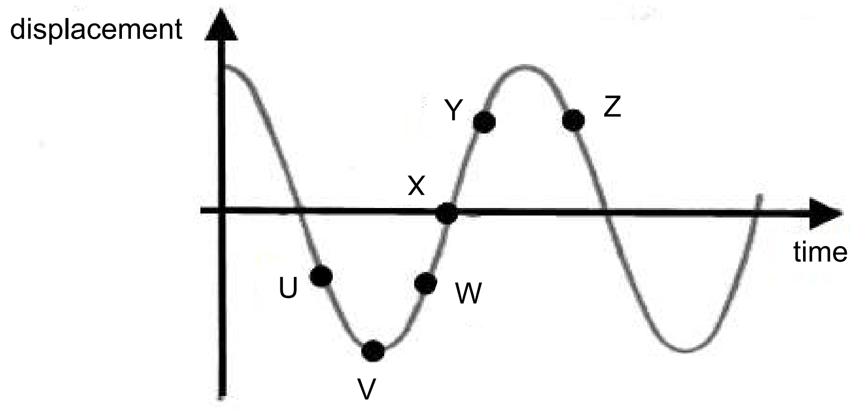
12 One mole of gas occupies a volume V at a pressure p and Celsius temperature θ. The graphs, **A** to **D**, show variation of pV with θ.

Line X is for one mole of nitrogen and line Y is for one mole of oxygen.
Relative molecular mass of nitrogen = 28
Relative molecular mass of oxygen = 32

Assuming both gases behave ideally, which of the following graphs is correct?



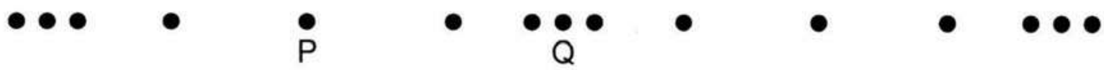
13 The diagram below shows a displacement-time graph of a body performing simple harmonic motion.



At which points, U, V, W, X, Y or Z, are the body travelling *and* accelerating in the opposite direction?

A U, Y **B** V, X **C** W, Z **D** X, Z

14 The diagram illustrates the displacement of particles in a longitudinal progressive waves of frequency *f* at an instant of time.



What is the time taken for a wavefront to travel the distance from P to Q?

A $\frac{1}{4f}$ **B** $\frac{1}{2f}$ **C** $\frac{1}{f}$ **D** $\frac{2}{f}$

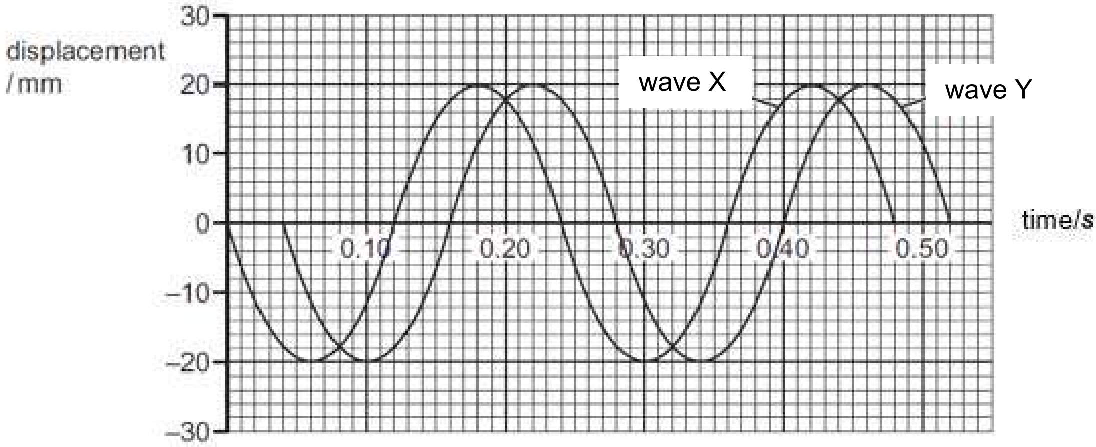
15 Plane polarised light of amplitude A is incident on a polarising filter aligned so that no light is transmitted.

The filter is now rotated through an angle of 30°.

What is the amplitude of the transmitted light?

A 0.25 A **B** 0.50 A **C** 0.75 A **D** 0.87 A

16 The diagram shows the variation with time of the displacement of two transverse progressive waves, X and Y.



Which of the following statements is correct?

A Wave X leads wave Y by $\pi/4$ rad.

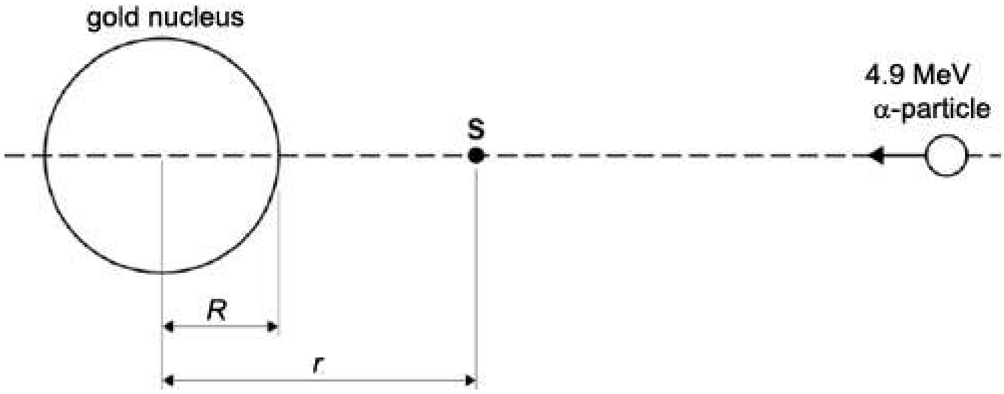
B Wave X lags wave Y by $\pi/4$ rad.

C Wave X leads wave Y by $\pi/3$ rad.

D Wave X lags wave Y by $\pi/3$ rad.

17 An α-particle with an initial kinetic energy of 4.9 MeV is directed towards the centre of a gold nucleus of radius *R* which contains 79 protons. The radius *R* of the gold nucleus is found to be 1.4×10^{-14} m.

The α-particle is brought to rest at point S, a distance *r* from the centre of the nucleus as shown in the figure.



What is the distance *r* of the α-particle to the nucleus?

A 1.4×10^{-14} m **B** 4.6×10^{-14} m **C** 2.2×10^{-7} m **D** 4.4×10^{-7}m

18 A wire of resistance R is melted and re-casted to half its original length.

What is the new resistance of the wire?

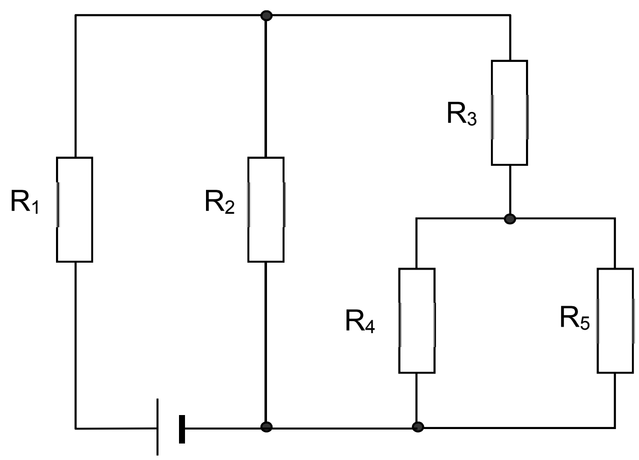
A $R/4$ **B** $R/2$ **C** R **D** $2R$

19 The potential difference across a resistor is 12 V. The current in the resistor is 2.0 A. A charge of 4.0 C passes through the resistor.

What is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

	energy/J	time/s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

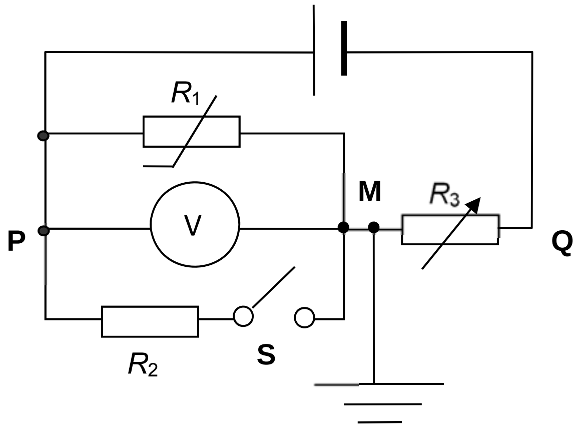
20 Each of the five resistors shown has the same resistance.



Which resistor will have the greatest potential difference across it?

A R_1 **B** R_2 **C** R_3 **D** R_4

21 A NTC thermistor R_1 is connected to an ideal battery of constant e.m.f. with two other resistors R_2 and R_3.



Assume that the voltmeter has infinite resistance.

Which of the following actions will cause an increase in the potential difference *V* measured by the voltmeter?

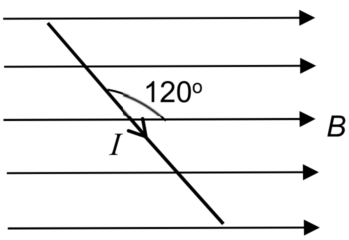
A Increase the temperature of the thermistor with S open

B Remove the earth connection at M with S open

C Close switch S

D Decrease resistance R_3 with S open

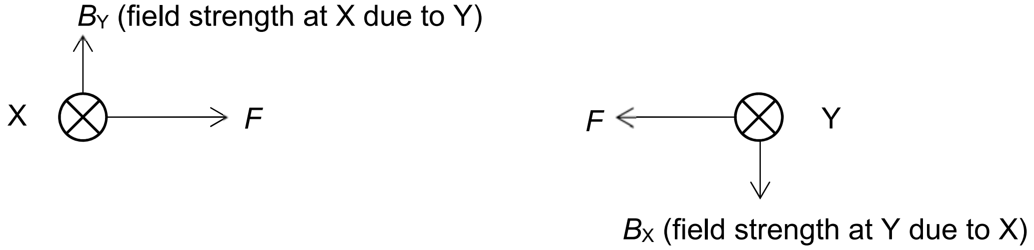
22 A wire 30 cm long with a mass of 4.0 g, is placed at an angle of 120° to a horizontal magnetic field of flux density 0.040 T. When a current *I* is passed through the wire, the wire accelerates uniformly upwards. The diagram below shows the top view of the set-up.



If the acceleration of the wire is 2.0 m s^{-2}, what is the current in the wire?

A 7.9 A **B** 4.5 A **C** 3.0 A **D** 0.77 A

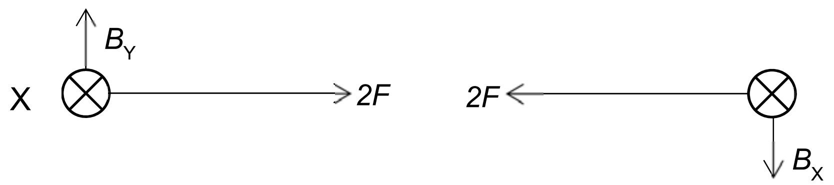
23 Two long, parallel, straight wires X and Y carry equal currents into the plane of the page as shown. The diagram shows arrows representing the magnetic field strength *B* at the position of each wire and the magnetic force *F* on each wire.



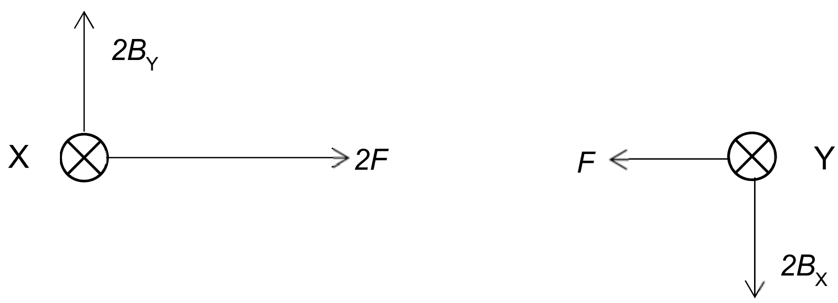
The current in wire Y is doubled. Which diagram best represents the magnetic field strengths and forces?

A

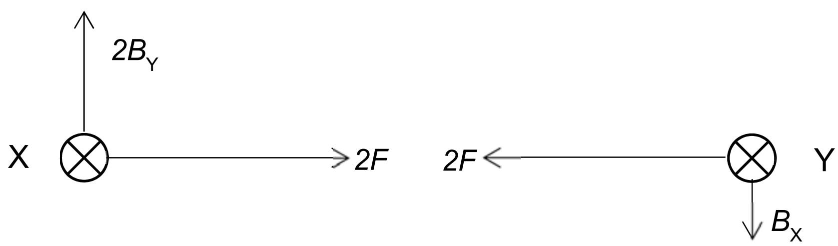
B



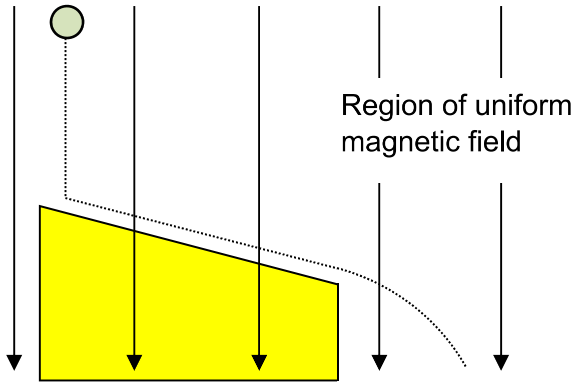
C



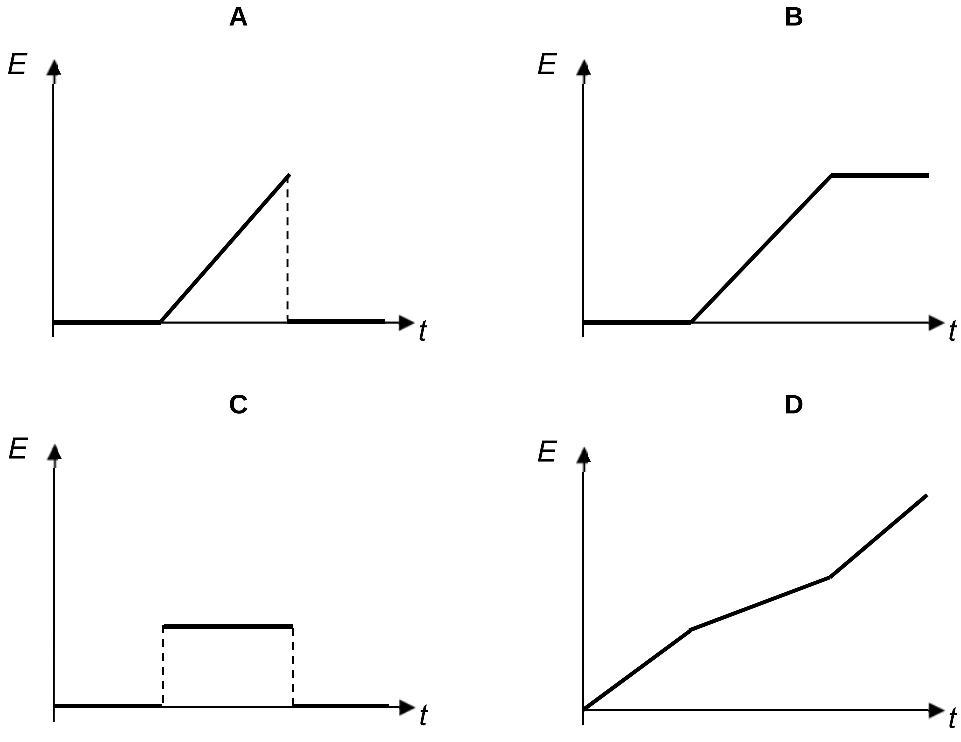
D



24 In a region of uniform magnetic field, a metal rod falls vertically from rest and lands on to a smooth slope. It continues to roll down the slope and launches off the slope as shown in the diagram.



Which graph best shows the variation with time t of the e.m.f E induced in the rod, from the time it is released?



25 A transformer with turns ratio of primary to secondary coil of 20:1 is 95% efficient due to joule heating effects.

A 240 V alternating voltage is connected to the primary coil and a 5.0 Ω resistor is connected to the secondary coil.

What is the current flowing in the primary coil?

A 48.0 A **B** 2.40 A **C** 0.126 A **D** 0.120 A

26 An alternating voltage *V*/V varies with time *t*/s according to the equation

$$V = 9\cos(100\pi t)$$

What is the mean power dissipated in a resistive load of 20 Ω?

A 2.0 W **B** 4.1 W **C** 6.4 W **D** 8.1 W

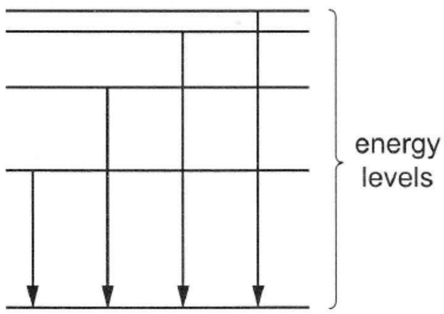
27 In 2010 the Japanese launched the world's first interplanetary solar sail spacecraft, called IKAROS. This works because photons reflected from the sail, of area A, undergo a change of momentum and, by Newton's third Law, exert a forward force on the sail.

A beam of light of intensity I is reflected at right angles to a solar sail.

If *f* is the frequency of the light, *h* is the Planck constant and *c* is the speed of light, what is the force exerted on the sail?

A $\dfrac{IA}{hf}$ **B** $\dfrac{2hf}{c}$ **C** $\dfrac{I}{c}$ **D** $\dfrac{2IA}{c}$

28 The diagram shows five electron energy levels in an atom and some transitions between them.



The line spectrum produced is in the visible spectrum and can be represented on a wavelength scale or a frequency scale.

Which diagram could represent the light emitted by the four transitions shown above?

A

B

C

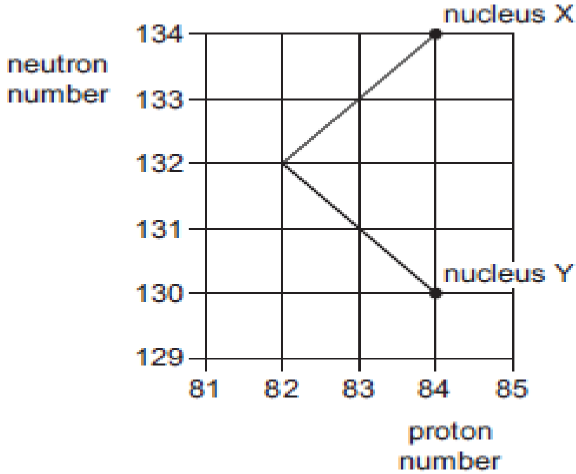
D

29 A detector is used for monitoring an *α*-source and a reading of 300 counts is observed. After a time equal to the half-life of the *α*-source, the reading has fallen to 155 counts.

If a 5 mm thick lead sheet is inserted between the *α*-source and the detector, what would the reading probably be?

A 0 counts **B** 5 counts **C** 10 counts **D** 20 counts

30 The graph of neutron number against proton number represents a sequence of radioactive decays.



Nucleus **X** is at the start of the sequence and, after the decays have occurred, nucleus **Y** is formed.

What is emitted during the sequence of decays?

A one α-particle followed by one β-particle

B one α-particle followed by two β-particles

C two α-particles followed by two β-particles

D two β-particles followed by one α-particle

TEMASEK JUNIOR COLLEGE
2018 Preliminary Examination
Higher 2

CANDIDATE NAME	
CIVICS GROUP	
INDEX NUMBER	

PHYSICS
9749/02

Paper 2 Structured Questions

24 August 2018
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST
Write your Civics group, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
Total	

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = Q/(4\pi\varepsilon_0 r)$
alternating current / voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 A skateboarder starts from rest at point A as shown in Fig. 1.1.

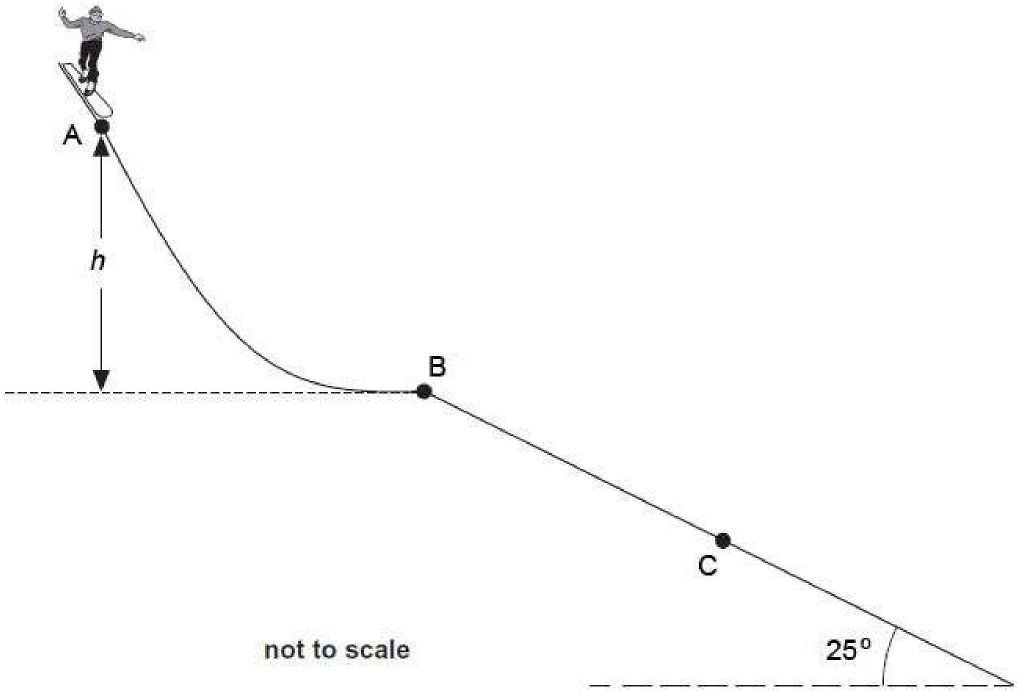


Fig. 1.1

The skateboarder reaches a speed of 17 m s^{-1} at point B.

Consider the skateboarder to be a point mass of 65 kg and ignore the effects of friction and air resistance.

(a) Calculate the height difference, h, between point A and point B.

h = ... m [2]

(b) The skateboarder takes off at point B, travelling horizontally with a velocity of 17 m s^{-1}. He lands at point C after being in the air for 1.6 s.

(i) Calculate v_v, the vertical component of his velocity, just before landing at point C.

v_v = ... m s^{-1} [2]

(ii) On Fig. 1.2, sketch the variation with time of the vertical component of the velocity v_v of the skateboarder from point B to point C.

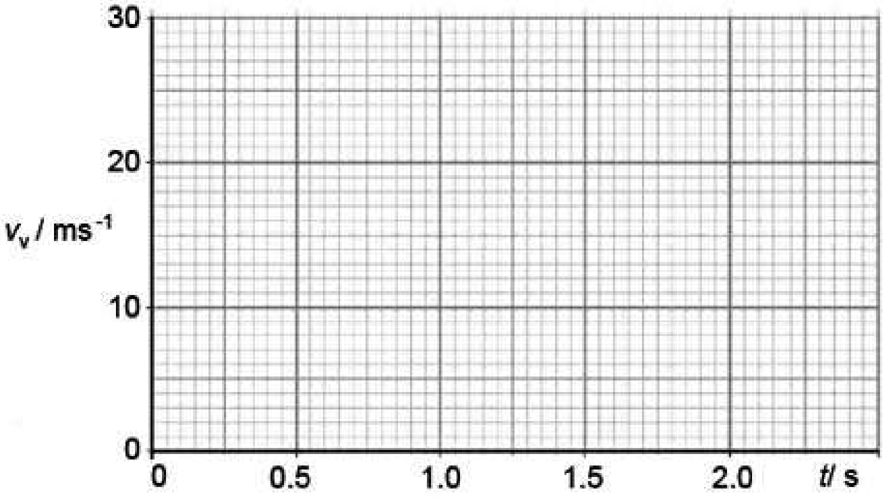


Fig. 1.2 [2]

(iii) Show that the magnitude of the resultant velocity just before landing at point C is 23 m s^{-1}.

[1]

(c) Explain why it is safer for the skateboarder to land on a downward slope than on a horizontal surface.

....

....

....

....

.... [2]

2 A rod PQ is attached at P to a vertical wall, as shown in Fig. 2.1.

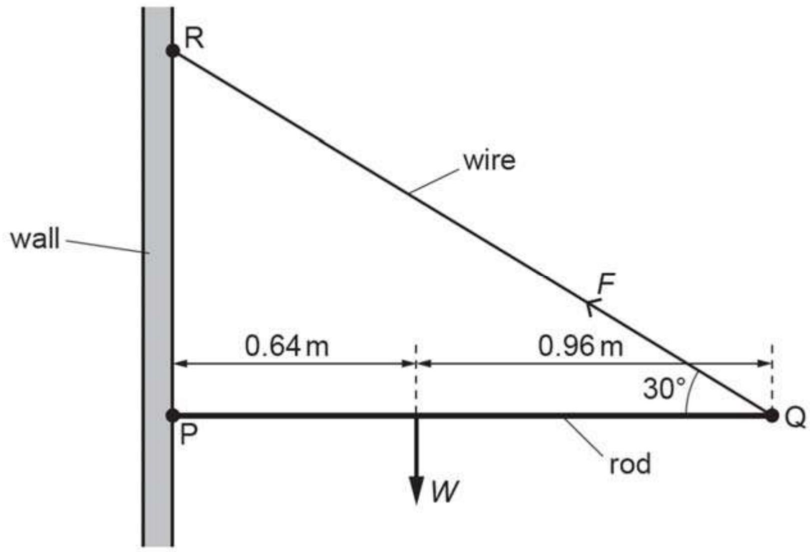


Fig. 2.1

The length of the rod is 1.60 m. The weight *W* of the rod acts at 0.64 m from P. The rod is kept horizontal and in equilibrium by a light wire attached to Q and to the wall at R. The wire provides a force *F* of 44 N on the rod at 30° to the horizontal.

(a) Determine

(i) the vertical component of *F*,

vertical component = ... N [1]

(ii) the horizontal component of *F*.

horizontal component = ... N [1]

(b) Determine the weight *W* of the rod.

W = ... N [2]

(c) Explain why the wall must exert a force on the rod at P to keep the rod in equilibrium.

....

....

....

.... [2]

(d) On Fig. 2.1, draw an arrow to represent the force acting on the rod at P. Label your arrow with the letter S. Explain how you arrive at the answer.

....

....

.... [2]

(e) Fig. 2.2 and Fig. 2.3 show two set-ups where the wire is attached to a different point on the rod.

Draw an arrow on each figure to represent the force acting on the rod at P. Label your arrows with the letter S_1 and S_2 respectively.

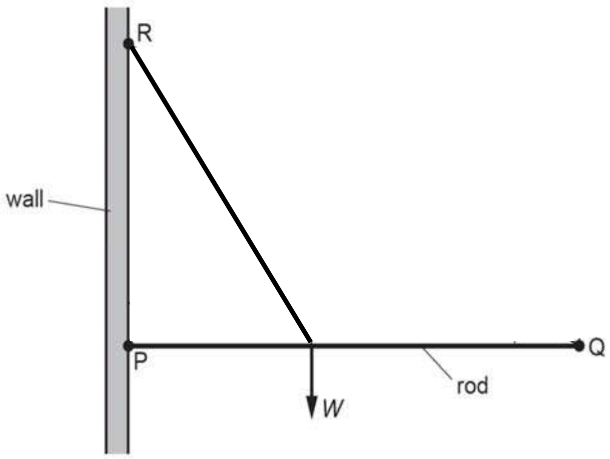


Fig. 2.2

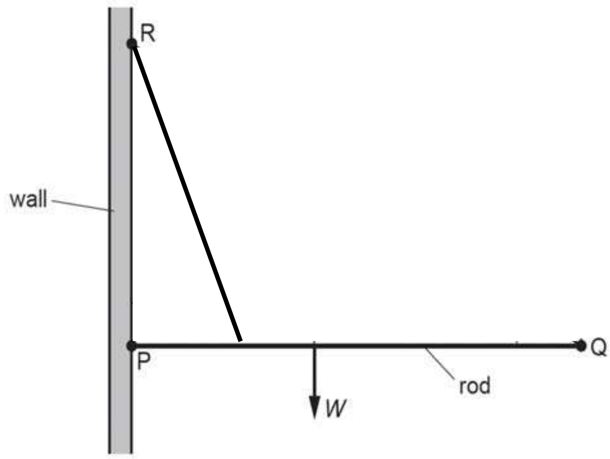


Fig. 2.3

[2]

3 **(a)** **(i)** State one difference between a stationary wave and a progressive wave.

....

....

....

.... [1]

(ii) State why electromagnetic waves can be polarised but sound waves cannot be polarised.

....

.... [1]

(b) In Fig. 3.1, T_1 and T_2 are two adjacent transmitters 1.0 m apart with a receiver aerial R at mid-point between them. The transmitters are set up to emit polarised coherent microwaves of wavelength 3.0 cm.

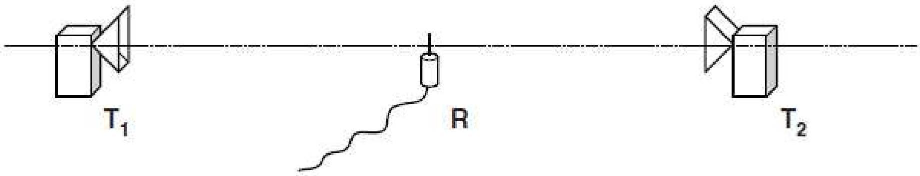


Fig. 3.1

(i) A student observes that the signal at the receiver R falls from maximum to zero when receiver R moved 0.75 cm towards a transmitter.

Explain these observations.

....

....

....

....

....

....

....

....

.... [4]

(ii) With R at the mid-point between T_1 and T_2, the student rotates T_2 through 90^o about an axis through T_1 and T_2 as shown in Fig. 3.2.

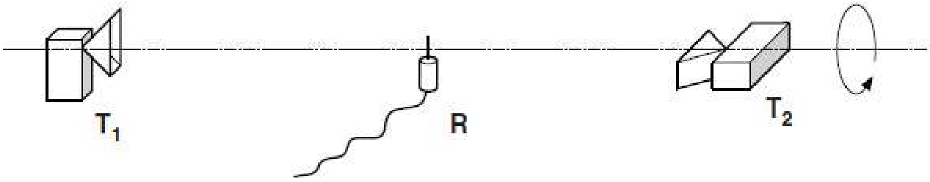


Fig. 3.2

The student observes that the intensity of the signal at R is halved.

The detected signal remains the same when R is moved 0.75 cm towards a transmitter.

Explain these observations.

....

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....

....

....

....

....

....

.... [3]

4 A d.c. power supply of e.m.f. 8.7 V and negligible internal resistance is connected by two identical connecting wires to three identical filament lamps, as shown in Fig. 4.1.

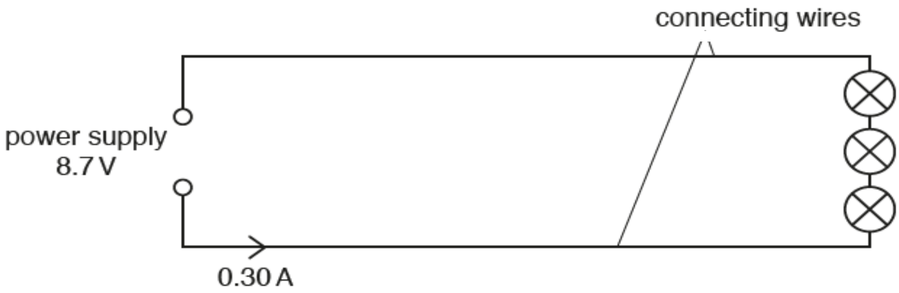


Fig. 4.1

The power supply provides a current of 0.30 A to the circuit.

The *I* –*V* characteristic for one of the lamps is shown in Fig. 4.2.

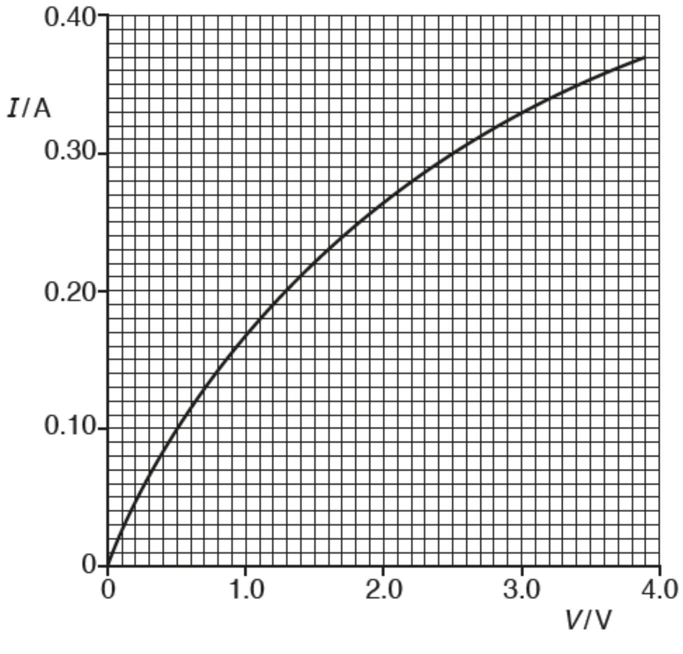


Fig. 4.2

(a) Show that the resistance of each connecting wire in Fig. 4.1 is 2.0 Ω.

[3]

(b) The resistance of the connecting wires does not vary with temperature.
On Fig. 4.2, sketch the *I*–*V* characteristic for **one** of the connecting wires. [2]

(c) Calculate the power loss in one of the connecting wires.

power loss = ... W [1]

(d) Some data for the connecting wires are given below.

cross-sectional area = 0.40 mm^2
resistivity = 1.7×10^{-8} Ω m
number density of free electrons = 8.5×10^{28} m^{-3}

Calculate

(i) the length of one of the connecting wires,

length = ... m [2]

(ii) the drift speed of a free electron in the connecting wires.

drift speed = ... m s^{-1} [2]

5 **(a)** A particle has mass *m*, charge +*q* and speed *v*.

State the magnitude and direction of the force, if any, on the particle when the particle is travelling along the direction of

(i) a uniform gravitational field of field strength *g*,

....

.... [2]

(ii) a uniform magnetic field of flux density *B*.

....

.... [1]

(b) Two charged horizontal metal plates, situated in a vacuum, produce a uniform electric field of field strength *E* between the plates. The field strength outside the region between the plates is zero.

The particle in **(a)** enters the region of the electric field at right-angles to the direction of the field, as illustrated in Fig. 5.1.

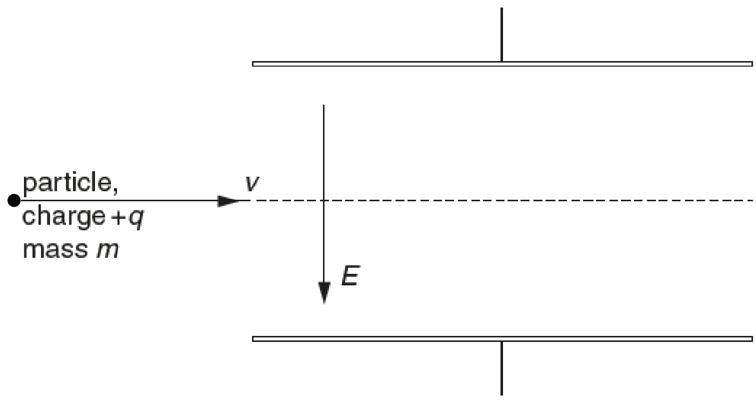


Fig. 5.1

A uniform magnetic field is applied in the same region as the electric field so that the particle passes undeviated through the region between the plates.

(i) State the direction of the magnetic field.

....

.... [1]

(ii) Derive, with clear explanations, an expression for the speed *v* in terms of the magnitudes of the electric field strength *E* and the magnetic flux density *B*.

[2]

(c) The same particle in (a) now enters a non-uniform magnetic field *B* at an angle θ with the horizontal as shown in Fig. 5.2.

By considering the components of the velocity parallel to and at right angles to the magnetic field, explain the subsequent path of the charged particle in the field.
Draw a sketch to illustrate the path in Fig. 5.2.

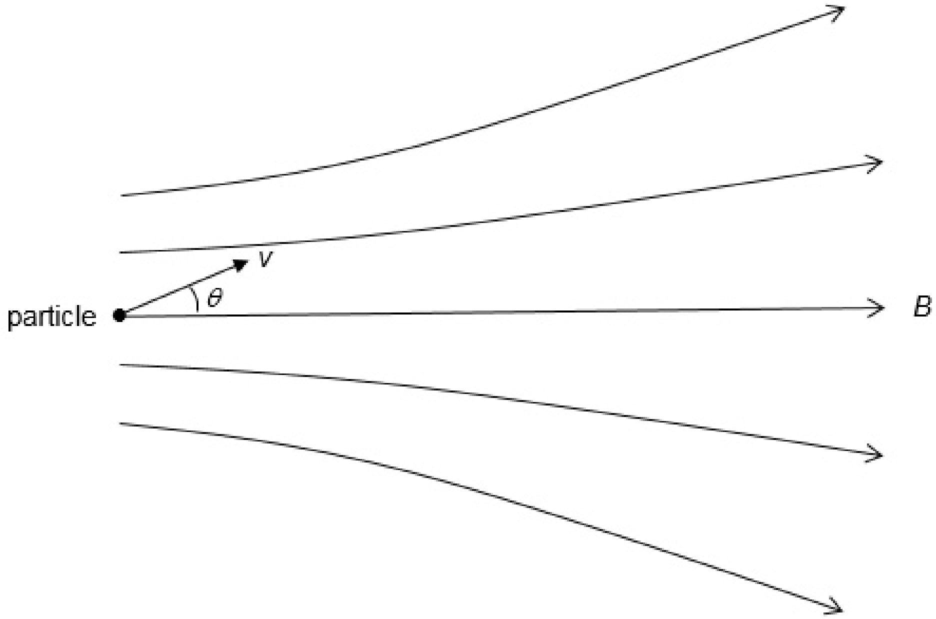


Fig. 5.2

....

....

....

.... [4]

6 **(a)** Explain what is meant by *binding energy* of a nucleus.

....

....

.... [1]

(b) **(i)** Give a sketch on Fig. 6.1 to show the variation of the binding energy per nucleon with nucleon number.

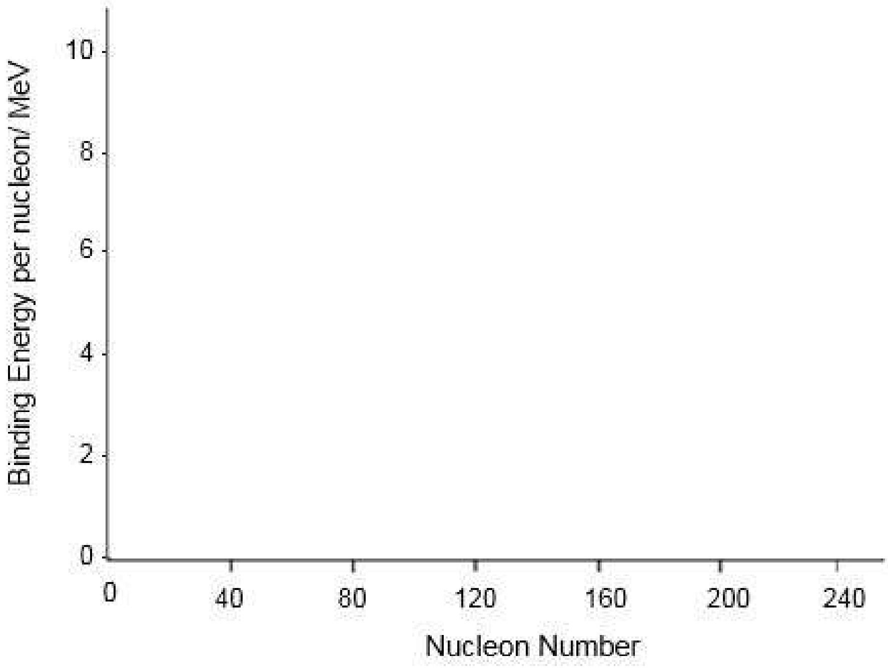


Fig. 6.1 [2]

(ii) With reference to your sketch in Fig. 6.1, explain how fission can be a potential source of energy.

....

....

.... [1]

(c) When a Uranium-235 nucleus undergoes fission, two nuclides are produced with the release of energy as shown in the equation below.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{139}_{54}Xe + ^{95}_{38}Sr + 2\,^{1}_{0}n$$

The masses of the nuclides are as follows:

nuclide	mass
$^{235}_{92}U$	235.043929 u
$^{139}_{54}Xe$	138.918793 u
$^{95}_{38}Sr$	94.919359 u
$^{1}_{0}n$	1.008665 u

(i) Explain how a chain reaction is able to occur for this nuclear fission.

....

.... [1]

(ii) Calculate the energy released in one reaction.

energy released = ... J [3]

(iii) Singapore's energy consumption in 2017 was approximately 50 TWh. Assuming an efficiency of 8.0 %, determine how long (in months) that the energy released from the fission of 2.0 kg of Uranium can be used to power Singapore.

time = ... months [4]

7 The decay of radioactive materials is a *random* process. On average, nuclides which decay quickly exist only for a short period of time, while nuclides which decay slowly last longer. One difficulty that arises with these calculations is when the radioactive material is a mixture of two or more nuclides. This question considers the case when a mixture of two radioactive nuclides is present. In decommissioning a nuclear power station, this difficulty is compounded by the presence of about a hundred different radioactive nuclides in significant quantities.

(a) Explain what it means to say that radioactive decay is a *random* process.

....

....

....

.... [2]

(b) State two physical quantities which do not cause a change in the rate of decay of a radioactive material.

1. ....

2. .... [2]

(c) Fig. 7.1 gives the variation with time of the total activity A_{mix} of a mixture of cobalt and nickel together with the separate activities A_c and A_N due to cobalt and nickel.

time/year	A_c / Bq	A_N / Bq	A_{mix} / Bq	ln (A_{mix} / Bq)
0	6900	250	7150	8.87
5	3540	241	3781	8.24
10	1820	232	2052	7.63
20	479	215	694	6.54
30	126	199	325	5.78
40	33.3	185	218	5.39
50	8.79	172	181	5.20
60	2.32	159	161	5.08
70	0.611	147	148	4.99
80	0.161	137	137	4.92
90	0.425	127	127	4.85
100	0.0112	118	118	4.77

Fig. 7.1

Fig. 7.2 shows the variation of ln A_{mix} with respect to time.

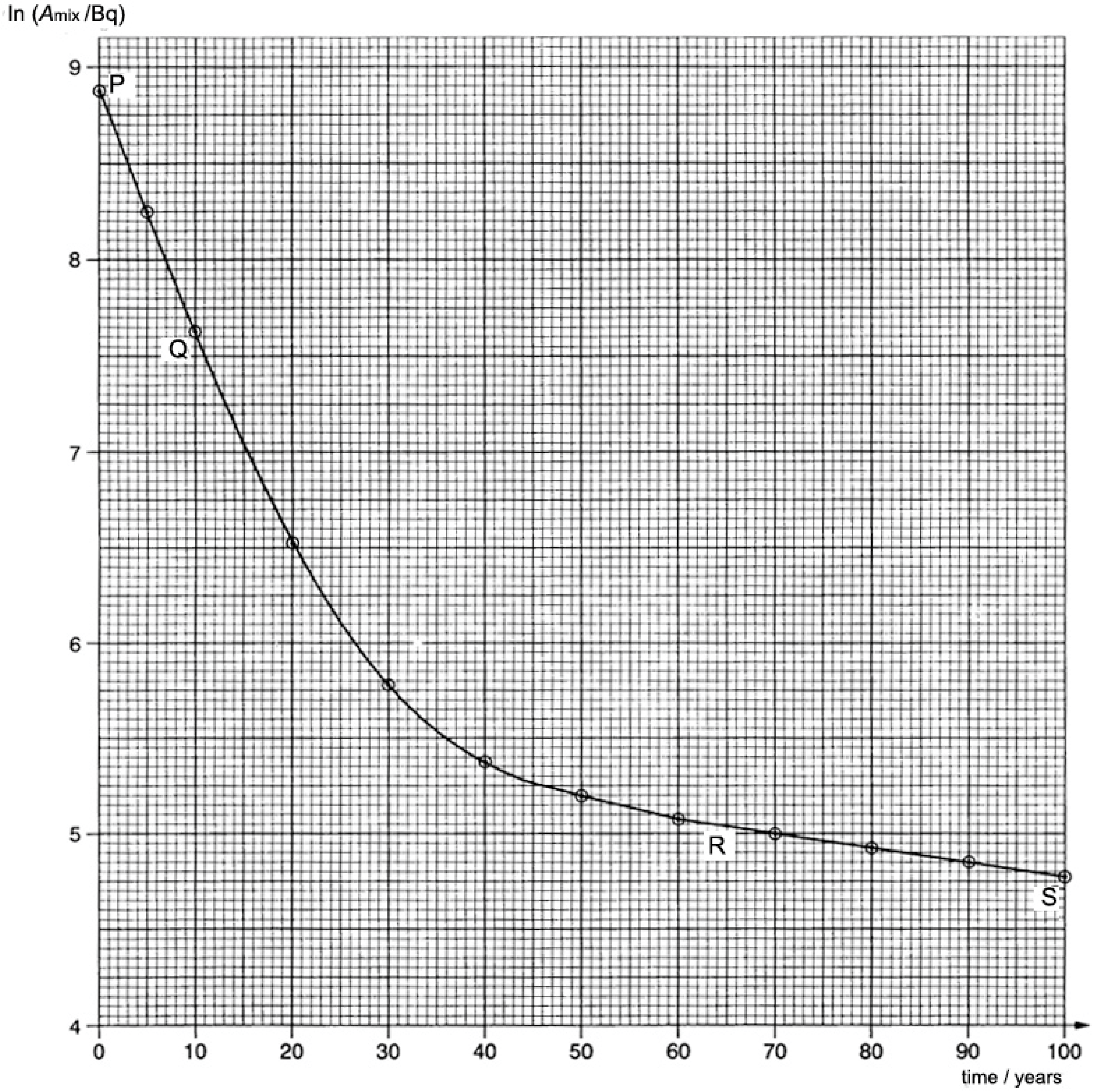


Fig. 7.2

(i) Explain the following:

1. PQ on the graph corresponds mainly to the decay of cobalt.

....

....

.... [2]

2. RS on the graph corresponds mainly to the decay of nickel.

....

....

.... [1]

3. The shape of QR is a curve.

....

....

....

.... [2]

(ii) Determine the gradients of

1. PQ,

2. RS.

gradient of PQ = ... $year^{-1}$

gradient of RS = ... $year^{-1}$ [4]

(iii) Given that the general decay law is of the form $x = x_o \exp(-\lambda t)$, use the gradients found in **(ii)** to estimate values of the decay constants for the cobalt and the nickel nuclides.

decay constant of cobalt = ... $year^{-1}$

decay constant of nickel = ... $year^{-1}$ [1]

(iv) Use your answer to **(iii)** to calculate the half-lives of the cobalt and nickel.

half-life of cobalt = ... years

half-life of nickel = ... years [3]

(d) In an actual reactor, activities of radioactive materials can often be 10^{12} times larger than those given in Fig. 7.1. Explain when and why each of these two nuclides would pose the greater hazard.

....

....

....

....

....

....

....

.... [3]

TEMASEK JUNIOR COLLEGE
2018 Preliminary Examination
Higher 2

CANDIDATE NAME	

CIVICS GROUP		INDEX NUMBER	

PHYSICS 9749/03

Paper 3 Longer Structured Questions

13 September 2018
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Civics group, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$
	$= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = Q/(4\pi\varepsilon_0 r)$
alternating current / voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this section in the spaces provided.

1 A solar propulsion engine uses solar power to ionize and accelerate atoms of xenon. The speed of the ejected xenon ions relative to the spaceship is 3.0×10^4 m s^{-1} as shown in Fig. 1.1.

Fig. 1.1

Fig. 1.2 shows the variation with time t of the acceleration a of the spaceship as a result of the ejection of xenon ions.

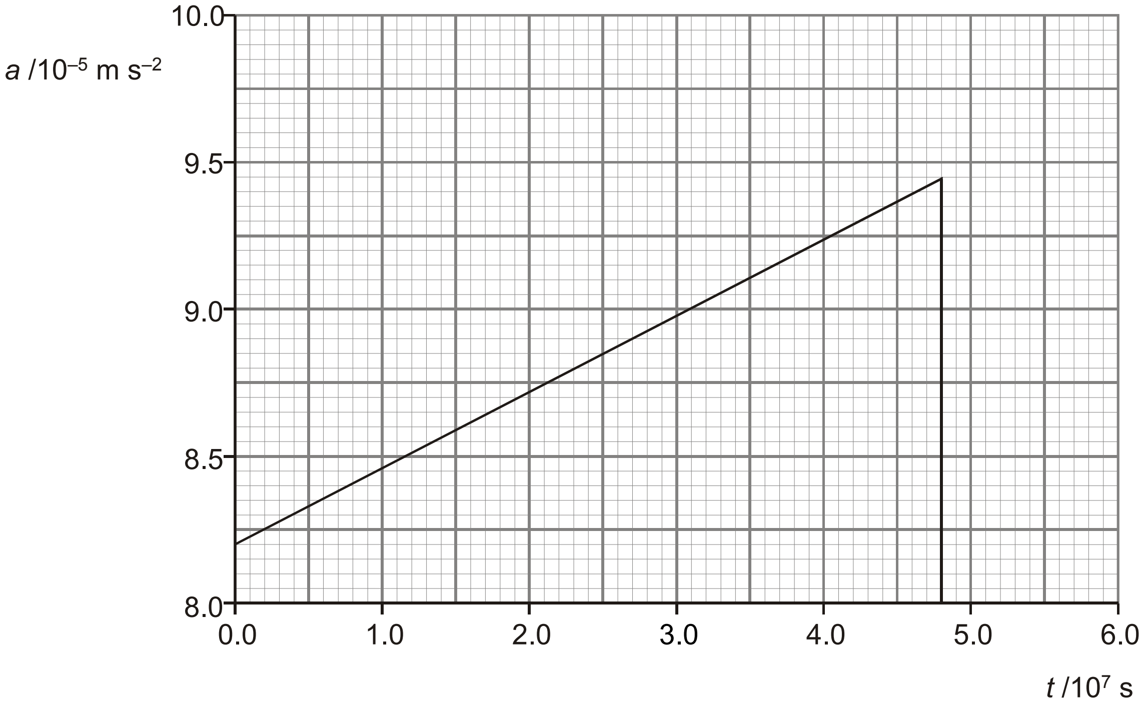


Fig. 1.2

(a) The xenon ions are ejected at a constant rate of 1.7×10^{-6} kg s^{-1}. Calculate the force exerted on the spaceship by the xenon ions.

force = ... N [2]

(b) Explain why the acceleration of the spaceship is increasing with time.

....

....

.... [1]

(c) The solar propulsion engine is switched on at time t = 0 when the initial velocity of the spaceship is zero.

Use Fig. 1.2 to determine the final velocity of the spaceship when the fuel runs out.

velocity = ... m s^{-1} [3]

(d) Sketch on Fig. 1.3 the corresponding variation with time t of the velocity v of the spaceship from t = 0 to t = 6.0 x 10^7 s.

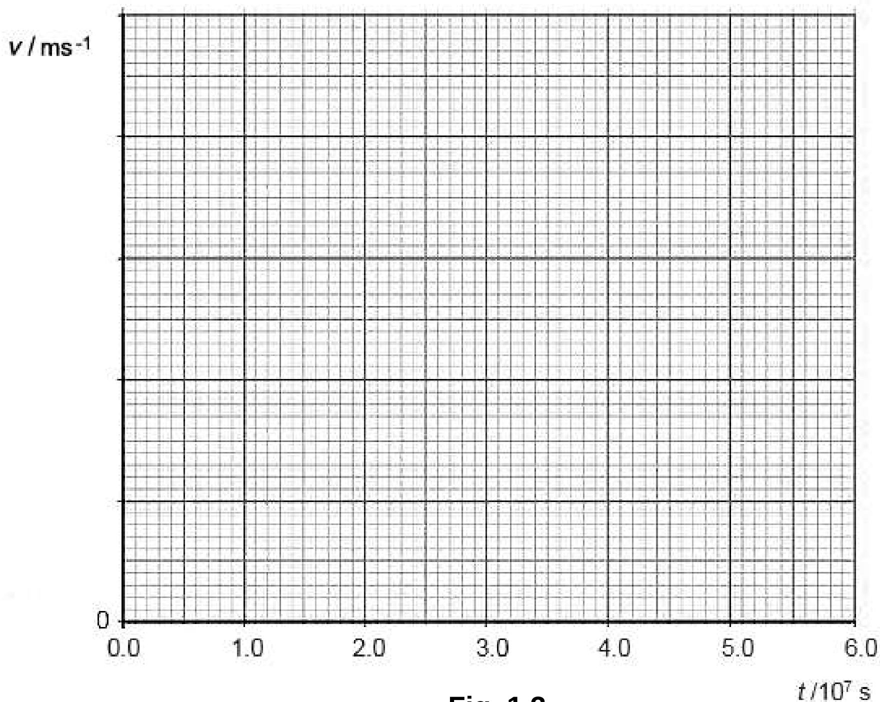


Fig. 1.3

[2]

2 **(a)** Explain what is meant by *escape speed*.

....

.... [1]

(b) A planet has radius R and the acceleration of free fall at its surface is g. The planet may be considered to be a sphere with its mass concentrated at its centre.

Deduce that the escape speed v_{es} is given by the expression

$$v_{es} = \sqrt{2gR}$$

Explain your working and state **one** assumption that is made in the derivation.

Assumption: ....

.... [3]

(c) Calculate the escape speed for a spherical planet of radius 1.7 x 10^3 km having an acceleration of free fall of 1.6 m s^{-2} at its surface.

speed = ... m s^{-1} [2]

(d) The mean translational kinetic energy E_K of a helium-4 atom at thermodynamic temperature T is given by the expression

$$E_K = \frac{3}{2}kT$$

where k is Boltzmann's constant.

Determine the surface temperature of the planet such that helium-4 atoms on the surface of the planet are able to reach the escape speed calculated in **(c)**.

temperature = ... K [2]

(e) Suggest **one** reason why, at temperatures below that calculated in **(d)**, helium atoms can still escape from the planet.

....

....

.... [1]

3 **(a)** A block of mass 0.40 kg slides in a straight line with a constant speed of 0.30 m s^{-1} along a smooth horizontal surface, as shown in Fig. 3.1.

Fig. 3.1

The block hits a spring and decelerates. The speed of the block becomes zero when the spring is compressed by 8.0 cm.

(i) Calculate the initial kinetic energy of the block.

kinetic energy = ... J [1]

(ii) The variation of the compression x of the spring with the force F applied to the spring is shown in Fig. 3.2.

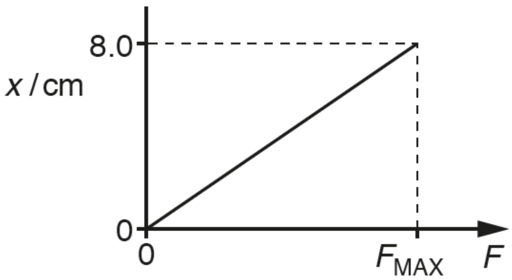


Fig. 3.2

Use your answer in **(a)(i)** to determine the maximum force F_{MAX} exerted on the spring by the block. Explain your working.

F_{MAX} = ... N [2]

(iii) Calculate the maximum deceleration of the block.

deceleration = ... m s^{-2} [1]

(iv) State and explain whether the block is in equilibrium

1. before it hits the spring,

....

....

2. when its speed becomes zero.

....

.... [2]

(b) The energy E stored in a spring is given by

$$E = \frac{1}{2}kx^2$$

where k is the spring constant of the spring and x is its compression.

The mass m of the block in **(a)** is now varied. The initial speed of the block remains constant and the spring continues to obey Hooke's law.

On Fig. 3.3, sketch the variation with mass m of the maximum compression x_0 of the spring.

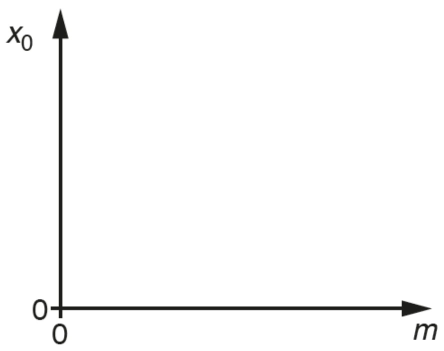


Fig. 3.3

[2]

4 A rigid flat plate is made to vibrate vertically with simple harmonic motion. The frequency of the vibration is controlled by a signal generator as shown in Fig. 4.1.

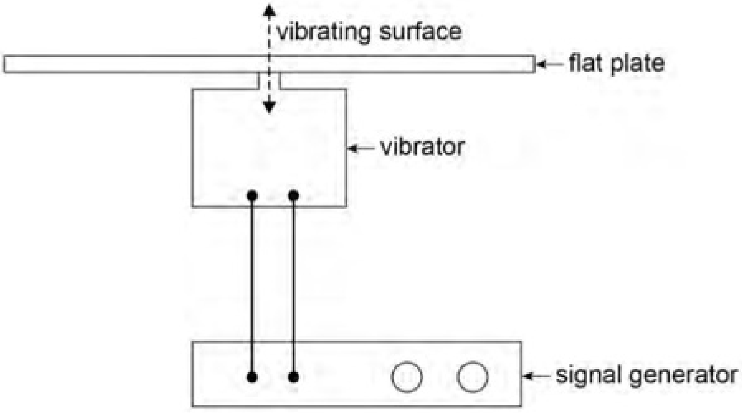


Fig. 4.1

Taking upward direction as positive, the variation with time *t* of the velocity *v* for the vibrating plate at one frequency is shown in Fig. 4.2.

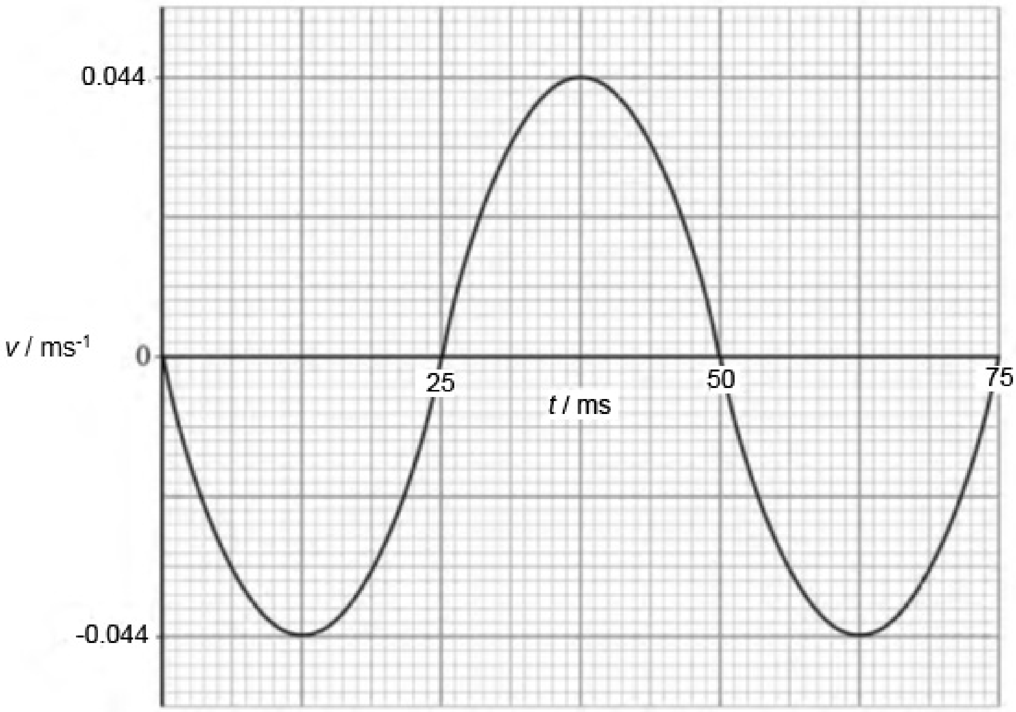


Fig. 4.2

(a) Show that the maximum displacement of the plate is 3.5×10^{-4} m.

[1]

(b) Draw on Fig. 4.3 the variation with time t of the displacement s of the plate between 0 and 75 ms.

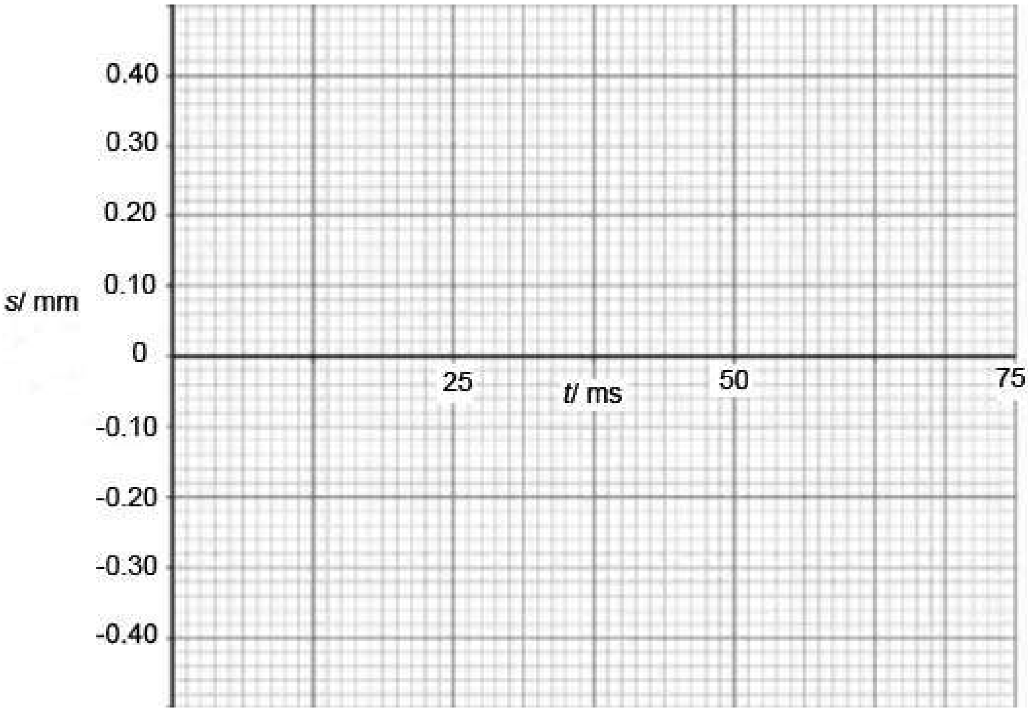


Fig. 4.3 [2]

(c) State **one** time at which the plate has maximum potential energy.

time = ... s [1]

(d) A small quantity of fine sand is placed onto the surface of the plate. Initially the sand grains stay in contact with the plate as it vibrates. The frequency of the vibrator is then gradually increased. Above a particular frequency the sand grains lose contact with the surface.

Explain how and why this happens.

....

....

....

....

....

....

.... [3]

5 Fig. 5.1 shows some equipotential lines around an electricity transmission cable at +200 kV.

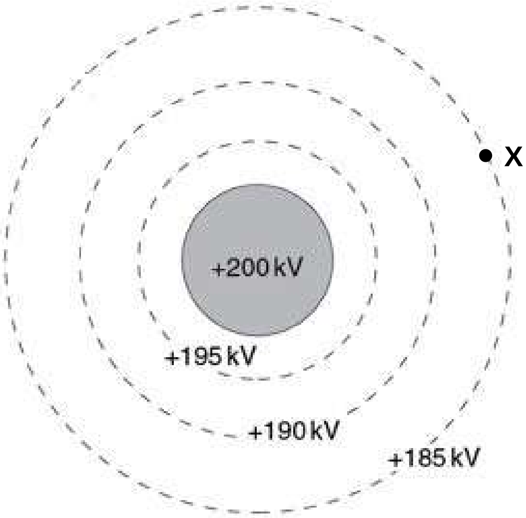


Fig. 5.1

(a) State the feature of the diagram which shows that the electric field strength decreases with distance from the transmission cable.

....

....

....

.... [2]

(b) The 195 kV equipotential line is 5.0 mm from the surface of the 200 kV transmission cable. Use this information to estimate the electric field strength at the surface of the cable.

electric field strength = ... $V\ m^{-1}$ [2]

(c) An electron is released from rest at point X. Determine the speed of the electron when it reaches the surface of the transmission cable.

speed = ... $m\ s^{-1}$ [2]

(d) Fig. 5.2 shows the transmission cable surrounded on three sides by an earthed metal shield at zero potential.

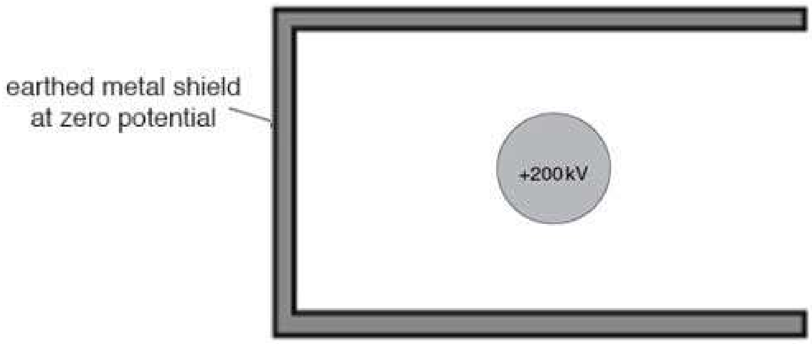


Fig. 5.2

On Fig. 5.2, sketch the shape of the electric field within and beyond the shield by drawing field lines from the cable to the shield and in the space beyond the open end.

[3]

6 Two coils P and Q are placed close to one another, as shown in Fig. 6.1.

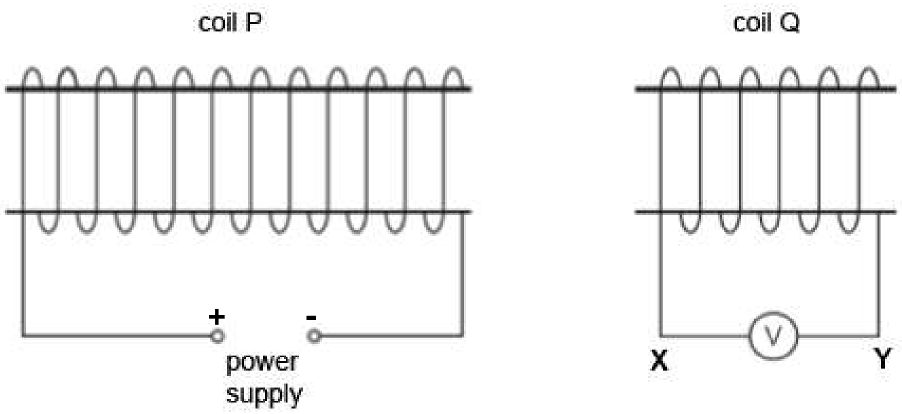


Fig. 6.1

(a) The current in coil P is constant. An iron rod is inserted into coil P.

During the time that the rod is moving,

(i) explain why, there is a reading on the voltmeter connected to coil Q.

....

....

....

....

....

.... [2]

(ii) state and explain whether point X or point Y on coil Q is at a higher potential.

....

....

....

....

....

....

....

.... [3]

(b) The current in coil P is now varied as shown in Fig. 6.2.

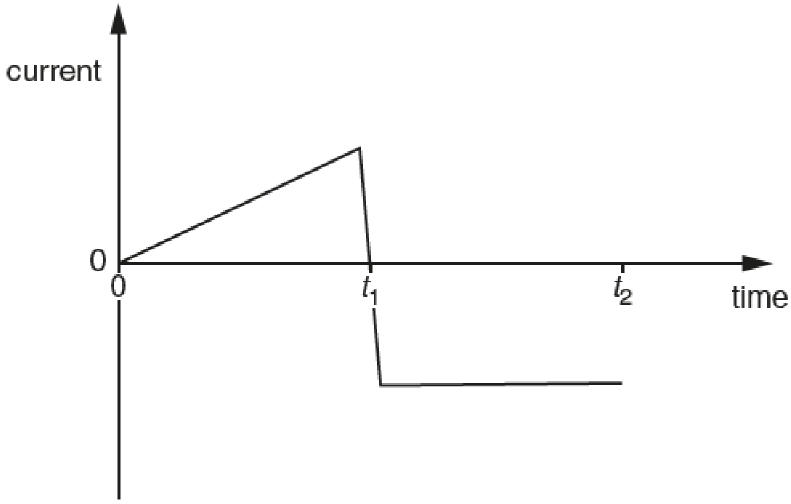


Fig. 6.2

On Fig. 6.3, show the variation with time of the reading of the voltmeter connected to coil Q for time t = 0 to time $t = t_2$.

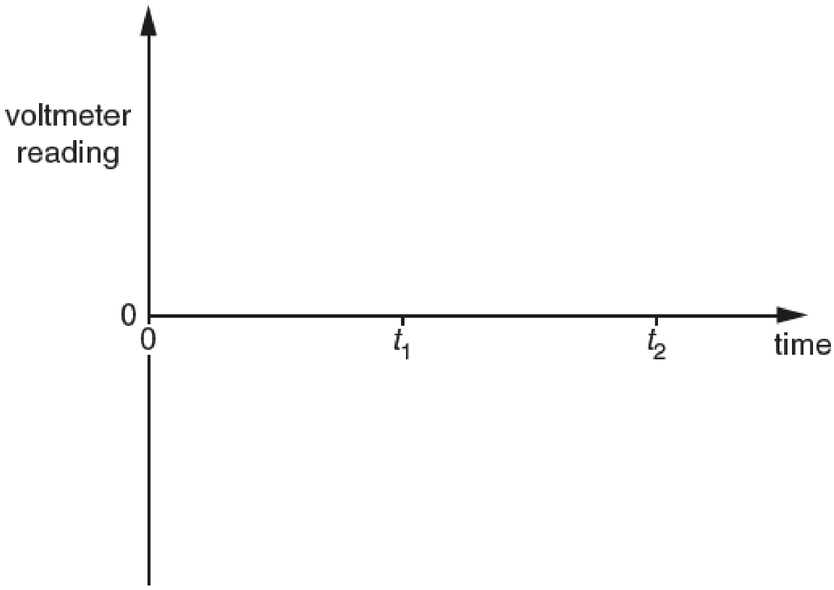


Fig. 6.3

[3]

7 **(a)** By reference to the photoelectric effect, state what is meant by the *threshold frequency*.

....

.... [1]

(b) Electrons are emitted from a metal surface when light of a particular wavelength is incident on the surface. Explain why the emitted electrons have a range of values of kinetic energy below a maximum value.

....

....

....

.... [2]

(c) The wavelength of the incident radiation is λ. The variation with 1/λ of the maximum kinetic energy E_{MAX} of electrons emitted from a metal surface is shown in Fig. 7.1.

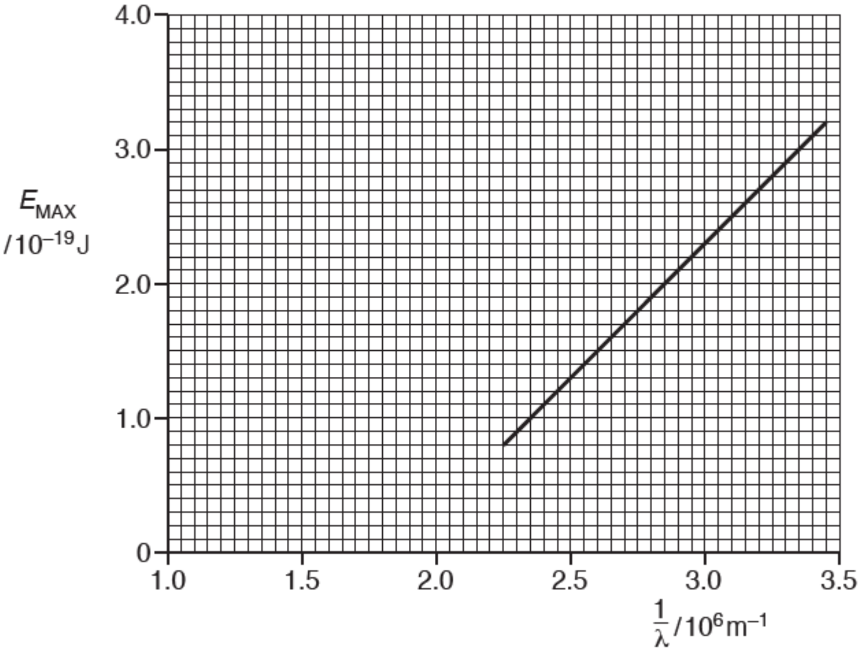


Fig. 7.1

(i) Use Fig. 7.1 to determine the threshold frequency f_0.

f_0 = ... Hz [2]

(ii) Use your answer in **(i)** to calculate the work function energy Φ.

Φ = ... J [2]

(iii) State an evidence from Fig. 7.1 that the classical wave theory cannot explain.

....

....

.... [1]

(iv) If the intensity of the radiation is doubled, state the changes in the graph, if any.

....

....

.... [1]

(v) Caesium metal has a lower work function energy than the metal in **(c)**.

On the axes of Fig. 7.1, sketch a line to show the variation with $1/\lambda$ of E_{MAX} for caesium metal. Label this line **C**.

[2]

Section B

Answer **one** question in this section in the spaces provided.

8 **(a)** The internal energy of an ideal gas is dependent on its state, and is given by the sum of the *random* kinetic energies of all its molecules.

(i) The state of an ideal gas depends on pressure, volume and two other quantities. Write down these two other quantities.

....

.... [2]

(ii) Explain why it is important to include the word *random* in this definition.

....

.... [1]

(iii) Explain why the potential energy of the molecules is not included in this definition.

....

.... [1]

(iv) State two physical conditions under which a real gas will behave approximately as an ideal gas.

....

.... [2]

(b) The pressure p exerted by an ideal gas is given by the equation

$$p = \frac{1}{3}\rho < c^2 >$$

(i) What do the symbols ρ and $<c^2>$ represent?

....

.... [2]

(ii) Use this equation to derive an expression for the total internal energy of n moles of an ideal gas at temperature T.

[2]

(iii) Air contains oxygen and nitrogen molecules. Assuming air is an ideal gas, state and explain whether each of the following quantities is the same for oxygen and nitrogen molecules in air at a given temperature.

1. mean translational kinetic energy per molecule

....

.... [1]

2. root mean square speed

....

.... [1]

(c) A heat engine uses 10 moles of an ideal gas as a working substance. Fig. 8.1 shows the changes in pressure and volume of the gas during one cycle ABCA of operation of the engine.

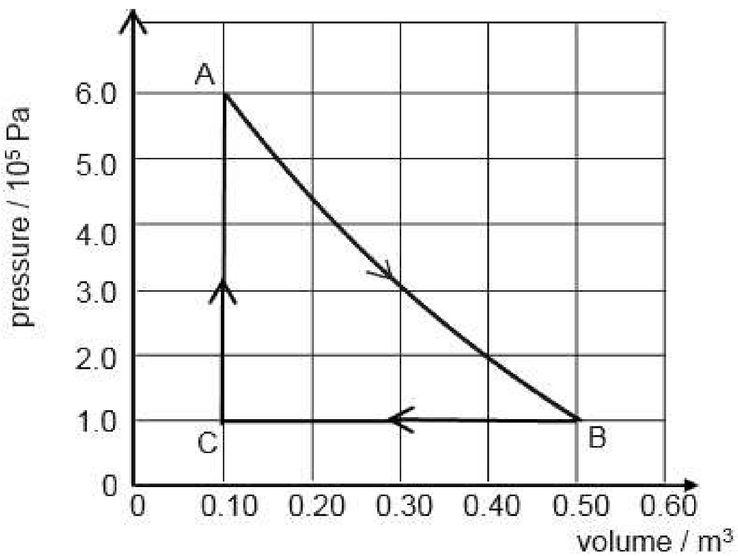


Fig. 8.1

(i) Using values from Fig. 8.1, calculate the temperature of the gas at point A.

temperature = ... K [2]

(ii) Show that the process A $\rightarrow$ B does not take place at a constant temperature.

....

.... [1]

(iii) Use Fig. 8.1 to estimate the net work done by the gas during one cycle.

work done = ... J [2]

(iv) Hence, or otherwise, state the amount of heat absorbed by the gas during one cycle.

heat absorbed = ... J [1]

(v) If the temperature at A is maintained throughout the process A $\rightarrow$ B, state and explain how your answer in **(c)(iv)** may change.

....

....

....

....

.... [2]

9 **(a)** State the *Principle of Superposition*.

....

....

....

.... [2]

(b) Laser beam of red light of wavelength 644 nm is incident normally on a diffraction grating having 550 lines per millimetre, as illustrated in Fig. 9.1.

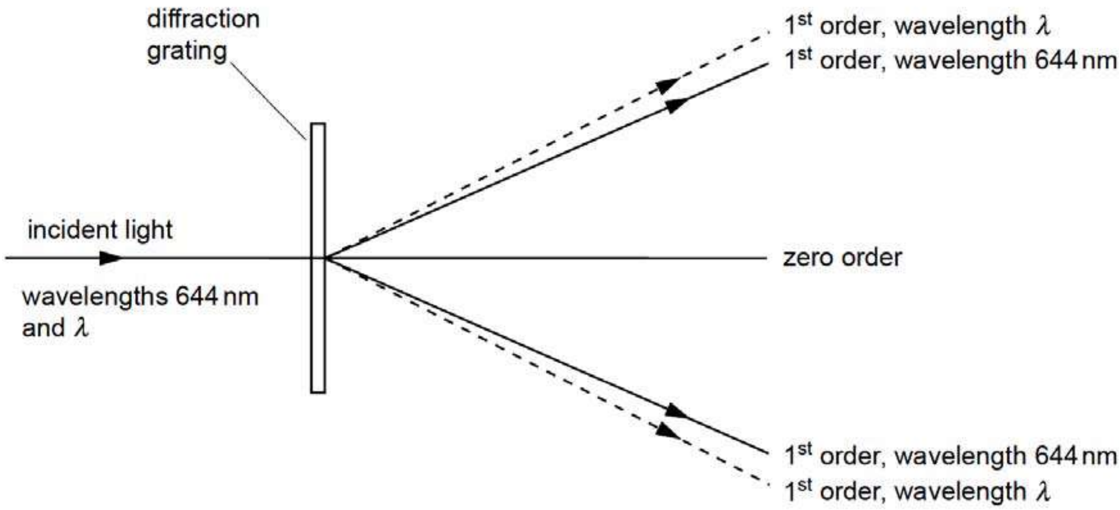


Fig. 9.1

Another laser beam of red light of wavelength λ is also incident normally on the grating. The first order diffracted light of both wavelengths is illustrated in Fig. 9.1.

(i) Determine the total number of bright spots of wavelength 644 nm that are visible.

total number of bright spots = ... [3]

(ii) State and explain

1. whether λ is greater or smaller than 644 nm,

....

....

.... [1]

2. in which order of diffracted light there is the greatest separation of the two wavelengths.

....

....

.... [1]

(c) The laser beam of red light of wavelength 644 nm is now placed in front of two slits as shown in Fig. 9.2.

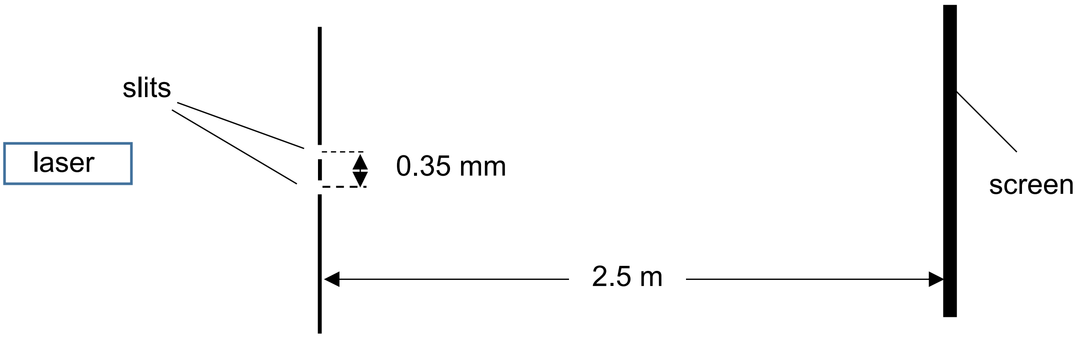


Fig. 9.2 (not to scale)

The distance from the slits to the screen is 2.5 m. The separation of the slits is 0.35 mm. The width of each slit is 2.4×10^{-5} m. The maximum intensity of the interference pattern formed on the screen is I.

(i) Explain how the interference pattern is formed on the screen.

....

....

....

....

....

.... [3]

(ii) One of the slits is now covered with an opaque object.

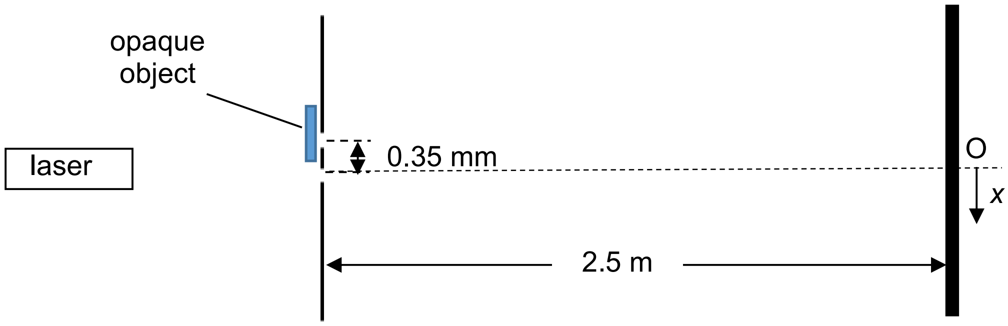


Fig. 9.3

An interference pattern is observed on the screen centred at O.

1. Calculate the width of the central fringe observed on the screen.

width = ... m [3]

2. On Fig. 9.4, sketch a graph to show the variation with distance *x* from point O of the intensity of the light observed on the screen. Draw at least 3 maxima.

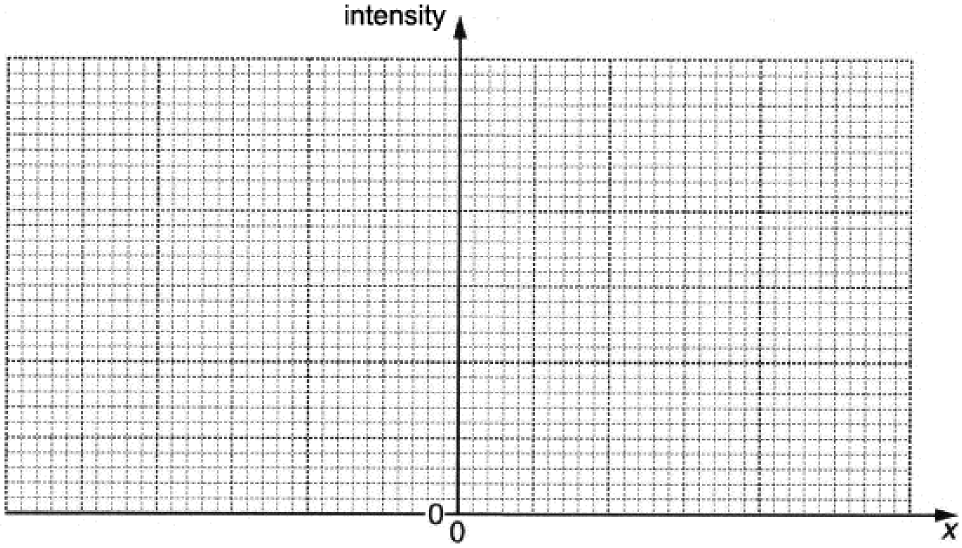


Fig. 9.4

[3]

3. Deduce, in terms of I, the maximum intensity of the interference pattern produced.

intensity = ... [2]

(iii) The laser together with another identical laser are positioned as seen in Fig. 9.5 such that the light from both sources pass through the uncovered slit at an angle of θ to each other.

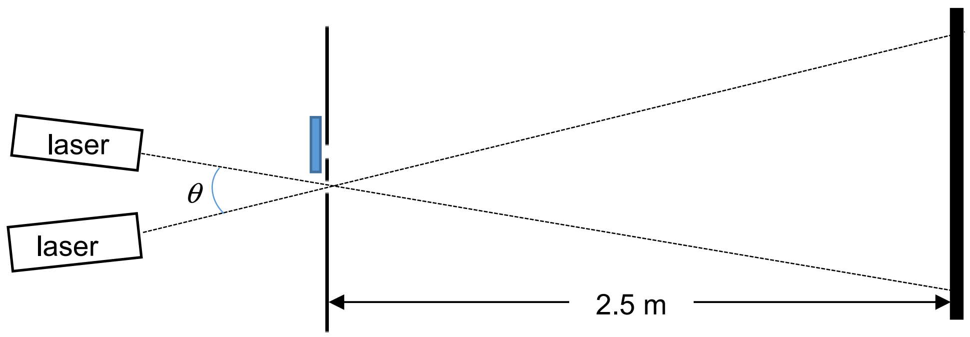


Fig. 9.5

State and explain whether the interference patterns formed by the two sources are resolved if θ is equal to 2.0°.

....

....

....

....

.... [2]

TEMASEK JUNIOR COLLEGE
2018 JC2 PRELIMINARY EXAMINATION
Higher 2

NAME

CG

PHYSICS 9749/04

PAPER 4

27 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper.

Shift
Laboratory

READ THESE INSTRUCTIONS FIRST

Write your name and C.G. in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of the papers.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
TOTAL	

1 In this experiment, you will investigate the motion of a small container in water.

(a) You have been provided with two glass marbles and a small container with a separate lid.

The dimensions of the glass marbles and the small container are shown in Fig. 1.1.

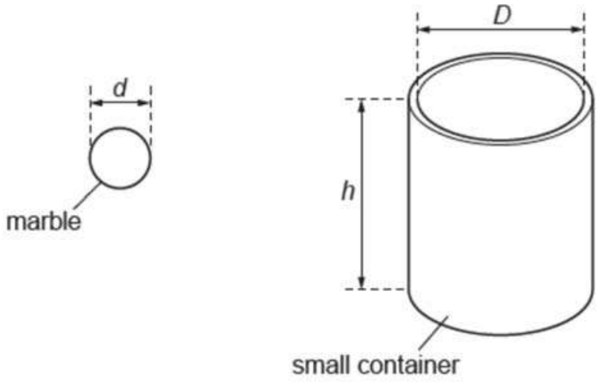


Fig 1.1

(i) Measure and record the diameter *d* of the marble.

d = ... [1]

(ii) Measure and record the height *h* and the inner diameter *D* of the small container.

h = ...

D = ... [1]

(b) **(i)** Place the small container in the tray. Fill the small container with water.
You may use the beaker to transfer water.

(ii) Place **one** glass marble in the small container. Wait until the water has stopped overflowing. Place the lid on the small container.

(iii) The fraction *x* of glass in the small container is given by

$$x = \frac{2nd^3}{3D^2h}$$

where *n* is the number of marbles in the small container.

Calculate *x*.

x = ... [1]

(iv) Justify the number of significant figures that you have given for your value of *x*.

....

....

.... [1]

(c) **(i)** Place the small container containing water and the marble in the cylinder as shown in Fig. 1.2.

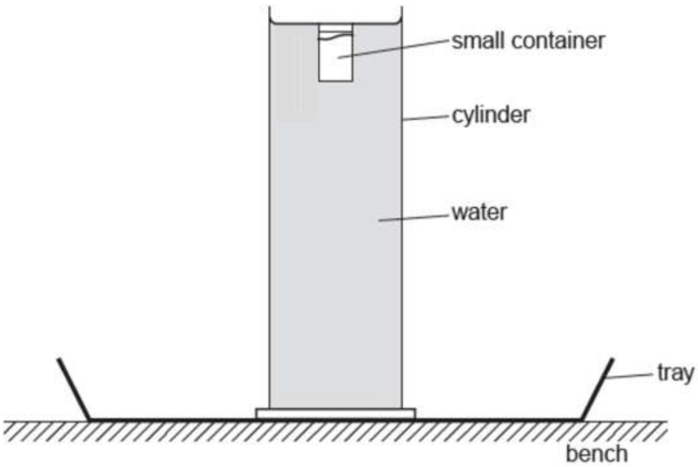


Fig. 1. 2

(ii) Release the small container and measure the time *t* taken for it to fall to the bottom of the cylinder.

t = ... [2]

(iii) Estimate the percentage uncertainty in your value of *t*.

percentage uncertainty = ... [1]

(d) Repeat **(b), (c)(i) and (c)(ii)** using **two** marbles.

x = ... [1]

t = ... [1]

(e) It is suggested that the relationship between t and x is

$$t^2 = \frac{k}{x}$$ where k is a constant.

(i) Using your data, calculate two values of k.

first value of k = ...

second value of k = ... [1]

(ii) State whether the results of your experiment support the suggested relationship. Justify your conclusion by referring to your value in **(c)(iii)**.

....

....

....

.... [1]

(f) **(i)** State **two** significant sources of error in this experiment.

1. ....

....

....

....

2. ....

....

....

.... [2]

(ii) Suggest an improvement that could be made to the experiment to address one of the sources of error identified in **(f)(i)**. You may suggest the use of other apparatus or a different procedure.

....

....

....

.... [1]

[Total : 14 marks]

2 In this experiment, you will investigate how the voltage across components in a circuit varies as the resistance of the circuit is changed.

(a) **(i)** Set up the circuit as shown in Fig. 2.1.

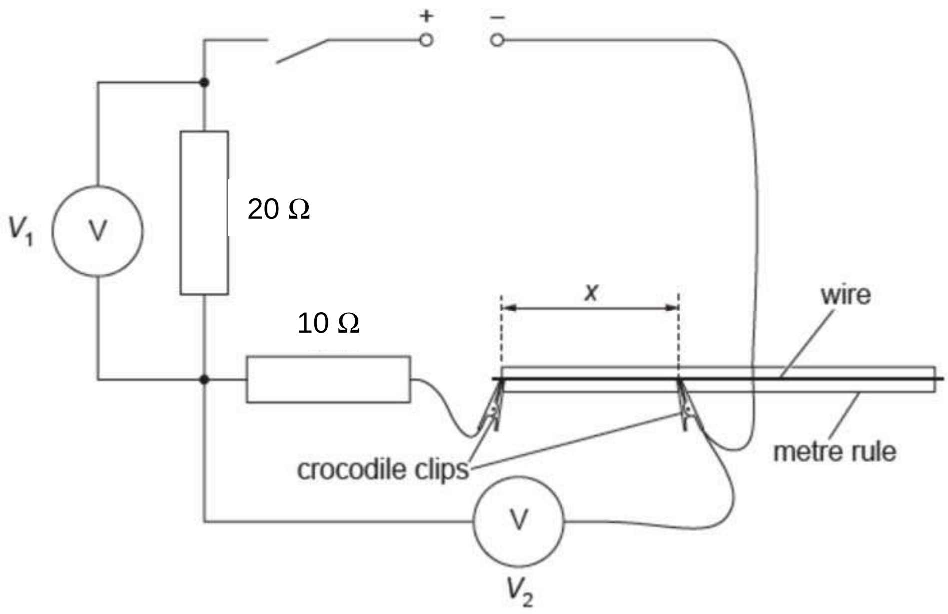


Fig 2.1

Attach the crocodile clips to the wire so that the distance *x* is approximately 20 cm.

(ii) Measure and record *x*.

x = ... [1]

(b) **(i)** Close the switch.

(ii) Record the voltmeter readings V_1 and V_2.

V_1 = ...

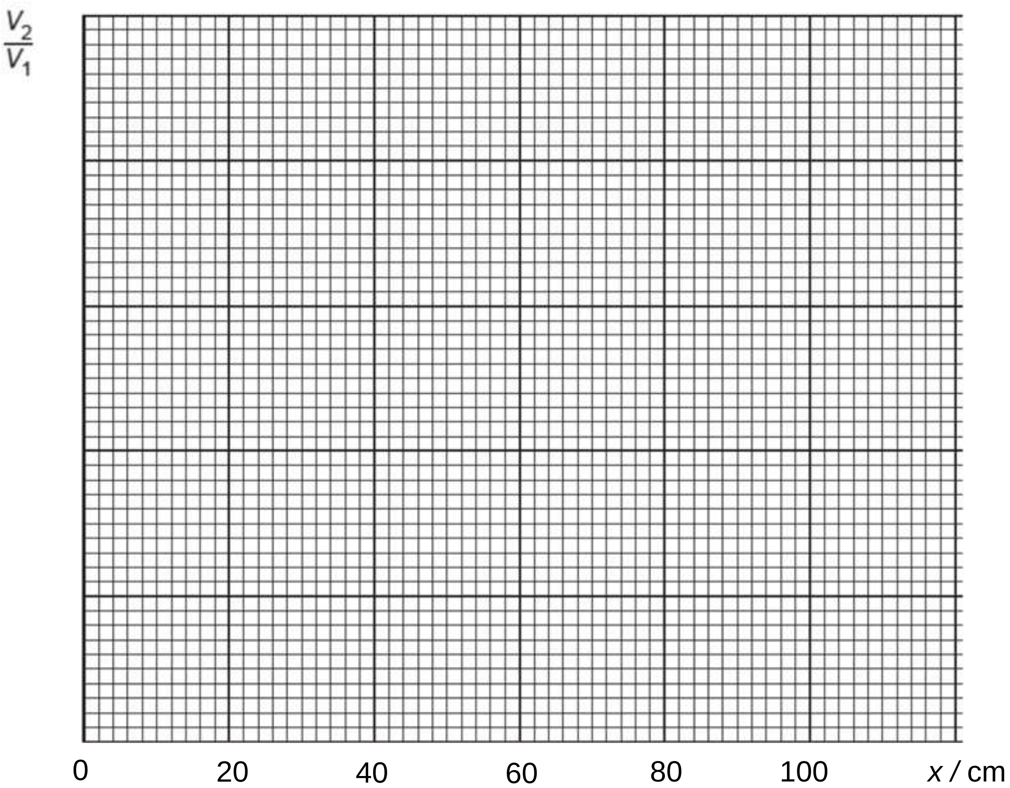
V_2 = ... [1]

(iii) Open the switch.

(c) Change x and repeat **(a)(ii)** and **(b)** until you have **five** sets of readings of x, V_1 and V_2 till x = 90 cm.
Include values of $\frac{V_2}{V_1}$ in your table.

[2]

(d) **(i)** Plot a graph of $\frac{V_2}{V_1}$ against x.



[2]

(ii) State the relationship between $\frac{V_2}{V_1}$ and x based on your graph.

.... [1]

(iii) On the same axes of your graph in **(d) (i)**, draw another line to represent the experimental results if the experiment is repeated using a **thinner** wire of the **same** material. Label this line Z. [2]

[Total : 9 marks]

3 In this experiment, you will investigate a metre rule rocking on a beaker.

(a) Assemble the apparatus as shown in Fig. 3.1 with the beaker placed horizontally. The centres of each of the two masses should be at the same distance *r* from the centre of the metre rule, where *r* is approximately 30 cm.

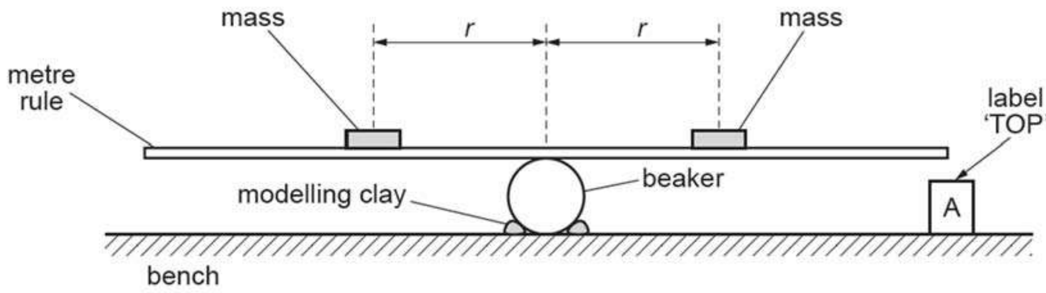


Fig. 3.1

(b) **(i)** Measure and record the distance *r*.

r = ... [1]

(ii) Explain how you measured *r* accurately.

....

....

.... [2]

(iii) Adjust the position of the metre rule on the beaker so that the metre rule is balanced and approximately parallel to the bench.

(c) **(i)** Hold down the end of the metre rule on A, as shown in Fig. 3.2.

(ii) Release the metre rule and measure and record the time *T* for it to move up and then down again to its lowest position, as shown in Fig. 3.2.

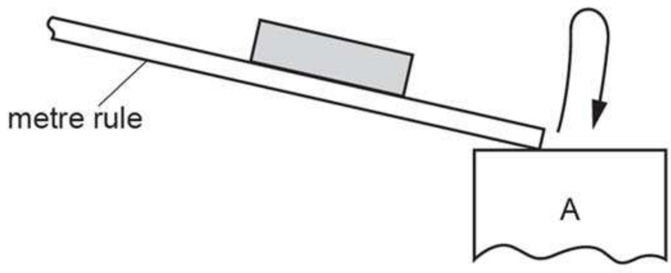


Fig. 3.2

T = ... s [1]

(d) Reposition the two masses at a different distance *r* from the centre of the metre rule and repeat **(b)(i), (iii)** and **(c)** to obtain further sets of values for *r* and *T*.

Present your results in a table.

[6]

(e) Theory suggests that T and r are related by the equation

$$T^3 = ar^2 + b$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b. Give appropriate units to your values.

a = ...

b = ... [4]

(f) Comment on any anomalous data or result that you may have obtained. Explain your answer.

....

....

.... [1]

(g) **(i)** State a significant source of error in this experiment.

....

....

.... [1]

(ii) Suggest one improvement that could be made to the experiment to address the source of error identified in **(g)(i)**. You may suggest the use of other apparatus or a different procedure.

....

....

.... [1]

[Total : 20 ma

Insert graph paper (original with Eunice)

4 Concrete is widely used for construction and its manufacture contributes 5% to the world's carbon dioxide (CO_2) production. One way of reducing the amount of CO_2 produced could be to use less cement in the production of concrete.

A company is producing concrete with low cement content and wishes to see how the material behaves under a compressive force. A compressive force applied to a concrete object will reduce the length of the object in the direction of the force very slightly.

The reduction in length of the object is to be measured using a strain gauge.

When a wire has its length changed, its resistance changes. A strain gauge consists of a length of thin wire as shown in Fig. 4.1.

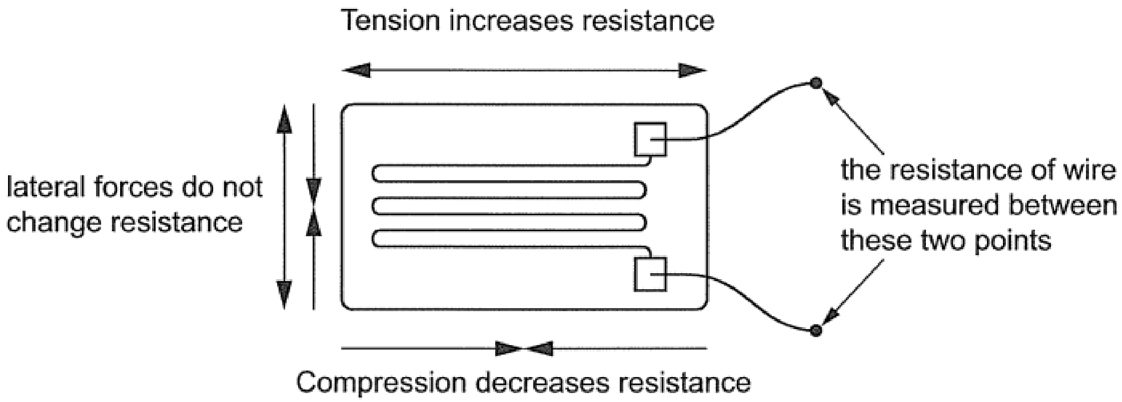


Fig. 4.1

The gauge consists of a wire wound backwards and forwards and embedded in thin plastic. The plastic is then bonded firmly to the specimen being investigated.

The relation between change in resistance ΔR and change in force ΔF is

$$\Delta R = k\,(\Delta F)^n$$

where k and n are constants.

You are provided with a small concrete cylinder, some heavy masses, a low voltage power supply and other equipment usually found in a Physics laboratory.

Design an experiment to determine the value of n for compressive forces applied to a small concrete cylinder along its axis.

You should draw a labelled diagram to show the arrangement of your apparatus and you should pay particular attention to

- **(a)** the equipment you would use,
- **(b)** the procedure to be followed,
- **(c)** how the compressive force and change in resistance are measured,
- **(d)** the control of variables,
- **(e)** any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

[Total : 12 marks]

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2018 TJC H2 Physics Prelim Paper 1 Solutions

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	**C**	**A**	**B**	**C**	**B**	**D**	**D**	**D**	**B**	**B**	**D**	**A**	**B**	**B**
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
C	**B**	**A**	**C**	**A**	**D**	**B**	**D**	**B**	**C**	**A**	**D**	**C**	**C**	**B**

1 **A** Units of $\Delta P = kgm^{-1}s^{-2}$, units of $\rho = kgm^{-3}$
Units of $\frac{\Delta P}{\rho} = m^2s^{-2}$, hence n =0.5

2 **C** The absolute uncertainty of the diameter is 0.02 x 5.0 = 0.1 cm.
The absolute uncertainty of the radius will be 0.1 cm / 2 = 0.05 cm
The fractional uncertainty of the radius will be 0.05 cm / 2.5 cm = 0.02.

3 **A** a-t graph obtained from gradient of v-t graph

4 **B** Taking downwards as positive,
$S = ut + \frac{1}{2} at^2$
$= -3.00 \times 5.00 + \frac{1}{2}\, 9.81(5.00)^2 = 108$ m

5 **C** By conservation of momentum:
$(2.0)(0.5) = (2.0 + 0.500)v_f \rightarrow v_f = 0.4$ m s^{-1}.
change in momentum = $p_f - p_i = 2.0\,(0.4 - 0.5) = -\,0.2$ Ns

6 **B** By AP, upthrust = weight of fluid displaced. Liquid X has smaller density and hence exerts a smaller upthrust.

Balanced rod implies object P must have a smaller weight and hence smaller mass.

7 **D** Take moments about pivot,

$M(4.0 \cos 50^o) = 45\,(7.0 + 4.0 \cos 50^o) \Rightarrow M = 170$ N

8 **D** GPE gained = mgh = mg sin α .s
Work done by force = F s
Divide the 2 eqns give answer D.

9 **D** Frictional force on the object provides the centripetal force $mr\omega^2$. Both objects have the same angular velocity and same mass, but the centripetal force required for Q is larger due to larger radius. When the centripetal force required exceeds the frictional force available, Q starts to slide.

10 **B** $\Delta U = m\Delta\phi \propto \Delta\phi$

$$\frac{\Delta U_{BC}}{\Delta U_{AB}} = \frac{\Delta\phi_{BC}}{\Delta\phi_{AB}} \Rightarrow \frac{-5.0}{+20} = \frac{\phi_C + 3.0}{-3.0 + 7.0}$$

$\Rightarrow \phi_C = -4.0$ J kg^{-1}

11 **B**

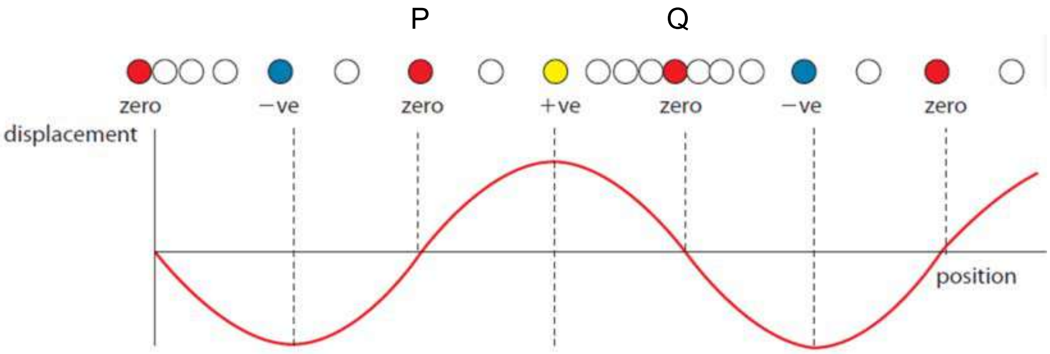
$$C_{rms} = \sqrt{\frac{3RT}{M}} \propto \sqrt{T} \propto \sqrt{PV} \quad \text{since } PV = nRT$$

$$\frac{C_{rms2}}{C_{rms1}} = \sqrt{\frac{P_1V_1}{P_2V_2}} = \sqrt{\frac{2(2)}{1(1)}} = 2$$

12 D If the gases are ideal $PV = nRT = nR(\theta + 273)$
So the graph of PV vs θ has a positive gradient (nR where n =1) , a y-intercept ($273nR$) and cuts the x scale at -273 (set $PV = 0$).

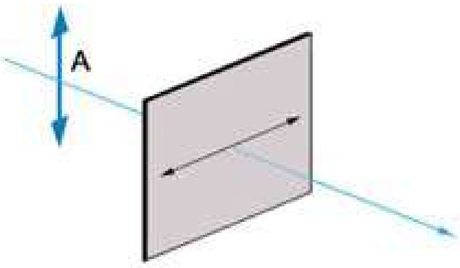
13 A At U, velocity is down (away from equilibrium point), acceleration is up (towards equilibrium point)
At Y, velocity is up, acceleration is down.

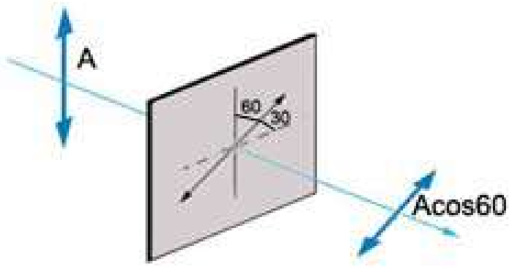
14 B



Distance between P and Q is ½ λ.
So time taken should be ½ T = 1/2f

15 B





Initially axis of polarization is 90° to polarized light, so zero light transmitted

When polaroid is rotated 30°, the two axes are now 60° to each other.

Resolve A with respect to new polarization axis. It is A cos 60° = 0.50 A

16 C Phase difference $\phi = \frac{t}{T} \times 2\pi = \frac{4}{24} \times 2\pi = \pi/3$
For time-axis, whichever (crest) is behind is leading.

17 B As α particle moves near nucleus, it experiences an electric force of repulsion that causes it to slow down to zero velocity. The distance r is known as the distance of closest approach.

loss in ke = gain in pe
$= Qq / 4\pi\varepsilon_o r$
$4.9 \times 10^6 \times 1.60 \times 10^{-19} \times 10^6 = (2 \times 1.6 \times 10^{-19})(79 \times 1.6 \times 10^{-19}) / 4\pi \times 8.85 \times 10^{-12} r$
$r = 4.64 \times 10^{-14}$ m

18 **A** $R = \frac{\rho l}{A}, \quad V = Al$

When re-cast, length = $l/2$, cross-sectional area = $2A$ since V is conserved.

Thus new resistance, $R' = \frac{\rho l/2}{2A} = \frac{1}{4}\frac{\rho l}{A} = \frac{1}{4}R$

19 **C** Energy = power x time = VIt = VQ = 12x4.0 = 48 J
Current I = Q/t so time t =Q/I = 4.0/2.0 = 2.0 s

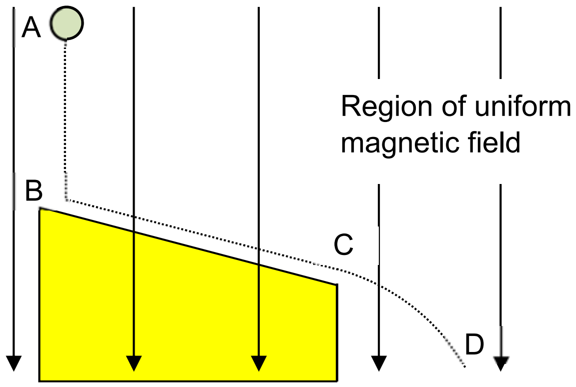
20 **A** Combined resistance of R_4 and R_5 = R/2
Combined resistance of R_3, R_4 and R_5 = 3R/2
Combined resistance of R_2, R_3, R_4 and R_5 = 3R/5
By potential divider principle, potential difference across R_1 is greater than potential difference across combined resistance of R_2, R_3, R_4 and R_5
Hence, R_1 has the greatest potential difference.

21 **D** By potential divider principle, voltmeter reading increases when effective resistance across thermistor is increased or resistance R_3 is reduced.

22 **B** $F_B - mg = ma$
$BIL\sin\theta - mg = ma$
$0.040 \times I \times 0.30 \times \sin 60^\circ - (0.0040 \times 9.81) = 0.0040 \times 2.0$
$I = 4.5\ A$

23 **D** Current in Y is doubled ⇒ B_Y is doubled. The force F is doubled for both wires too, as it is an equal action and reaction force.

24 **B**



$E = Blv$, where v is the horizontal component of the rod's velocity. From point A to B, the rod is moving vertically along the magnetic field, hence E is zero. From B to C, as the rod rolls down the slope, the component of its weight parallel to the slope caused its velocity to increase. Hence, the horizontal velocity component increases at a constant rate and E increases linearly too. From C to D, the rod is moving in projectile motion. Its horizontal velocity component is constant and E remains constant.

25 **C** The output voltage is 240/20 = 12 V, and output current is 12/5 A.
Output power = V x I = 12 x12/5 = 28.8, which is 0.95 of the input power.

0.95x 240 I = 28.8
I = 0.126 A

26 **A** $\langle P \rangle = V_{rms}^2/R$
$= (9/\sqrt{2})/\ 20 = 2.0$ W

27 **D** Total force exerted due to reflection of photons $F = \dfrac{N(2mc)}{t}$

But intensity of light $I = \dfrac{Nhf}{tA}$, so $\dfrac{N}{t} = \dfrac{IA}{hf}$

Also $E = mc^2 = hf$

Total force $F = \dfrac{IA}{hf}(2mc) = \dfrac{IA}{mc^2}(2mc) = \dfrac{2IA}{c}$

28 **C** Since $\Delta E = hf$, from energy level diagram, the energy difference is lesser towards bigger f (emission from higher levels).

Wavelength is inversely proportional to frequency, hence the spectrum is in opposite order.

29 **C** Let C be original number of counts due to the α-source.
Let B be the background count.
C + B = 300 ------ (1)
0.5C + B = 155 ------ (2)
Solving, C = 290
Lead would block all the counts due to the α-source.
Hence, only background count of 10 is detected.

30 **B**

Solutions to 2018H2P2

1 **(a)** Use of $mgh = ½ m v^2$ ***and*** *makes h subject* C1

h = 14.7 or 15 (m) A1

(b) **(i)** Calculate the final vertical velocity at C (using v = 0 + at=9.81x1.6) C1

v = 15.7 or 16 (m s^{-1}) A1

(ii) Straight line of positive gradient) □ A1

Starting at 0 ms^{-1} and ends at 16 ms^{-1} at 1.6 s. A1

(b) **(iii)** Use of pythagoras' theorem: M1

resultant $v^2 = 15.7^2 + 17^2$

$v = 23$ or 23.1 m s^{-1}

(c) slope: smaller change in vertical component of velocity/ smaller change in vertical component of momentum B1

by Newton's second law, the force experienced = rate of change of momentum is less, so less risk of injury B1

Bonus mark: if she bends her knees during landing, she increases time for (same) change of momentum, so force exerted on her is even lesser.

2 **(a)** **(i)** (vertical component = 44 sin 30° =) 22 N A1

(ii) (horizontal component = 44 cos 30° =) 38(.1) N A1

(b) W × 0.64 = 22 × 1.60 C1 C1

(W =) 55 N A1

(c) For a system in equilibrium, net force = 0 B1

F has a horizontal component (not balanced by W) B1
or F has 38 N acting horizontally
or 38 N acts on wall
or vertical component of F does not balance W
or F and W do not make a closed triangle of forces

(d) line from P towards point on wire vertically above W and direction up B1
three non-parallel coplanar forces must act through the same line B1

(e) line from P towards right B1
line from P towards point on wire vertically below W and direction down B1

3 **(a)** **(i)** Any difference about Amplitude/Phase difference/Energy B1

Comparison between a stationary wave and a progressive wave

	Stationary	Progressive
Energy	No net transfer of energy from one point to another. Energy is confined within the wave and there is interchange of K.E. and P.E.	Energy is transferred in the direction of travel of the wave.
Phase	All particles between two adjacent nodes are *in phase*. Particles on opposite sides of a node will be in *anti-phase*.	All points within one wavelength vibrate with different phase.
Amplitude	Varies from zero at nodes to maximum at antinode.	Same for all particles in the wave.
Wavelength	2 x distance between adjacent nodes or antinodes	Distance between adjacent particles which are in phase.
Frequency	All particles vibrate in SHM with same frequency except at nodes	All points vibrate in SHM with same frequency.
Waveform	Does not advance	Advances in the direction of velocity of the wave

(ii) only transverse waves can be polarised B1

(b) **(i)** the waves of equal f and amplitude in opposite direction interfere/superpose producing a stationary wave B1
stationary wave has nodes and antinodes B1
the resultant signal is zero at a node distance from max (antinode) B1
to zero (node) is $\lambda/4$ = 0.75 cm B1

(ii) emitted waves are polarised (in vertical plane) B1
when T_2 is rotated by 90°, the two waves at right angles superposed to produce a resultant constant amplitude (of $A\sqrt{2}$) B1

Since intensity is proportional to square of amplitude , signal intensity is halved) B1

Note:no stationary wave is produced since waves are at right angles to each other)

4 **(a)** p.d. across one lamp = 2.5 V C2
resistance = [(8.7 – 7.5) / 0.3] / 2
= 2.0 Ω A1

(b) straight line through the origin M1
with gradient of 0.5. A1

(c) $P = I^2 R$
$= 0.30^2 \times 2.0$
= 0.18 W A1

Alternative method:
use $P = V I$ or $P = V^2 / R$

(d) **(i)** $R = \rho l / A$ C1
$l = (2.0 \times 0.40 \times 10^{-6}) / 1.7 \times 10^{-8}$
= 47 m A1

(ii) $I = A n v q$
$v = 0.30 / (0.40 \times 10^{-6} \times 8.5 \times 10^{28} \times 1.6 \times 10^{-19})$ C1
$= 5.5 \times 10^{-5}$ m s^{-1} A1

5	(a)	(i)	force = mg in the direction of the field	M1 A1
		(ii)	no force	B1
	(b)	(i)	force due to E-field downwards so force due to B-field upwards into the plane of the paper	M1 A1
		(ii)	force due to magnetic field = Bqv force due to electric field = Eq	B1
			forces are equal (and opposite) so Bv = E or Eq = Bqv so E = Bv	B1
	(c)		Component of velocity at right angle to the field results in a magnetic force at right angle to both this velocity and the field	B1
			radius r =mv/Bq, as B decreases, radius r increases The particle describes a helical path with increasing radius and increasing pitch.	B1

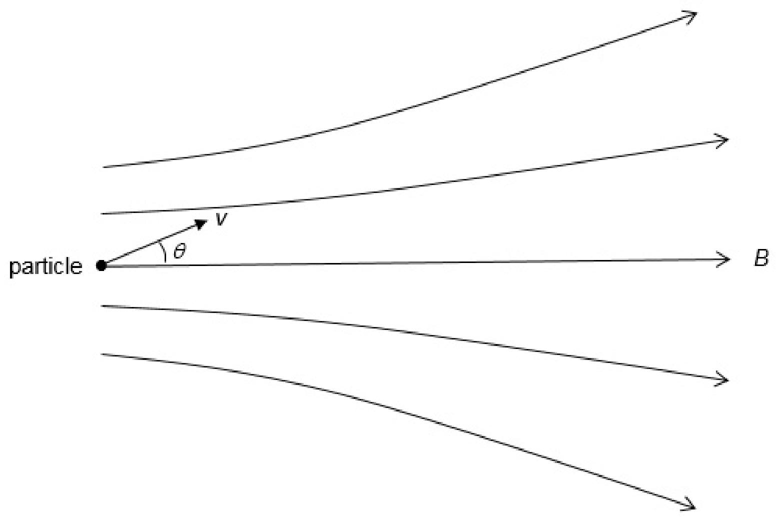
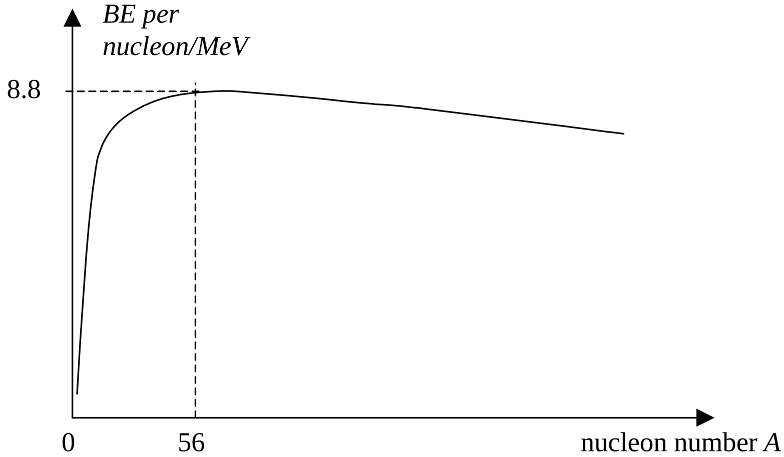


Diagram helical path with increasing radius B1
Correct Direction of path B1

6 **(a)** The binding energy of a nucleus is the energy released when a nucleus is formed from its constituent protons and neutrons. B1

(b)(i)



Correct Shape B1

Correct labelling for max BE B1

(b)(ii) In nuclear fission, a heavy nucleus splits to give two daughter nuclei of greater binding energy per nucleon. Hence, there is an overall energy release during the process. B1

(c)(i) A **chain reaction** is able to occur as the neutrons released in the fission produce an additional fission in at least one further nucleus. B1

(c)(ii) Energy released in one reaction = $(m_u + m_n - (m_{xe} + m_{sr} + 2m_n))\ uc^2$ M2

= (235.043929 + 1.008665 – (138.918793 + 94.919359 + 2(1.008665)) x x $[3 \times 10^8]^2$

= 2.94×10^{-11} J A1

(c)(iii) No of reactions that will take place in 2 kg Uranium M1

= (2000/235) x 6.02 x 10^{23}

= 5.12 x 10^{24}

Energy from 2 kg of Uranium = 2.94 x 10^{-11} x 5.12 x 10^{24} M1

Useful Energy from 2 kg of Uranium = 0.080 x 2.94 x 10^{-11} x 5.12 x 10^{24} M1

= 1.21 x 10^{13} J

Amount of time t = (1.21 x 10^{13}/(50 x 10^{12}) x 12 = 2.9 months A1

7	**(a)**	Random – it cannot predict which and when a nucleus will decay.	B1
		Nucleus has a constant probability of decay per unit time.	B1
	(b)	it is not affected by any external factors such as 1. temperature, 2. pressure	B2
	(c)(i)	**1** (from Fig 7.1, it can be deduced $T_{1/2}$ for Co is around 5 years and for Ni is around 90 years.)	B1
		So activity of Co should be higher at the start. Region P is dominantly due to activity of Co.	A1
		Hence ln A_{mix} against t graph should give a straight line PQ	
		2 In region RS, most of Co has decayed, so activity is mainly due to Ni	B1
		3 In region QR, both Co and Ni contribute to the activity	B1
		Activity A_{mix} is sum of A_C and A_N	A1
		Hence ln A_{mix} against t graph gives a curve.	
	(ii)	**1** grad of PQ = (7.63 – 8.87) / 10	B1
		= - 0.124 yr^{-1}	A1
		2 grad of RS = (4.77 – 5.08) / 40	B1
		= - 0.00775 yr^{-1}	A1
	(iii)	$\ln A = \ln A_o - \lambda t$ Hence decay constant λ= magnitude of gradient = same as above decay constant of cobalt = 0.124 yr^{-1} decay constant of nickel = 0.00775 yr^{-1}	A1
	(iv)	$T_{1/2} = \ln 2 / \lambda$	M1
		Cobalt: $T_{1/2}$ = ln 2 / 0.124 = 5.59 yr	A1
		Nickel: $T_{1/2}$ = ln 2 / 0.00775 = 89.4 yr	A1
	(d)	Co has very high initial activity (because of large decay constant at the start) – hence more hazardous) award 1 mk if student mentioned both will be hazardous initially as they are in large dosage	B1
		As half life of Co is short (5.59 years) – activity will be small after that number of years, hence less hazardous.	B1
		However Ni has a long half-life (about 90 years), it remains hazardous for a long time.	B1

2018H2P3Solutions

1 **(a)** $F_{\text{on fuel}} = v\dfrac{dm}{dt}$ C1

$= 3.0\times10^{4}\times1.7\times10^{-6} = 0.051\,\text{N} = F_{\text{on rocket}}$ A1

(b) Since F is constant and a = F/m, with *m* decreases with time, *a* increases with time. B1

(c)
change in velocity = area under graph
= ½(9.45 + 8.20) × 10^{-5} × 4.80 × 10^{7} = 4240 m s^{-1} M2

final v = 4240 - 0 = 4240 m s^{-1} A1

(d) Shape is parabolic from t = 0 to t = 4.8 x 10^{7} s, starting from v = 0 to final v at 4240 m s^{-1} B1

Between t = 4.8 x 10^{7} to t = 6.0 x 10^{7} s, no more force so constant v at 4240 m s^{-1} B1

2 **(a)** speed (of object) at surface (of planet) / specified starting point so that object may move to infinity / escape gravitational field of planet B1

(b) loss in kinetic energy = gain in (gravitational) potential energy
$\frac{1}{2}mv^{2} = \frac{GMm}{R}$ C1

But $g = \frac{GM}{R^{2}}$ C1

Hence $v = \sqrt{2gR}$ *(no mark for answer)*
assumption: *e.g.* planet is isolated / no friction / no atmosphere *etc.* A1

(c) $v = \sqrt{2(1.6)1.7\times10^{6}}$ C1
$= 2.3\times10^{3}\ \text{m s}^{-1}$ A1

(d) $\frac{1}{2}\left(4\times1.66\times10^{-27}\right)\left(2.3\times10^{3}\right)^{2} = \frac{3}{2}\left(1.38\times10^{-23}\right)T$ C1
T = 850 K A1

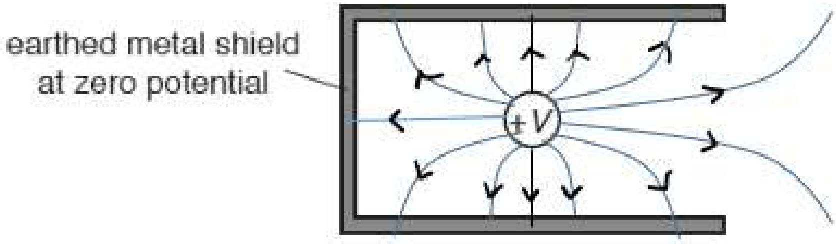
(e) atoms have a distribution of speeds / atoms may collide in upper atmosphere and gain speed B1

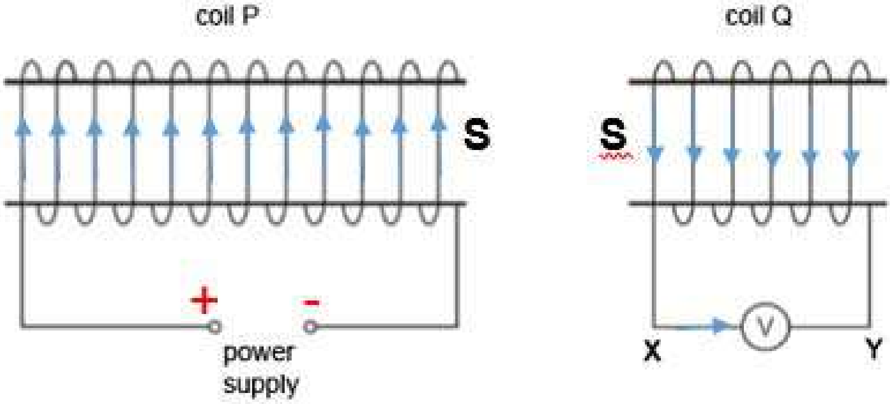
3	**(a)**	**(i)**	Initial kinetic energy of block = $\frac{1}{2}mv^2 = \frac{1}{2}(0.40)(0.30)^2 = 1.8\times10^{-2}$ J	B1
		(ii)	(change in) kinetic energy = work done on spring / (change in) elastic potential energy	C1
			$1.8\times10^{-2} = \frac{1}{2}F_{MAX}(0.080)$	
			$F_{MAX} = 0.45(\text{N})$	A1
		(iii)	$a = F_{MAX} / m = 0.45 / 0.40$ $= 1.1$ (m s^{-2})	A1
		(iv)	1. constant velocity / resultant force is zero, so in equilibrium	B1
			2. decelerating / resultant force is not zero, so not in equilibrium	B1
	(b)		curved line from the origin ($x_o^2 \propto m$ or $x_o \propto \sqrt{m}$)	M1
			with decreasing gradient	A1

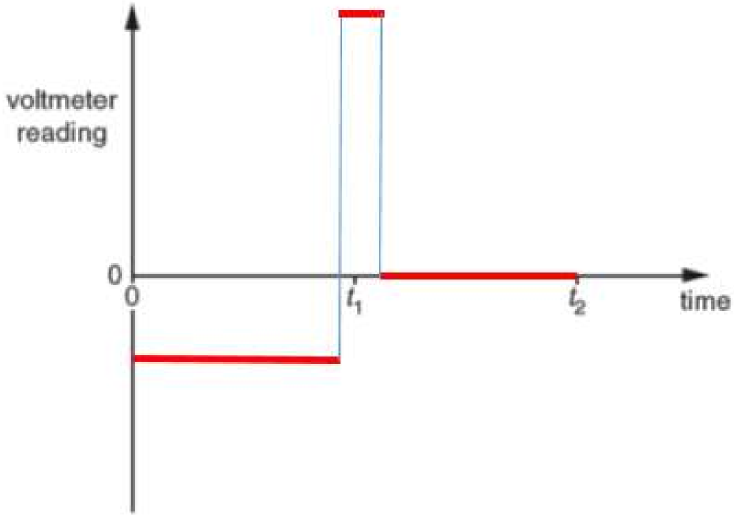
4	**(a)**	$f = 1/T = 1/0.05 = 20$ Hz $v_o = \varpi x_o = (2\pi f) x_o$ $x_o = 0.044/2\pi(20) = 3.5 \times 10^{-4}$ m	M1
	(b)	Cosine shape drawn,	A1
		maximum at $t = 0$, amplitude 3.5×10^{-4} m	A1
	(c)	(any of the following when the velocity is zero) 0.00s, 0.025s,0.050s or 0.075s □	A1
	(d)	Acceleration of plate (in shm) is proportional to (frequency)^2 or $a = \omega^2 x = (2\pi f)^2 x$.	B1
		As frequency increases, acceleration increases until it is equal to g, the acceleration due to gravity.	M1
		When the sand and plate are both free falling at g, the acceleration due to gravity, there is zero contact force between sand and plate when the vibrating surface.	A1

5	(a)	Equipotential lines are closer together near the cable but further apart away from cable.	B1
		Since electric field strength = potential gradient($E = dV/dx$), so E decreases with distance	B1
	(b)	$E = dV/dx = (200\text{-}195) \times 10^3/0.0050$	M1
		$= 1.0 \times 10^6$ Vm^{-1}	A1
	(c)	Gain in ke = loss in pe	M1
		$\frac{1}{2} mv^2 = eV$ $v = \sqrt{2eV/m} = \sqrt{2\times1.6\times10^{-19}\times1500/9.11\times10^{-31}}$	
		$= 2.30 \times 10^7$ ms^{-1}	A1

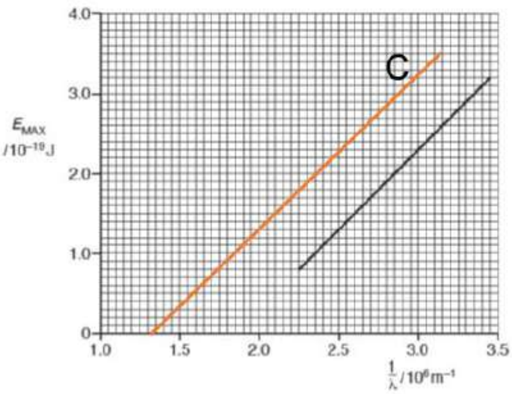
(d) Correct pattern/shape/arrow direction B1
Lines fall perpendicularly to surface of shield B1
Some lines drawn diverging outside open end of shield B1



6	**(a)**	**(i)**	iron rod concentrates/improves flux density / flux/B-field in coil P by Faraday's law, change of flux in coil Q produces induced e.m.f.	B1 B1
		(ii)	By Lenz's law, an induced emf is produced in coil Q to oppose increase in flux by RHGR induced current should externally from X to Y to set up a field/S-pole at end X to oppose the increase in field/flux.  X has higher potential.	M1 M1 A1
	(b)	constant reading (either polarity) from time zero to near t_1 spike in one direction near t_1 clearly showing a larger voltage of opposite polarity zero reading from near t_1 to t_2		B1 B1 B1



7	**(a)**	minimum frequency of e.m. radiation/a photon (not "light") for emission of electrons from a metal surface	B1
	(b)	E_{MAX} corresponds to electron emitted from surface electron (below surface) requires energy to bring it to surface,so less than E_{MAX}	B1 B1
	(c)(i)	$1/\lambda_0 = 1.85 \times 10^6$ (allow 1.82 to 1.88) $f_0 = c / \lambda_0 = 3.00 \times 10^8 \times 1.85 \times 10^6$ $= 5.55 \times 10^{14}$ Hz	C1 A1
	(c)(ii)	$\Phi = hf_0$ $= 6.63 \times 10^{-34} \times 5.55 \times 10^{14}$ (allow ECF from (c)(i)) $= 3.68 \times 10^{-19}$ J	 C1 A1
	(c)(iii)	The classical wave theory cannot explain the existence of the threshold frequency [since it predicts that if sufficiently intense light is used, the electrons would absorb enough energy to escape.]	B1
	(c)(iv)	No change in the graph [Max kinetic energy is independent of the intensity of light]	B1
	(c)(v)	sketch: straight line with same gradient x- intercept is less since threshold frequency is less	M1 A1



Section B

8 **(a)** **(i)** Amount of substance — B1
Thermodynamic temperature. — B1

(award 1 mark for "no of moles and temperature".)

(ii) Molecules collide with one another in a haphazard manner hence they possess different kinetic energies at any time. — B1

(iii) No intermolecular forces in ideal gas, hence no potential energy — B1

(iv) Low pressure — B2
High temperature

(b) **(i)** ρ = density of gas — B1
$\langle c^2 \rangle$ = mean square speed — B1

(ii) $p = 1/3\ \rho \langle c^2 \rangle$ — M1
=> $pV = 1/3\ M \langle c^2 \rangle$ since $\rho = M/V$
For ideal gas, $pV = n\,RT$
Hence, $1/3\ M \langle c^2 \rangle = n\,RT$ — B1

Total KE = $½\, M \langle c^2 \rangle = 3/2\ n\,RT$

(iii) 1. Same because average K.E. is proportional to temperature — B2
2. Different because the masses of the gases are different.

(c) **(i)** pV = nRT — M1
$(6.0 \times 10^5)\ (0.10) = (10)\ (8.31)\ T$ — A1

T = 722 K

(ii) The products of p and V are not constant. For example, the product of p and V is 5.0×10^4 J at B, but 6.0×10^4 J at A. — B1
(Accept calculation of temperature at B = 600 K)

(iii) Work done in one cycle estimated from the area enclosed — M1
= 8.8×10^4 J — A1
(Note the positive sign as net work is done by the gas)

(iv) In one cycle $\Delta U = q + W = 0$ => $q = 8.8 \times 10^4$ J — A1

(v) Curve for process A → B gentler/enclosed area larger — B1
Hence *W* larger implies, *q is* larger. — B1

9 **(a)** The Principle of Superposition states that when two or more waves of the same kind overlap, the resultant displacement at any point at any instant — B1, B1 is the vector sum of the displacements that the individual waves would have separately produced at that point and at that instant.

(b) $d \sin\theta = n\lambda$ M1

(i) $\left(\frac{10^{-3}}{550}\right)\sin 90 = n(644 \times 10^{-9})$ A1

$n = 2.8$

Highest order that can be seen is the 2nd order.

Hence total number of bright lines observed is 5. A1

(ii)

1. Since θ is greater, λ is also greater. B1
2. When n is larger, Δθ is larger, thus the greatest separation occurs in the second order. B1

(c) **(i)** The coherent waves from the laser meet at a point on the screen with a constant phase/path difference. B1

When waves meet in phase with phase difference of n(2π rad) or path difference of nλ where n is an integer, constructive interference occurs. B1

When the waves meet exactly out of phase (any equivalent explanation of minima e.g. (n+½)λ or (n+½)×2 π rad, destructive interference occurs. B1

(ii) 1.

$\sin\theta = \frac{\lambda}{b}$ M1

sin θ = $(6.44 \times 10^{-7})/(2.4 \times 10^{-5})$

θ = 1.54° A1

tan 1.54° = *O'Y* /2.5

O'Y = 0.067 m

Width = 0.067 x 2 = 0.134 m A1

2.

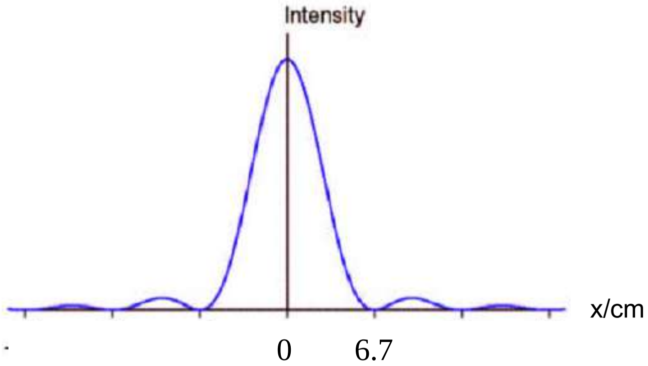


Diagram should show 3 maximas, symmetrical about O | B1
Correct shape, with decreasing intensity | B1
Correct spacing labelled | B1
Any missing- minus 1 mark

(ii) 3.

$I \propto A^2$

With 2 slits,

When Intensity = I, amplitude of maxima = A + A

With 1 slit,

Amplitude of maxima = A | C1

$I' = (A/2A)^2 \times I = \frac{1}{4} I$ | A1

(iii) Rayleigh criterion stated. | B1

Yes as the interference patterns formed by the two sources are resolved when θ is equal or greater than 1.54°. | B1

Name: ______________________________________ CG: ___________ Date: _____________

Suggested Mark Scheme

Question 1

No	Marking Instructions	Mark	Score
(a)(i)	*d* recorded to nearest 0.1 mm with unit	1	
(a)(ii)	*h* and *D* recorded to nearest 0.1 mm or 1 mm with unit with evidence of repeat timing	1	
(b)(iii)	*x* calculated correctly to correct s.f.	1	
(b)(iv)	Correct justification of s.f. in *x* linked to s.f. in *D, d* and *h* (lowest s.f.)	1	
(c)(ii)	Value of *t* to correct d.p. with unit (5.0 s ≤ t ≤ 9.0 s) Evidence of repeat timing	1 1	
(c)(iii)	Correct calculation of % uncertainty using sensible value of Δt (0.2 s ≤ Δt ≤ 0.5 s). (May vary based on students' repeat values)	1	
(d)	Second value of *x* Second value of average *t*	1 1	
(e)(i)	Correct calculations of the two *k* values	1	
(e)(ii)	Draw conclusion based on stated criterion. (e.g. not obeyed because % difference of *k* values > % uncertainty of *t* in (c)(iii))	1	
(f)(i)	Two sources of error. Relevant points might include: 1. Difficult to release small container from same position every time with reason (e.g. placing fingers in water, changing level of water surface, difficult to judge start point) 2. Small container does not always fall vertically (e.g. cylinder tilted at an angle / hits sides on descent) 3. Timing is too short / large uncertainty in timing 4. Difficult to identify end point with reason (e.g. difficult to see due to refraction, glass curvature) 5. Only 2 marbles were able to fit into the small container 6. Bubble / air in container	2	
(f)(ii)	One improvement each. Relevant points might include: 1. Better method to hold and release cylinder (e.g. use a pincer / make a mark for reference to ensure same water level for each release) 2. Method to attach string symmetrically / ensure symmetrical distribution of masses (e.g. use glass beads / sand / modelling clay for even mass distributions) 3. Use a longer tube / video the descent and view frame by frame) 4. Method to identify end point (e.g. mark at bottom of cylinder) 5. To fit more marbles (so as to have a larger n), use cubic masses / smaller spheres, sand / modelling clay or to use a larger container 6. Puncture a small hole in the lid to release bubble / air	1	
	Total	14	

Question 2

No	Marking Instructions	Mark	Score
(a)(ii)	*x* recorded to nearest mm with unit	1	
(b)(ii)	V_1 and V_2.recorded to correct d.p. with unit (2 or 3 d.p. in V)	1	
(c)	Collected and tabulated 5sets of data. V_2V_1 calculated correctly to correct s.f.	1 1	
(d)(i)	Linear graph with y-intercept. Appropriate scales – awkward scales (e.g. 3:10) are not allowed and scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Correct labelling of axes with correct units. All observations plotted to an accuracy of half a small square and line of best fit drawn with a fair scatter of points on either side of the line	1 1	
(d)(ii)	Correct conclusion of the relationship based on student's result	1	
(d)(ii)	Line Z with steeper gradient and same y-intercept	1 1	
	Total	9	

Question 3

No	Marking Instructions	Mark	Score
(b)(i)	*r* recorded to nearest mm with unit with unit with evidence of repeat timing	1	
(b)(ii)	Measure diameter *D* of the masses in different orientations and calculate the average *D*. Record readings R_1 and R_2 of the outer edges of the masses. Then $r = ½ (R_2 – R_1 –D)$ <u>OR</u> Measure centre to centre (through the gap) of the 2 slotted masses Divide by 2	1 1	
(c)(ii)	2.6 s ≤ *T* ≤ 4.6 s Evidence of repeat timing	1	
(d)	Collected 6 or more sets of data (*r, T*). Award 1 mark if assistance was rendered, or collected only 5 sets of data	2	
	Each column heading contains an appropriate quantity and unit	1	
	Consistency in no. of d.p. for raw readings (*r* to nearest mm, *T* to 0.1 s)	1	
	Correct calculation of quantities (T^3, r^2)	1	
	All calculated values given to appropriate no. of s.f.	1	
(e)	Linearising equation and deriving gradient / y-intercept of graph	1	
	Appropriate scales – awkward scales (e.g. 3:10) are not allowed and scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Correct labelling of axes with correct units	1	
	All observations plotted to an accuracy of half a small square	1	
	Line of best fit – with a fair scatter of points on either side of the line	1	
	Gradient – hypotenuse of the triangle is greater than half the length of the drawn line. Read-offs must be accurate to half a small square	1	
	Y intercept – read off directly from the graph to half a small square or determined from $y = mx + c$ using a point on the line	1	
	Value of *a* and *b* calculated correctly with correct units, if any	1	
(f)	Appropriate comment on any anomaly	1	
(g)(i)	One source of error. Relevant points might include: 1. Difficult to ensure that the metre rule on the beaker is horizontal at the start 2. Difficult to measure distance *r* accurately as the mass obscure the scale reading of the metre rule	1	
(g)(ii)	One improvement. Relevant points might include: 1. Use a spirit level or another ruler to check for equal height of horizontal metre rule at both ends 2. Measure diameter of mass with a vernier caliper and add half the diameter to the reading of the inner edge of mass	1	
	Total	20	

Q4 Planning Question

Marks	Marking Points
	Design
A1	Diagram with workable arrangement: cylinder with mass on top and strain gauge attached
A2	Strain gauge has correct orientation on the cylinder
A3	Correct circuit diagram with voltmeter, ammeter and power supply / ohmmeter
	Procedure
B1	Method to measure mass and determine $\Delta F = mg$
B2	Method to measure resistance ($R = V/I$) and determine ΔR
B3	Method to vary compression (e.g. load different masses)
B4	Maintain constant temperature (monitor with a thermometer)
	Safety and Analysis
C1	Wear goggles in case concrete cracks Clamp / secure cylinder to bench to avoid toppling
C2	Plot lg ΔF against lg ΔR to show relationship and gradient gives n
	Details (Max 3 D marks)
D1	Preliminary experiments to determine suitable range of masses for observable / meaningful ΔR
D2	Compressive force applied centrally to cylinder
D3 D4	Check for permanent deformation of concrete (if resistance returns to original value when masses are removed)
D5	Other possible good physics suggestions
12	

VICTORIA JUNIOR COLLEGE

2018 JC2 PRELIMINARY EXAMINATIONS

PHYSICS **9749/01**
Higher 2
20 Sep 2018

Paper 1 Multiple Choice **THURSDAY**

2 pm- 3 pm

Additional Materials: Multiple Choice Answer Sheet **1 Hour**

READ THESE INSTRUCTIONS FIRST

Write in soft pencil (2B or softer).
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT group and shade your index number on the Answer Sheet provided.

HOW TO SHADE YOUR INDEX NUMBER:
Eg. If your class is 17S43, index number is 06, then shade 1740306.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers A B C and D**.**
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J mol^{-1} K^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + (½)\, at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{GM}{r}$
temperature	$T / K = T / °C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_o \cos \omega t$ $= \pm\omega\sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + ...$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential,	$V = Q/4\pi\varepsilon_o r$
alternating current/voltage,	$x = x_o \sin \omega t$
Magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
Magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
Magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 To find the resistivity of a semiconductor, a student makes the following measurements of a cylindrical rod of the material.

length = (25 ± 1) mm
diameter = (5.0 ± 0.1) mm
resistance = (68 ± 1) Ω

He calculates the resistivity to be 5.341×10^{-2} Ω m.
How should the uncertainty be included in his statement of the resistivity?

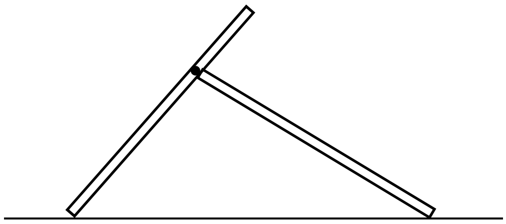
A $(5.34 \pm 0.07) \times 10^{-2}$ Ω m
B $(5.34 \pm 0.09) \times 10^{-2}$ Ω m
C $(5.3 \pm 0.4) \times 10^{-2}$ Ω m
D $(5.3 \pm 0.5) \times 10^{-2}$ Ω m

2 Ball 1 is launched up an inclined plane from point A with an initial speed that is the minimum speed for it to just reach point B at the top of the plane. At the same moment that Ball 1 is launched up the plane, Ball 2 is released from rest from point B. The two balls collide at a point C somewhere on the inclined plane.

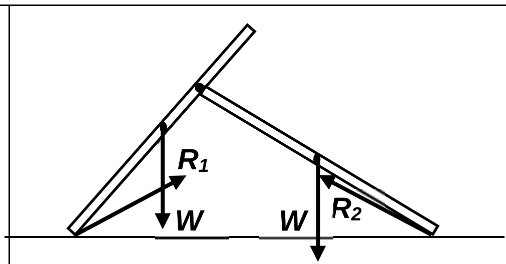
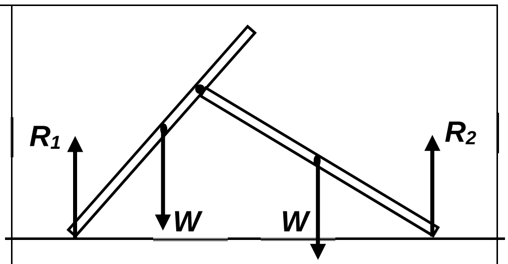
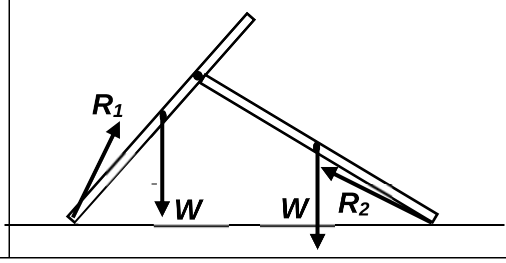
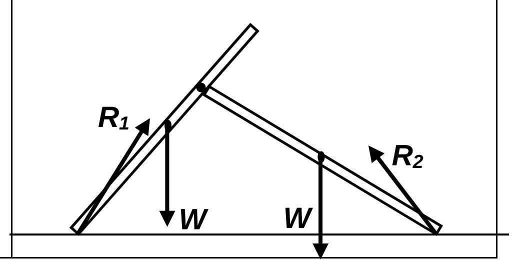
What is the ratio of the distance AC to the distance BC?

A 1 **B** 2 **C** 3 **D** 4

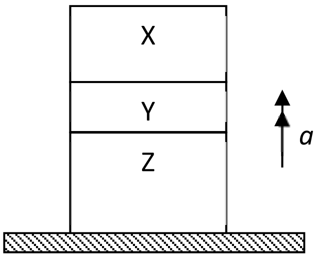
3 Two identical uniform rods, each of weight W, are hinged together to form a structure which is resting on a rough floor as shown.



If the reaction forces acting on the structure by the floor are R_1 and R_2, which of the following shows the forces acting on the structure?

A		**B**	
C		**D**	

4 Three crates X, Y and Z of masses *3m, m* and *5m* respectively, are stacked on top of one another on the floor of a lift which is moving upwards with an acceleration *a*.



What is the magnitude of the force exerted by crate Y on crate Z during this acceleration?

A $4mg + 4ma$ **B** $4mg + 5ma$

C $4mg - 4ma$ **D** $4mg - 5ma$

5 A 100 kg crate is pulled from rest across a floor with a constant force of 320 N. For the first 20.0 m, the floor is frictionless and for the next 10.0 m, a constant frictional force of 30.0 N acts on the crate. What is the final speed of the crate?

A 8.00 m s^{-1} **B** 8.37 m s^{-1}

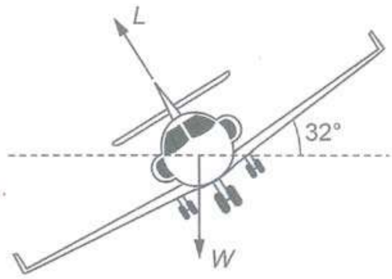
C 13.6 m s^{-1} **D** 13.9 m s^{-1}

6 A truck of mass 3500 kg has an engine which can deliver a constant power. The truck experiences a constant frictional force of 3250 N. The truck travels at a velocity of 16 m s^{-1} when it is accelerating at 0.35 m s^{-2}. What is the maximum speed that the lorry can achieve on level ground?

A 6.0 m s^{-1} **B** 12 m s^{-1}

C 20 m s^{-1} **D** 22 m s^{-1}

7 A small aircraft flies at speed v in a horizontal circle of radius r. To do so, the plane of its wings must be at an angle of 32° to the horizontal as shown. The directions of the two forces in the vertical plane acting on the aircraft, weight W and lift L, are also shown.



At which angle to the horizontal must the aircraft fly in a horizontal circle of radius $\frac{r}{2}$ at a speed of $2v$?

A 17° **B** 51° **C** 68° **D** 79°

8 Which statement about geostationary orbits is false?

A A geostationary orbit must be directly above the equator.

B All satellites in geostationary orbits must have the same mass.

C The period of a geostationary orbit must be 24 hours.

D There is only one possible radius for a geostationary orbit.

9 A satellite of mass 690 kg orbits the Earth along a circular path of radius 7.2×10^6 m. Its orbital speed is 7.5 km s^{-1}. A rocket engine on the satellite is fired. The satellite falls into a lower orbit of radius 6.5×10^6 m where its orbital speed becomes 7.9 km s^{-1}.

Which statement about the change to the total energy of the satellite caused by the rocket burn is correct? [Mass of the Earth = 6.0×10^{24} kg]

A The satellite gains approximately 2×10^9 J.

B The satellite gains approximately 3×10^9 J.

C The satellite loses approximately 2×10^9 J.

D The satellite loses approximately 4×10^9 J.

10 The specific heat capacity of a liquid is to be found using a continuous flow calorimeter. First an input power of 10 W is used. When the input power is 18 W it is found that the liquid flow rate must be *tripled* to give the same temperature rise. What is the rate of heat lost to the surroundings?

A 3.3 W **B** 6.0 W

C 6.7 W **D** 7.5 W

11 The density of helium at 150 kPa is 0.178 kg m^{-3}. What is the root-mean-square speed of its particles?

A 130 m s^{-1} **B** 232 m s^{-1}

C 1300 m s^{-1} **D** 1600 m s^{-1}

12 A particle is oscillating with simple harmonic motion described by the equation:

$$y = 5\sin(20\pi t)$$

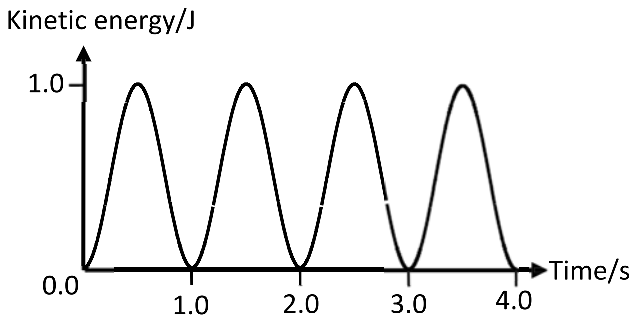
where *y* is in meters and *t* is in seconds.

How long does it take the particle to travel from its position of maximum displacement to a position half way between the maximum displacement and the equilibrium position?

A Less than 12.5 ms **B** 12.5 ms

C Between 12.5 ms and 25 ms **D** 25 ms

13 The time-variation of the kinetic energy of a particle undergoing simple harmonic motion with amplitude of 3.0 cm is shown in the figure below.



What is the maximum velocity of the particle?

A $0.59\ m\ s^{-1}$ **B** $0.30\ m\ s^{-1}$ **C** $0.094\ m\ s^{-1}$ **D** $0.19\ m\ s^{-1}$

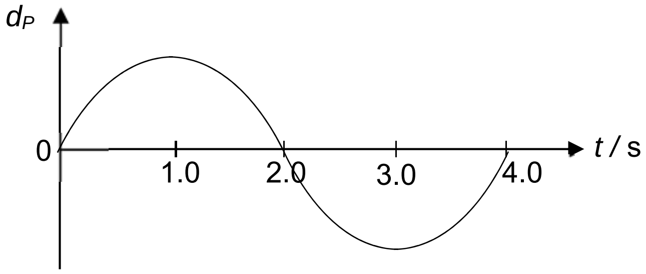
14 An antenna broadcasts a signal uniformly in all directions using a power of 240 W. A receiver dish of diameter 3.0 m and 750 m away receives the signal.

What is the power received by the dish?

A 9.6×10^{-7} W **B** 3.8×10^{-6} W
C 2.4×10^{-4} W **D** 2.9×10^{-3} W

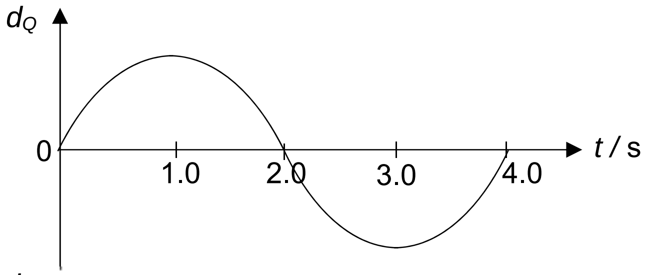
15 P and Q are two points 12 m apart.

A wave travels from P to Q at a speed of 3.0 m s^{-1}. The graph below shows how the displacement of P, d_P, varies with time t:

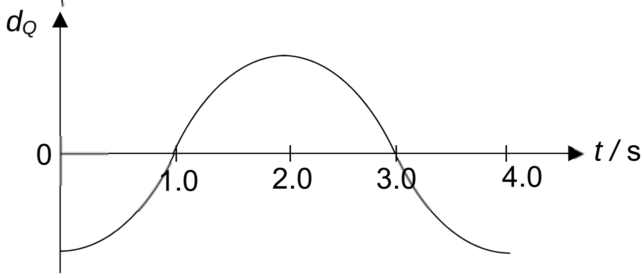


Which of the following graphs correctly shows how the displacement of Q, d_Q, varies with time t?

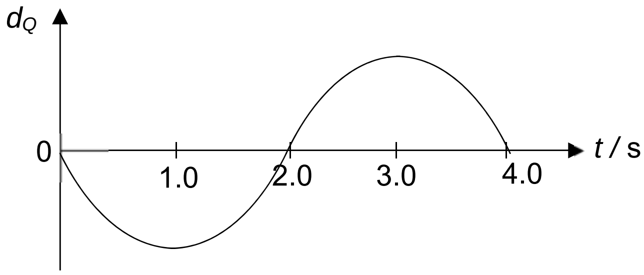
A



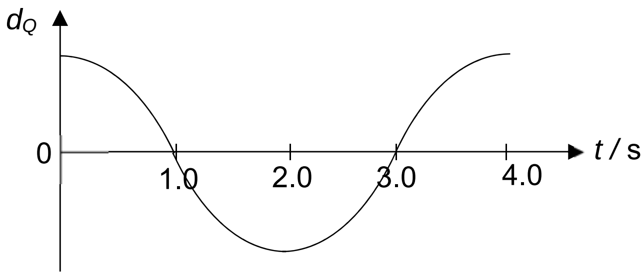
B



C



D



16 A string of length 1.0 m is fixed at both ends, and made to vibrate. Which of the following wavelengths cannot be formed on the string?

A 0.50 m **B** 0.67 m **C** 1.3 m **D** 2.0 m

17 A satellite orbits the Earth at a height of 120 km. It has a camera of aperture 2.5 cm. By considering a wavelength of visible light of 5.5×10^{-7} m, what is the nearest distance between two objects on the surface of Earth that can be distinguished as separate objects?

A 1.3 m **B** 2.6 m **C** 3.9 m **D** 5.2 m

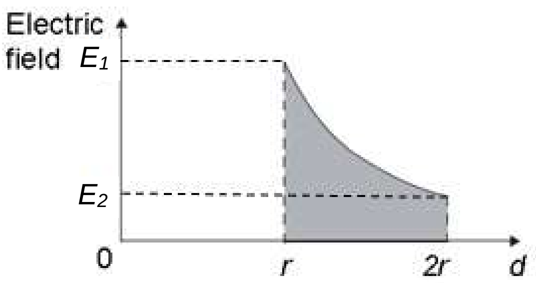
18 Two equal and opposite charges $+q$ and $-q$ are situated 1.00 m apart.

At a point P, 0.40 m from the charge $+q$, the magnitude of the electric field strength due to the charge $+q$ alone is 12 N C^{-1}.

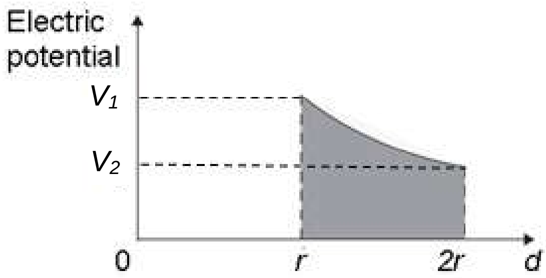
What is the magnitude of the electric field strength at P due to both charges?

A 17 N C^{-1} **B** 20 N C^{-1} **C** 23 N C^{-1} **D** 30 N C^{-1}

19 The two graphs below represent the variation with distance, d, for $d = r$ to $d = 2r$ of the electric field and the electric potential around an isolated point charge. The electric field strengths and potentials at the two positions are E_1, E_2, V_1 and V_2 respectively as shown in the diagram.



Graph 1

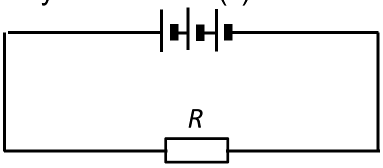


Graph 2

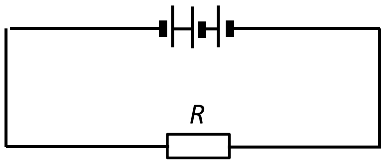
The work done by an external force in moving a test charge $+q$ from $d = 2r$ to $d = r$ is equal to

A q x shaded area under Graph 1.
B q x shaded area under Graph 2
C $q \times \frac{1}{2}(E_1 + E_2)$.
D $q \times (V_2 - V_1)$.

20 Three identical cells each having an e.m.f of 1.5 V and a constant internal resistance of 2.0 Ω are connected in series with a 4.0 Ω resistor *R*, firstly as in circuit (i), and secondly as in circuit (ii).



Circuit (i)

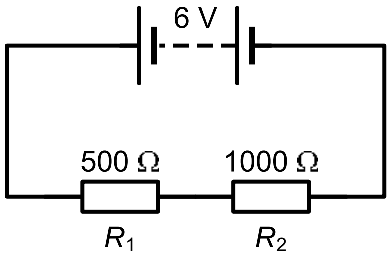


Circuit (ii)

What is the ratio $\frac{power\ in\ R\ in\ circuit\ (i)}{power\ in\ R\ in\ circuit\ (ii)}$?

A 9.0 **B** 7.2 **C** 5.4 **D** 3.0

21 The diagram shows a 6 V battery, with negligible internal resistance, connected in series to two resistors R_1 and R_2.
R_1 has a resistance of 500 Ω and R_2 has a resistance of 1000 Ω.



A third resistor with a resistance of 500 Ω is placed in parallel across R_2.
Which statement about the new circuit is correct?

A The current in R_2 is larger than before.

B The current through the battery is smaller than before.

C The potential difference across R_1 is larger than before.

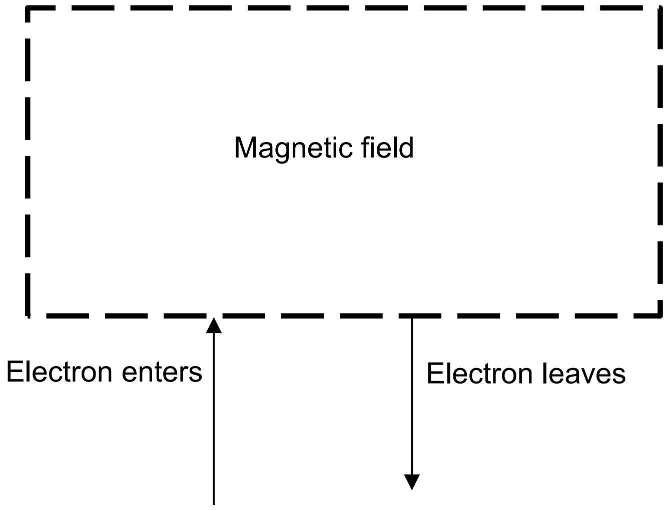
D The potential difference across R_2 is now greater than the potential difference across R_1.

22 An electric kettle, designed for travelers, can be used with different supply voltages. It is rated at 600 W for a 240 V r.m.s. alternating supply. What will be its power output if it is connected to a 120 V direct supply?

A 150 W **B** 300 W

C 600 W **D** 1.20 kW

23 An electron travelling at a speed of 5.0×10^7 m s^{-1} enters perpendicularly into a rectangular region of uniform magnetic field of strength 3.0 T, as shown below. The field is perpendicular to the page:



How much time does the electron spend inside the magnetic field?

A	2.3×10^{-31} s	**B**	1.1×10^{-23} s
C	1.2×10^{-19} s	**D**	6.0×10^{-12} s

24 A straight wire XY 2.0 cm long carrying a current of 1.5 A is placed at the centre of a solenoid 1.2 m long with 20 000 turns of wire and carrying a current of 3.0 A, so that the wire XY is perpendicular to the magnetic field produced by the solenoid.

What is the magnetic force acting on the wire XY?

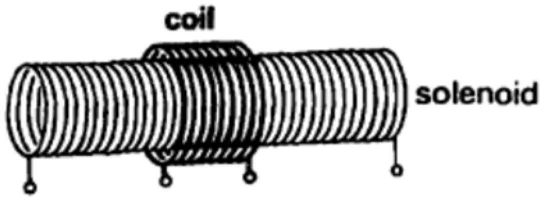
A	6.0×10^{-4} N	**B**	7.2×10^{-4} N
C	1.9×10^{-3} N	**D**	2.3×10^{-3} N

25 A copper disc of area *A* rotates at angular frequency ω at the centre of a long solenoid of length *L* and having *N* turns. The solenoid carries a current *I*. The plane of the disc is normal to the magnetic flux. The rotation rate is adjusted so that the e.m.f. generated between the centre of the copper disc and its rim is 10% of the potential difference across the ends of the solenoid.

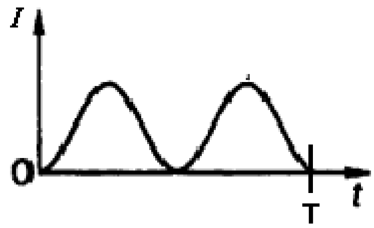
Which expression gives the potential difference across the ends of the solenoid?

A $10\mu_o NIA\omega$
B $1.6\mu_o NIA\omega/L$
C $0.1\mu_o NIA\omega$
D $0.016\mu_o NIA\omega/L$

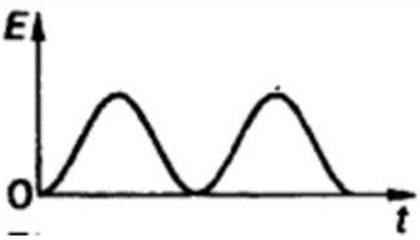
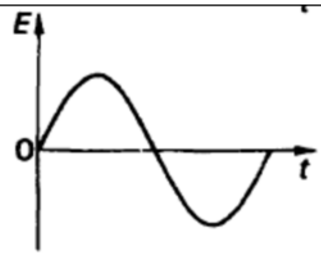
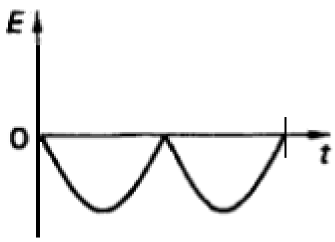
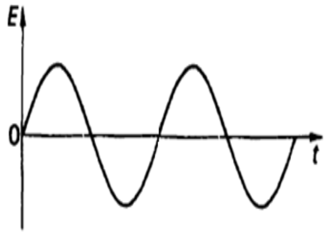
26 The diagram shows a short coil wound over the middle part of a long solenoid.



The solenoid current *I* is varied with time *t* as shown in the sketch graph. As a consequence, the flux density of the magnetic field due to the solenoid varies with time. The relation between *B* and *I* is $B = \mu_0 n I$ where *n* is the number turns per unit length.



Which graph shows how the e.m.f. *E* induced in the short coil varies with time *t?*

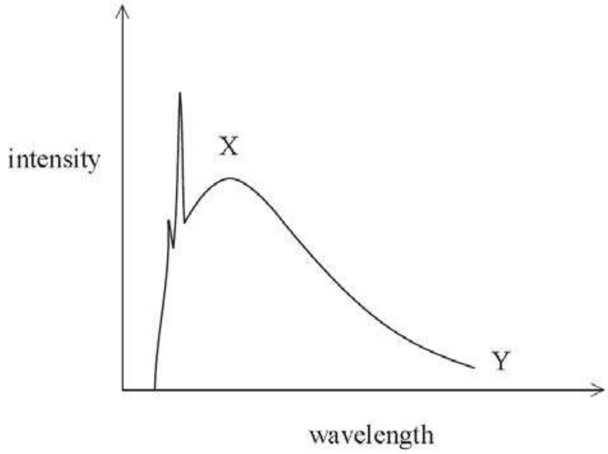
A		**B**	
C		**D**	

27 In a photoelectric effect experiment, ultraviolet light of wavelength 150 nm shines on a clean metal surface. The stopping potential was determined to be 2.1 V.

What is the work function of the metal used?

A 2.1 eV **B** 6.2 eV **C** 8.3.eV **D** 10.4 eV

28 The diagram shows a typical X-ray spectrum produced by the bombardment of a heavy metal target by high energy electrons.



Which of the following best explains the part of the spectrum labelled XY?

A The diffraction of the electrons striking the metal target.
B The acceleration of the electrons striking the metal target.
C Electron transitions between energy levels in the atoms of the metal target.
D The decrease in kinetic energy of photons.

29 Which of the following statements concerning nuclear properties is true?

A The greater the binding energy of a nucleus, the more stable it is.

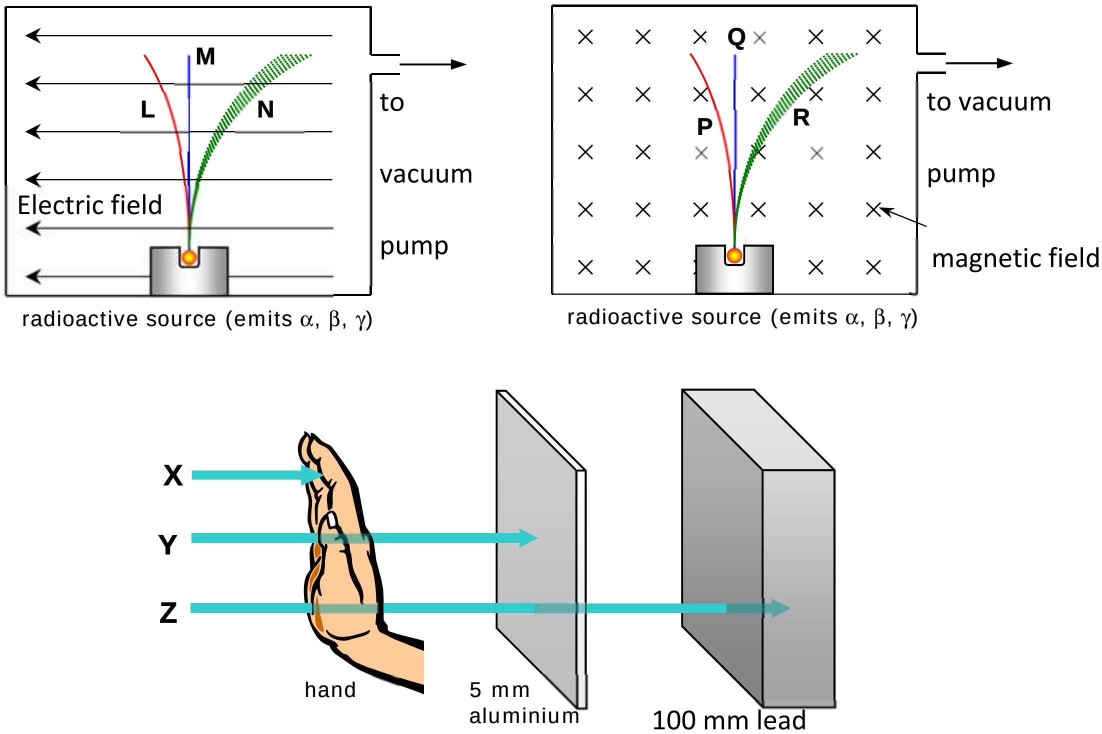
B If the total rest mass of the products of a reaction is greater than the total rest mass of the reactants, this reaction is impossible.

C The half-life of a radioactive substance can be changed by allowing the substance to react chemically to produce a new radioactive compound.

D When a stationary nucleus decays by emitting a γ-photon, the nucleus will move off in an opposite direction to the photon.

30 A radioactive source emits alpha, beta and gamma radiation. The three diagrams below illustrate the behaviours of the three radiations from this source.

Which three labels refer to the same kind of radiation?



A	L, R, X	**B**	M, Q, X	**C**	L, P, Z	**D**	N, R, Y

Name : _______________________________ CT group: ____________

VICTORIA JUNIOR COLLEGE
2018 JC2 PRELIMINARY EXAMINATIONS

PHYSICS	**9749/02**
Higher 2	**12 Sep 2018**
Paper 2 Structured Questions	**WEDNESDAY**
	8 am – 10 am
	2 Hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and CT group at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
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sf	
units	
Total (max. 80)	

This document consists of **18** printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J mol^{-1} K^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + (½)\, at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{GM}{r}$
temperature	$T / K = T / °C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_o \cos \omega t$ $= \pm\omega\sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = Q/4\pi\varepsilon_o r$
alternating current/voltage,	$x = x_o \sin \omega t$
Magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
Magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
Magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer all questions in the spaces provided

1(a) When an object is placed in water, it experiences an upthrust.

(i) Explain what is meant by upthrust. [1]

(ii) A container contains two liquids A and B which do not mix. The densities of liquids A and B, denoted by ρ_A and ρ_B, are 1.30×10^3 kg m^{-3} and 0.900×10^3 kg m^{-3} respectively. A cubical solid of side 0.200 m and mass 9.20 kg stays upright in equilibrium in between the two liquids as shown in Fig. 1.1. The depth of the solid submerged in Liquid A is denoted by *x*.

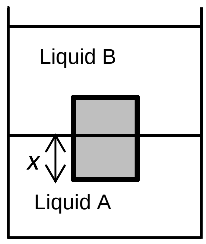


Fig. 1.1

1. Write down an expression for the upthrust exerted on solid by Liquid A in terms of x, ρ_A and g. [1]

2. Write down an expression for the upthrust exerted on solid by Liquid B in terms of x, ρ_B and g. [1]

3. Hence, or otherwise, determine *x*. [2]

(b) A hungry bear walks out from a cave onto a horizontal uniform beam of length L, supported on the left by a hinge attached to a wall, in an attempt to retrieve some "goodies" hanging at the right end (Fig. 1.2). The total weight of the bear and the beam is 900 N. The goodies weigh 80.0 N. Fig. 1.3 gives the tension T in the cable as a function of the bear's position given as a fraction x/L of the beam length.

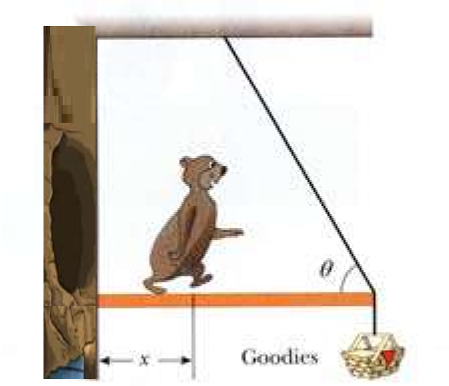


Fig. 1.2

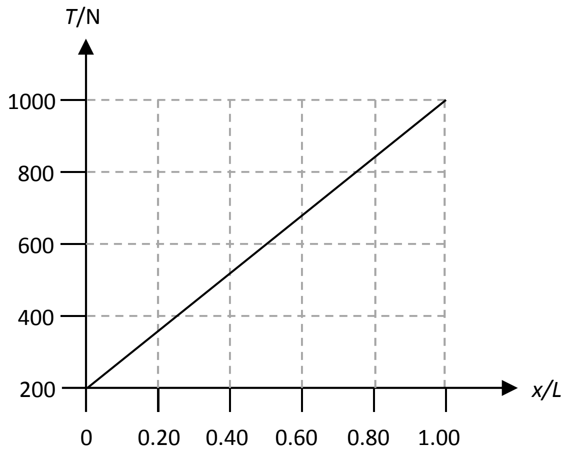


Fig. 1.3

(i) By considering the bear standing at the centre of the beam, calculate the angle θ. [2]

(ii) Suggest where, on the beam, the bear should stand so that his weight does not produce a moment on the beam. [1]

(iii) Calculate the mass of the beam. [2]

2(a) Explain the various energy conversions that occur during each of the following events:

(i) A car moving on a rough horizontal road coming to a stop. [2]

(ii) A mass is attached to the bottom of a vertical spring. The mass is lowered slowly until it reaches an equilibrium position and remains stationary at that position. [3]

(b) The skateboarder in Fig. 2.1 below is 55 kg. She enters the ramp of height *h* at point A with a speed of 6.5 m s^{-1} and leaves the ramp vertically upwards at point B. The skateboarder experiences an average frictional force of 2.0 N by the ramp. The distance travelled between A and B is 2.0 m and *h* is 1.3 m.

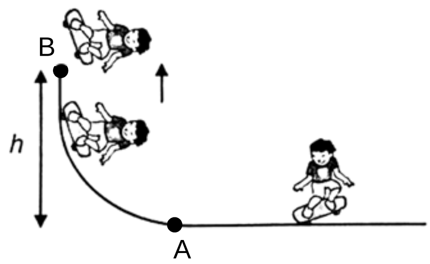


Fig. 2.1

(i) Determine the speed of the skateboarder as she exits point B. [3]

(ii) State and explain whether your answer to b(i) will be different if the ramp is replaced by the one shown in Fig. 2.2 below. The average frictional force by the ramp is still 2.0 N. The points A and B are in the same positions as in Fig. 2.1. [2]

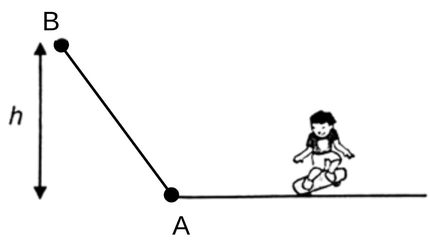
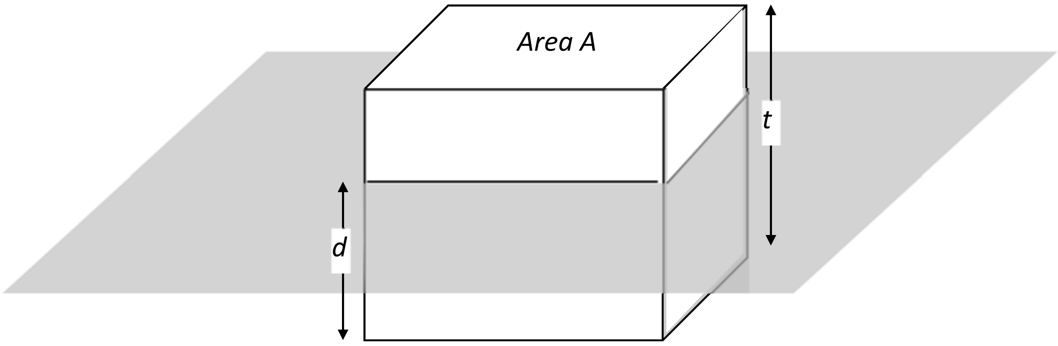


Fig. 2.2

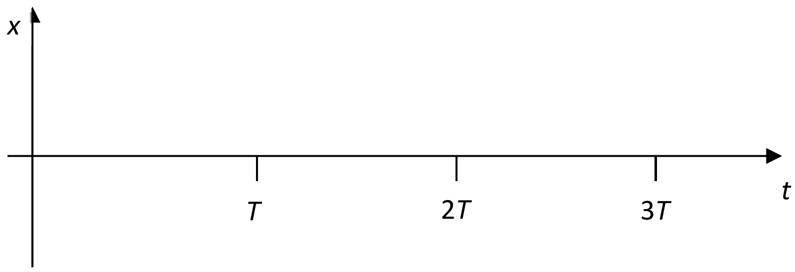
3(a) A rectangular block of wood of cross-section *A* and thickness *t* floats horizontally in water as shown in the figure below.



When the block is pushed downwards and then released, it undergoes ***damped*** harmonic motion.

(i) Explain why the motion of the block undergoes damping. [1]

(ii) Sketch a labelled graph showing the variation of displacement *x* with time *t* for a time interval over three periods. [2]



(b) Surface water waves from a constant amplitude wave generator are incident on the block. These causes ***forced oscillations*** in the motion of the block. The frequency of the wave generator is varied and ***resonance*** was observed at a particular frequency.

(i) Explain the terms ***'forced oscillations'*** and ***'resonance'*** with reference to the motion of the block. [2]

(ii) Resonance occurs when the water waves incident on the block has a speed of 0.90 m s^{-1} and wavelength 0.30 m.

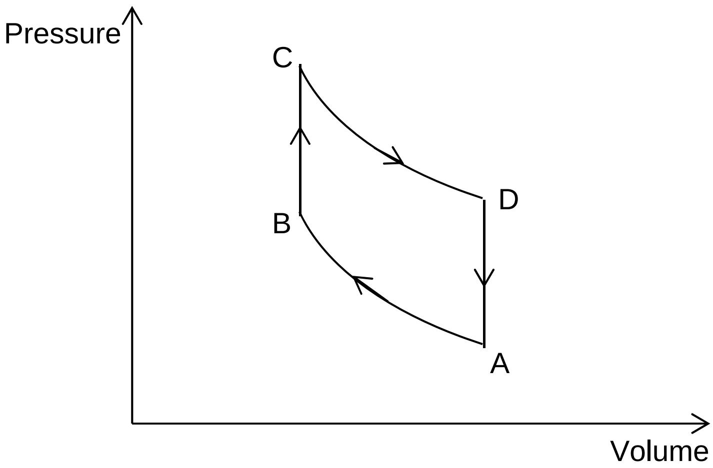
1. Calculate the frequency of the water waves. [1]

2. Given that the expression for the natural frequency of the oscillating block is given by $f = \frac{1}{2\pi}\sqrt{\frac{28}{m}}$ where f is in Hz and m in kg, calculate the mass of the block. [1]

3. Describe and explain what happens to the amplitude of vertical oscillations of the block after the block has absorbed some water. [2]

4(a) State the First Law of Thermodynamics in words. [1]

(b) A gas in an engine undergoes a cyclic process ABCD, as shown in the pressure – volume diagram below:



AB and CD are adiabatic processes, while BC and DA are isochoric processes.

(i) For process AB, the work done is 10 J. Calculate the change in internal energy of the gas. State whether it is an increase or decrease. [2]

For process BC, 70 J of heat is supplied to the gas, while for process CD, 25 J of work is done.

(ii) Calculate the heat flow during process DA. State whether it is into or out of the gas. [3]

(iii) Calculate the efficiency of the engine. [2]

(iv) The engine executes 3000 cycles per minute. Calculate its useful power output. [2]

5(a) State Lenz's law and explain how you would use a coil and a magnet to demonstrate the law. Make clear the use of any other apparatus in your explanation. [4]

(b) An instrument based on induced electromotive force (e.m.f.) is used to measure the speed of a projectile.

A small, strong but light magnet is imbedded in the projectile as shown in Fig. 5.1. The projectile passes through the two identical coils with N turns each, separated by a distance d with constant speed. As the projectile passes through each coil, a pulse of e.m.f. is induced in the coil. The time interval between the pulses can be measured accurately with an oscilloscope.

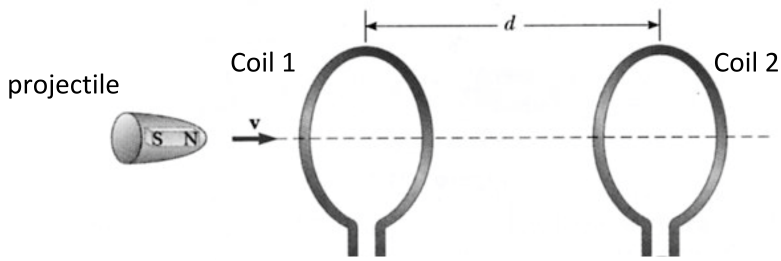


Fig 5.1

(i) Use the laws of electromagnetic induction to explain why an e.m.f. is induced in the coils. [2]

(ii) In Fig. 5.2, draw clearly a graph of the variation of induced e.m.f. against time for the arrangement shown in Fig. 5.1.

On your graph, label clearly which pulse is from coil 1 and which is from coil 2.

Fig. 5.2

(iii) If the pulse separation is 2.40 ms and *d* is 1.50 m, calculate the speed of the projectile. [1]

(iv) State and explain how the graph in Fig. 5.2 will differ if the speed of the projectile is increased. [2]

6. Radioactive decay is the *spontaneous* and random emission of radiation from a radioactive source. Radioactive nuclide $^{131}_{52}\text{Te}$ decays by β emission to form $^{131}_{53}\text{I}$. $^{131}_{53}\text{I}$ is not stable, and decays by β emission to the stable isotope $^{131}_{54}\text{Xe}$. The *half-life* for this second decay is very much longer than that for the decay of $^{131}_{52}\text{Te}$. A sample of pure $^{131}_{52}\text{Te}$ is prepared at time $t = 0$. Fig 6.1 shows the activity A of the sample over a period of 10 hours.

***t*/hr**	***A*/Bq**
0	1.00×10^{12}
1	1.94×10^{11}
2	3.95×10^{10}
3	1.08×10^{10}
4	2.66×10^{9}
5	2.27×10^{9}
6	2.12×10^{9}
7	2.12×10^{9}
8	2.12×10^{9}
9	2.12×10^{9}
10	2.12×10^{9}

Fig. 6.1

(a) Explain the meaning of the terms *spontaneous* and *half-life*. [2]

(b) The relation between activity A and time t follows the expression

$$A = A_0 e^{-\lambda t}$$

where A_0 is the initial activity and λ is a constant.

Data from Fig. 6.1 is used to obtain values for ln A. The variation with time t of ln A is plotted on the graph of Fig 6.2.

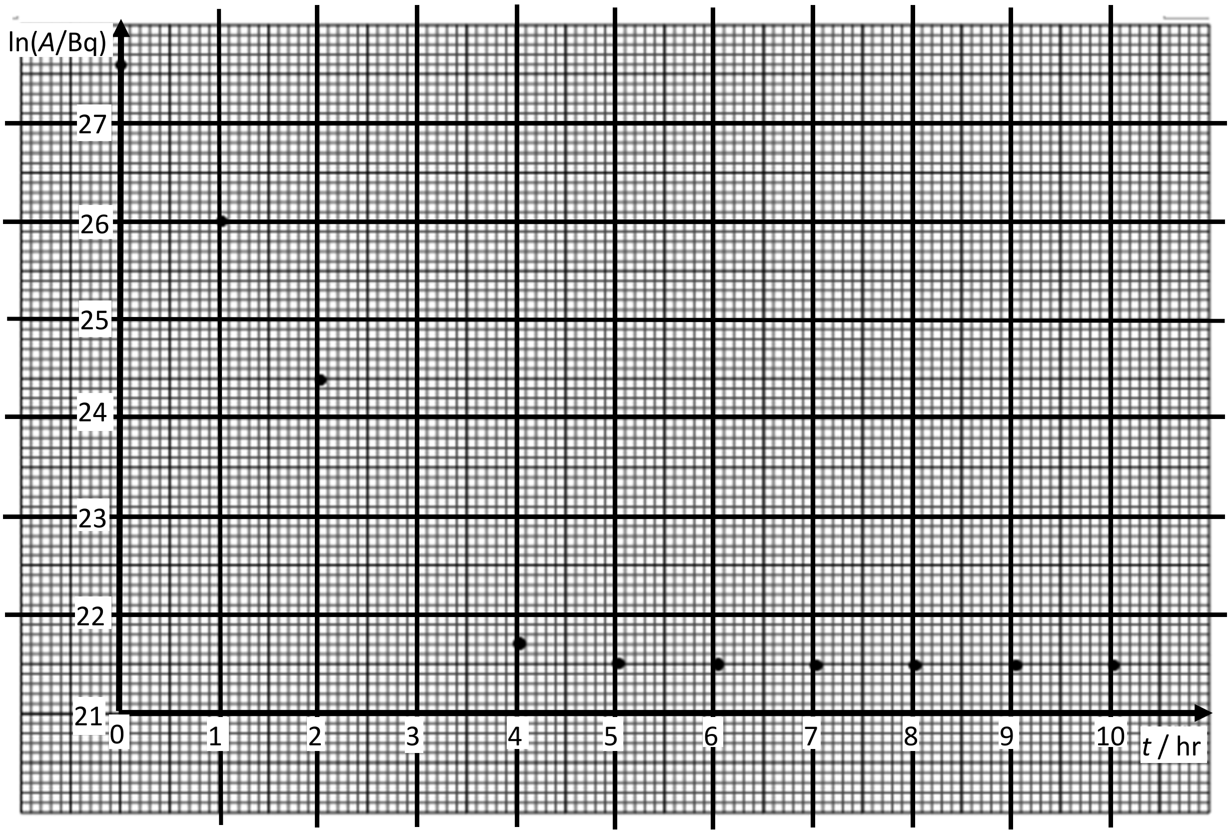


Fig. 6.2

(i) Determine ln A for t = 3 hr. [1]

(ii) On Fig. 6.2,

1. plot the point corresponding to t = 3 hr,
2. draw the line of best fit for all the points. [2]

(iii) Explain the shape of the line drawn in **(ii)**. [2]

(iv) Using the line drawn in **(ii)**, show that the decay constant of ${}^{131}_{52}\text{Te}$ is approximately 1.5 hr^{-1}. [2]

(v) Hence, or otherwise, deduce the initial number of ${}^{131}_{52}\text{Te}$ nuclei. [2]

(vi) Explain why the amount of ${}^{131}_{53}\text{I}$ in the sample first increases and then decreases. [2]

(vii) Assume that all the $^{131}_{52}Te$ has been converted to $^{131}_{53}I$ after about 6 hours. Calculate the half-life of $^{131}_{53}I$. [3]

7. Bats emit high frequency sound waves and receive reflected echoes. They use the echoes to locate their position. This process is called echolocation.

Sound waves emitted by the bat travel at 340 m s^{-1}. Their typical frequency range is 20 kHz to 80 kHz.

(a) Calculate the range of wavelengths for this frequency range. [2]

(b) Bats emit two waveforms, wave B and wave P, which superpose to form wave E.

Wave B (shown in Fig. 7.1) gives information about the surrounding background.

Wave P (not shown in Fig. 7.1) enables the bat to detect insect prey.
Wave E (shown in Fig. 7.1) is the superposition of wave B and wave P.

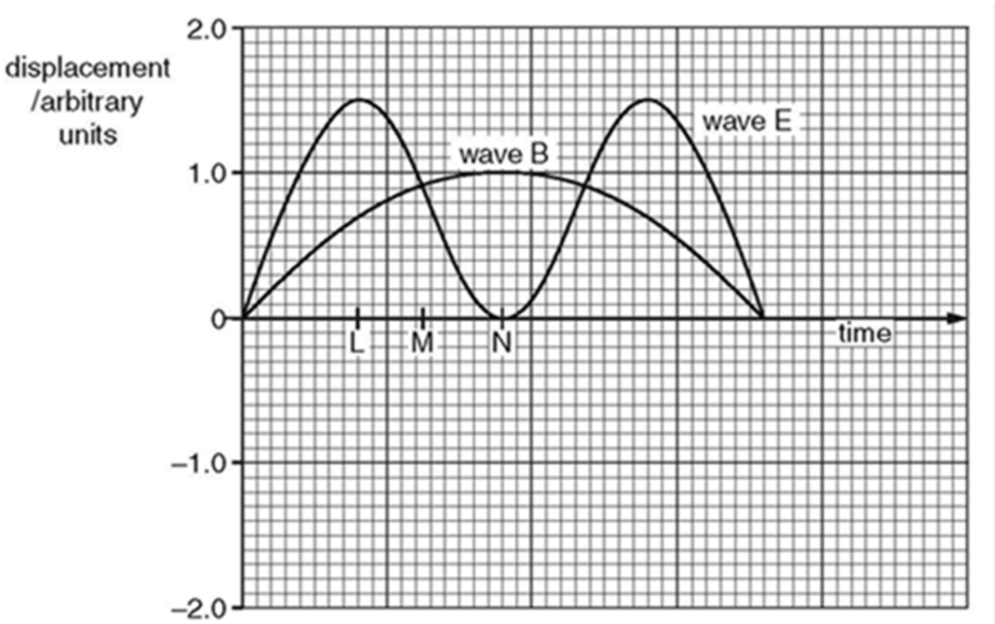


Fig. 7.1

(i) Use the principle of superposition to determine the displacement of wave P at times corresponding to points L, M and N on the time axis.

Write the displacement values in the spaces provided. [3]

displacement of wave P at L = ... units

displacement of wave P at M = ... units

displacement of wave P at N = ... units

(ii) Hence draw the waveform for wave P on Fig. 7.1. [1]

(c) An effect known as the Doppler effect uses changes in frequency to determine speeds.

The change in frequency, Δf, shown by wave P when it is reflected by an insect travelling with speed v is given approximately by the formula

$$\frac{\Delta f}{f} = \frac{2v}{c}$$

where c represents the speed, 340 m s^{-1}, of sound waves emitted by the bat.

(i) Wave P has a frequency of 50.80 kHz. Its apparent frequency after reflection is 51.25 kHz.

Calculate the speed of the insect. [2]

(ii) The bat best discriminates small insect prey when the wavelength of the reflected wave P is similar in size to the insect.

State the wave property that is being demonstrated in this situation. [1]

(d) The bat's high frequency waves are strongly attenuated in air. Fig. 7.2 shows the variation of intensity *I* with range in air *x* for the high frequency waves.

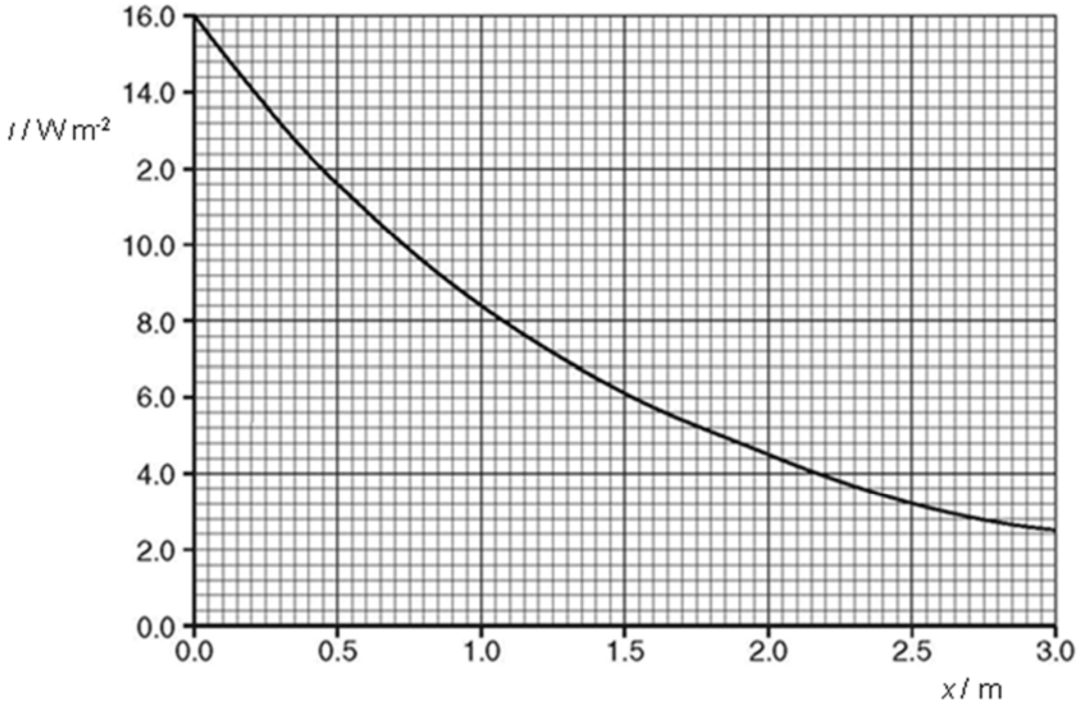


Fig. 7.2

The shape of the curve in Fig. 7.2 suggests that the decrease of the intensity *I* with range in air *x* could be exponential. In order to test this suggestion, a graph of ln *I* against *x* is plotted. This is shown in Fig. 7.3.

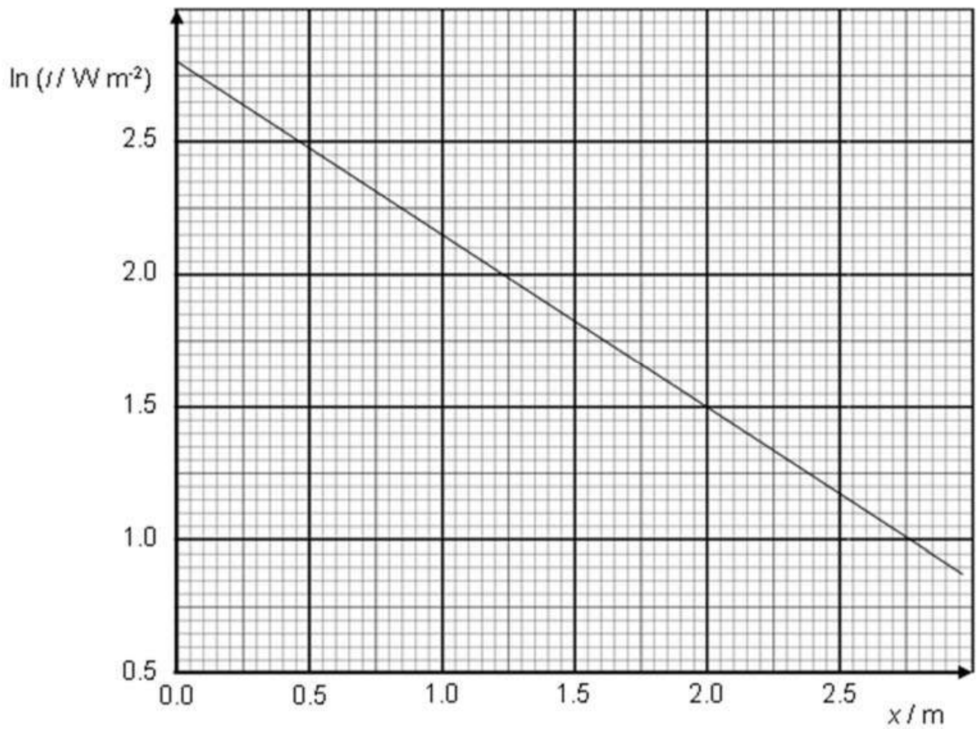


Fig 7.3

(i) Show that Fig. 7.3 indicates a relationship of the form

$$I = I_o e^{-\alpha x}$$

where α is a constant. [3]

(ii) The constant α is known as the attenuation coefficient.

1. State the SI unit of α. [1]

2. Use Fig. 7.3 to show that the value of α is about 0.7 units. [1]

(iii) On the axes of Fig. 7.3, sketch a graph to show a possible variation with range in air *x* of the intensity *I* of this high frequency wave if the value of α is 1.4. [2]

End of paper

Name : ________________________________ CT group : ______________

VICTORIA JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATIONS 2018

PHYSICS **9749/03**

Higher 2 **18 Sep 2018**

TUESDAY

Paper 3 Longer Structured Questions

2 pm – 4 pm

2 Hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and CT group at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
7	
Section B	
8	
9	
Units	
sf	
g	
Total	

This question set consists of a total of **22** printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J mol^{-1} K^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + (½)\,at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho g h$
gravitational potential,	$\phi = -\frac{GM}{r}$
temperature	$T / K = T / °C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_o \cos \omega t$ $= \pm\omega\sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \dots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \dots$
electric potential,	$V = Q/4\pi\varepsilon_o r$
alternating current/voltage,	$x = x_o \sin \omega t$
Magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
Magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
Magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this section in the spaces provided.

1. (a) Group the following terms into pairs, so that in each pair a quantity is given followed by its corresponding unit.

power, volt, watt, magnetic flux, magnetic flux density, potential difference, tesla, weber. [2]

(b) Explain why it is technically incorrect to define speed as distance travelled per second. Include in your answer the correct statement defining speed. [2]

(c) An archer fires an arrow with an initial velocity *v* and hits a target which is a distance *d* away and on the same horizontal level as the bow, as illustrated in **Fig. 1**. The arrow is aimed so that, on release, it makes an angle θ with the horizontal.

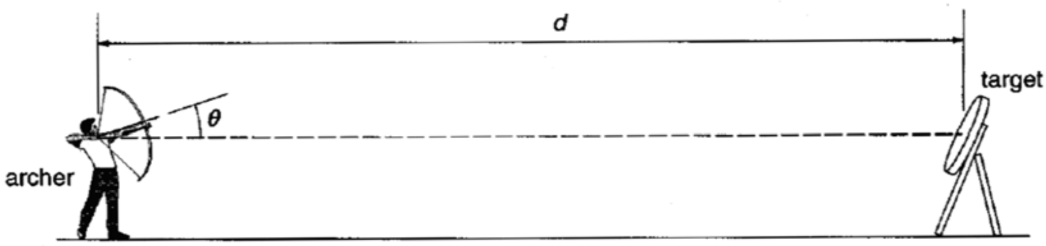


Fig. 1

(i) Assuming air resistance is negligible, write down an expression for *d* in terms of *v*, θ, and the time of flight *t*. [1]

(ii) Write down an expression for the time of flight t in terms of v, θ and the acceleration of free fall g. [1]

(iii) The distance d is given by the expression

$$d = \frac{v^2 \sin 2\theta}{g}.$$

Calculate two possible angles, θ_1 and θ_2, for an arrow with initial velocity v = 32 m s^{-1} and a target at a distance d of 94 m from the bow. [3]

2(a)(i) A man pushes a heavy rock resting on the ground, but it does not move. A student says that this is because the pushing force is balanced by the reaction to this force. Explain why the student's argument is wrong. [2]

(ii) Draw a labelled diagram to show the forces acting on the rock. [2]

(b) Block A of mass 2.0 kg moves with a velocity 10 m s^{-1} to the right on a smooth horizontal table. Block B of mass 3.0 kg moves with a velocity of 5.0 m s^{-1} in front of A in the same direction. A light spring of force constant 500 N m^{-1} is attached to B as shown in **Fig. 2.1** below.

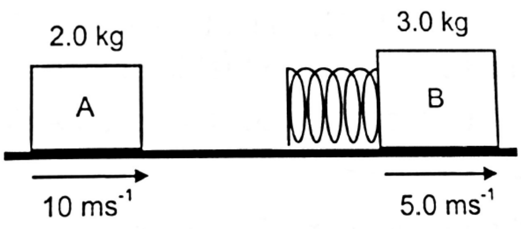


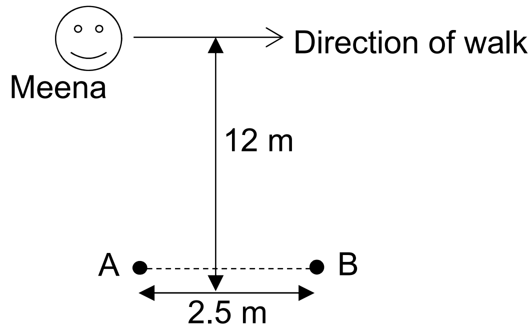
Fig. 2.1

(i) When A collides with B, there will be an instant when the spring experiences maximum compression. Describe the motion of A and B when maximum compression of the spring takes place. [1]

(ii) Calculate the final velocity of the two blocks at the instant the spring is at its maximum compression. [2]

(iii) Hence calculate the maximum compression of the spring. [2]

3 Two identical sound speakers placed at positions A and B are connected to the same signal generator, 2.5 m apart. Meena walks in a direction parallel to AB, 12 m away, as shown in the figure below:



As she walks, she detects a series of loud and soft sounds.

(a) Adjacent loud regions are 0.60 m apart. Calculate the frequency of the sound used. The speed of sound is 340 m s^{-1}. [3]

(b) At one of the loud regions, Meena detects an intensity of *I*. The amplitude of each wave from each speaker is *A*.

(i) State the resultant wave amplitude at Meena's location. [1]

The power output of one of the speakers is reduced to half its original value, while the other speaker remains unchanged.

(ii) For the speaker with the reduced power output, state the amplitude of its wave at Meena's location in terms of *A*. [1]

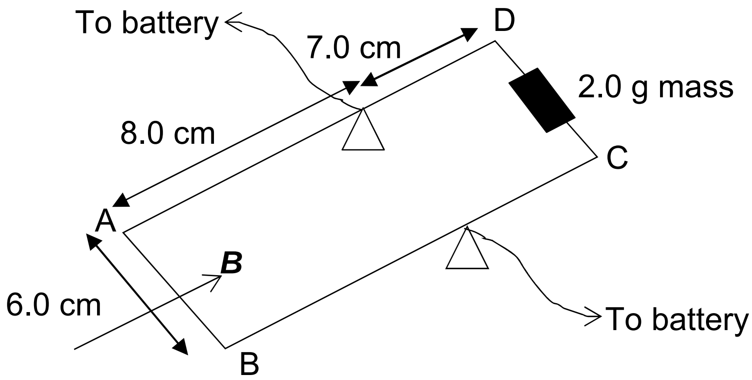
(iii) Calculate the new resultant wave amplitude at Meena's location in terms of *A*. [1]

(iv) Calculate the new intensity detected by Meena in terms of *I*. [2]

4. A light rectangular wire frame ABCD is used as a current balance. It has the following dimensions:

AB = CD = 6.0 cm
BC = DA = 15.0 cm

The wire frame is pivoted such that the pivot is 8.0 cm from AB, and 7.0 cm from CD. A 2.0 g mass is attached to CD. Side AB is entirely immersed in a uniform horizontal magnetic field ***B*** which is perpendicular to AB, as shown in the diagram below:



A current of 3.0 A flows through the wire frame, and as the result, the frame is found to come to a rest in the horizontal orientation.

(a) State the direction (AB or BA) of the current. [1]

(b) Calculate the magnetic field, ***B***. [3]

(c) Explain why such a current balance cannot be used to measure the strength of a magnetic field that is not horizontal. [3]

5. A stream of electrons travelling at a speed of 6.8×10^{6} m s^{-1} and making an angle of 30° to the horizontal enters the region between two horizontal parallel plates at point P. The electrons are deflected and exit horizontally at point Q as shown in **Fig. 5.1**.

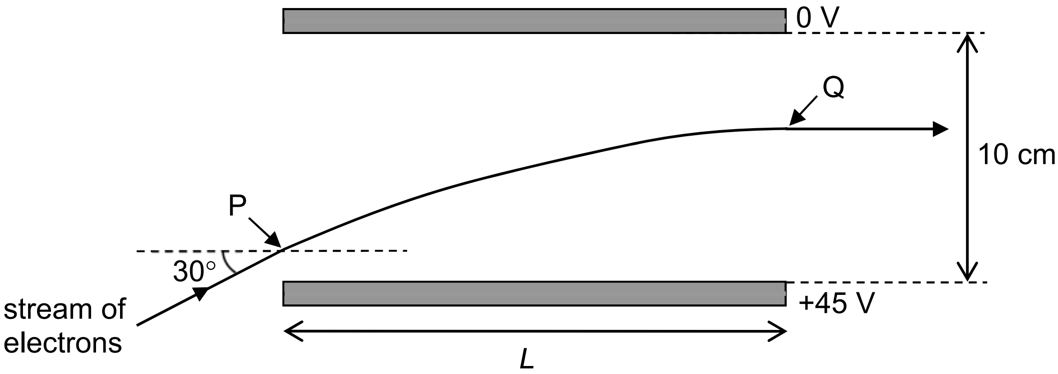


Fig. 5.1

The length of the plates is *L* and their separation is 10 cm. The potential of the lower plate is +45 V with respect to the upper plate.

(a) Show that the magnitude of the acceleration of an electron between the plates is 7.9×10^{13} m s^{-2}. [2]

(b) Determine the length L of the plates. [3]

(c) Charged particles travelling horizontally at a speed of 6.8×10^{6} m s^{-1} are now entering the region between the plates at point Q as shown in **Fig. 5.2**.

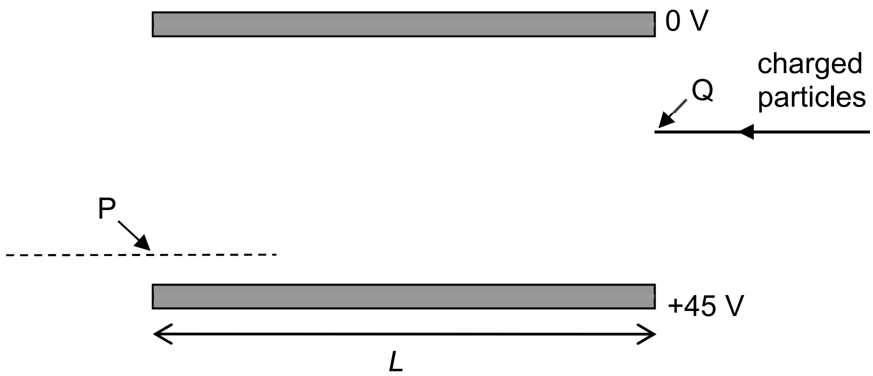


Fig. 5.2

(i) On **Fig 5.2**, sketch the path of the charged particles between the plates if they were electrons. Label this path A. [1]

(ii) On **Fig 5.2**, sketch the path of the charged particles between the plates if they were protons. Label this path B. [1]

(iii) Explain two differences between paths A and B. [2]

I.

II.

6. Fig. 6.1 shows the variation of binding energy per nucleon for nuclides with a nucleon number greater than 40.

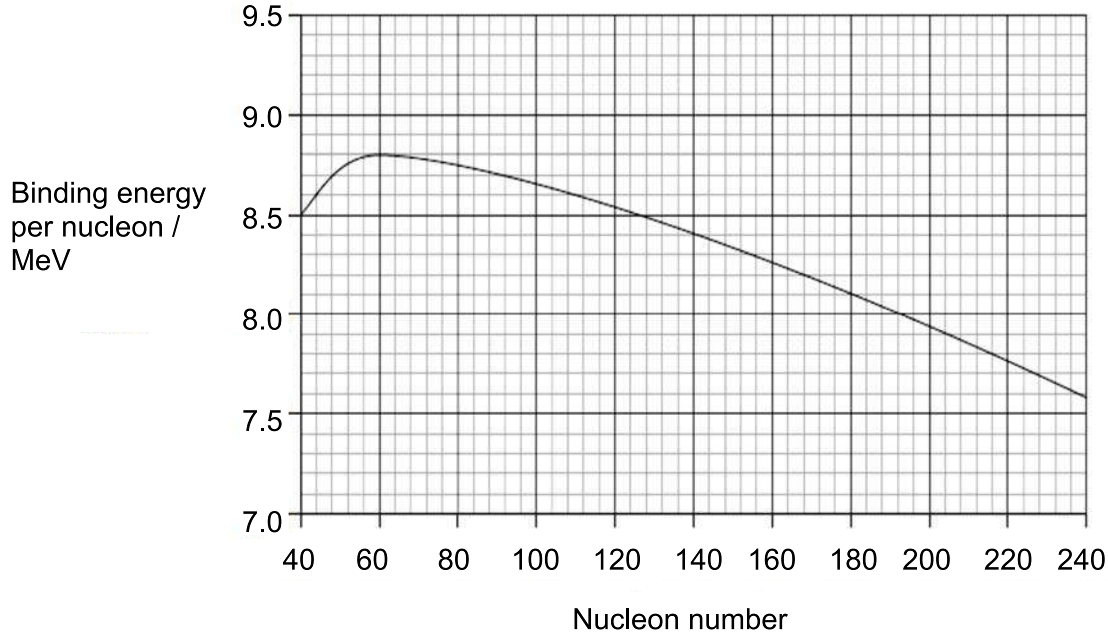


Fig 6.1

The following nuclear reaction occurs when a slow moving neutron is absorbed by an isotope of uranium-235.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + \text{neutrons}$$

(a) Determine the number of neutrons produced in this reaction. [1]

(b) Explain how this reaction is able to produce energy. [2]

(c) Use the graph in **Fig. 6.1** to determine the energy released in the above reaction. [3]

(d) Suggest why the neutron is not included in the calculation above. [1]

7(a) In an electron microscope, electrons are accelerated by an electric field in order to investigate the structure of matter. This is done by analyzing the diffraction pattern produced when the accelerated electron beam is passed through the arrangement of atoms in solids. This technique is possible due to the phenomenon known as wave–particle duality.

(i) Explain what is meant by the term *wave–particle duality* as applied to this technique. [1]

(ii) Estimate the kinetic energy of electrons such that they can be used to measure the distance between adjacent atoms in crystals, which is typically about 0.1 nm. [4]

(iii) The percentage uncertainty in measuring the electron's velocity is 10%. Calculate the minimum uncertainty in a simultaneous measurement of the electron's position. [2]

(iv) Calculate the energy of a photon which has the same wavelength as the electron. [2]

(b) Scientists suggests the use of *protons* to replace the electrons in the electron microscope in part (a).

(i) Determine the associated wavelength of protons with the same kinetic energy as the electrons in part (a). [1]

(ii) State and explain whether the use of protons would make a better or less effective probe of small-scale structures. [1]

Section B

Answer **one** question in this section in the spaces provided.

8(a) One end of a string is secured to the ceiling and a metal ball of mass 50 g is tied to its other end. The length of the string is 1.50 m. The ball is initially at rest in the vertical position. The ball is raised through a vertical height of 70 cm (see **Fig. 8.1** below). When the ball is released, it describes a circular arc as it passes through the vertical position.

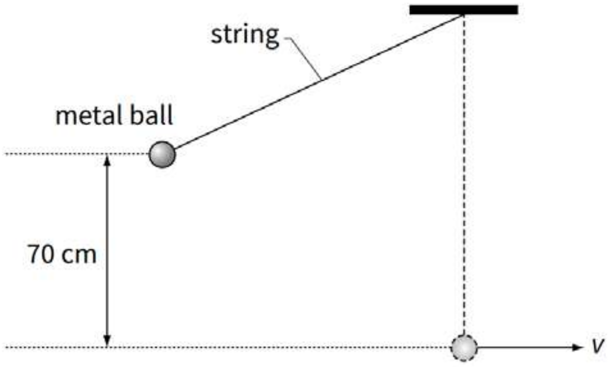


Fig. 8.1

(i) Ignoring the effects of air resistance, show that the speed *v* of the ball is $3.7\ \text{m s}^{-1}$ as it passes through the vertical position. [1]

(ii) Draw a labelled force diagram to show all the forces acting on the ball when the string is in the vertical position. [2]

(iii) Calculate the centripetal force on the ball when it is in the vertical position. [2]

(iv) Explain why the tension in the string when it is vertical is not equal to the weight of the ball. [2]

(v) Calculate the tension in the string when it is vertical. [2]

(b) **Fig. 8.2** shows the dwarf planet, Pluto, and its moon, Charon. These can be considered to be a double planetary system orbiting each other about their joint centre of mass. To simplify the situation, assume that Pluto has a circular orbit of radius r_P and Charon has a circular orbit r_C. The distance between the centres of mass of Pluto and Charon is 1.96×10^4 km.

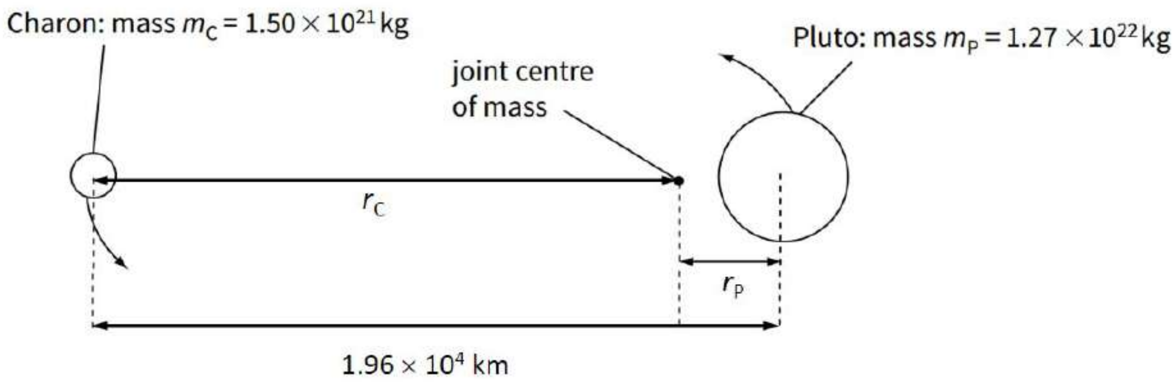


Fig. 8.2

(i) Explain what is meant by the gravitational field strength at a point. [1]

(ii) Calculate the gravitational field strength at the centre of Charon due to Pluto alone, and state its direction. [3]

(iii) Both Pluto and Charon have the same angular speed about their joint centre of mass. Show that the ratio of the masses is given by the expression: [3]

$$\frac{m_P}{m_C} = \frac{r_C}{r_P} .$$

(iv) Calculate the radius r_C of Charon's orbit. [2]

(v) Calculate Charon's orbital period. [2]

9(a) (i) Define the *ohm*. [1]

(ii) On **Fig 9.1** below, sketch a graph to show how you would expect the current in a tungsten filament lamp to change as the potential difference across the lamp increases slowly from $-V$ to + *V*.

[1]

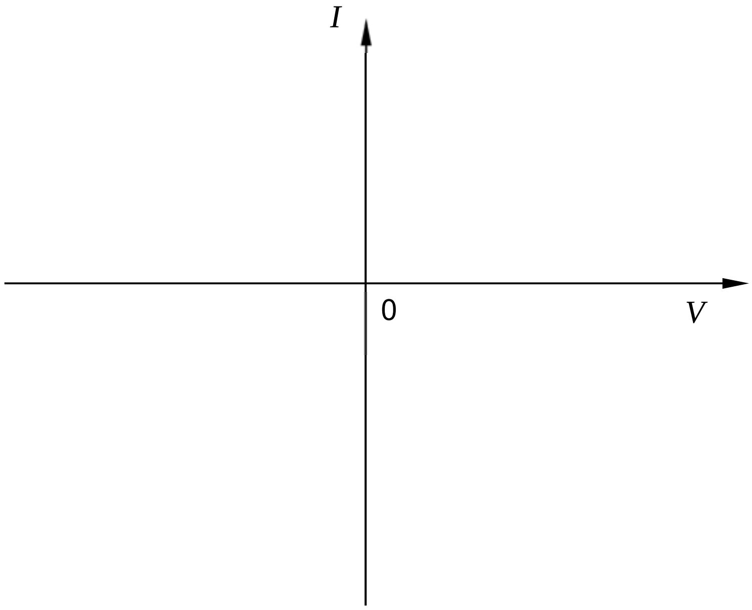


Fig 9.1

(iii) State how you would obtain the resistance of the lamp from your graph at a particular potential difference across the lamp. [1]

(iv) Draw a circuit set-up that could be used to investigate the *I*-*V* characteristics of a lamp as shown in **Fig 9.1**. [2]

(b) A circuit is setup as shown below in **Fig 9.2**. A cell *E* with internal resistance *r* is connected to a network of resistors.

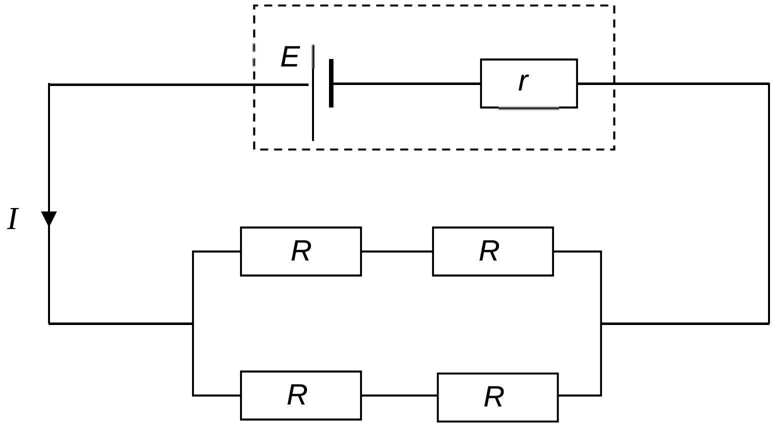


Fig 9.2

(i) Find the current I in the circuit, in terms of *R*, *r* and *E*. [2]

(ii) Show that the fraction of power dissipated in the external resistors by the battery is $\dfrac{R}{R+r}$. [2]

(iii) Suggest a reason for having 4 resistors connected in a network as shown in **Fig 9.2** instead of just using a single resistor of resistance *R*. [1]

(c) A resistor of resistance of $8.2\ \text{k}\Omega$ and a LDR (light dependent resistor) are connected in series, as shown below in **Fig 9.3**. The resistance of the LDR when light is shone on it is $420\ \Omega$ and when dark is 134 kΩ.

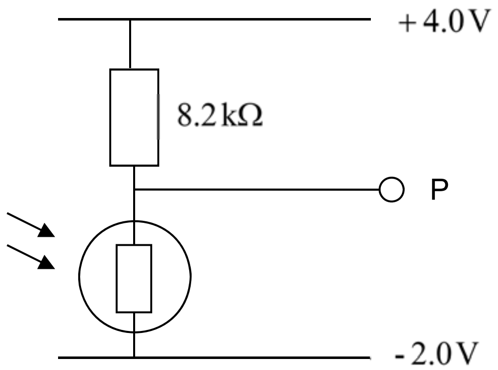


Fig 9.3

Calculate the potential at point P when

(i) light is shone on the LDR, [2]

Potential at P = _________ V

(ii) no light is shone on the LDR (dark). [1]

Potential at P = _________ V

(iii) An alarm is now connected in parallel with the LDR in **Fig 9.3** and a laser beam is directed at the LDR in a simple burglar alarm system. When a burglar blocks the laser that is shining continuously on the LDR, the alarm is triggered. Assume that the resistance of alarm is very large. Explain clearly how the LDR is used to turn on/off the alarm in such a system. [2]

(d) A circuit is set up as shown in **Fig 9.4** below. The resistance of the potentiometer wire has a resistance of 1.5 Ω and is 1.00 m long. The movable contact J can be connected to any point along wire XY.

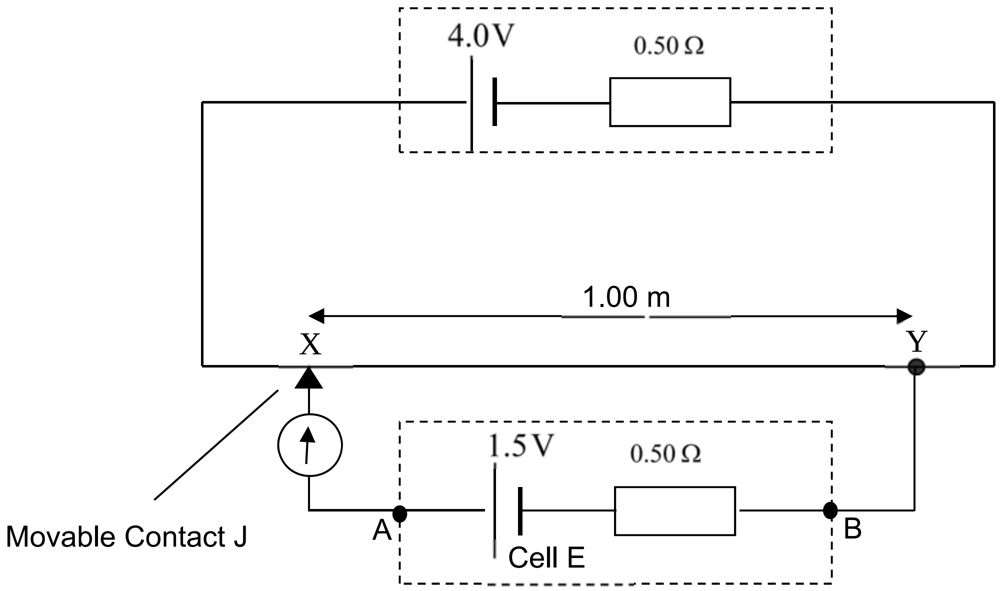


Fig 9.4

(i) Determine the distance of the contact J from X, such that there is no deflection in the galvanometer. [2]

(ii) A 1.50 Ω resistor is connected across points A and B (in parallel with cell E). Determine the new distance of the contact J from X, such that there is no deflection in the galvanometer. [3]

End of paper

VICTORIA JUNIOR COLLEGE
Preliminary Examination
Higher 2

CANDIDATE NAME ……………………………………………………………..

CT GROUP ……………………………..

Physics **9749/04**

Paper 4 Practical **27 August 2018**

2 hours 30 minutes

Additional Materials: As listed in the instructions below

READ THESE INSTRUCTIONS FIRST

Write your name and CT group in the spaces at the top of this page.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
4	
Total	

This document consists of **17** printed pages.

1. In this experiment, you will investigate a system in equilibrium due to several forces.

(a) Measure and record the length L_o between the ends of the spring, as shown in Fig. 1.1. **Note that this distance includes the two loops at the ends**.

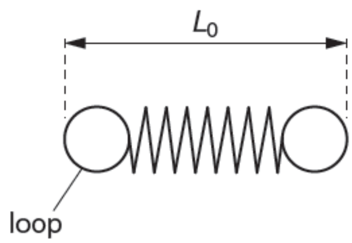


Fig. 1.1

L_o = ...m [1]

(b) (i) Set up the apparatus as shown in Fig. 1.2. Mass m should be 0.200 kg. The longer string, after attaching to the spring and inclusive of the loop for mass m, should be of **approximate length 80 cm**.

Do not change the height of the pulley or the clamp.

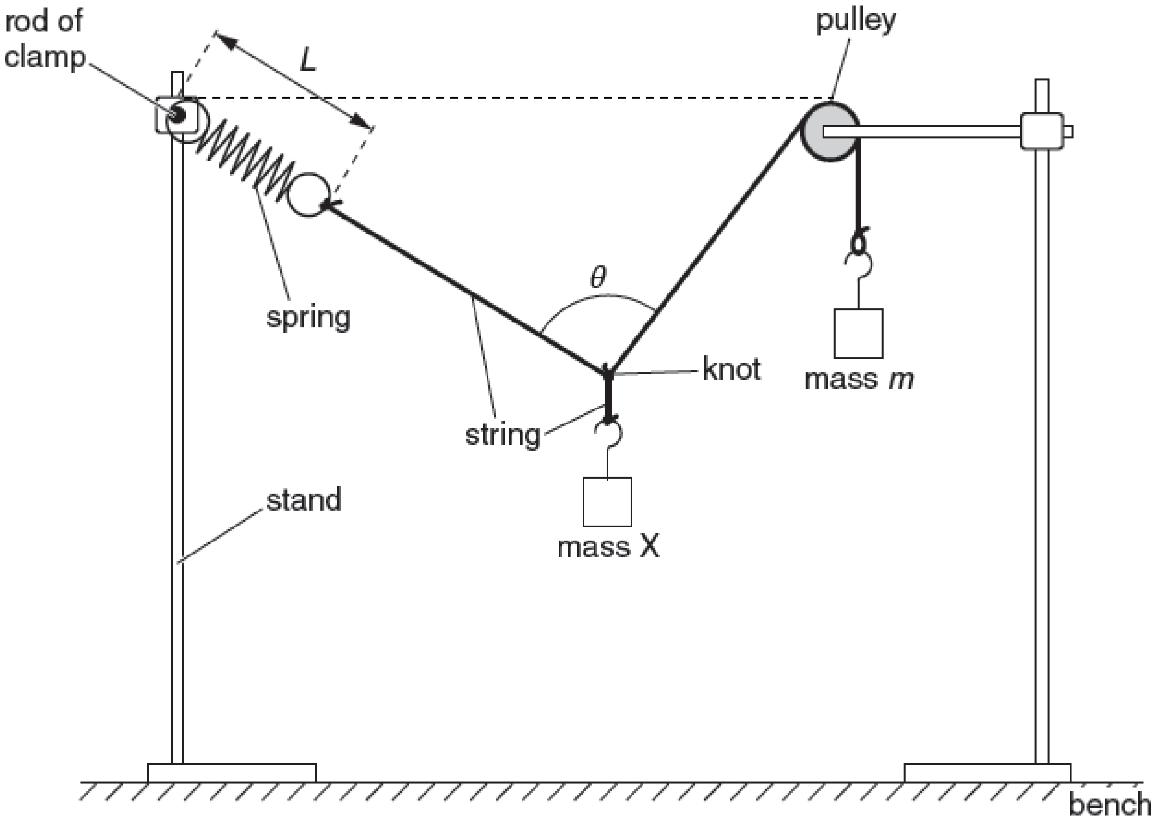


Fig. 1.2

(ii) **Adjust the apparatus until the angle θ is 90°.**

You may move the stands sideways or slide the knot along the string.

(iii) Measure and record the distance L between the ends of the spring loops.

L = ...m

(iv) Calculate the extension e of the spring using $e = L - L_o$.

e = ...m [1]

(c) Add further slotted masses to vary *m.*

Repeat (b)(ii), (b)(iii) and (b)(iv) for each additional mass until you get a few sets of values of *m* and *L*.

Include values of m^2, e and e^2 in your table. Include your previous results.

[4]

(d) (i) Plot a graph of e^2 against m^2 on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient *P* and y-intercept Q of this line.

P = ...[1]

Q = ...[1]

(e) The gradient P and y-intercept Q can be expressed as

$$P = \frac{Q}{M^2} \qquad \text{and} \qquad Q = \frac{g^2}{k^2}$$

respectively where k is the spring constant of the spring, M is the mass of X, *and* g = 9.81 N kg^{-1}.

Calculate M and k.

M = ...[2]

k = ...[2]

[Total: 16 marks]

2. In this experiment, you will determine the resistivity ρ of a metal.

(a) You have been provided with two bare wires of different lengths. One wire is taped to a metre rule. The second wire has a crocodile clip at each end. The wires have the same diameter *d*.

(i) Take the wire with crocodile clips. Measure and record *d*.

d = ...[1]

(ii) Calculate the cross-sectional area *A* of the wire.

A = ...[1]

(iii) Measure and record the exposed length *L* of the wire between the crocodile clips, as shown in Fig. 2.1.

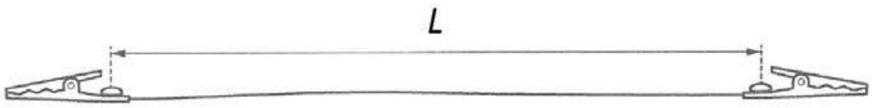


Fig. 2.1

L = ...[1]

(b) Using the wire taped to the metre rule, set up the circuit as shown in Fig. 2.2.

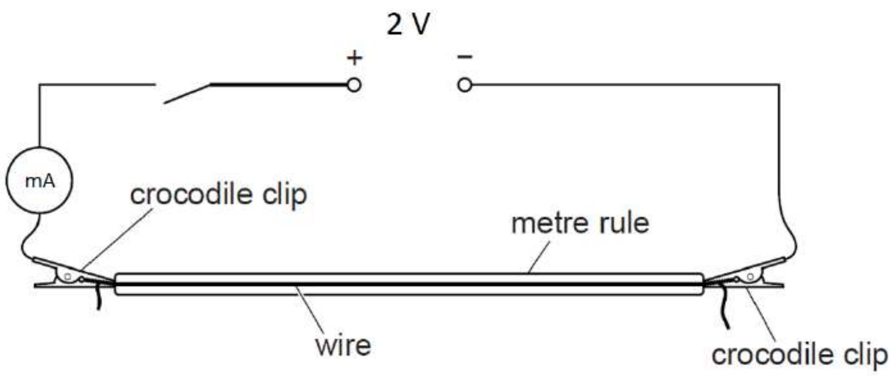


Fig. 2.2

(c) (i) Attach the wire with crocodile clips to the wire on the metre rule as shown in Fig. 2.3.

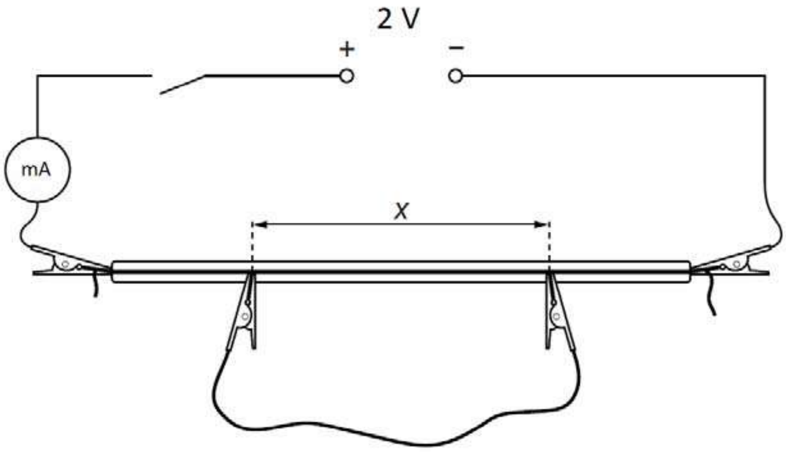


Fig. 2.3

The distance x between the crocodile clips should be approximately 50 cm.

(ii) Measure and record x.

x = ...[1]

(d) (i) Close the switch.

(ii) Record the ammeter reading I.

I = ...A [1]

(iii) Open the switch.

(e) Theory suggests that

$$\frac{1}{I} = \frac{\rho}{2A}\left(1 - \frac{x^2}{x+L}\right)$$

where ρ is the resistivity of the material of the wire.

Determine a value for ρ.

ρ = ...Ω m [2]

[Total: 7 marks]

3. In this experiment, you will model the action of a see saw.

(a) Measure and record the thickness *t* of the metre rule.

t = ...[1]

(b) (i) Measure and record the diameter *d* of cylinder A.

d = ...

(ii) Calculate *w*, where *w* = *d* – *t*.

w = ...[1]

(c) (i) Use blu tack to secure beaker A to the bench and balance the metre rule on the cylinder, as shown in Fig. 3.1 below:

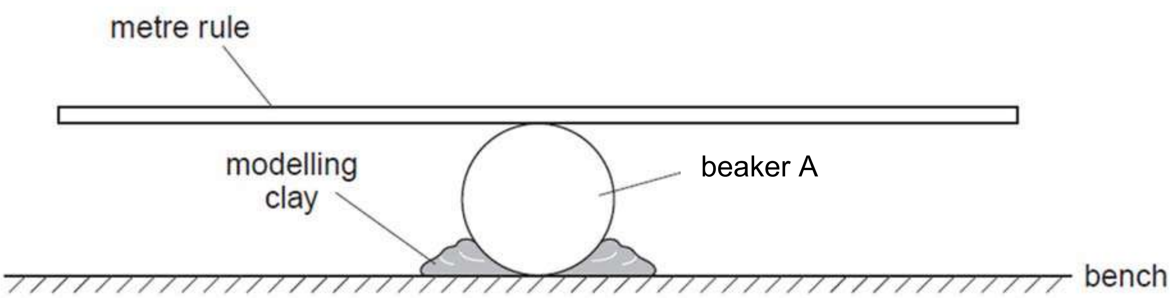


Fig. 3.1

(ii) Move one end of the rule downwards. Release the rule and watch the movement. The end of the rule will move upwards and then downwards again, completing a swing as shown in Fig. 3.2 below:

The time taken for each swing is *T*.

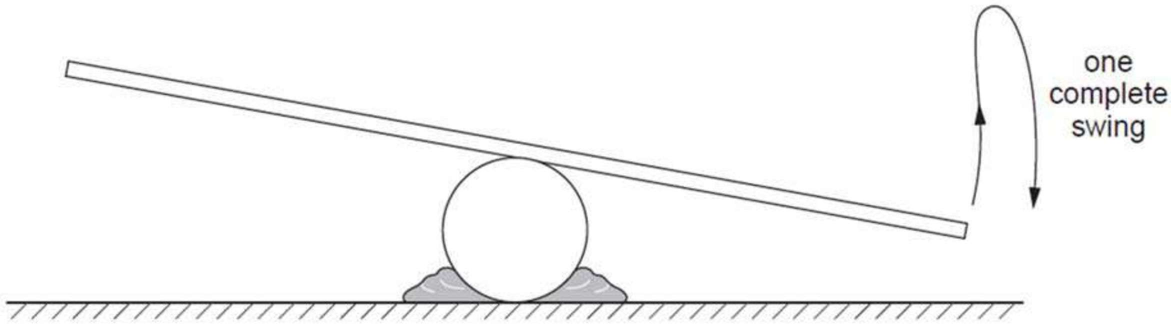


Fig. 3.2

By timing several of these complete swings, determine an accurate value for *T*.

T = ...[2]

(d) Estimate the percentage uncertainty in your value of *T*.

Percentage uncertainty = ...[1]

(e) Repeat (b) and (c) for beaker B.

d = ...

w = ...

T = ...

[2]

(f) It is suggested that the quantities *T* and *w* are related by the equation

$$T^2 = \frac{k}{w}$$

where *k* is a constant.

(i) Using your data, calculate two values of *k*.

First value of *k* = ...

Second value of *k* = ...

[1]

(ii) State whether your results of your experiment support the suggested relationship. Justify your conclusion by referring to your value in (d).

....

....

....

....

.... [1]

(g) (i) Describe two sources of uncertainty or limitations of the procedure for this experiment.

1. ....

....

....

....

2. ....

....

....

....[2]

(ii) Describe an improvement that could be made to this experiment to address one of the errors identified in (g)(i). You may suggest the use of other apparatus or different procedures.

....

....

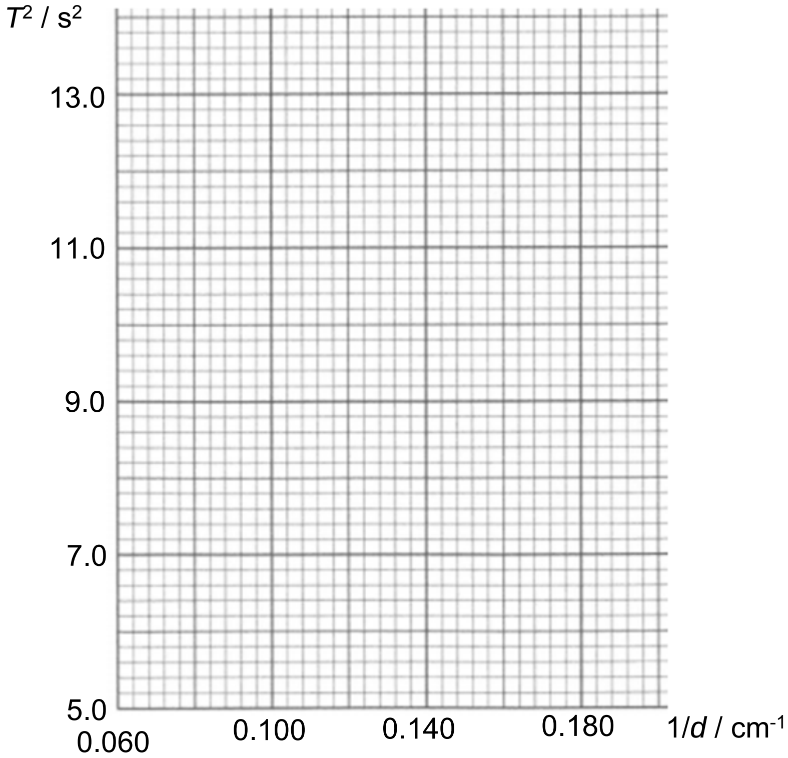
....

....[1]

(h) The experiment is repeated using cylinders of different diameters. The results are shown in the table below. Values of T^2 and $1/d$ are included:

T / s	T^2 / s^2	d / cm	1/d / cm^{-1}
3.672	13.48	5.0	0.20
3.101	9.616	7.0	0.14
2.719	7.392	9.0	0.11
2.412	5.818	11.0	0.0909
2.301	5.295	13.0	0.0769

(i) Plot the points on the grid and draw the straight line of best fit.



[1]

(ii) Determine the y-intercept of the line.

y-intercept = ... [2]

(iii) Use your answer in (h)(ii) to state whether T^2 is inversely proportional to d.

....

....

....

....[1]

(i) A manufacturer of playground see-saws wants to find out what length of the plank would give a period of oscillation of 1 second. Instead of building full-size see-saws, he decides to use models similar in design to those shown above to study the relationship, setting the diameter of the cylinder at 10.0 cm.

Plan an investigation to find the length of the plank needed to give a period of 1 second.

Your account should include:

- Your experimental procedure
- Details of the table of measurements with appropriate units
- How you would find the length of the plank to give a period of 1 second. [5]

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....[5]

[Total: 21 marks]

4. Two identical coils are connected together and arranged as shown in Fig. 4.1.

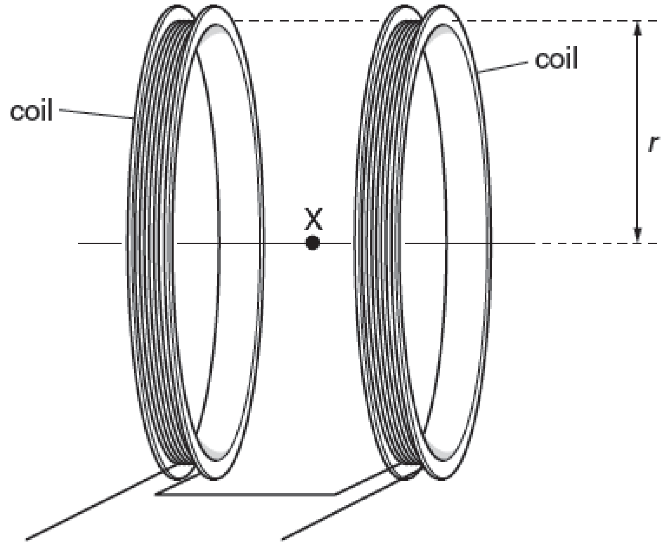

Fig. 4.1

The coils are in the vertical plane and are parallel to each other. When the coils are connected to a power supply, there is a magnetic field between them.

It is suggested that the magnetic flux density B of the field at the point X can be expressed as

$$B = \frac{0.72\mu_o NI}{r}$$

where r is the radius of the coils, N is the number of turns on each coil, I is the current in the coils and μ_o is the permeability of free space.

You are provided with a power supply, two coils of wires with a known number of turns and a meter (connected to a sensor) to measure the magnetic flux density. You may also use any of the other equipment usually found in a physics laboratory.

Design an experiment to determine the value of μ_o.

You should draw a diagram to show the arrangement of your apparatus and you should pay particular attention to

(a) the equipment you would use
(b) the procedure to be followed
(c) the control of variables
(d) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

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[11]

[Total: 11 marks]

Prelim Practical apparatus

Qn 1

Quantity	Apparatus
1	30 cm ruler
1	string – 1m
1	string – 10 cm
1	expendable spring
2	retort stands with 2 bosses and 2 clamps
1	free-running pulley
1	Mass X with hook
1	50 g mass hanger
3	50 g slotted masses
2	20 g slotted masses
1	10 g slotted masses
1	small set square
1	scissors

Qn 2

Quantity	Apparatus
1	1.5 V dry cell with holder
1	digital multimeter
1	metre rule
1	110 cm length of 36 swg constantan wire attached to a metre rule – **Label G**
1	100 cm length of 36 swg constantan wire with crocodile clips on both ends – **Label F**
5	connecting leads
1	switch
1	micrometre screw gauge (shared)

Qn 3

Quantity	Apparatus
some	blu tack
1	250 ml big beaker for pivot – **Label A**
1	100 ml small beaker for pivot – **Label B**
1	metre rule
1	stopwatch
1	vernier calliper (shared)

Answers to JC2 Preliminary Examination Paper 1 (H2 Physics)

Suggested Solutions:

1	D	**6**	D	**11**	D	**16**	C	**21**	C	**26**	D
2	C	**7**	D	**12**	C	**17**	B	**22**	A	**27**	B
3	D	**8**	B	**13**	C	**18**	A	**23**	D	**28**	B
4	A	**9**	C	**14**	C	**19**	A	**24**	C	**29**	D
5	C	**10**	B	**15**	A	**20**	A	**25**	B	**30**	D

1 D

Resistivity, $\rho = \dfrac{RA}{l} = \dfrac{R\pi\left(d/2\right)^2}{l}$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta R}{R} + 2\left(\frac{\Delta d}{d}\right) + \frac{\Delta l}{l} = \frac{1}{68} + 2\left(\frac{0.1}{5.0}\right) + \frac{1}{25}$$

$\Delta\rho = 0.5\times10^{-2}\ \Omega\text{ m}\quad(1\text{ s.f.})$

$\therefore\ \rho = (5.3 \pm 0.5)\times10^{-2}\ \Omega\text{ m}$

2 C

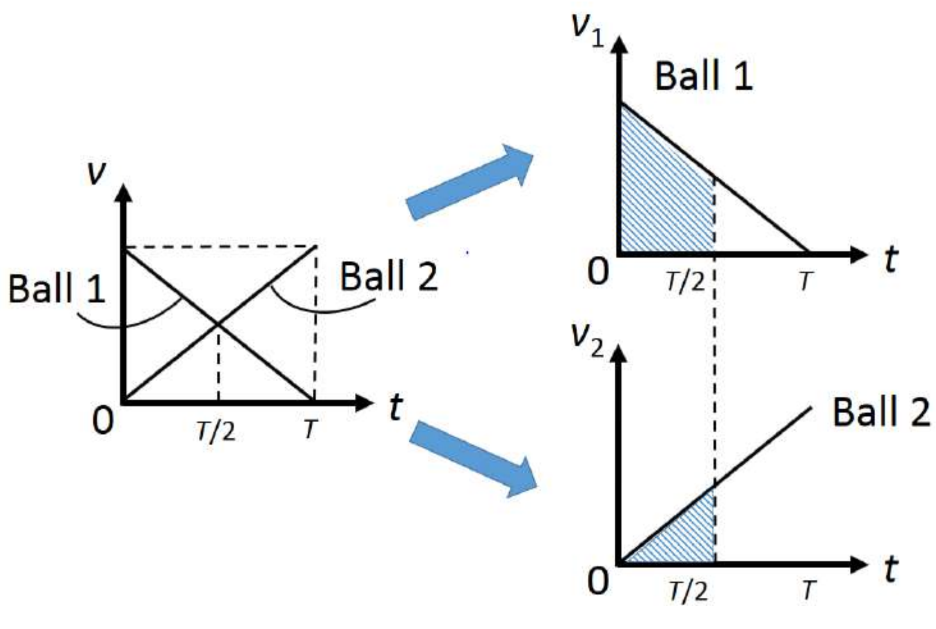
Method 1: Faster (guess & check using graphical method)

If Ball 1 doesn't collide with Ball 2, it will take time T to reach the top. Similarly, Ball 2 will take time T to reach the bottom.

Because both balls are experiencing the same gravitational acceleration ($g\sin\theta$), the initial speed of Ball 1 is the same as the final speed of Ball 2.

Guess: Is it possible that the balls collide at time = $T/2$?

Check: At time = $T/2$, apply the math of similar triangles to see that Ball 1 travels ¾ of the way up the slope (refer to the shaded area under Ball 1's curve). At time = $T/2$, Ball 2 travels ¼ of the way down the slope (refer to the shaded area under Ball 2's curve). So the balls do indeed collide at time = $T/2$, and Ball 1 travels 3 times further than Ball 2.



Method 2: Slower (using equations and graphs of kinematics)
Apply "$s = ut + (1/2)\,at^2$" and let t be the time of collision:

For Ball 1: $s_{AC} = ut + \frac{1}{2}(-a)t^2 = ut - \frac{1}{2}at^2$

For Ball 2: $s_{BC} = (0)t + \frac{1}{2}at^2 = \frac{1}{2}at^2$

$s_{AB} = s_{AC} + s_{BC} = ut - \frac{1}{2}at^2 + \frac{1}{2}at^2$

$\therefore s_{AB} = ut$ --- (1)

Suppose there is no collision. Let T be the time taken by either ball to travel the entire length of the slope s_{AB}.

Apply "$s = \left(\frac{u+v}{2}\right)t$" to Ball 1 gives: $s_{AB} = \left(\frac{u+0}{2}\right)T$

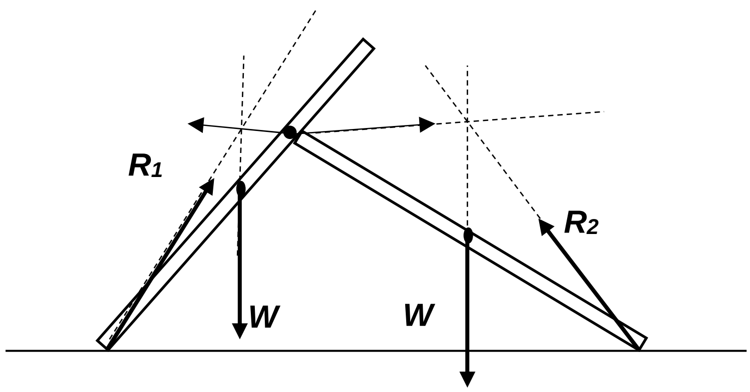
$\therefore s_{AB} = \frac{uT}{2}$ --- (2)

Equating (1) and (2) gives $t = \frac{T}{2}$

Refer to the previous v-t graphs for Balls 1 & 2. After time $T/2$, apply the math of similar triangles to see that Ball 1 travels ¾ of the way up the slope (refer to the shaded area under Ball 1's curve). After $T/2$, Ball 2 travels ¼ of the way down the slope (refer to the shaded area under Ball 2's curve). So the balls collide after $T/2$, and Ball 1 travels 3 times further than Ball 2.

3 D

The system is in equilibrium. Extrapolated lines of action of all 3 forces acting on each of the rods must intersect at a common point.



4 A

Forces on all 3 masses: $F_{\text{floor on Z}} - (m_X + m_Y + m_Z)g = (m_X + m_Y + m_Z)a$

$F_{\text{floor on Z}} - 9mg = 9ma$

$F_{\text{floor on Z}} = 9mg + 9ma$

Forces on Z alone: $F_{\text{floor on Z}} - F_{\text{Y on Z}} - m_Z g = m_Z a$

$$F_{\text{floor on Z}} - F_{\text{Y on Z}} - m_Z g = m_Z a$$
$$F_{\text{Y on Z}} = F_{\text{floor on Z}} - m_Z g - m_Z a$$
$$F_{\text{Y on Z}} = 9mg + 9ma - 5mg - 5ma = 4mg + 4ma$$

5 C

By considering conservation of energy,
gain in KE = work done by force – work done against frictional forces

$$\frac{1}{2}mv^2 = Fd_{total} + fd_{10}$$
$$\frac{1}{2}(100)v^2 = (320)(30) - (30)(10)$$
$$v = 13.6 \text{ m s}^{-1}$$

6 D

Find driving force: $F_D - f = ma$

$F_D = (3500 \times 0.35) + 3250 = 4425$ N

Power supplied by engine: $P = Fv$

$P = 4425 \times 16 = 70800$ W

At maximum speed, driving force = frictional force.
Since power supplied is constant,

$$70800 = 3250v$$
$$v = 21.8 \text{ m s}^{-1}$$

7 D

Deduce that L is tilted at 32° to the vertical, so

$L \sin 32^\circ = \dfrac{mv^2}{r}$ --- (1)

and $L \cos 32^\circ = mg$ --- (2)

(1) ÷ (2) gives: $\tan 32^\circ = \dfrac{v^2}{rg}$

When r is halved to $r/2$ and v is doubled to $2v$, let the angle be ϕ.

We now have: $\tan\phi = \dfrac{(2v)^2}{\left(\dfrac{r}{2}\right)g} = 8\left(\dfrac{v^2}{rg}\right) = 8(\tan 32^\circ)$

$\therefore\ \phi = 78.7^\circ$

8 B

Apply Newton's second law to a geostationary satellite of mass *m*:

$$F = \frac{GM_E m}{r^2} = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$$

$$\frac{GM_E}{r^3} = \frac{4\pi^2}{T^2} = \frac{4\pi^2}{(24\text{ hours})^2}$$

Notice that *m* cancels out, so the geostationary orbit is independent of the mass of the satellite.
But the period and radius of orbit have unique values.

9 C

Total initial energy of the satellite:

$$E_i = GPE_i + KE_i = -\frac{GMm}{r_i} + \frac{1}{2}mv_i^2$$

$$= -\frac{(6.67\times10^{-11})(6.0\times10^{24})(690)}{7.2\times10^6} + \frac{1}{2}(690)(7.5\times10^3)^2$$

$$= -1.895\times10^{10}\text{ J}$$

Total final energy of the satellite:

$$E_f = GPE_f + KE_f = -\frac{GMm}{r_f} + \frac{1}{2}mv_f^2$$

$$= -\frac{(6.67\times10^{-11})(6.0\times10^{24})(690)}{6.5\times10^6} + \frac{1}{2}(690)(7.9\times10^3)^2$$

$$= -2.095\times10^{10}\text{ J}$$

$E_f < E_i$, so the satellite loses total energy.

Change in total energy = $E_f - E_i$ = -2.0×10^9 J

In other words, the satellite loses approximately 2×10^9 J.

10 B

Using $P_{input} = \frac{m}{t}c\Delta T + h$

$$10 = \frac{m}{t}c\Delta T + h \quad \text{K K K (1)}$$

$$18 = \frac{3m}{t}c\Delta T + h \quad \text{K K K (2)}$$

Solving (1) and (2), rate of heat loss to the surrounding, h = 6.0 W

11 D

From the kinetic theory of gases, $p = \frac{1}{3}\rho\langle c^2\rangle$

Therefore, root-mean-square speed, $C_{r.m.s.} = \sqrt{\frac{3p}{\rho}} = \sqrt{\frac{3(150\text{x}10^3)}{0.178}} = 1600\text{ m s}^{-1}$

12 C

Using $y = 5\sin(20\pi t)$

At position of maximum displacement, $5 = 5\sin(20\pi t_1)$

$$\Rightarrow 20\pi t_1 = \frac{\pi}{2}$$
$$\Rightarrow t_1 = 0.025\,\text{s}$$

At position half way between maximum displacement and the equilibrium position,

$$2.5 = 5\sin(20\pi t_2)$$
$$\Rightarrow 20\pi t_2 = \frac{5\pi}{6}$$
$$\Rightarrow t_2 = 0.042\,\text{s}$$

Required time taken, $t = t_2 - t_1 = 0.042 - 0.025 = 0.017\,\text{s} = 17\ \text{ms}$

13 C

From the graph, period of oscillation, $T = 2.0\,\text{s}$

Maximum velocity, $V_{\max} = wx_0$, where x_o is the amplitude of the oscillation.

$$= \frac{2\pi}{T} x_o = \frac{2\pi}{2.0}\left(3.0\times10^{-2}\right) = 0.094\,\text{ms}^{-1}$$

14 C

Intensity at dish from antenna I = $\frac{P_{antenna}}{4\pi d^2}$

Power received = I A_{dish}

$$= \frac{P_{antenna}}{4\pi d^2}\pi r_{dish}^2$$
$$= \frac{240}{4\pi(750)^2}\pi(1.5)^2$$
$$= 2.4 \times 10^{-4}\ \text{W}$$

15 A

The wave takes 4 s to go from P to Q.

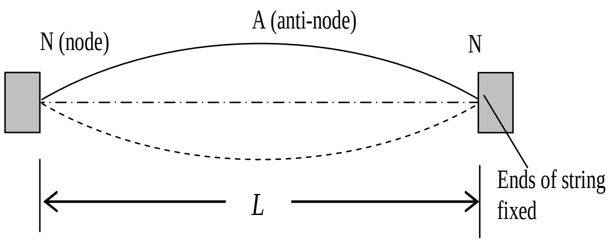
Look at the graph for P, at t = 0, for example. It starts from 0, and becomes more positive as time progresses.

So for Q, the same thing should happen at t = 4 s.

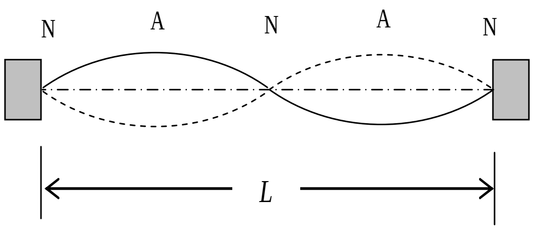
Looking at the 4 options, only A satisfies this requirement.

16 C

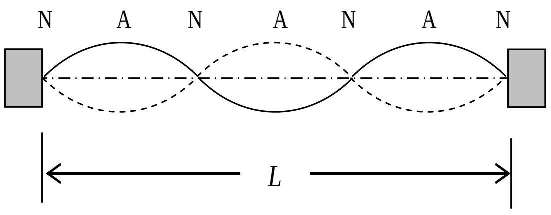
For a string fixed at both ends, these are the 1st few modes of vibration:



$\lambda = 2.0$ m



$\lambda = 1.0$ m

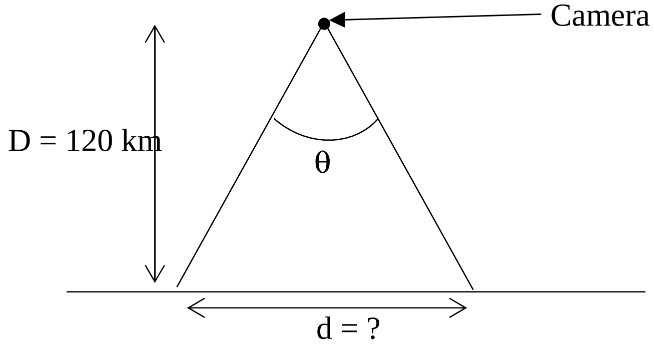


$\lambda = 0.67$ m

$\lambda = 1.3$ m is impossible.

17 B

Rayleigh's criterion



Just resolved: $\theta = \dfrac{\lambda}{a} \approx \dfrac{d}{D}$ when θ is very small.

$d = \dfrac{\lambda D}{a}$

$= \dfrac{5.5\times10^{-7}\times120\times10^{3}}{2.5\times10^{-2}}$

$= 2.6$ m

18 A

$$E_q = k\frac{q}{r_q^2} = k\frac{q}{0.40^2} = 12 \text{ N C}^{-1}$$

$$kq = 1.92$$

$$\begin{aligned} E_{\text{total}} &= E_q + \left(-E_{-q}\right) \\ &= k\frac{q}{r_q^2} + \left(-k\frac{-q}{r_{-q}^2}\right) \\ &= \frac{1.92}{0.40^2} + \frac{1.92}{0.60^2} \\ &= 17.3 \text{ N C}^{-1} \end{aligned}$$

19 A

From work energy theorem:

$$W = \int F dr = q\int E dr$$

Hence work done is the area under E-field distance graph.

20 A

Power in R in circuit (i) $= I^2R = \left(\frac{3E}{3r+R}\right)^2 R = \left(\frac{3(1.5)}{3\times2+4}\right)^2 \times 4 = 0.81\ W$

Power in R in circuit (ii) $= I^2R = \left(\frac{E}{3r+R}\right)^2 R = \left(\frac{1.5}{3\times2+4}\right)^2 \times 4 = 0.09\ W$

$$\frac{\text{power in } R \text{ in circuit (i)}}{\text{power in } R \text{ in circuit (ii)}} = \frac{0.81}{0.09} = 9$$

21 C

When a 500 Ω resistance is connected in parallel with the 1000 Ω R_2, the effective resistance of these two resistors become smaller than 500 Ω. Hence the p.d across R_2 will become smaller than before, while the p.d across R_1 will be larger than before.

22 A

Power, $P = \frac{V^2}{R}$

For the same kettle, R is constant.

Therefore, $P \propto V^2$

$$\Rightarrow \frac{P_2}{P_1} = \left(\frac{V_2}{V_1}\right)^2$$

$$\Rightarrow \frac{P_2}{600} = \left(\frac{120}{240}\right)^2$$

$$\Rightarrow P_2 = \left(\frac{120}{240}\right)^2 600 = 150\,\text{W}$$

23 D

Find period of electron:

Centripetal force = magnetic force

$m\omega v = Bev$

$m\left(\frac{2\pi}{T}\right)v = Bev$

$T = \frac{2\pi m}{Be}$

$= \frac{2\pi \times 9.11 \times 10^{-31}}{3.0 \times 1.60 \times 10^{-19}}$

$= 1.192 \times 10^{-11}$ s

But the electron only travels half a circle, so time spent = T/2 = 6.0×10^{-12} s.

24 C

Wire XY is perpendicular to the magnetic field of the solenoid, so magnetic force acting on XY = $B_{solenoid} I_{XY} L_{XY}$

$= (\mu_0 n_{solenoid} I_{solenoid}) I_{XY} L_{XY}$

$= (4\pi \times 10^{-7} \times \frac{20000}{1.2} \times 3.0) \times 1.5 \times 2.0 \times 10^{-2}$

$= 1.9 \times 10^{-3}$ N

25 B

For a solenoid, the internal B-field is: $B = \mu_0 \frac{N}{L} I$

Using Faraday's Law, the induced emf between the rim and center of the disk is:

$$
\begin{aligned}
E &= \frac{d\Phi}{dt} \\
&= B\frac{dA}{dt} \\
&= \mu_0 \frac{N}{L} I \frac{A}{T} \qquad \text{(A radius on the disc will sweep out an area } A \text{ in time } T\text{)} \\
&= \mu_0 \frac{N}{L} IA \frac{\omega}{2\pi} \\
&= 0.16 \mu_0 NIA\omega / L
\end{aligned}
$$

Since the emf between the ends of the solenoid is 10 times larger than the induced emf,

$$E_{\text{solenoid}} = 1.6 \mu_0 NIA\omega / L$$

26 D

Calculus method:

For a solenoid with a current *I*, and *I* varies with time as given:

$B \propto I = I_0 \sin^2 \omega t$

Hence using Faradays law to find the emf in the smaller coil:

$$E = A\frac{dB}{dt} = kI_0 \sin 2\omega t = E_0 \sin \omega' t$$

The result is a graph with twice the frequency of the graph given.

Reasoning method:
For a solenoid with a current *I*, $B \propto I$
Consider the **first half period**: the current increases then decreases, so the magnetic flux experienced by the smaller coil also increases and decreases,
Applying Faraday's Law and Lenz's Law, the emf induced will be in opposite directions during the increase compared to the decrease.
Thus for one complete period as shown in the graph, the emf induced will be positive, then negative then positive then negative again.

27 B

Using Einstein's Photoelectric equation, $\frac{hc}{\lambda} = \phi + eV_S$

$$\phi = \frac{hc}{\lambda} - eV_S$$

$$= \frac{(6.63\times10^{-34})(3.00\times10^{8})}{150\times10^{-9}} - (1.60\times10^{-19})(2.1)$$

$$= 9.9\times10^{-19}\text{ J}$$

$$= 6.2\text{ eV}$$

28 B

The spectrum labelled XY is due to "bremsstrahlung" radiation or braking radiation which refers to the acceleration of the electrons striking the metal target.

29 D

Option D is true. Conservation of momentum: Total Initial momentum = 0.
Hence, when γ-photon emitted in one direction, the nucleus must recoil with an equal magnitude momentum in the opposite direction such that the total momentum remains 0.

Option A is not true. The greater the binding energy *per nucleon*, then the more stable the nucleus.

Option B is not true. The reaction is still possible with the provision of input of energy to the reactants.

Option C is not true. The half-life of a radioactive substance cannot be changed chemically.

30 D

Alpha particles are L, P and X.
Beta particles are N, R and Y.
Gamma particles are M, Q and Z.

2018 Physics prelim exam H2 P2 suggested answers

1(a)(i) Upthrust on an object immersed in a fluid is the net upward force acting on the object by the fluid due to the pressure difference acting on the top and bottom of the object.

(ii) Upthrust by liquid A = weight of liquid A displaced

$= V_A \rho_A g$

$= (0.200^2)(x)\rho_A g$

(ii) Upthrust by liquid B = weight of liquid B displaced

$= V_B \rho_B g$

$= (0.200^2)(0.200 - x)\rho_B g$

(iii) Weight of container = Upthrust by Liquid A + Upthrust by Liquid B

(9.20)(9.81) = $(0.200^2)(x)\rho_A g$ + $(0.200^2)(0.200 - x)\rho_B g$

(9.20)(9.81) = $(0.200^2)(x)(1.30\times10^3)(9.81)$ + $(0.200^2)(0.200 - x)(0.900\times10^3)(9.81)$

19.62 = 156.96 *x*

x = 0.125 m

(b)(i) When the bear is at the centre, the tension in the cable is 600 N.

Taking moments about the hinge,
Sum of clockwise moments = sum of anticlockwise moments,

$$(0.5L)(900) + (L)(80.0) = (600\sin\theta)(L)$$

$$\sin\theta = \frac{530}{600}$$

$$\theta = 62.0°$$

(ii) The bear should be standing on the hinge.

(iii) When the bear is standing on the hinge, the tension in the cable is 200 N.

Taking moments about the hinge,
By conservation of moments, the sum of clockwise moments = sum of anticlockwise moments,

$(0.5L)(m_b g) + (L)(80.0) = (200 \sin 62.0°)(L)$

$m_b g = 193$ N

$m_b = 19.7$ kg

2(a)(i) The kinetic energy of the car is used to do work against resistant forces such as friction on the road.

(ii) As the mass moves downwards, it loses gravitational potential energy. This loss in gravitational potential energy is converted to elastic potential energy stored in the stretched string and work done against the force exerted by the hand.

(b)(i) By conservation of energy,

Loss in KE = gain in GPE + word done against friction

$$\frac{1}{2}m(v_i^2 - v_f^2) = mgh + fd$$

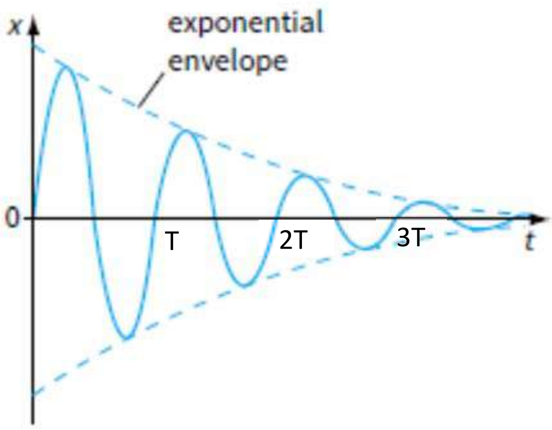
$$\frac{1}{2}(55)(6.5^2 - v_f^2) = (55)(9.81)(1.3) + (2.0)(2.0)$$

$$v = 4.1 \text{ m s}^{-1}$$

(ii) If the ramp is replaced by the one shown in the figure, the distance travelled will be shorter and hence the work done against friction will be smaller. Therefore, the speed the skateboarder exits at point B will be higher.

3(a)(i) As the block oscillates in the liquid, energy is needed to overcome the resistive (viscous) forces present in the liquid. Energy of the oscillating system thus decreases, resulting in damped oscillations.

(ii)



(b)(i) The motion of the block is in **forced oscillation** as the water waves provides the external periodic driving force to continuously supply energy to the block to compensate for the loss of energy due to damping. The block will therefore oscillate with a constant amplitude and at the frequency of the water waves.

When the driving frequency of the water waves matches the natural frequency of the block in the water, **resonance** occurs. At this particular frequency, there is maximum transfer of energy from the water waves to the block, so the block oscillates with the maximum amplitude.

(ii) 1. $v = f\lambda \Rightarrow f = \frac{v}{\lambda} = \frac{0.90}{0.30} = 3.0\,\text{Hz}$

2. $f = \frac{1}{2\pi}\sqrt{\frac{28}{m}} \Rightarrow m = \frac{28}{4\pi^2 f^2} = \frac{28}{4\pi^2(3.0)^2} = 78.8\,\text{g}$

3. When the block has absorbed some water, its mass increases, so its natural frequency becomes lower, so resonance no longer occurs. Hence the amplitude of vertical oscillation will be lower.

4(a) The increase in internal energy of a system is equal to the sum of the heat supplied to the system and the work done on the system.

(b)(i) AB: volume is compressed, so $(W_{on})_{AB}$ is positive.
Adiabatic: $Q_{AB} = 0$

$\Delta U_{AB} = Q_{AB} + (W_{on})_{AB}$
$= 0 + 10$

$= 10$ J [A1] (Increase)

(ii) For a complete cycle, $\Delta U_{AB} + \Delta U_{BC} + \Delta U_{CD} + \Delta U_{DA} = 0$

$\Delta U_{AB} + [Q_{BC} + (W_{on})_{BC}] + [Q_{CD} + (W_{on})_{CD}] + [Q_{DA} + (W_{on})_{DA}] = 0$
$10 + [70 + 0] + [0 – 25] + [Q_{DA} + 0] = 0$
$Q_{DA} = -55$ J
So 55 J of heat leaves the gas.

(iii) Efficiency $= \frac{\text{Net useful work done by gas}}{\text{Heat input}}$

$= \frac{[(W_{by})_{CD} - (W_{by})_{AB}}{Q_{BC}}$

$= \frac{25 - 10}{70}$

$= 21\ \%$

(iv) Useful power output
= (Net useful work done by gas per cycle) x (No. of cycles per second)
$= (25 - 10) \times \frac{3000}{60}$
$= 750$ W

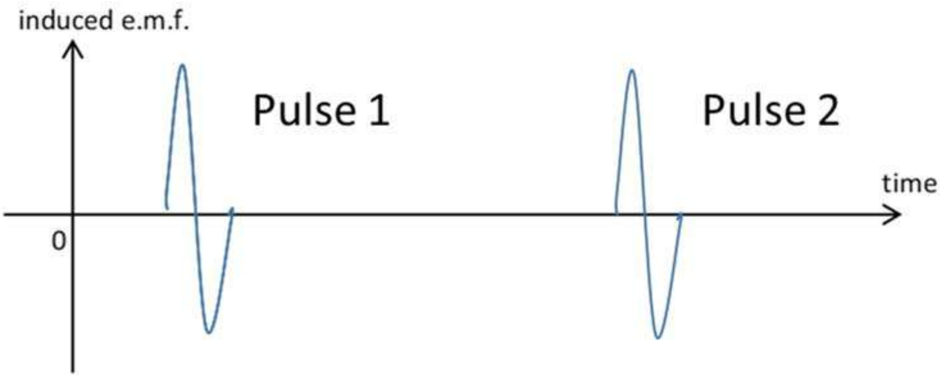
5(a) Lenz's law states that the induced emf and hence current in conductor will be such that it opposes the change causing it.

Using a clamp and retort stand, rigidly hold a coil connected to a galvanometer in a closed circuit with a switch. Freely hang a magnet as an oscillating pendulum from another retort stand and allow the magnet to oscillate such that its plane of oscillation brings the magnet closer and further from one end of the coil.

As the magnet approaches, an induced current will flow in the coil, producing a magnetic field that opposes the motion of the magnet, slowing it down, this can be seen as a deflection in the galvanometer. As the magnet oscillates away, the induced current will flow in the coil in the opposite direction to produce a magnetic field that attracts the magnet, further slowing it down.

(b)(i) As the projectile approaches the coils, the magnetic field experienced at each coil becomes larger, the closer the projectile is. The coils thus experience changing magnetic flux and hence according to Faraday's law, experience an emf.

(ii)



(iii) $v = \frac{d}{t} = \frac{1.50}{2.40 \times 10^{-3}} = 625 \text{ m s}^{-1}$

(iv) The pulses will be closer together as the bullet takes a shorter time to travel between the coils.

The amplitude of the induced emf of each pulse will be larger as the coils will experience a higher rate of change of magnetic flux linkage.

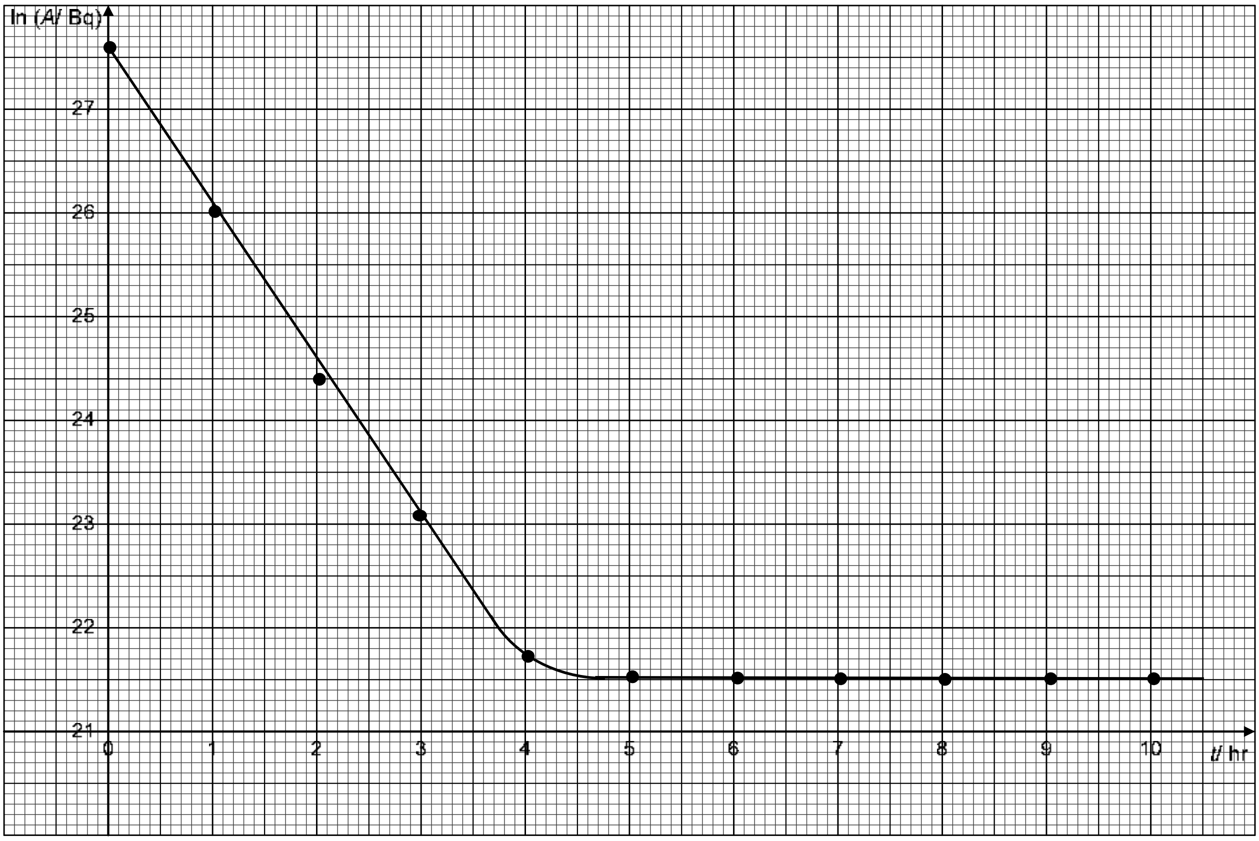
6(a) Spontaneous means that the decay process occurs on its own accord and are unaffected by physical or chemical means.

Half-life of a radioactive element is the *average* time taken for half the original number of the radioactive nuclei to decay.

(b)(i) From the table, at t = 3 hr, $A = 1.08 \times 10^{10}\ Bq$

$\Rightarrow \ln A = \ln(1.08 \times 10^{10}) = 23.103$

(ii)



(iii) From 0 to 3 hrs, the graph is linear with a negative slope. This is because the activity is predominantly that of ${}^{131}_{52}\text{Te}$ as there are only small amounts of ${}^{131}_{53}\text{I}$. So the combined activity follows the linear equation: $\ln A = -\lambda t + \ln A_0$ for ${}^{131}_{52}\text{Te}$.

From 3 to 6 hrs, the graph is a curve as the activity of ${}^{131}_{53}\text{I}$ nuclei grows and the activity of ${}^{131}_{52}\text{Te}$ decreases. So the resultant activity is due to two different nuclides, and doesn't follow the linear equation above.

From 6 to 10 hrs, the line is horizontal due mainly to the activity of ${}^{131}_{53}\text{I}$ which has a very long half-life as compared to ${}^{131}_{52}\text{Te}$. A long half-lfe means a low decay rate, which means that the activity hardly changes.

(iv) Decay constant of ${}^{131}_{52}\text{Te}$ can be obtained from the *gradient* of the linear part of the graph from 0 to 3 hrs.

$$\therefore \lambda = -\frac{27.60 - 23.40}{0.00 - 2.80} = 1.50\,\text{hr}^{-1}$$

(v) From the table, at *t* = 0 hr, $A_0 = 1.00 \times 10^{12}\ Bq$

Since, $A = \lambda N$

$$\Rightarrow N_0 = \frac{A_0}{\lambda} = \frac{1.00\times10^{12}}{1.5/(60\times60)} = 2.40\times10^{15}$$

(vi) Initially the rate of production of $^{131}_{53}\text{I}$ is much *higher* than the rate of its decay to $^{131}_{54}\text{Xe}$, hence the amount of $^{131}_{53}\text{I}$ increases.

Later, most of the $^{131}_{52}\text{Te}$ would have decayed, resulting in the rate of production of $^{131}_{53}\text{I}$ to be *lower* than its rate of decay to $^{131}_{54}\text{Xe}$. Hence, the amount of $^{131}_{53}\text{I}$ will then decrease.

(vii) Assuming that all the $^{131}_{52}\text{Te}$ has been converted to $^{131}_{53}\text{I}$, the number of $^{131}_{53}\text{I}$ isotopes after 6 hours is 2.40 x10^{15} and its activity is 2.12 x10^{9} Bq (*from table*).

Since, $A = \lambda N = \dfrac{\ln 2}{t_{1/2}} N$

$$\Rightarrow t_{1/2} = \frac{\ln 2}{A} N = \frac{\ln 2}{2.12\times10^{9}}\left(2.40\times10^{15}\right) = 7.85\times10^{5}\,\text{s}$$

7(a) $\lambda = v/f$

$$\lambda_1 = \frac{340}{20000} = 0.017\text{ m}$$

$$\lambda_2 = \frac{340}{80000} = 0.0043\text{ m}$$

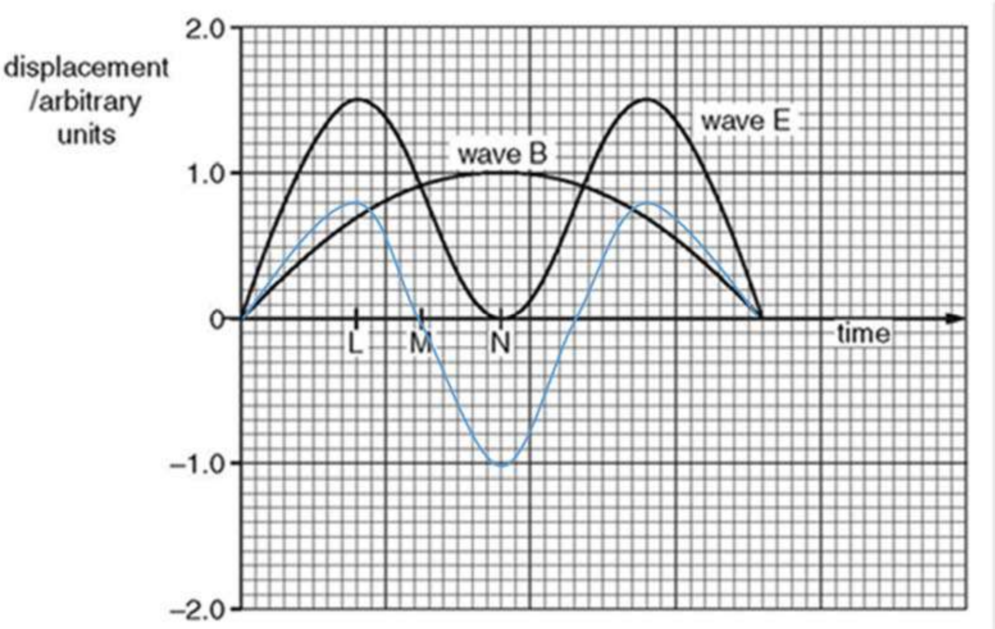
Range: 0.0043 to 0.017 m.

(b)(i) $x_L = 1.5 - 0.70 = 0.80$

$x_M = 0.90 - 0.90 = 0.00$

$x_N = 0.0 - 1.0 = -1.00$

(ii)



[A1]

(c)(i) $\dfrac{51.25-50.8}{50.8}=\dfrac{2v}{340}$

$v=1.51\ \text{m s}^{-1}$

(ii) Diffraction

(d)(i) The graph is linear with a negative gradient. Its y intercept = 2.8 ≈ ln16.

So the graph supports the equation ln*I* = -αx + ln16

$I = 16e^{-\alpha x}$

$= I_0 e^{-\alpha x}$

(ii) 1. m^{-1}

2. gradient=$\dfrac{2.80-0.85}{0.0-3.0}=-0.65\ \text{m}^{-1}$

$\therefore \alpha \approx 0.7\ \text{m}^{-1}$

(iii) Draw a graph with a constant more negative (steeper) gradient.

The y-intercept should be the same as before.

VJC Prelim 2018, H2 Physics, Paper 3 – Suggested Solutions

Section A

1(a) power, watt
potential difference, volt
magnetic flux, weber
magnetic flux density, tesla

(b) Speed is a quantity, so it should be defined in terms of other quantities. But "second" is a unit (or second isn't a quantity), so the statement is incorrect.
Speed is the distance travelled per unit time.

(c)(i) horizontal component of the velocity, $v_x = v\cos\theta$
Range, $d = (v\cos\theta)t$

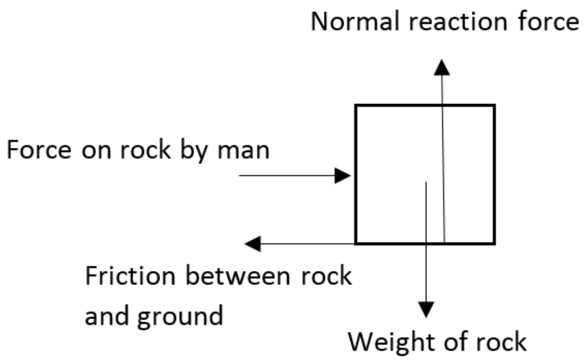
(ii) vertical component of the velocity, $v_y = v\sin\theta$
$s_y = u_y t + (1/2)at^2$
$0 = (v\sin\theta)t + (1/2)(-g)t^2$

$$t = \frac{2v\sin\theta}{g}$$

(iii)
$$\sin 2\theta = \frac{dg}{v^2} = \frac{(94)(9.81)}{(32)^2}$$
$= 0.9005$
$2\theta = 64.23°$ or $115.8°$
$\theta_1 = 32.1° = 32°$
$\theta_2 = 57.9° = 58°$

2(a)(i) The student's argument is not correct because the reaction force acts on the man, i.e. the reaction force on the man and the force the man exerts on the rock are acting on two different bodies, so they do not cancel out.

(ii)



Note: The normal reaction force and weight of rock must form an anticlockwise couple, to balance the clockwise couple from the horizontal forces.

2(b)(i) Block A and B moves with the same velocity when maximum compression of the spring takes place.

(ii) By the conversation of momentum,
total initial momentum = total final momentum

$m_A u_A + m_B v_B = (m_A + m_B)v$

$(2.0)(10) + (3.0)(5.0) = (2.0 + 3.0)v$

$v =$ 7.0 m s^{-1}

(iii) Let maximum compression be *x*.
By conservation of energy,
loss in KE of block A = gain in EPE in the spring + gain in KE of block B

$\frac{1}{2}m_A(u_A^2 - v_A^2) = \frac{1}{2}kx^2 + \frac{1}{2}m_B(v_B^2 - u_B^2)$

$\frac{1}{2}(2.0)(10^2 - 7.0^2) = \frac{1}{2}(500)x^2 + \frac{1}{2}(3.0)(7.0^2 - 5.0^2)$

$x =$ 0.24 m

3a. $\Delta y = \frac{\lambda D}{d}$

$= \frac{vD}{fd}$

Frequency of sound, $f = \frac{vD}{d\Delta y}$

$= \frac{340 \times 12}{2.5 \times 0.60}$

= 2720 Hz

bi. 2*A*

ii. $\frac{A}{\sqrt{2}}$ = 0.707 *A*

iii. $\left(A + \frac{A}{\sqrt{2}}\right)$ = 1.7071*A*

≈ 1.71*A*

iv. Old intensity: $I = k(2A)^2$, k = constant

$= 4kA^2$

New intensity: $I' = k(1.7071A)^2$

$= 2.91kA^2$

$= 0.729\ I$

4a. (Reasoning: the magnetic force must be downward, to balance the weight of the mass on the other end. Use Fleming's left-hand rule.)

B to A

b. Take moments about pivot

Anticlockwise moment = clockwise moment

BIL x 8.0 x 10^{-2} = mg x 7.0 x 10^{-2}

$$B = \frac{mg \times 7.0 \times 10^{-2}}{IL \times 8.0 \times 10^{-2}}$$

$$= \frac{2.0 \times 10^{-3} \times 9.81 \times 7.0 \times 10^{-2}}{3.0 \times 6.0 \times 10^{-2} \times 8.0 \times 10^{-2}}$$

$= 9.5 \times 10^{-2}$ T

c.

- A non-horizontal field will generate a magnetic force with a horizontal component.
- This horizontal component force will not generate any moment about the pivot.
- So you can't tell what is its magnitude (and therefore you won't know what is the total value of the magnetic field).

5 **(a)**

$E = \frac{V}{d} = \frac{45}{0.10} = 450$ V m^{-1} or $F_E = qE = \left(1.60 \times 10^{-19}\right) \times 450 = 7.2 \times 10^{-17}$ N

$F_E = m\,a$

$e\,E = m\,a$

$(1.60 \times 10^{-19}) \times 450 = (9.11 \times 10^{-31}) \times a$

$a = 7.903 \times 10^{13}$ m s^{-2} or 7.9×10^{13} m s^{-2}

(b)

$v_y = u_y + a_y\,t$

$0 = (6.8 \times 10^6 \times \sin 30°) + (-7.9 \times 10^{13})\,t$

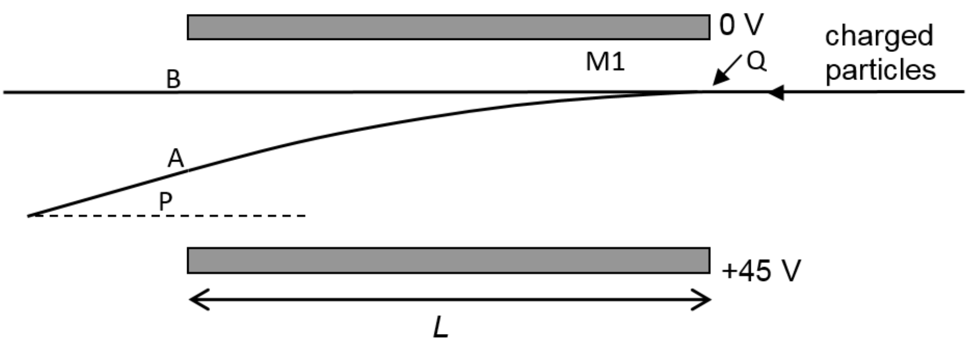
$t = 4.304 \times 10^{-8}$ s

$s_x = u_x\,t + ½\,a_x\,t^2$

$L = (6.8 \times 10^6 \times \cos 30°) \times (4.304 \times 10^{-8}) + 0$

$L = 0.253$ m or 0.25 m

(c)



(i) Electrons from Q will have a smaller vertical displacement than previously as its horizontal speed now is higher. Path A exits above point P.

(ii) Mass of protons is 1800 times more than electrons. Vertical displacement of protons will be 1800 times less than that of electrons. Path B is almost straight and the upward vertical displacement is much less than Path A.

(iii) **I.** Path A and path B are deflected in opposite directions: due to opposite charges, the forces acting on electrons and protons are in opposite directions.

II. Path A shows a much greater deflection than Path B (Path B is nearly straight): Electrons and protons experience the same force. Due to the much smaller mass of electrons, they experience a much larger acceleration than protons and hence a larger vertical displacement.

6(a) $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$

3 neutrons are produced.

(b) From the graph U has lower binding energy per nucleon than the products Ba and Kr. Multiplying by the number of nucleons, U has lower binding energy than both (Ba + Kr) together.
This means that U required less energy to break up the nucleus into its constituent nucleons, and more energy is being released when both Ba + Kr are formed from the constituent nucleons. Hence overall, there is a net release of energy.

(c) Energy required to break U = 7.63 x 235 = 1793 MeV
Energy released when Ba + Kr formed = 8.40 x 141 + 8.70 x 92 = 1985 MeV
Net energy released = 1985 – 1793 = 192 MeV.

(d) Neutron is a free particle and has no binding energy. Thus it is not included in the calculation.

7 (a)

(i) In this technique, particles of electron exhibit wave-like behaviour as evidenced by the diffraction pattern produced by the electron beam.

(ii) In order for diffraction to occur, the associated wavelength of the electrons is about 0.1 nm.

By de Broglie equation,

momentum of the electrons, $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{0.1\times10^{-9}} = 6.63\times10^{-24}\ \text{kg m s}^{-1}$

Kinetic energy of the electrons,

$$KE = \frac{p^2}{2m} = \frac{\left(6.63\times10^{-24}\right)^2}{2\left(9.11\times10^{-31}\right)} = 2.4\times10^{-17}\ \text{J} \approx 2\times10^{-17}\ \text{J}$$

(iii) Momentum, $p = mv$

$$\Rightarrow \frac{\Delta p}{p} = \frac{\Delta v}{v} = 10\%$$

Uncertainty in electron's momentum,

$$\Delta p = \frac{10}{100}\left(6.63\times10^{-24}\right) = 6.63\times10^{-25}\text{ kg m s}^{-1}$$

Using Heisenberg's uncertainty principle, $\Delta x \Delta p \geq h$

uncertainty in electron's position, $\Delta x \geq \frac{h}{\Delta p} = \frac{6.63\times10^{-34}}{6.63\times10^{-25}} \approx 1\times10^{-9}\text{ m}$

(iv) Energy of photon,

$$E = \frac{hc}{\lambda} = \frac{\left(6.63\times10^{-34}\right)3.0\times10^{8}}{0.1\times10^{-9}} = 2.0\times10^{-15}\text{ J} \approx 2\times10^{-15}\text{ J}$$

(b)

(i) Using $KE = \frac{p^2}{2m}$

momentum of the protons,

$$p = \sqrt{2m(KE)} = \sqrt{2\left(1.67\times10^{-27}\right)\left(2.4\times10^{-17}\right)} = 2.8\times10^{-22}\text{ kg m s}^{-1}$$

associated wavelength of the protons, $\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}}{2.8\times10^{-22}} \approx 2\times10^{-12}\text{ m}$

(ii) The use of protons would make a *more* effective probe because its associated wavelength is *smaller* than that of the electrons, thus producing images of higher resolution.

Section B

8(a)(i) The loss in GPE of the ball is converted into its KE.

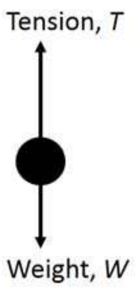
mgh = (1/2)*mv*^{2}

$v = \sqrt{2gh} = \sqrt{2(9.81)(0.70)}$

= 3.706 m s^{-1}(For 'Show' questions, must show substitution and unrounded answer first)

= 3.7 m s^{-1}

(ii)



(iii) Centripetal force, $F_c = \dfrac{mv^2}{r} = \dfrac{(0.050)(3.706)^2}{(1.50)}$

= 0.4578 N = 0.458 N

(iv) The ball is moving in a circular path, so it is experiencing an acceleration. According to Newton's first law, there must be a resultant force on the ball. So $T \neq W$, otherwise there will be no resultant force on the ball.

(v) Applying Newton's second law,

$F_{net} = ma = F_c$

$T - W = F_c$

$T = W + F_c = (0.050)(9.81) + 0.4578$

= 0.9483 = 0.948 N

(b)(i) The gravitational field strength at a point is the gravitational force per unit mass acting at that point.

(ii) $g = \dfrac{GM}{d^2}$, where d is the distance between the COMs of Charon and Pluto

$$g = \frac{(6.67\times10^{-11})(1.27\times10^{22})}{(1.96\times10^{7})^2}$$

= 2.205×10^{-3} m s^{-2}

= 2.21×10^{-3} m s^{-2}

g points towards the centre of Pluto.

(iii) ω is the angular speed about the joint centre of mass.

Centripetal force on pluto, $F_P = m_P r_P \omega^2$ & centripetal force on Charon, $F_C = m_C r_C \omega^2$

The centripetal force is provided by the gravitational force on each body, and the gravitational forces have the same magnitude, according to Newton's third law.

So $m_P r_P \omega^2 = m_C r_C \omega^2$

$\therefore \dfrac{m_P}{m_C} = \dfrac{r_C}{r_P}$

(iv) $r_P = \left(\dfrac{m_C}{m_P}\right) r_C$

$r_P + r_C = 1.96\times10^7$ m

$\left(\dfrac{m_C}{m_P}\right) r_C + r_C = 1.96\times10^7$ m

$$r_C = \frac{1.96\times10^7 \text{ m}}{1+\left(\dfrac{m_C}{m_P}\right)} = \frac{1.96\times10^7 \text{ m}}{1+\left(\dfrac{1.50\times10^{21}\text{ kg}}{1.27\times10^{22}\text{ kg}}\right)}$$

= 1.753×10^7 m = 1.75×10^7 m

(v) gravitational field strength experienced by Charon = centripetal acceleration experienced by Charon

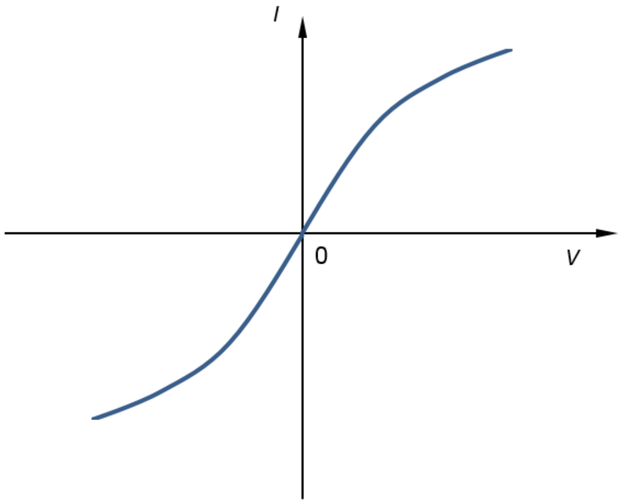
$$g = r_C \omega^2 = r_C \left(\frac{2\pi}{T} \right)^2$$

$$T = \sqrt{\frac{4\pi^2 r_C}{g}} = \sqrt{\frac{4\pi^2 (1.753 \times 10^7)}{2.205 \times 10^{-3}}}$$

$= 5.60 \times 10^5$ s

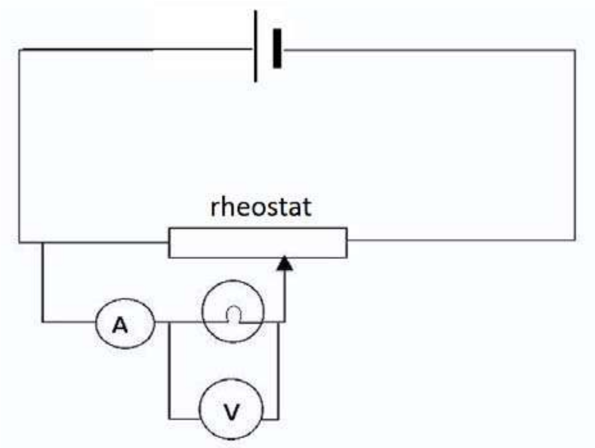
9(a)(i) The ohm is the unit of resistance such that 1 Ω is the resistance where the potential difference between 2 points across a conductor is 1 V produces a current of 1 A flowing through it.

(ii)



(iii) Resistance R is the ratio of the p.d V to the current I at that particular p.d on the graph.

(iv)



b(i) Total resistance of the 4 parallel resistors = $(1/2R + 1/2R)^{-1} = R$.
$I = E/(R + r)$.

(ii) Power in the 4 parallel resistors = $I^2 R$, where I = E/(R+r)
Power in the battery = IE

$$\frac{power\ in\ external\ resistors}{power\ by\ batter} = \frac{I^2 R}{IE}$$

$$= \frac{I\ R}{E}$$

$$= \frac{E\ R}{R + r}\ \frac{1}{E}$$

$$= \frac{R}{R + r}$$

(iii) Having 4 resistors in parallel, each resistor only dissipates ¼ of the power compared to a single resistor.
Hence 4 resistors in parallel can have a higher power rating than just a single resistor.

(c)(i) When light shone on LDR, resistance of LDR is 420 Ω.
p.d across LDR = $\frac{420}{420+8200} \times 6.0 = 0.29\ V$

Hence potential at P, V_P = 0.29 – 2.0 = -1.71 V

(ii) When LDR in the dark, resistance of LDR = 134 kΩ.
p.d across LDR = $\frac{134\ \text{k}\Omega}{134\ \text{k}\Omega+8.2\ \text{k}\Omega} \times 6.0 = 5.65\ V$

Hence potential at P, V_P = 5.65 – 2.0 = 3.65 V.

(iii) The alarm is placed in parallel with the LDR.
When the laser beam is shining on the LDR, the resistance of the LDR will be low. By potential divider principle, the p.d. across the LDR and alarm will be low. The alarm will remain turn off.
When the burglar blocked the laser beam, the resistance of the LDR will be high. Hence the p.d across the LDR and alarm will be high. This will turn on the alarm.

(d)(i) There will be no deflection in the galvanometer when the p.d across JY = 1.5 V.
Let the balance length (between J and Y) be *L*. Then

$$V_{JY} = \frac{L \times 1.50}{(1.50+0.50)} \times 4.0 = 1.5$$

L = 0.500 m.

Hence distance from X = 1.00 – L_{JY} = 0.50 m.

(ii) When 1.50 Ω connected with the 1.5 V cell, the terminal p.d across the 1.50 Ω is

$$V = \frac{1.50}{1.50+0.50} \times 1.5 = 1.13\ V$$

There will null deflection when V_{JY} = 1.13 V. Then

$$V_{JY} = \frac{L' \times 1.50}{(1.50+0.50)} \times 4.0 = 1.13$$

L' = 0.377 m.

Hence distance from X = 1.00 – 0.377 = 0.62 m.

VICTORIA JUNIOR COLLEGE
Preliminary Examination
Higher 2

CANDIDATE NAME ……**Suggested Solution**…………………………………..

CT GROUP ……………………………..

Physics **9749/04**

Paper 4 Practical **27 August 2018**

2 hours 30 minutes

Additional Materials: As listed in the instructions below

READ THESE INSTRUCTIONS FIRST

Write your name and CT group in the spaces at the top of this page.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
4	
Total	

This document consists of **17** printed pages.

1. In this experiment, you will investigate a system in equilibrium due to several forces.

   (a) Measure and record the length L_o between the ends of the spring, as shown in Fig. 1.1. **Note that this distance includes the two loops at the ends**.

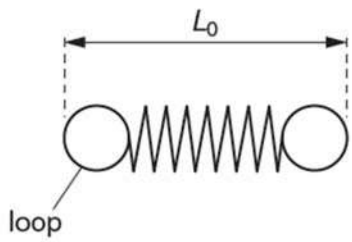


Fig. 1.1

L_o = 0.050 m (3dp) [1]

   (b) (i) Set up the apparatus as shown in Fig. 1.2. Mass m should be 0.200 kg. The top ring of the spring should be at the **same height** as the top of the pulley. The longer string, after attaching to the spring and inclusive of the loop for mass m, should be of **approximate length 80 cm**.

   Do not change the height of the pulley or the clamp.

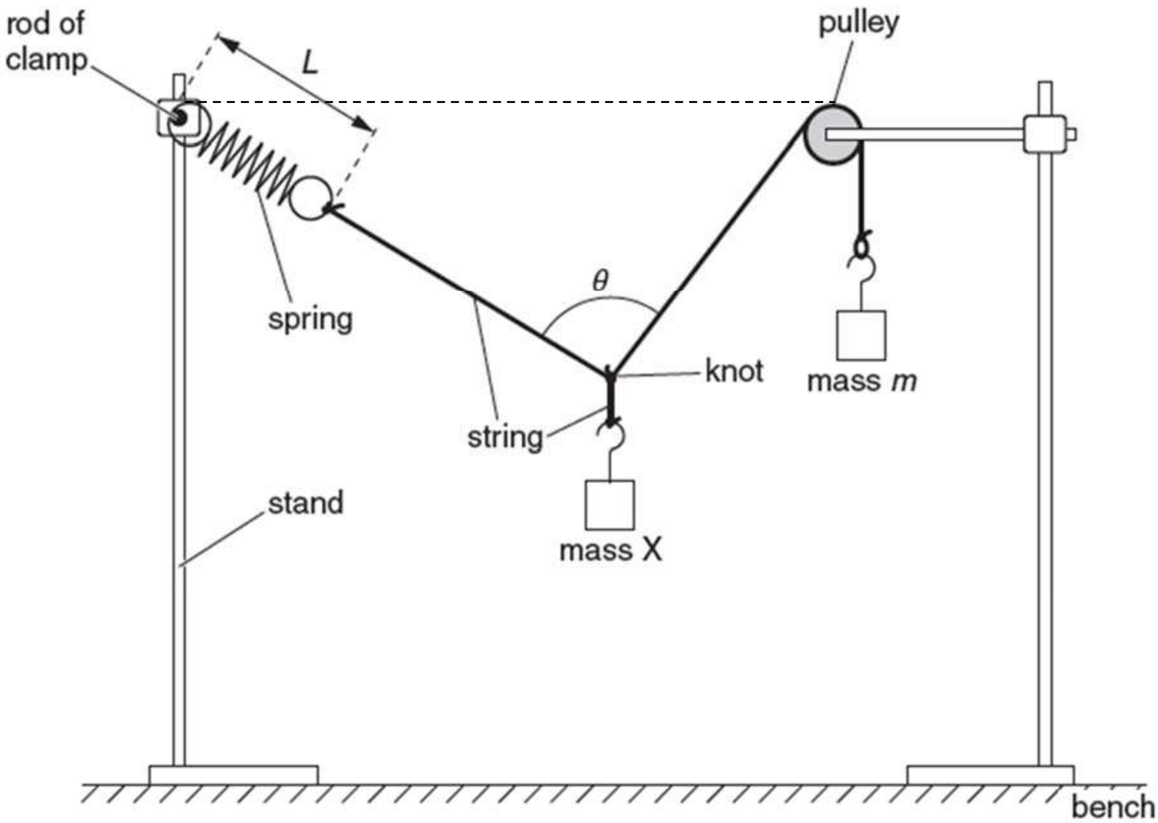


Fig. 1.2

(ii) **Adjust the apparatus until the angle *θ* is 90°.**

You may move the stands sideways or slide the knot along the string.

(iii) Measure and record the distance *L* between the ends of the spring loops.

L = 0.126 m (3dp)

(iv) Calculate the extension *e* of the spring using $e = L – L_o$.

$e = L - L_o$
$= 0.126 – 0.050$
$= 0.076$ m

e = 0.076 m (3dp) [1]

(c) Add further slotted masses to vary *m.*

Repeat (b)(ii), (b)(iii) and (b)(iv) for each additional mass until you get a few sets of values of *m* and *L*.

Include values of m^2, *e* and e^2 in your table. Include your previous results.

Lo = 0.050 m

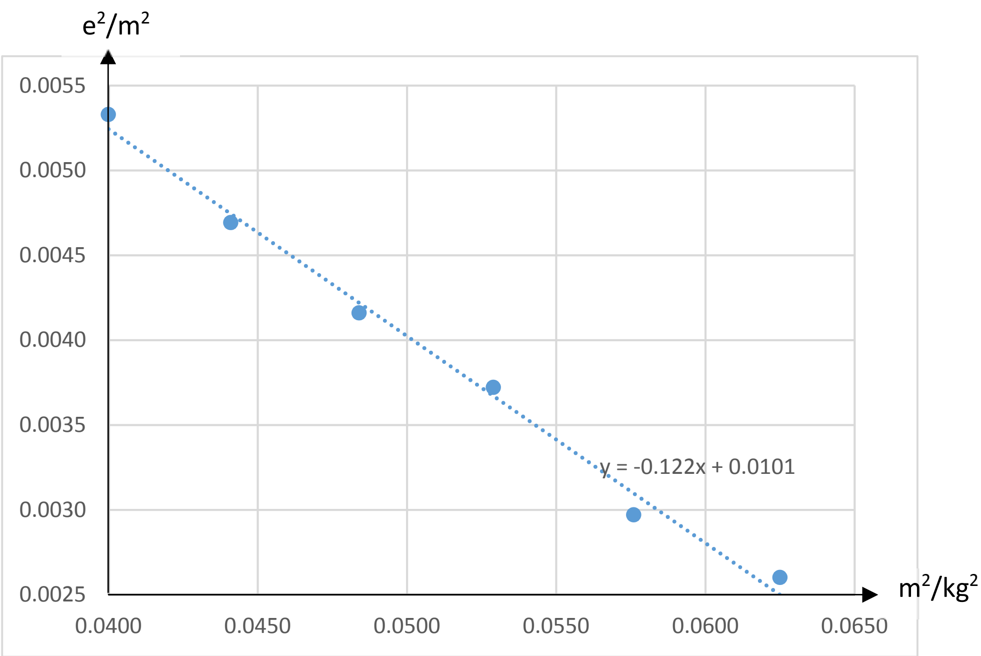
m/kg	L_1/m	L_2/m	e_1/m	e_2/m	<e>/m	e^2/m^2	m^2/kg^2
0.200	0.123	0.123	0.073	0.073	0.073	0.0053	0.0400
0.210	0.118	0.119	0.068	0.069	0.069	0.0047	0.0441
0.220	0.115	0.114	0.065	0.064	0.065	0.0042	0.0484
0.230	0.110	0.112	0.060	0.062	0.061	0.0037	0.0529
0.240	0.104	0.105	0.054	0.055	0.055	0.0030	0.0576
0.250	0.101	0.101	0.051	0.051	0.051	0.0026	0.0625

[4]

(d) (i) Plot a graph of e^2 against m^2 on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient *P* and y-intercept Q of this line.



P = <u>-0.122 m² kg⁻²</u> [1]

Q = <u>0.0101 m²</u> [1]

(e) The gradient *P* and y-intercept *Q* can be expressed as

$$-P = \frac{g^2}{k^2} \qquad \text{and} \qquad Q = -PM^2$$

respectively where *k* is the spring constant of the spring, *M* is the mass of X, *and* *g* = 9.81 N kg^{-1}.

Calculate *M* and *k*.

$$-P = \frac{g^2}{k^2}$$

$$k^2 = \frac{g^2}{-p}$$

$$k^2 = \frac{9.81^2}{-(-0.122)} = 788.8$$

$$k = 28.1 \text{ N m}^{-1}$$

$$Q = -PM^2$$

$$M^2 = \frac{Q}{-P} = \frac{0.0101}{-(-0.122)}$$

$$M^2 = 0.08279$$

$$M = 0.288 \text{ kg}$$

M = <u>0.288 kg</u> [2]

k = <u>28.1 N m^{-1}</u> [2]

[Total: 16 marks]

2. In this experiment, you will determine the resistivity ρ of a metal.

(a) You have been provided with two bare wires of different lengths – wire F has a crocodile clip at each end and wire G is taped to a metre rule. The wires have the same diameter *d*.

(i) Measure and record *d* of wire F.

d/mm
0.175
0.179
0.183
<d> = 0.179

Zero error = (0.000 ± 0.005) mm
Corrected d = 0.179 – 0.000
= (0.18 ± 0.01) mm

d = 0.18 mm (2dp) [1]

(ii) Calculate the cross-sectional area *A* of the wire.

$$A=\pi(\frac{d}{2})^2=\pi\left(\frac{0.18\times10^{-3}}{2}\right)^2$$

$A=2.5\times10^{-8}$ m²

A = 2.5×10^{-8} m² (2sf) [1]

(iii) Measure and record the exposed length *L* of wire F between the crocodile clips, as shown in Fig. 2.1.

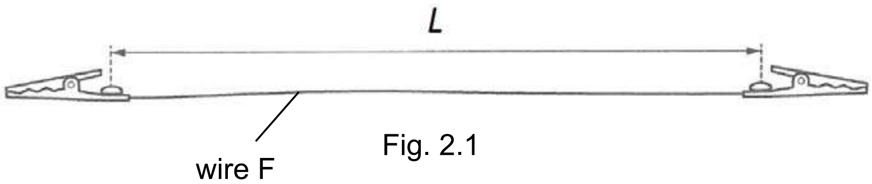


Fig. 2.1

L = 1.040 m (3dp) [1]

(b) Using wire G taped to the metre rule, set up the circuit as shown in Fig. 2.2.

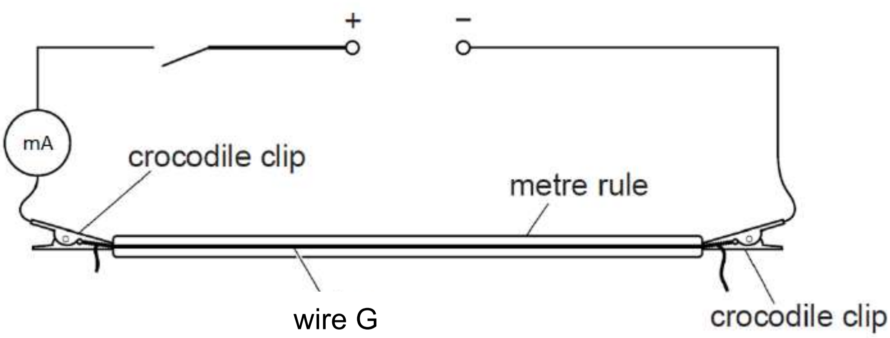


Fig. 2.2

(c) (i) Attach wire F to wire G on the metre rule as shown in Fig. 2.3.

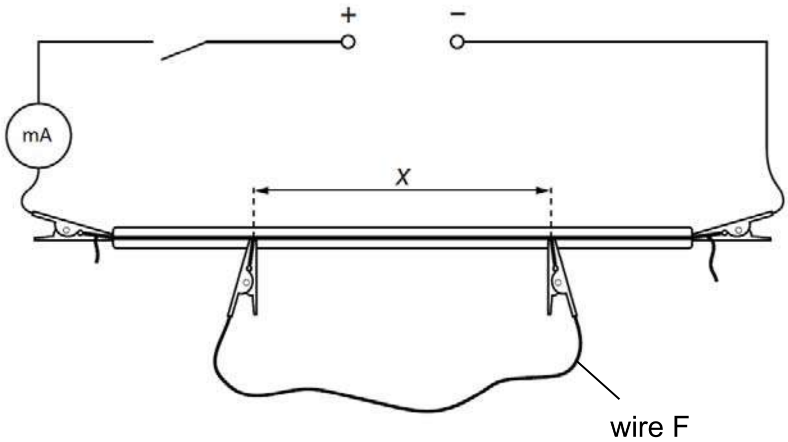


Fig. 2.3

The distance x between the crocodile clips should be approximately 50 cm.

(ii) Measure and record x.

x = <u>0.500 m (3dp)</u> [1]

(d) (i) Close the switch.

(ii) Record the ammeter reading I.

I = <u>0.0800 (4dp)</u> OR <u>80.0 x 10^{-3} (3dp)</u> A [1]

(iii) Open the switch.

(e) Theory suggests that

$$\frac{1}{I}=\frac{\rho}{2A}\left(1-\frac{x^2}{x+L}\right)$$

where ρ is the resistivity of the material of the wire.

Determine a value for ρ.

$$\frac{1}{80.0\times10^{-3}}=\frac{\rho}{2(2.5\times10^{-8})}\left(1-\frac{0.500^2}{0.500+1.060}\right)$$

$$\rho=7.5\times10^{-7}\,\Omega\,\mathrm{m}$$

ρ <u>= 7.5 x 10^{-7}</u> Ω m [2]

[Total: 7 marks]

3. In this experiment, you will model the action of a see saw.

(a) Using vernier caliper, measure and record the thickness *t* of the metre rule.

t_1 = 6.60 mm
t_2 = 6.60 mm
<*t*> = 6.60 mm

t = 6.60 mm OR 6.60×10^{-3} m [1]

(b) (i) Measure and record the diameter *d* of beaker A.
Measured using vernier caliper:

d_1 = 68.00 mm
d_2 = 68.00 mm
<*d*> = 68.00 mm

OR

Measured using metre rule:
d_1 = 0.068 m
d_2 = 0.068 m
<*d*> = 0.068 m

d = 68.00 mm or 0.068 m

(ii) Calculate *w*, where *w* = *d* – *t*.
w = *d* – *t*
w = 68.00 – 6.60 = 61.40 mm

OR

w = 0.068 – 0.00660 = 0.061 mm

w = 61.40 mm OR 0.061 mm [1]

(c) (i) Use blu tack to secure beaker A to the bench and balance the metre rule on the beaker, as shown in Fig. 3.1 below:

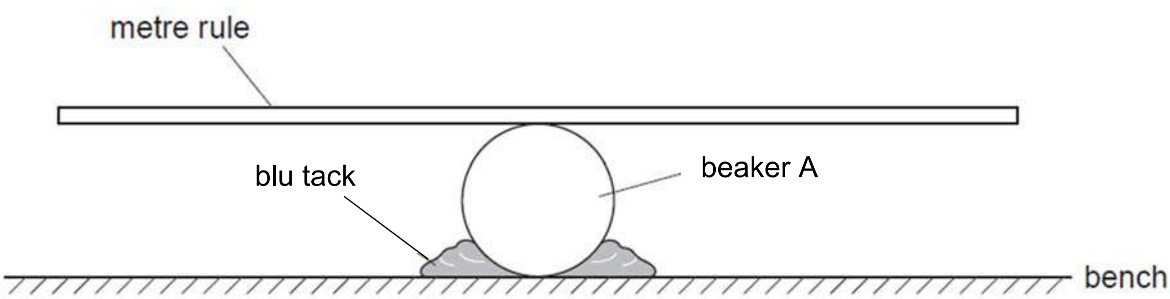


Fig. 3.1

(ii) Move one end of the rule downwards. Release the rule and watch the movement. The end of the rule will move upwards and then downwards again, completing a swing as shown in Fig. 3.2 below:

The time taken for each swing is *T*.

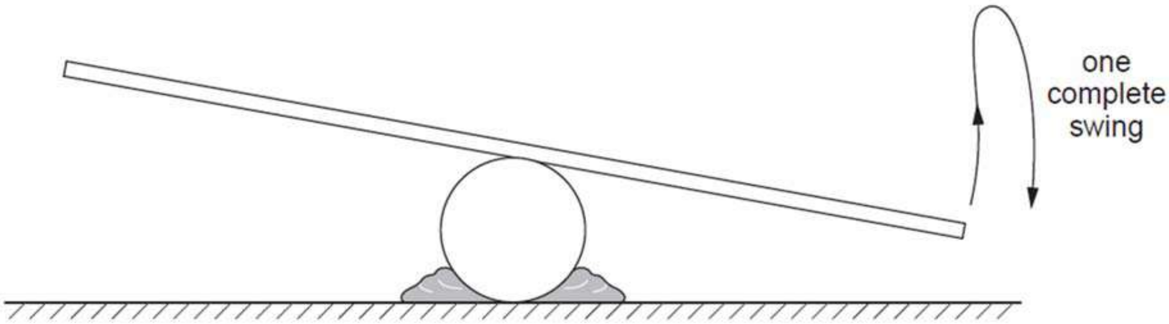


Fig. 3.2

By timing several of these complete swings, determine an accurate value for *T*.

N = 10 oscillations

t_1 = 29.99 s
t_2 = 30.91 s
$<t>$ = 30.45 s

$$T = \frac{<t>}{N} = \frac{30.45}{10} = 3.045\,\text{s}$$

T = <u>3.045 s (4sf)</u> [2]

(d) Estimate the percentage uncertainty in your value of *T*.
Take $\Delta t = 0.3$ s

$$\frac{\Delta T}{T} = \frac{\Delta t}{t} = \frac{0.3}{30.45} = 0.0099$$

$$\frac{\Delta T}{T} = 0.0099 \times 100\% = 1\%$$

Percentage uncertainty = <u>1 % (1 or 2 sf)</u> [1]

(e) Repeat (b) and (c) for beaker B.

d = 51.00 mm

w = *d* – *t* = 51.00 – 6.60 = 44.40 mm

N = 5 oscillations

t_1 = 17.40 s

t_2 = 17.73 s

<*t*> = 17.57 s

$$T = \frac{<t>}{N} = \frac{17.57}{5} = 3.513 \text{ s}$$

d = 51.00 mm

w = 44.40 mm

T = 3.513 s

[2]

(f) It is suggested that the quantities *T* and *w* are related by the equation

$$T^2 = \frac{k}{w}$$

where *k* is a constant.

(i) Using your data, calculate two values of *k*.

For set 1:

$k = T^2 w$

$k = 3.045^2 \times (61.40 \times 10^{-3})$

$k = 0.569$ s² m

For set 2:

$k = T^2 w$

$k = 3.513^2 \times (44.40 \times 10^{-3})$

$k = 0.548$ s² m

First value of *k* = 0.569 s² m

Second value of *k* = 0.548 s² m

[1]

(ii) State whether your results of your experiment support the suggested relationship. Justify your conclusion by referring to your value in (d).

$$\frac{\Delta k}{k} = \frac{0.569 - 0.548}{0.569} = 0.037 = 3.7\%$$

Since difference in *k* is about 3.7% and this difference is larger than $2\frac{\Delta T}{T} = 2(1) = 2\%$ of the error in *T*, then it is unlikely that $T^2 = \frac{k}{w}$ is valid. [1]

(g) (i) Describe two sources of uncertainty or limitations of the procedure for this experiment. [2]

1. The beaker is not of uniform diameter, with the mouth of the beaker being wider than the body. This makes it difficult to ensure that the ruler can be placed horizontally in equilibrium.

2. The plastic beaker is compressible. When the ruler is placed above, the beaker becomes compressed and *w* becomes smaller.

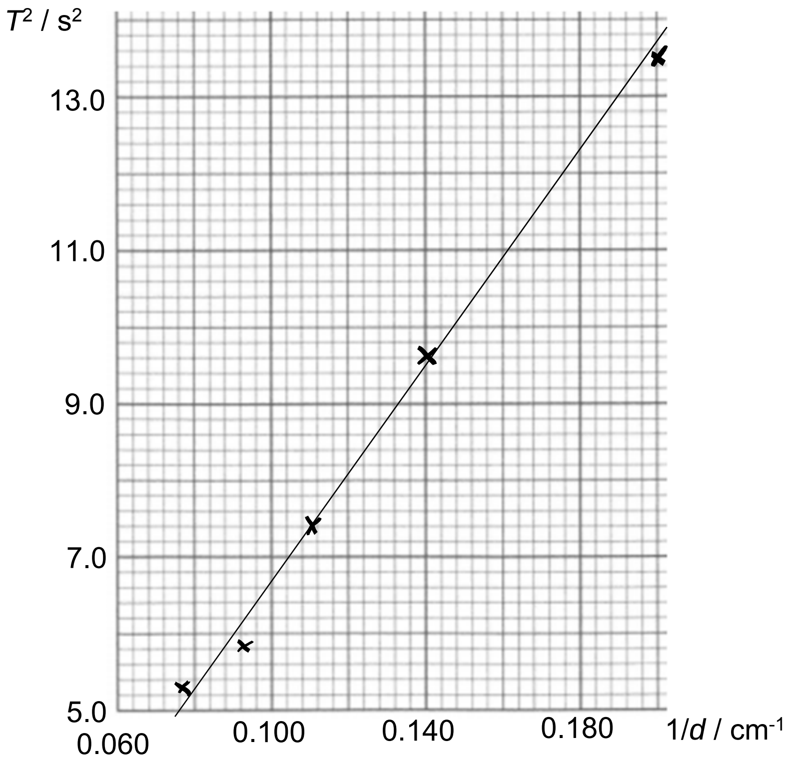
(ii) Describe an improvement that could be made to this experiment to address one of the errors identified in (g)(i). You may suggest the use of other apparatus or different procedures. [1]

1. Use a rod of uniform diameter.
2. Use a beaker of a stiffer material e.g. glass beaker.

(h) The experiment is repeated using cylinders of different diameters. The results are shown in the table below. Values of T^2 and $1/d$ are included:

T / s	T^2 / s^2	d / cm	1/d / cm^{-1}
3.672	13.48	5.0	0.20
3.101	9.616	7.0	0.14
2.719	7.392	9.0	0.11
2.412	5.818	11.0	0.0909
2.301	5.295	13.0	0.0769

(i) Plot the points on the grid and draw the straight line of best fit.



[1]

(ii) Determine the y-intercept of the line.

$$grad = \frac{12.3 - 5.0}{0.180 - 0.076} = \frac{7.3}{0.104} = 70.2$$

Subst (0.076, 5.0) into y = mx + c
5.0 = (70.2)(0.076) + c
c = 5.0 – 5.34 = - 0.34

y-intercept = <u>- 0.34 s^2</u> [2]

(iii) Use your answer in (h)(ii) to state whether T^2 is inversely proportional to *d*. [1]

The graph of T^2 vs 1/d is <u>a straight line</u> with y-intercept = - 0.34 s^2. <u>The y-intercept is close to the origin</u> within experimental error. Hence, T^2 is inversely proportional to *d*.

(i) A manufacturer of playground see-saws wants to find out what length of the plank would give a period of oscillation of 1 second. Instead of building full-size see-saws, he decides to use models similar in design to those shown above to study the relationship, setting the diameter of the cylinder at 10.0 cm.

Plan an investigation to find the length of the plank needed to give a period of 1 second.

Your account should include:

- Your experimental procedure
- Details of the table of measurements with appropriate units
- How you would find the length of the plank to give a period of 1 second.
- Control of variables [5]

Procedure:

1. Using a plank of length *L*, measured with a metre rule, placed on cylinder of diameter D = 0.100 m. Oscillate plank. Take timing, *t*, for *N* oscillations using a stopwatch such that timing exceeds 15 s. Record time *t*. Repeat timing and take average <*t*>. Period of oscillations, *T*, is calculated using <*t*>/*N*.
2. Repeat step 2 another 5 times by using planks of different lengths. If period *T* > 1 s, use shorter lengths *L* for subsequent experiment. If *T* < 1 s, use longer lengths to make sure that periods obtained are in a range which includes 1.0 s.
3. Include table with appropriate units.

Length/m	t_1/s	t_2/s	<t>/s	T/s

4. Plot a graph of *T* vs *L*. Draw the best fit curve. On graph, locate the length *Lo* such that *T* = 1.00 s.
5. Control of variables:
   - Use planks of same width and/or thickness by measuring with vernier caliper.
   - Use planks made of same material so that period will not be affected.

[Total: 21 marks]

4. Two identical coils are connected together and arranged as shown in Fig. 4.1.

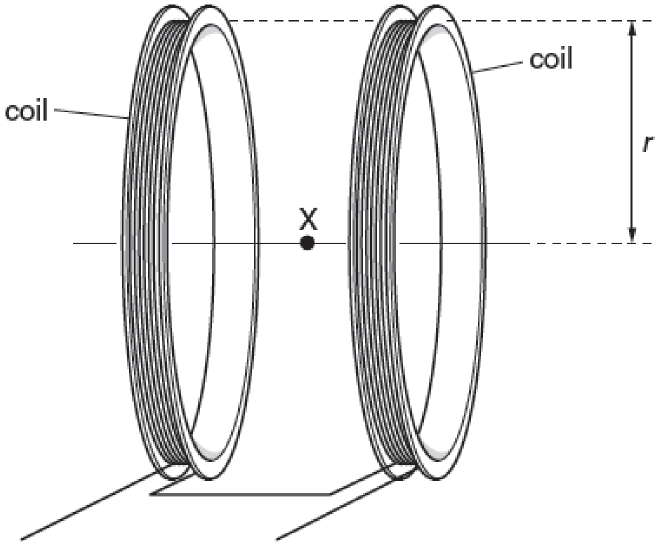


Fig. 4.1

The coils are in the vertical plane and are parallel to each other. When the coils are connected to a power supply, there is a magnetic field between them.

It is suggested that the magnetic flux density B of the field at the point X can be expressed as

$$B = \frac{0.72\mu_o NI}{r}$$

where r is the radius of the coils, N is the number of turns on each coil, I is the current in the coils and μ_o is the permeability of free space.

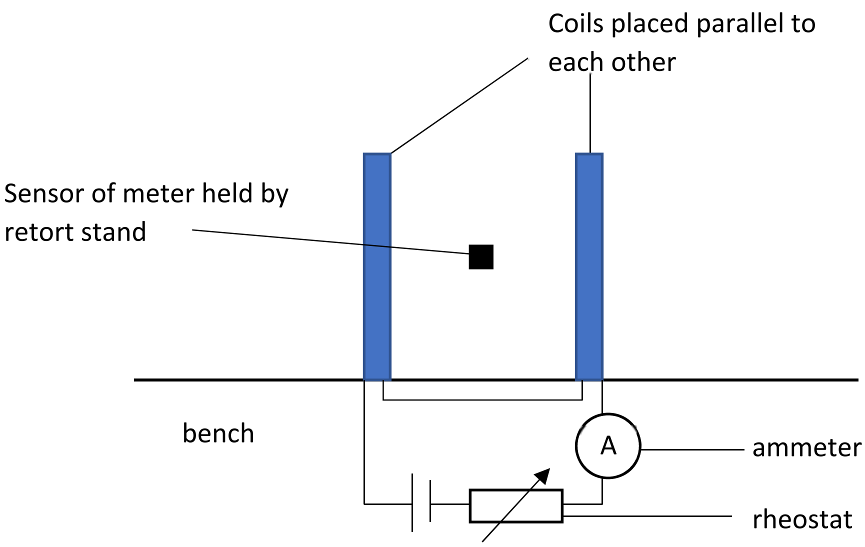
You are provided with a power supply, two coils of wires with a known number of turns and a meter (connected to a sensor) to measure the magnetic flux density. You may also use any of the other equipment usually found in a physics laboratory.

Design an experiment to determine the value of μ_o.

You should draw a diagram to show the arrangement of your apparatus and you should pay particular attention to

(a) the equipment you would use
(b) the procedure to be followed
(c) the control of variables
(d) any precautions that should be taken to improve the accuracy and safety of the experiment.

4. Diagram:



Procedure:
Measure diameter, D, of coil using vernier caliper. Measure at different positions and take average to reduce random error. Radius, r, of coil can be determined by D/2.

Place the 2 coils vertically on the bench. Use blu tack to stick both coils onto the bench to prevent them from shifting. Measure distance between the 2 coils using a metre rule and find the mid-point. Also measure the height of the coil and find the mid-point. Using a plastic retort stand, clamp the sensor of the meter to measure the magnetic flux density r cm above the bench at the mid-point using a set square.

Set rheostat to largest resistance. Switch on the power supply. Measure and record current, I, of coil using ammeter. Measure and record the magnetic flux density, B, using the meter provided.

Vary I by adjusting the resistance of the rheostat to obtain another 5 sets of I and B.
Plot a graph of B vs I. If a straight line through the origin is obtained, then the equation is valid. The gradient of the graph is equal to $0.72\mu_o N/r$.

$$\mu_o = \frac{gradient \times r}{0.72N}$$

Control of variables:
The distance between the coils must be kept constant by measuring with metre rule as it will affect the magnetic flux density.

Orientation of the coils to the Earth's magnetic field should be kept constant by not shifting the position of coils.

Accuracy and safety precautions:
Ensure that the coils are aligned parallel by measuring the distance between the coil using a metre rule at different sides and make sure the distances are the same.

Use large current to create a large magnetic field so as to reduce percentage error in the measurement.

Adjust the orientation of the sensor so that it is placed at right angles to the direction of magnetic field so as to obtain a maximum reading.

To ensure distance between coils is constant and their plane parallel to each other, the coils can be mounted through a cylinder of radius *r*.

Switch off circuit when not in use to avoid overheating of coil; do not touch coil because it is hot due to high current.

Since large current is used, an appropriate fuse can be used in the circuit to ensure current doesn't exceed what's planned.

Ensure no other magnetic materials are nearby so that the magnetic field measured will be mainly due to the coils.

Placed coils close together to give a high field strength to reduce percentage error.

[Total: 11 marks]

Candidate's Name ………………………………….……… CTG ……….……

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2018

PHYSICS **9749/1**

HIGHER 2 **14th September 2018**

1 hour

Paper 1 Multiple Choice

Additional Material:
Optical Mark Sheet

FLORESCAT CONCORDIA

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name and CTG on the Optical Mark Sheet in the spaces provided.
Shade your NRIC in the space provided.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D.**

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Optical Mark Sheet.

Read the instructions on the Optical Mark Sheet carefully.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	$T/°C + 273.15$
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle C^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{(x_o^2 - x^2)}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 A student counts the oscillations of a simple pendulum but mistakenly starts by counting "1" instead of "0" when the bob is released. He finishes at a count of "10".

What is the percentage error in the student's calculation of the period, due to this mistake?

A 10% low **B** 10% high **C** 11% low **D** 11% high

2 A ball is thrown horizontally from the top of a tower and fall towards the ground below. The initial velocity of the stone is v.

Assuming that air resistance is negligible, what is the vertical velocity and horizontal displacement of the ball t seconds after leaving the tower?

	Vertical velocity	Horizontal displacement
A	gt	$\frac{1}{2} gt^2$
B	$v + gt$	$vt + \frac{1}{2} gt^2$
C	gt	$vt + \frac{1}{2} gt^2$
D	gt	vt

3 A ball of mass 0.050 kg, initially moving at 0.40 m s^{-1}, is struck by a racket exerting an average force of 250 N in the opposite direction for 1.2 ms. What is the final speed of the ball?

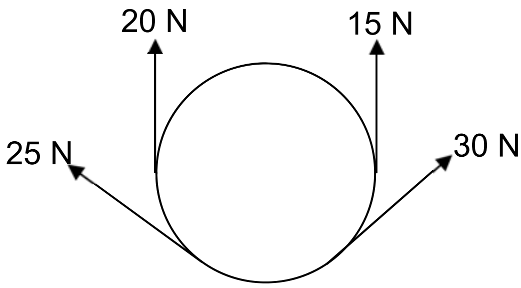
A 5.6 m s^{-1} **B** 6.0 m s^{-1} **C** 6.4 m s^{-1} **D** 12.2 m s^{-1}

4 A sub-atomic particle of mass 0.113 u collides head-on elastically with a stationary neutron. If the neutron moves off with a speed of 3.8×10^6 m s^{-1}, what is the initial speed of the sub-atomic particle?

A 1.49×10^7 m s^{-1} **B** 1.87×10^7 m s^{-1}

C 3.74×10^7 m s^{-1} **D** 4.85×10^7 m s^{-1}

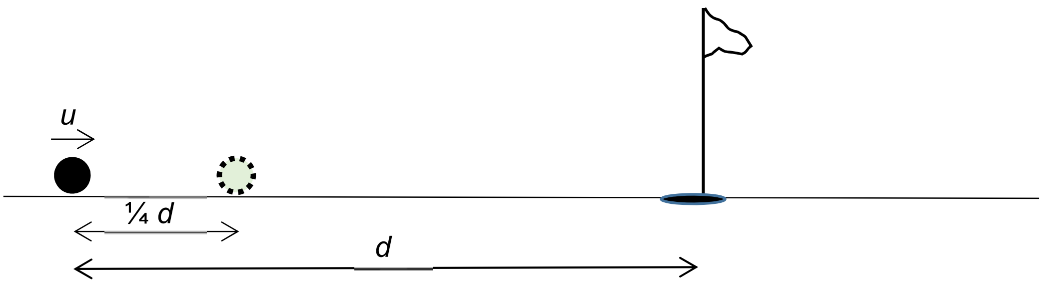
5 Four coplanar forces act on a circular disc as shown.



What is the net force and net torque on the disc?

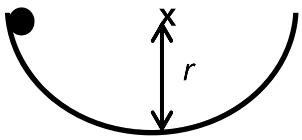
	Net force	Net torque
A	Zero	Non-zero
B	Zero	Zero
C	Non-zero	Non-zero
D	Non-zero	Zero

6 A golfer badly misjudges a hit, sending the ball only one-quarter of the distance to the hole. The hit gave the ball an initial speed of u, along a straight line on the grass. If the force of resistance due to the grass is constant, what should be the minimum initial speed needed to get the ball to the hole from its original position?



A $2u$ **B** $3u$ **C** $4u$ **D** $8u$

7 A small object of weight *mg* is released from rest at the rim of a smooth semi-spherical bowl of radius *r*. What is the magnitude of the normal force (in terms of *mg*) acting on the object when it passes the bottom of the bowl?



A *mg* **B** 2.0 *mg* **C** 2.5 *mg* **D** 3.0 *mg*

8 A car travels over a hump of radius *r*. When it is at the highest point of the hump, the driver whose safety belt is not secured, becomes weightless for an instant. What is the speed of the car, in terms of *r* and *g*, at this particular instant?

A $\sqrt{\frac{rg}{2}}$

B $\frac{\sqrt{rg}}{2}$

C $\sqrt{rg}$

D rg

9 A satellite is at a height *h* above the surface of the Earth. If the radius of the Earth is *r*, and the acceleration due to gravity at the Earth's surface is *g*, the period of orbit of the satellite will be

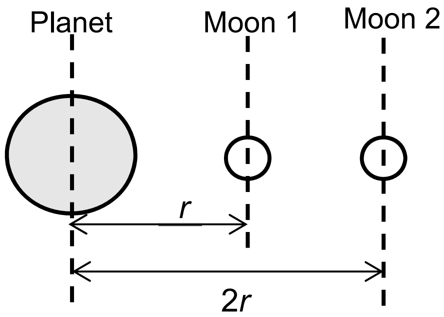
A $2\pi\sqrt{\frac{r+h}{g}}$

B $2\pi\sqrt{\frac{(r+h)^2}{gr}}$

C $2\pi\sqrt{\frac{r^2}{g(r+h)}}$

D $2\pi\sqrt{\frac{(r+h)^3}{gr^2}}$

10 A planet has two moons with identical mass. Moon 1 is in circular orbit of radius r. Moon 2 is in a circular orbit of radius $2r$.



What is the ratio of $\dfrac{\text{Force exerted by planet on Moon 2}}{\text{Force exerted by planet on Moon 1}}$?

A 4 **B** 2 **C** 0.5 **D** 0.25

11 A flask of volume 3.0×10^{-4} m^3 contains nitrogen gas at a pressure of 2.5×10^5 Pa and temperature of 27 ^{O}C.

What is the number of nitrogen molecules in the flask?

A 0.030 **B** 0.25 **C** 1.8×10^{22} **D** 2.0×10^{23}

12 Which of the following statements is not a valid assumption of kinetic theory of gases?

A Intermolecular forces between molecules are negligible.

B The molecules experience negligible change in momentum on collision with the walls of the container.

C The molecules experience negligible change in average kinetic energy on collision with the walls of the container.

D The duration of a collision is negligible compared with time between collisions.

13 Which one of the following statements always applies to a damping force acting on a vibrating system?

A It is the same direction as the acceleration.

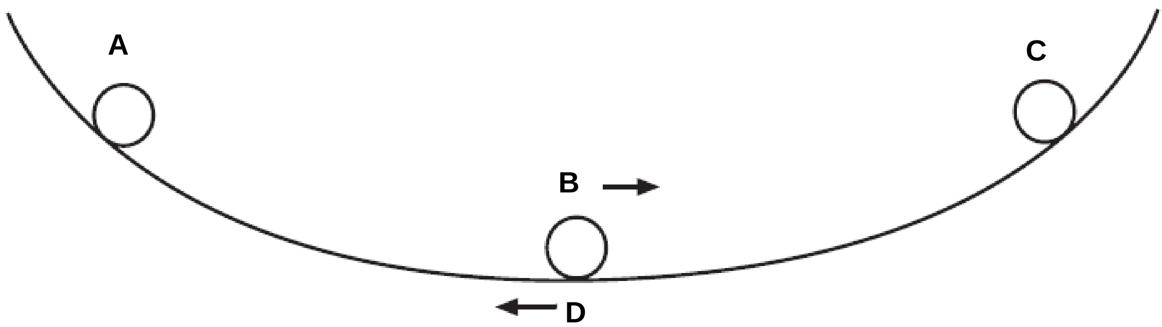
B It is the opposite direction to the velocity.

C It is the same direction as the displacement.

D It is proportional to the displacement.

14 A ball bearing rolls on a concave surface, as shown in the diagram, in approximate simple harmonic motion. It is released from **A** and passes through the lowest point **B** before reaching **C**. It then returns through the lowest point **D**.

At which stage, **A**, **B**, **C** or **D**, does the ball bearing experience maximum acceleration to the left?



15 Consider a sound source of power, P, emitting energy uniformly in all directions. A sensitive microphone at a distance 5.0 m from the sound source detects the intensity of the sound as 3.0×10^{-4} W m^{-2}. The microphone is then moved to 10.0 m from the sound source. In order to detect sound of intensity that is doubled at this new location, that is, 6.0×10^{-4} W m^{-2}, the power of the source must be increased to

A 2P **B** 4P

C 8P **D** 16P

16 A car passes you on the highway and you notice the tail lights of the car are 1.26 m apart. The car is 14.4 km away when the tail lights appear to merge into a single spot of light.

What is the angular resolution as the lights just appear to merge into a single spot of light?

A 4.73×10^{-3} radians **B** 8.75×10^{-3} radians

C 4.73×10^{-5} radians **D** 8.75×10^{-5} radians

17 In a Young's double-slit experiment, a coherent monochromatic light illuminates the two slits, producing an interference pattern on a screen some distance away.

Which modification increases the separation between the dark fringes on the screen?

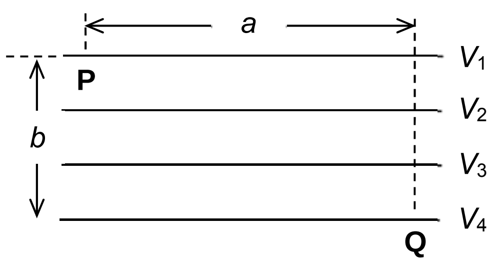
A Increasing the slit separation

B Decreasing distance between the screen and the slits

C Using monochromatic light of higher intensity

D Using monochromatic light of lower frequency

18 An electron, placed at a point **P** inside a uniform electric field, experiences a force of magnitude F. The horizontal lines below are equipotential lines and $V_4 > V_1$.

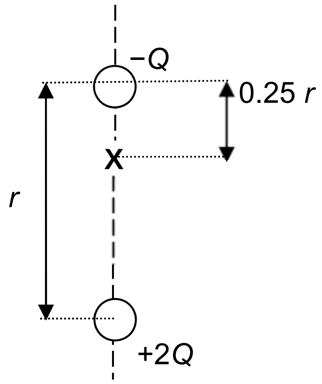


The electron is moved from **P** to **Q**. What is the work done on the electron?

A $-Fb$ **B** $-Fa$

C Fb **D** Fa

19 Two point charges of −Q and +2Q are lined up in a vertical straight line as shown below. The distance between them is r.



What is the electric potential energy of a point charge +3Q when it is placed at position X, a distance 0.25 r from –Q?

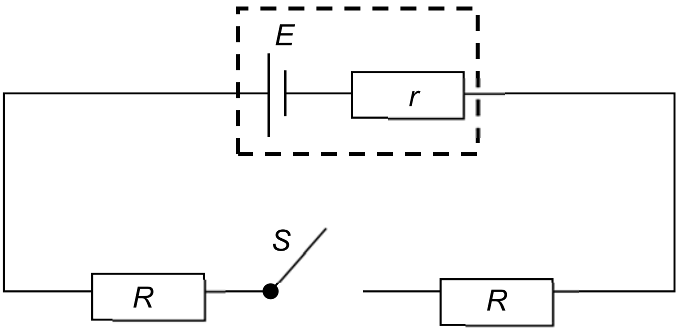
A $\dfrac{5Q^2}{\pi\varepsilon_0 r}$

B $\dfrac{Q^2}{\pi\varepsilon_0 r}$

C $-\dfrac{5Q^2}{\pi\varepsilon_0 r}$

D $-\dfrac{Q^2}{\pi\varepsilon_0 r}$

20 A battery, with an e.m.f E and internal resistance r, is connected to a switch S and two identical resistors in series. Each resistor has resistance R.



Which of the following statements is correct when the switch S is closed?

A The rate at which energy is dissipated across R is $\dfrac{E^2}{4R}$.

B The rate at which energy is dissipated across R is $\dfrac{E^2 r}{2R+r}$.

C The rate at which energy is dissipated across r is $\dfrac{E^2 r}{(2R+r)^2}$.

D It is impossible to determine the rate at which energy is dissipated across R.

21 Wire X has resistivity *ρ*. Another wire Y, of the same resistance as X, has triple the length and double the diameter of wire X.

The resistivity of wire Y is

A $\frac{4\rho}{3}$

B $\frac{3\rho}{4}$

C $\frac{3\rho}{2}$

D $\frac{2\rho}{3}$

22 With 4 resistors, each having a resistance of 12 Ω, it is **impossible** to arrange all 4 resistors to have an effective resistance of

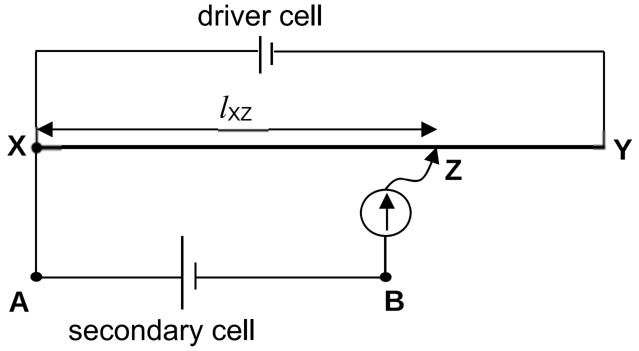
A 9.0 Ω

B 12 Ω

C 20 Ω

D 24 Ω

23 In a typical potentiometer circuit as shown below, the balance length l_{XZ} is **NOT** increased by



A decreasing the e.m.f. of the driver cell.

B increasing the e.m.f. of the secondary cell.

C adding a fixed resistor in series with the driver cell.

D adding a fixed resistor in series with the secondary cell.

24 A wire has diameter 0.35 mm and the number density of charge carriers is 7.8×10^{28} m^{-3}. The current in the wire is 0.15 A.

What is the drift velocity of the charge carriers?

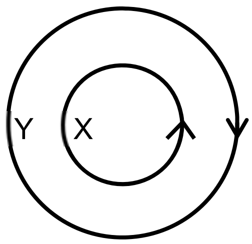
A 1.2×10^{-18} m s^{-1}

B 3.1×10^{-11} m s^{-1}

C 3.1×10^{-5} m s^{-1}

D 1.2×10^{-4} m s^{-1}

25 Two flat circular coils, X and Y, each with 100 turns, are arranged as shown in the diagram. X has radius 0.120 m and carries a current of 1.5 A in the anti-clockwise direction, Y has radius 0.180 m and carries a current of 1.0 A in the clockwise direction. Both coils are arranged such that their centres coincide.



What is the magnitude and direction of the total magnetic flux density at the centre of the coils?

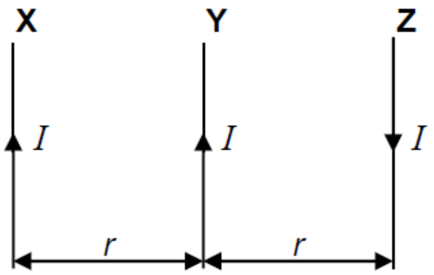
A $347\mu_o$ into the page

B $347\mu_o$ out of the page

C $905\mu_o$ into the page

D $905\mu_o$ out of the page

26 The figure below shows three parallel wires **X**, **Y** and **Z** which carry currents I of equal magnitude in the directions shown.



The resultant force experienced by **X** due to the currents in **Y** and **Z** is

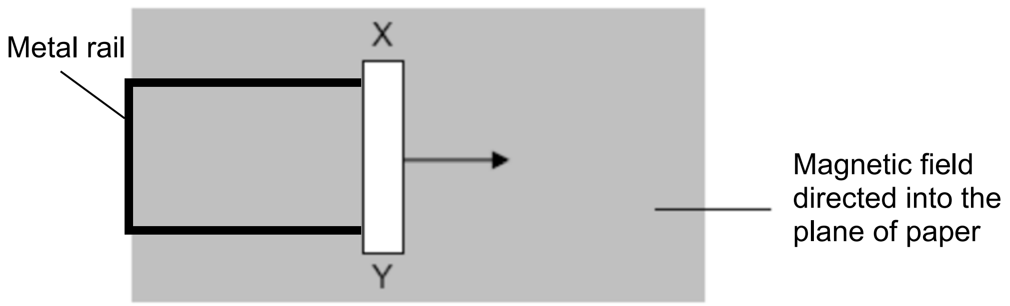
A zero.

B away from Y

C towards Y.

D along Y.

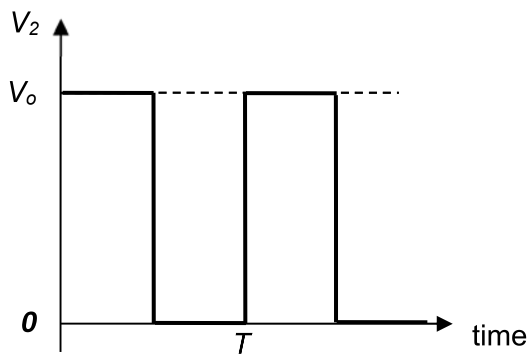
27 A metal rod XY is moving to the right on a metal rail, perpendicular to a magnetic field as shown below.



Which of the following correctly describes the magnetic force acting on the rod and the potential of the rod?

	Magnetic force on rod	Potential of rod
A	directed to the left	X is higher than Y
B	directed to the right	X is higher than Y
C	directed to the left	Y is higher than X
D	directed to the right	Y is higher than X

28 A sinusoidal potential difference with peak voltage V_o is applied across a resistor R and produces heat at a mean rate W. What is the mean rate of heat produced when another potential difference with the same peak voltage, as shown below, is applied across the same resistor?



A W

B $\sqrt{2}\,W$

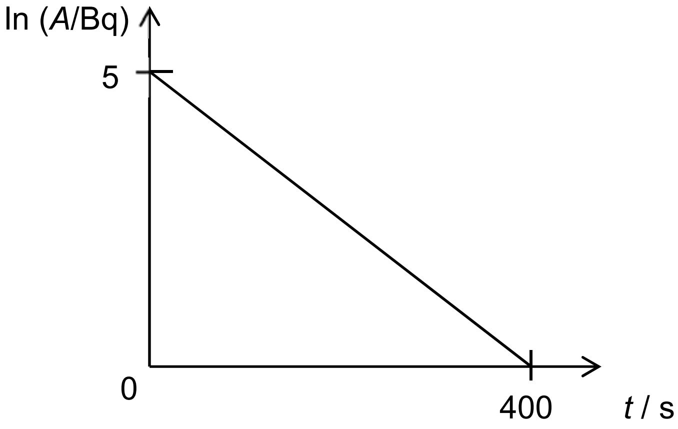
C $2W$

D $4W$

29 The transition of electrons between three consecutive energy levels in a particular atom gives rise to three spectral lines. The shortest and longest wavelengths of those spectral lines are λ_1 and λ_2 respectively. The wavelength of the other spectral line is

A $\frac{\lambda_1+\lambda_2}{2}$ **B** $\lambda_1 - \lambda_2$ **C** $\frac{\lambda_1\lambda_2}{\lambda_1+\lambda_2}$ **D** $(\frac{1}{\lambda_1} - \frac{1}{\lambda_2})^{-1}$

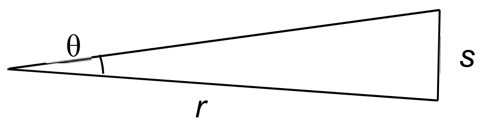
30 The graph below shows how the natural logarithm of the activity *A* of a radioactive isotope varies with time *t*. What is the half-life of the isotope?

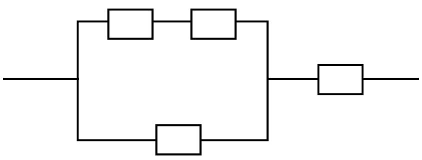
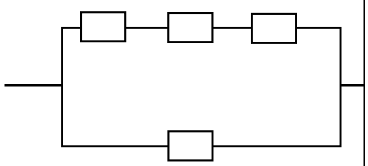
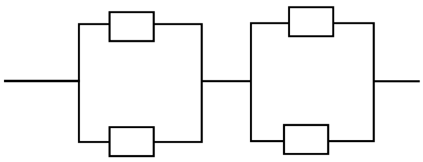


A 200 s **B** 55 s **C** 24 s **D** 0.42 s

--- End of paper ---

S/N	Answer	Explanation
1	A	Let t be the timing displayed on the students' stopwatch. True period = $t \div 9$ Mistaken period = $t \div 10$ Absolute error = $(t \div 9) - (t \div 10) = t / 90$ Percentage error = (Absolute error ÷ True period) × 100% = $[(t / 90) \div (t \div 9)] \times 100\%$ = 10 % The mistaken period is smaller than the true period. Thus the error is "low".
2	D	$v_y = 0$, $a_x = 0$, $a_y = g$
3	A	From N2L, $\langle F \rangle = \Delta mv \div \Delta t$ $\Rightarrow 250 = 0.050v - [-0.050(0.40)] \div (1.2 \times 10^{-3})$ $\Rightarrow v = 5.6 \text{ m s}^{-1}$
4	B	Conservation of Linear Momentum: $0.113u_1 + 0 = 0.113v_1 + 1(3.8 \times 10^6)$ Elastic: $u_1 - 0 = 3.8 \times 10^6 - v_1$ Thus, $u_1 = 1.87 \times 10^7 \text{ m s}^{-1}$
5	D	From the diagram, it is obvious that the net force is not zero (all forces are pointing upwards or have a vertical component pointing upwards) Taking the centre of the disc as a pivot, the sum of anti-clockwise moments = $(15 + 30)r$, where r is the radius of the disc. This expression is equal to the sum of clockwise moments = $(20 + 25)r$.
6	A	Net work done = change in KE First hit: $-F_f (1/4\, d) = 0 - ½\, m\, u^2$ --- (1) Second hit: $-F_f (d) = 0 - ½\, m\, u_1^{\,2}$ --- (2) Thus, (2) / (1) $\Rightarrow 4 = u_1^{\,2} / u^2$ $\Rightarrow u_1 = 2\,u$
7	D	By C.O.M.E., Gain in KE = Loss in GPE Thus, $½\, m\, v^2 = mgr$

		$mv^2/r = 2.0\ mg$ --- (1) For circular motion, $\Sigma F = mv^2/r$ Thus, $N - mg = 2.0\ mg$ $N = 3.0\ mg$
8	**C**	For circular motion, $\Sigma F = mv^2/r$ $mg - N = mv^2/r$ $mg = mv^2/r$ [weightless $\Rightarrow N = 0$] $v = \sqrt{(rg)}$
9	**D**	Kepler's Third Law: General expression is $T^2 = (4\pi^2 / GM)\ r^3$ Using symbols in this question, we have $T^2 = (4\pi^2 / GM)\ (r + h)^3$ But, $g = GM / r^2$ Thus, $T^2 = (4\pi^2 / g\ r^2)\ (r + h)^3$
10	**D**	When separation r is doubled, force F decreases by 4 times.
11	**C**	$pV = NkT$ $N = pV / kT = (2.5 \times 10^5)\ (3.0 \times 10^{-4}) / [1.38 \times 10^{-23} \times (273.15 + 27)] = 1.8 \times 10^{22}$
12	**B**	
13	**B**	Damping force opposes motion
14	**C**	Maximum displacement and always directed towards the centre.
15	**C**	I = P/ A so with twice the I and twice the r(which makes 4 times of A), P has to increase 8 folds.
16	**D**	 $s \approx r\theta$ $1.26 \approx 14.4 \times 10^3\ \theta$ $\theta \approx 8.75 \times 10^{-5}$ radians
17	**D**	$x = \lambda D / a$ - lower f, longer λ
18	**C**	Imagine there are parallel plates, bottom plate will be higher potential, thus the force on the electron is directed vertically downwards.

19	**D**	Total Electric potential energy = $\frac{3Q(2Q)}{4\pi\varepsilon_0\left(\frac{3r}{4}\right)}+\frac{3Q(-Q)}{4\pi\varepsilon_0\left(\frac{r}{4}\right)}$ $= -\frac{Q^2}{\pi\varepsilon_0 r}$
20	**C**	current across r is $\left(\frac{E}{2R+r}\right)$. Hence P = $\left(\frac{E}{2R+r}\right)^2$r
21	**A**	$\frac{\rho_x l_x}{A_x}=\frac{\rho_y(3l_x)}{4A_X}$ $\rho_y=\frac{4}{3}\rho_x$
22	**D**	 20 Ω  9 Ω  12 Ω
23	**D**	At null deflection, no current flows through secondary cell, hence no effect if you placed resistor in series with it.
24	**D**	Using I = nAvq V = 0.15 / [7.8 x 10^{28} x (0.35 x 10^{-3} / 2)^2 π x 1.6 x 10^{-19}] = 1.2 x 10^{-4} m s^{-1}
25	**B**	For X, *B* = (100)(1.5)μ_o / (2)(0.120) = 625 μ_o out of the plane. For Y, *B* = (100)(1.0)μ_o / (2)(0.180) ≈ 278 μ_o into the plane. Therefore, resultant *B* = 625 μ_o – 278 μ_o = 347μ_o out of the plane.
26	**C**	Attraction towards Y and Z.
27	**A**	By Fleming's RHR, induced current flow from Y to X in the rod, hence X is of higher potential.

		Induced current will cause an opposing effect to the change and thus the magnetic force will be directed to the left.
28	**A**	For sinusoidal input, Mean Power, W = $\frac{{V_{rms}}^2}{R} = \frac{\left(\frac{V_0}{\sqrt{2}}\right)^2}{R} = \frac{{V_0}^2}{2R}$ Mean power for square wave, P_B = $\frac{{V_{rms}}^2}{R} = \frac{\left(\frac{V_0}{\sqrt{2}}\right)^2}{R} = \frac{{V_0}^2}{2R}$ = W
29	**D**	For the spectral line with <u>shortest</u> wavelength, the energy difference between the involved levels = $\frac{hc}{\lambda_1}$, which is the <u>largest</u> For the spectral line with <u>longest</u> wavelength, the energy difference between the involved levels = $\frac{hc}{\lambda_2}$, which is the <u>smallest</u> Thus, the energy difference between levels for the third spectral line = $\frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$ Let the wavelength of this third spectral line be λ_3. Thus, the energy difference can also be expressed as $\frac{hc}{\lambda_3}$. We then have $\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$
30	**B**	Given $A = A_o \exp(-\lambda t)$, then, $\ln A = \ln A_o - \lambda t$ Thus, the gradient = $-\lambda$ $\Rightarrow$ 5/400 = $-\lambda$ = ln 2 / $t_{1/2}$ $\Rightarrow$ $t_{1/2}$ = 55 s

Candidate's Name ………………………………………………   CTG ………………

YISHUN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018

PHYSICS **9749/2**

HIGHER 2 **28th August 2018**

2 hours

Paper 2 Structured Questions

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
For numerical answers, **all** working should be shown clearly.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Paper 2 (30.0%)	
1	/3
2	/7
3	/10
4	/15
5	/10
6	/15
7	/20
Penalty	
Total	
	/ 80

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	$T/°C + 273.15$
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle C^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{(x_o^2 - x^2)}$
electric current,	I	=	$A n v q$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 Archimedes' number, Ar, is dimensionless (unitless) and is used in the study of objects in fluids. The number is given by the following expression

$$\mathrm{Ar} = \frac{gL^3\rho_\ell(\rho - \rho_\ell)}{\mu^2}$$

whereby g is the acceleration due to gravity, L is the characteristic length of the object, ρ_l is the density of the fluid, ρ is the density of the object and μ is the dynamic viscosity of the fluid.

Determine the units of μ..

units of μ.= ……………………... [3]

2 **(a)** Explain what is meant by the following terms when used in the context of forces.

(i) Centre of gravity

....

....

.... [1]

(ii) Friction

....

....

.... [1]

(b) Fig. 2.1 shows a man performing a bungee jump.

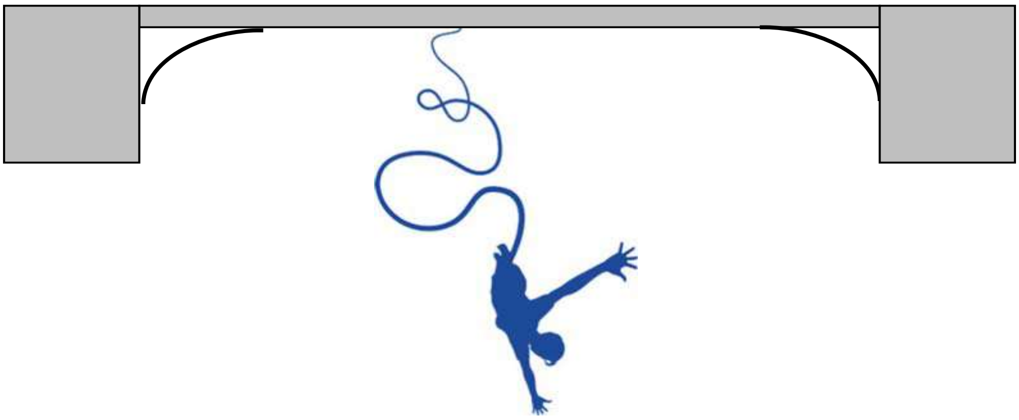


Fig. 2.1

He falls 42 m before the elastic rope secured to him starts to exert some force on him. The force-extension graph for this rope is shown in Fig. 2.2.

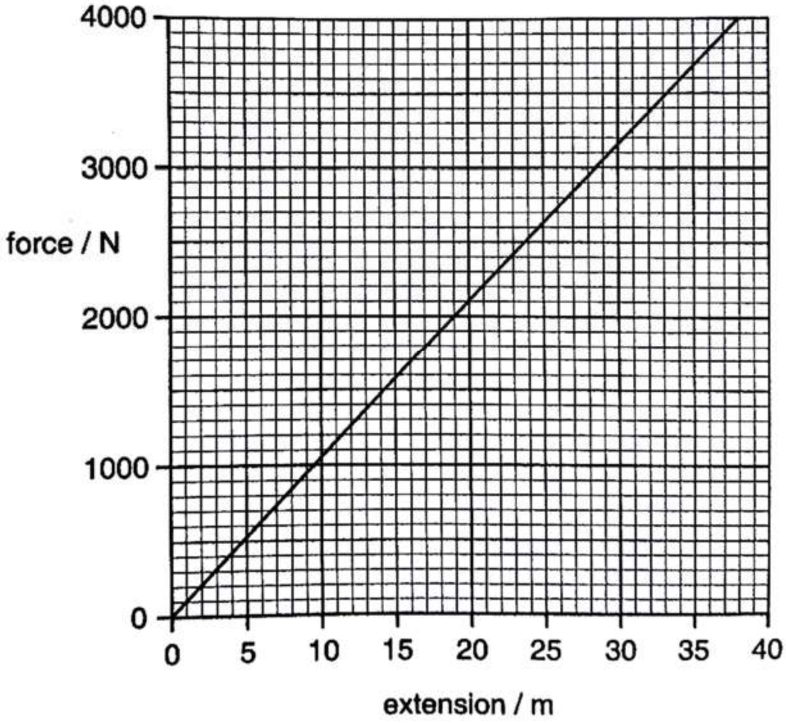


Fig. 2.2

The total distance the man falls before he stops for the first time is 78 m.

(i) Deduce

1. the extension of the rope when the man stops for the first time, and

extension = ……………………. m [1]

2. the elastic potential energy stored in the rope at this time.

elastic potential energy = ……………………. J [2]

(ii) Show that the man has a mass of approximately 90 kg.

[2]

3 **(a)** A cylinder of fixed volume contains some nitrogen gas at a pressure of 2.1×10^5 Pa. The gas has a density 1.5 kg m^{-3} and the molar mass of nitrogen is 14 g, calculate

(i) the root-mean-square speed of the nitrogen molecules,

root-mean-square speed = …………………….m s^{-1} [2]

(ii) the temperature of the nitrogen gas in the cylinder.

temperature = …………………….K [2]

(iii) Using kinetic theory of gases, state and explain what will happen to the pressure of the nitrogen gas when the temperature of the gas is increased.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [3]

(b) A refrigerator door is opened and room temperature air (25 °C) filled the 1.5 m^3 compartment of the refrigerator. A 2.0 kg chicken, also at room temperature, is placed in the refrigerator and the door is closed.

If the power rating of the refrigerator is 200 W, with an efficiency of 0.80, calculate the time required to cool the chicken and air in the refrigerator to thermal equilibrium at a temperature of 4.0°C.

(Density of air = 1.25 kg m^{-3}, specific heat capacity of air = 1.02 × 10^3 J kg^{-1} K^{-1}, specific heat capacity of chicken = 3.48 × 10^3 J kg^{-1} K^{-1})

time required = …………………….s [3]

4 A rod is attached vertically to a horizontal turntable at point **P**, 0.080 m from the centre **Q**, as shown in Fig. 4.1.

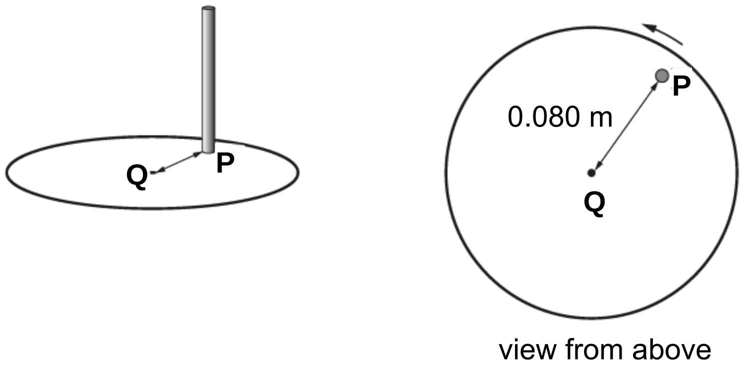


Fig. 4.1

(a) The turntable rotates around **Q** at 45 rotations per minute. Calculate

(i) the angular velocity of the rod,

angular velocity of rod = ...rad s^{-1} [2]

(ii) the acceleration of the rod and state its direction.

acceleration of rod = ...m s^{-2} [2]

direction of acceleration= .... [1]

(b) When the rod is illuminated from the side, its shadow on a screen oscillates.

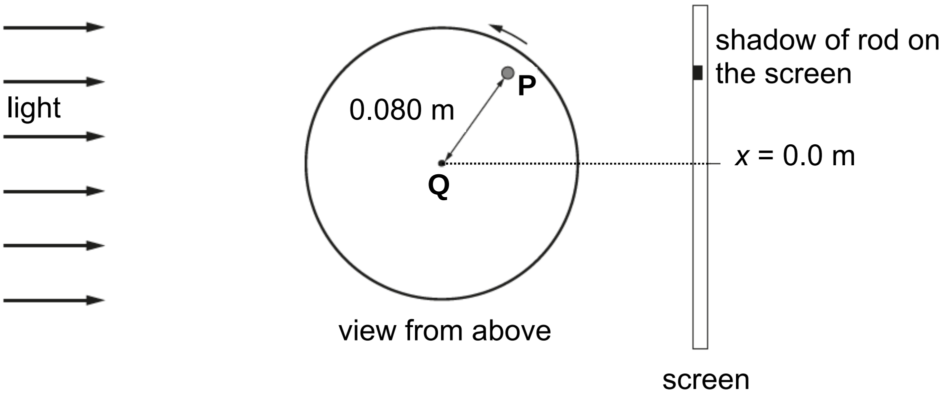


Fig. 4.2

The displacement x in metres of the centre of the shadow from the centre of oscillation and the acceleration a of the shadow may be written

$$x = A \sin(\omega t)$$

where t is time in seconds, A is the amplitude of oscillation and ω is the angular velocity of the rod.

(i) Using the values given in **(a)**,

1. calculate the period of oscillation of the shadow, and

period of oscillation = ... s [1]

2. derive an expression for the acceleration of the shadow in terms of t.

expression for acceleration = ... [2]

(ii) Determine the acceleration of the shadow at t = 0.20 s.

acceleration =..................................m s^{-2} [2]

(iii) In Fig. 4.3, sketch the variation of acceleration of the oscillation with time for at least two cycles. Label the necessary values.

[3]

Fig. 4.3

(iv) Fig. 4.4 shows a second rod, which is now attached vertically to the turntable at point **R**, 0.060 m from centre **Q**, such that angle **PQR** is a right angle.

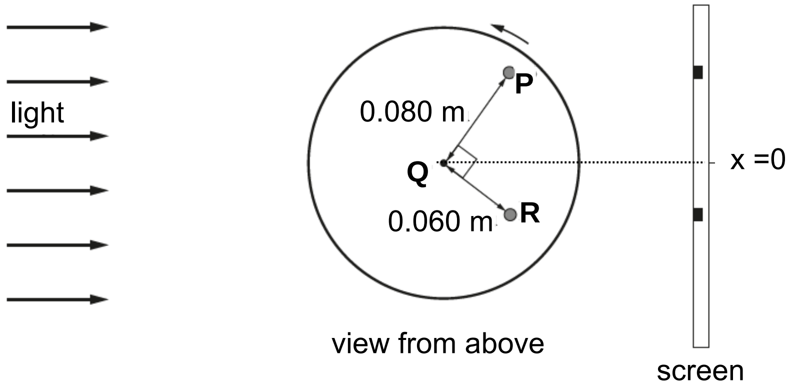


Fig. 4.4

If the expression for displacement of the shadow of the first rod at **P** in **(b)** is $A \sin(\omega t)$, derive an expression for displacement of the shadow of the second rod at **R** with the necessary values of its amplitude and ω.

expression for displacement = ... [2]

5 **(a)** The graph Fig. 5.1 shows how the resistance, R_R, of a metal resistor and the resistance, R_{Th}, of a thermistor change with temperature.

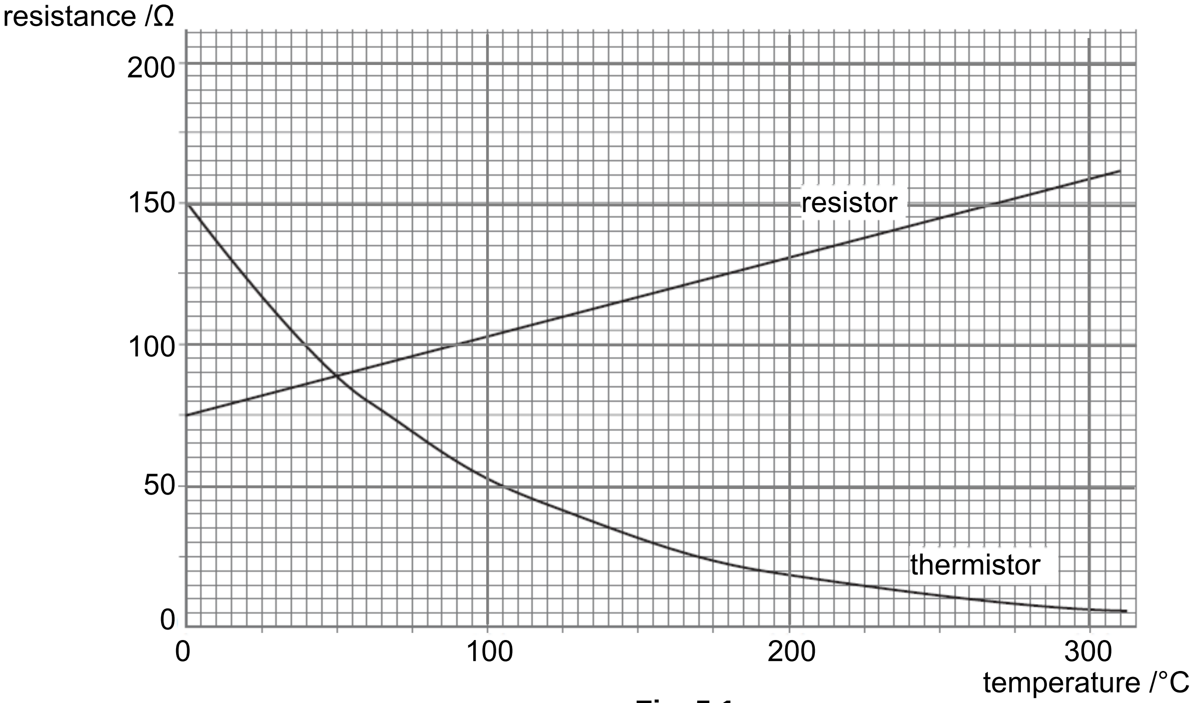


Fig. 5.1

(i) State the values of the resistance R_R and R_{Th} at a temperature of 105 °C.

R_R = ... Ω [1]

R_{Th}= .... Ω [1]

(ii) The resistor and thermistor are connected in series to a 12 V battery of negligible internal resistance, as shown in Fig. 5.2.

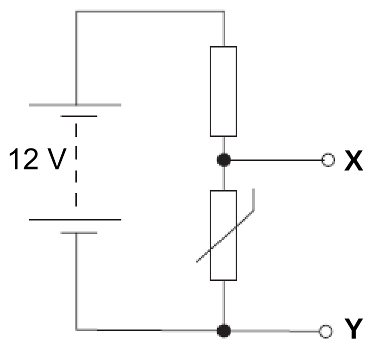


Fig. 5.2

Calculate the potential difference across **XY** at 105 °C.

potential difference across **XY** = ... V [2]

(iii) Assuming that the temperature of the resistor always equals the temperature of the thermistor, deduce the temperature, without any further calculations when the potential difference across the resistor is 6.0 V. Explain your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(b) Fig. 5.3 shows a potentiometer, made from uniform resistance wire AB of length *l* and resistance *R,* connected in series with an e.m.f. source *E*.

It is used to change the potential difference across an appliance of resistance *S*.

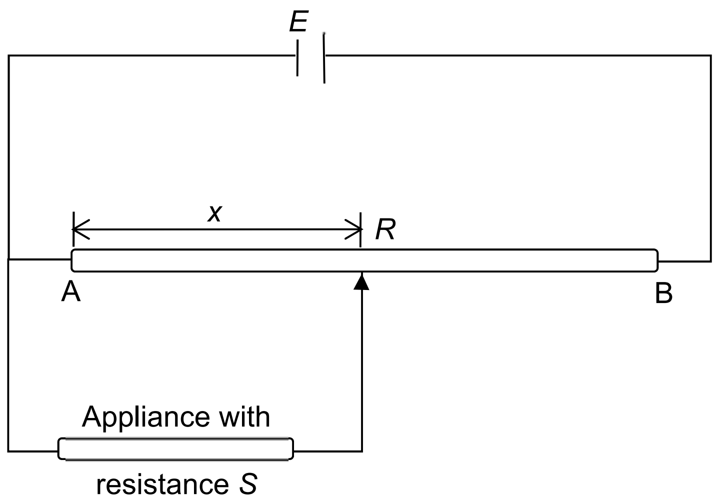


Fig. 5.3

(i) Derive an expression of the potential difference across the appliance as a function of the distance *x* of the sliding contact from the end A of the resistance wire in terms of *E*, *x* and *l* . Explain your working clearly.

expression of potential difference = ... [2]

(ii) Hence or otherwise, calculate the current through the appliance when

E = 5.0 V, x = 20.0 cm, l = 1.00 m and S = 10.0 Ω.

current through appliance = ... A [1]

(iii) The appliance is removed and replaced with a cell of unknown e.m.f. ε and a galvanometer is connected in series with the cell, as shown in Fig. 5.4.

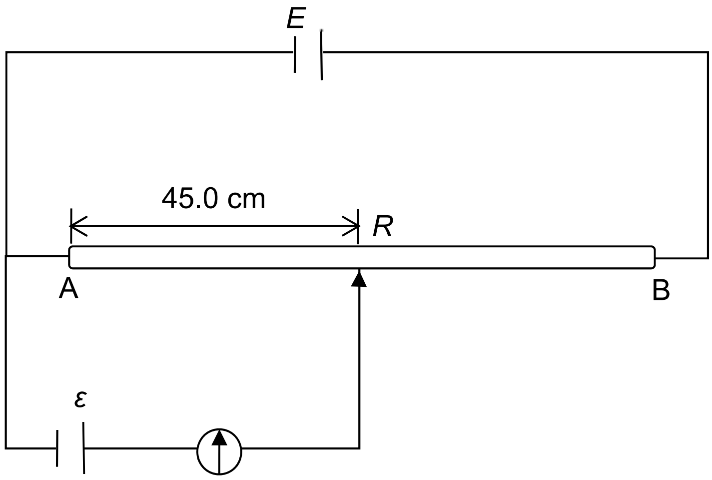


Fig. 5.4

The galvanometer shows null deflection when the sliding contact is at the 45.0 cm mark. Calculate ε, using the values of E and l given in **(b)(ii)**.

ε = ... V [1]

6 **(a)** State what is meant by the photoelectric effect.

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………... [2]

(b) Light shines on a metal surface which is part of the circuit shown in Fig. 6.1 below. The wavelength of the light is shorter than the threshold wavelength, λ_m of the metal.

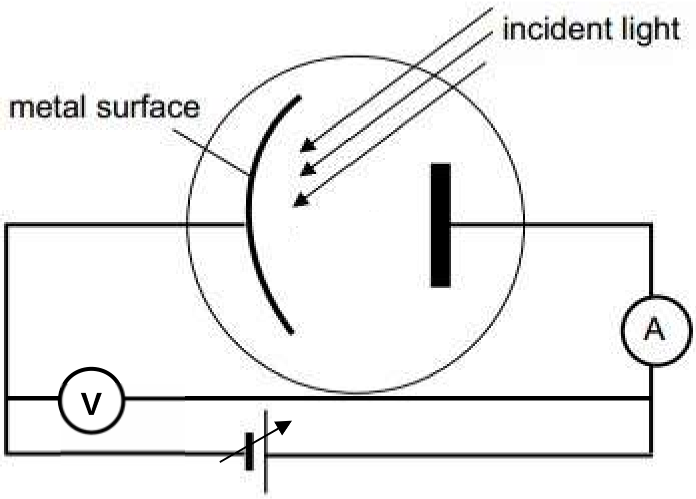


Fig. 6.1

Fig. 6.2 below shows the variation of ammeter reading with voltmeter reading.

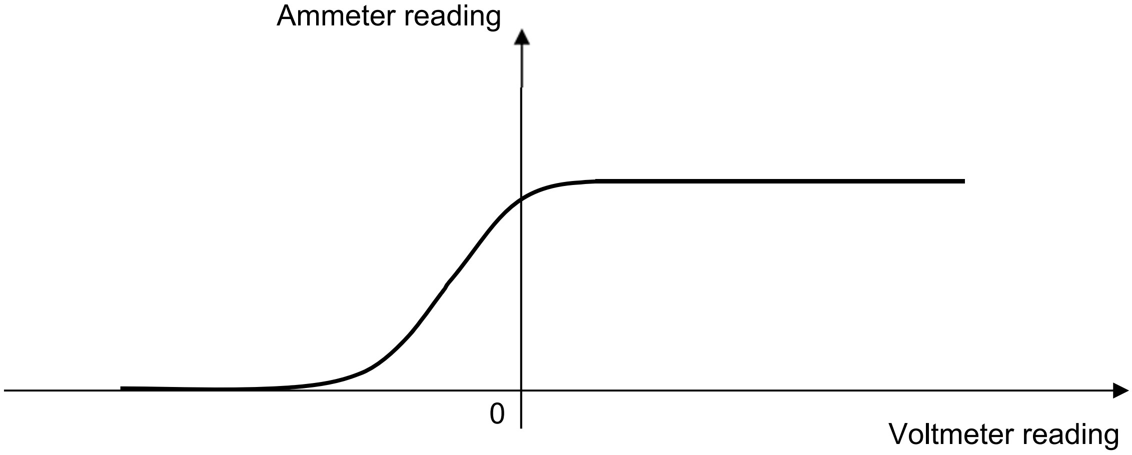


Fig. 6.2

(i) The incident light has now a longer wavelength but the same intensity as the earlier light. This new wavelength is also shorter than λ_m. Sketch, on Fig. 6.2, the new graph.

[2]

(ii) At constant frequency of incident light, use quantum theory to explain why

1. photocurrent is proportional to intensity of the light, and

…………………………………………………………………………………….

…………………………………………………………………………………….

…………………………………………………………………………………….

…………………………………………………………………………………….

……………………………………………………………………………………. [2]

2. there is hardly any delay in time between irradiation of the metal surface and emission of electrons from the metal surface.

…………………………………………………………………………………….

…………………………………………………………………………………….

……………………………………………………………………………………. [1]

(c) Fig. 6.3 shows the experimental set-up for an electron diffraction experiment.

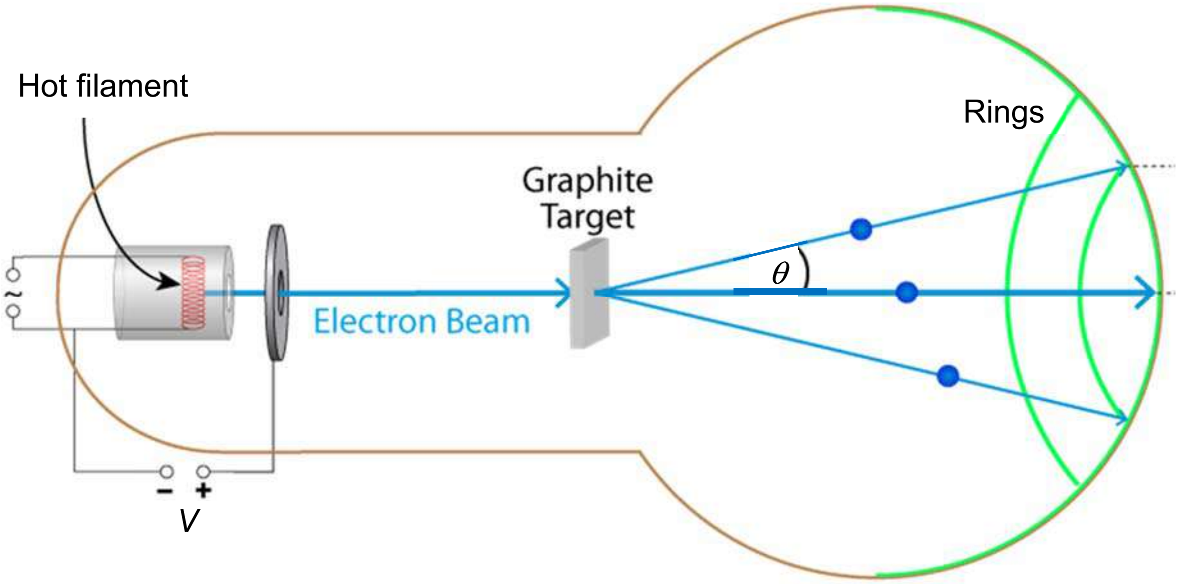


Fig. 6.3

Bright rings appear on the curved screen.

When V was 625 V, it was found that first off-centre maxima (ring) occurred at θ = 9.96°.

The diffraction of the electron beam is in accordance to the following expression

$$2d \sin \theta = n \lambda_{dB}$$

whereby d is the inter-atomic distance in the target, n the order number and λ_{dB} the de Broglie wavelength of an electron in the beam.

(i) Determine the values of

1. λ_{dB} , and

λ_{dB} = ………………………… m [2]

2. *d*.

d = ………………………… m [2]

(ii) State and explain what happens to the rings when the value of *V* is decreased.

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

………………………………………………………………………………….. [4]

7 Bridges, a type of structure commonly found in daily life, are often built to span over physical obstacles such as a body of water or a valley, for the purpose of providing passage over the obstacles.

Designs of bridges depend mainly on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it. Common types of bridges are beam, truss, cantilever and suspension bridges. A beam bridge, support by pillars at its both ends, span across a stream, is illustrated in Fig. 7.1.

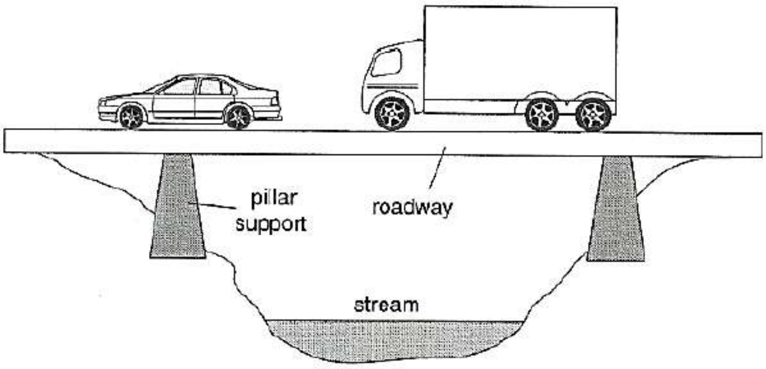


Fig. 7.1

The traditional building materials for bridges are stones, wood and steel, and more recently reinforced and pre-stressed concrete. These materials have different qualities of strength, workability, durability and resistance against corrosion. They differ also in their structure, texture and colour. For bridges, one should use a material which results in the best bridge in terms of shape, technical quality, functionality, economics and compatibility with the environment.

(a) Bridges bend when vehicles or pedestrians cross them. Hence, it is important to ensure that bridges do not bend too much when they are loaded.

Fig. 7.2 shows a simple model of a beam bridge built to investigate how the deflection of a wooden beam varies with the amount of load applied to the beam. The beam of length L, is supported on its two ends. A load of weight W is hung from the center of the beam. The deflection d is measured for the different loads and length of beams. A series of graphs are plotted as shown in Fig. 7.3.

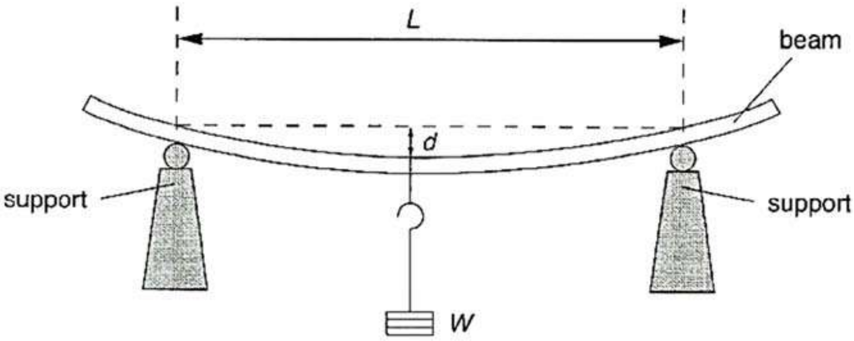


Fig. 7.2

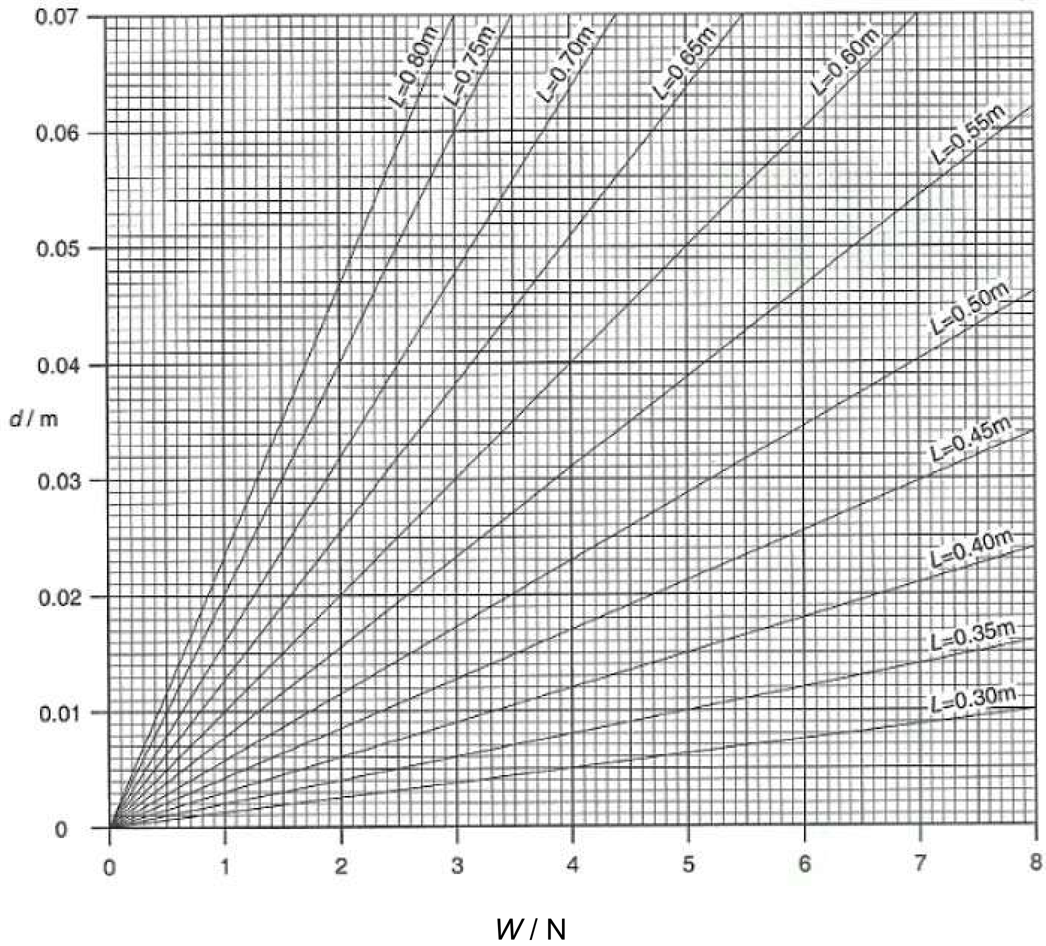


Fig. 7.3

The relation between *d* and *L* is thought to follow the expression

$$d = k\,L^n$$

where *k* and *n* are constant.

(i) A load of 3 N is applied to the different length of beams. [3]

Complete Fig. 7.4.

L / cm	*d* / cm	log (*L* /cm)	log (*d* /cm)
30	0.40	1.48	-0.40
35			
40	0.90	1.60	-0.046
45			
50	1.70	1.70	0.230
55	2.30	1.74	0.362
60	3.00	1.78	0.477
65			
70	4.80	1.85	0.681
75	6.00	1.88	0.778

Fig. 7.4

(ii) Plot a graph of log (*d* / cm) against log (*L* / cm) in Fig. 7.5. [3]

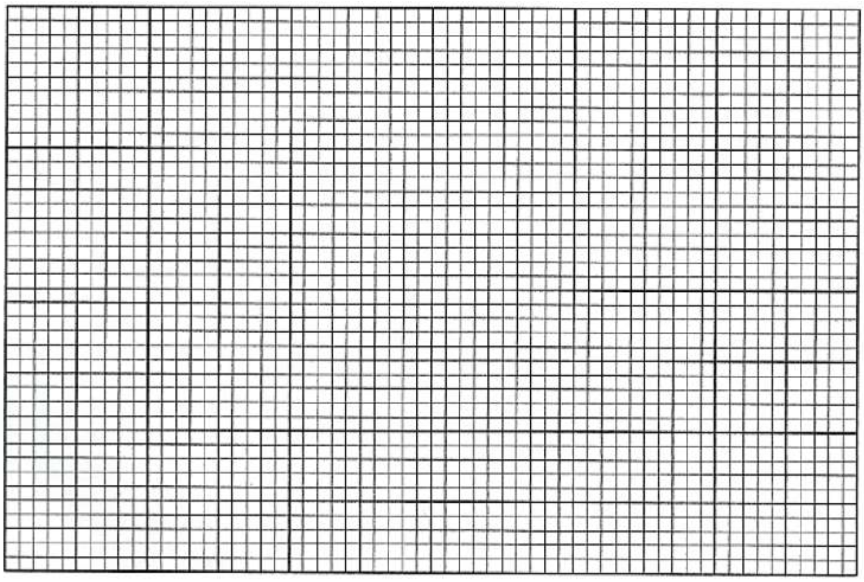


Fig. 7.5

(iii) Using Fig. 7.5, determine the value of *k*. The unit of *k* is not required.

k = ……………………….. [2]

(b) A beam bridge supported at both of its ends might also sag under its own weight. Hence the stiffness of the materials used to build the bridges is important. A physical quantity, Young's modulus, *Y*, also known as elastic modulus, is a measure of stiffness of material. It is the ratio of tensile stress to tensile strain exerted on the material, i.e.

$$Y = \text{Tensile stress} / \text{Tensile strain}$$

To measure the Young's modulus of the wooden beam in Fig. 7.2, forces *F* of same magnitude but opposite direction is applied on both ends of a wooden beam of length Lo = 1.000 m and cross-sectional area *A* of 5.0×10^{-5} m^2 as shown in Fig. 7.6. Under tension forces, the beam will elongate. Its extension in length is denoted as ΔL.

The tensile stress of the wooden beam is the ratio of the force *F* to the cross-sectional area *A*. While the tensile strain of the wooden beam is the ratio of the extension of length ΔL to the original length *L*.

$$\text{Tensile stress} = F / A$$

$$\text{Tensile strain} = \Delta L / L$$

Fig. 7.6

Fig. 7.7 shows the forces applied to the beam and the respective extension of the beam.

F / N	*ΔL* / mm
1.0	0.018
2.0	0.032
3.0	0.060
4.0	0.072
5.0	0.092
6.0	0.112

Fig. 7.7

(i) Plot a graph of force *F* against extension *ΔL* in Fig. 7.8. [3]

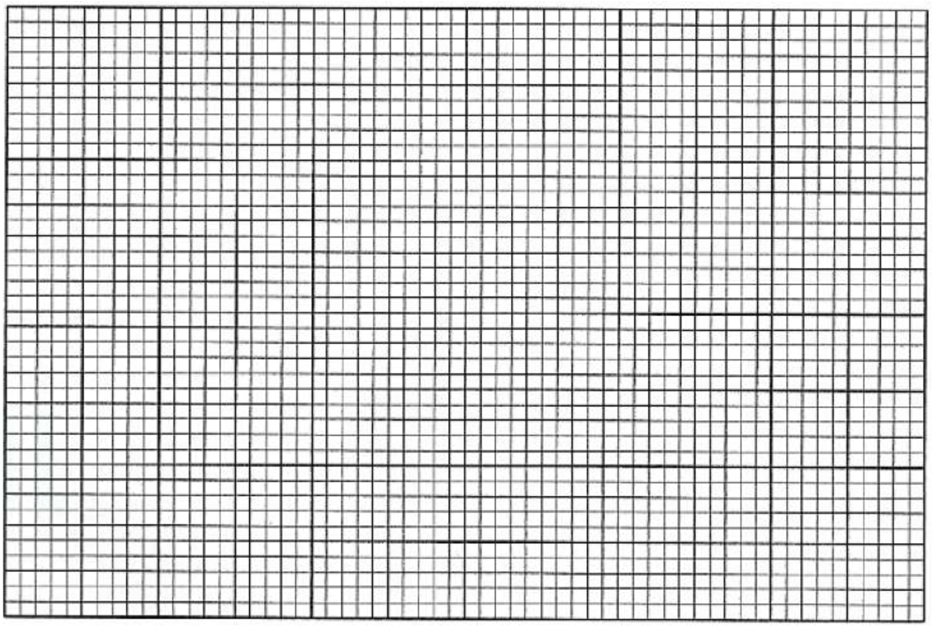


Fig. 7.8

(ii) From Fig. 7.8, determine the gradient of the graph.

gradient = ……………………….. [2]

(iii) Hence or otherwise, determine the Young's Modulus, *Y*, of the wooden beam.

Y = ……………………….N mm^{-2} [2]

(iv) A structural engineer wants to use a stiffer material instead of wood to construct a beam bridge.

1. Suggest a material which is stiffer than wood and can be used to construct a beam bridge.

…………………………………………………………………………………... [1]

2. In Fig. 7.8, sketch the force against extension graph of a beam made of a stiffer material than wood. Label the graph S. Explain your answer.

………………………………………………………………………….………

………………………………………………………………………….………

………………………………………………………………………….……… [2]

(c) The loading of the beam is often non-uniform along its length, as shown in Fig. 7.9. This means that the moments of forces have to be considered.

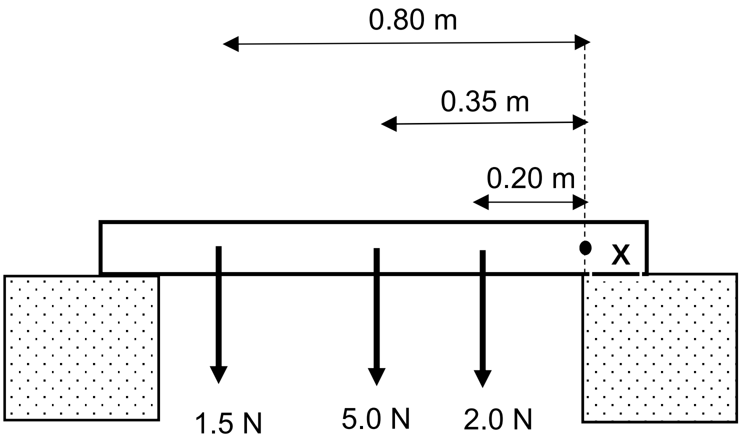


Fig. 7.9

Calculate the total moment of the forces acting on the beam about point X in Fig. 7.9. You may assume that the weight of the beam is negligible.

moment = ………………………..N m [2]

--- End of paper ---

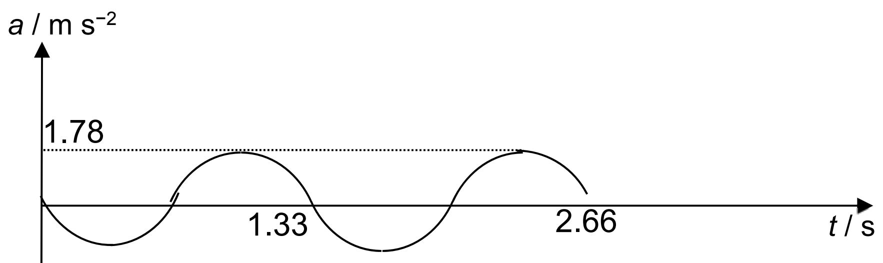
Suggested Solutions

1	From the given equation, $\mu^2 = gL^3 \rho_l (\rho - \rho_l) / Ar$ [μ^2] = (m s^{-2}) (m)^3 (kg m^{-3}) (kg m^{-3}) Thus [μ] = kg m^{-1} s^{-1}	**1** **1** **1**

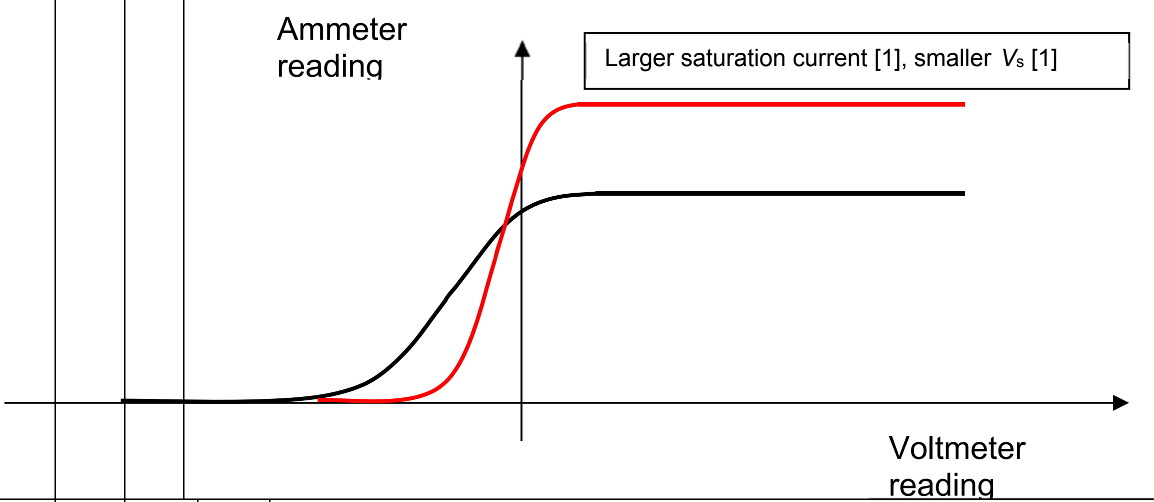
2	**(a) (i)**	The point of a body through which the entire weight of the body appears to act.	**1**
	(ii)	The force between two surfaces that opposes relative motion between them.	**1**

2	**(b)**	**(i)**	**1.** x = 78 – 42 = 36 m **2.** EPE = ½ Fx = ½ (3800)(36) = 68400 J	**1** **1** **1**
	(b)	**(ii)**	GPE lost = EPE gained or a statement to the same effect Mgh = 68400 M = 68400 / (9.81 × 78) = 89.4 kg ≈ 90 kg	 **1** **1**

3	**(a)**	**(i)**	$pV = (1/3)\ N\ m\langle c^2\rangle$ where $\rho = Nm/v$ $p = 1/3\ \rho\ \langle c^2\rangle$ $(\langle c^2\rangle)^{0.5} = [(3 \times 2.1 \times 10^5) / 1.5]^{0.5}$ $= 648\ (650)\ \text{m s}^{-1}$	 **1** **1**
		(ii)	$½\ m\ \langle c^2\rangle = 3/2\ kT$, $m = Mr / N_A$ $T = (m\ \langle c^2\rangle) / 3k$ $= [(14 \times 10^{-3}) / (6.02 \times 10^{23})] * (648^2) / (3 \times 1.38 \times 10^{-23})$ $= 236\ (240)$ K	 **1** **1**
		(iii)	When the temperature of the gas is increased, the <u>frequency of collisions on the wall</u> will increase and the <u>root-mean-square speed of the molecules will increase.</u> The gas molecules exert <u>a greater force on the walls</u> of the container due to greater change in momentum. Hence <u>pressure will increase</u>.	**1** **1** **1**
	(b)		Energy to be removed by refrigerator = energy loss by chicken + air $Q = 2.0 \times 3.48 \times 10^3\ (25 - 4.0) + 1.25 \times 1.50 \times (1.02 \times 10^3) \times (25 - 4.0)$ $= 1.86 \times 10^5$ J $Qsup = (1.86 \times 10^5) / 0.80$ $t = Qsup / P = 1160\ (1200)$ s	 **1** **1** **1**

4	**(a)**	**(i)**		$\omega = \frac{45(2\pi)}{60}$ $= 4.71 rad\ s^{-1}$	**1** **1**
		(ii)		$a = r\omega^2 = (0.08)(4.712389)^2$ $= 1.78\ m\ s^{-2}$ towards the centre	**1** **1** **1**
	(b)	**(i)**	**1.**	Period = $2\pi/T$ = 1.33 s	**1**
			2.	Differentiation twice from x = A sin (ωt) OR $a = -\omega^2 x = -\omega^2 A \sin(\omega t)$ input values :a =- 0.080 x22.2 sin (4.71*t*) = -1.7765 sin (4.71*t*) = -1.78 sin (4.71*t*)	**1** **1**
		(ii)		a = -1.78 sin (4.71x 0.20) = 1.44 m s^{-2}	**1** **1**
		(iii)		 • *two cycles [1]* • *period labelled* • *max a labelled.*	**1** **1** **1**
		(iv)		0.060 cos 4.71t Cosine expression [1] allow sin (4.71 t - π/2) Correct values [1]	**1** **1**

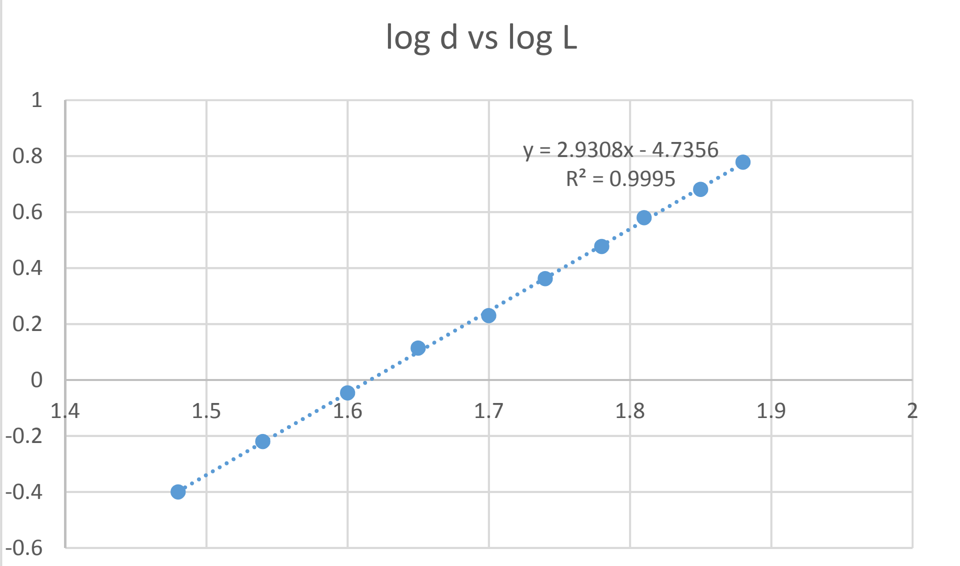
5	**(a)**	**(i)**	R_R = 105 Ω R_{Th} = 50 Ω	**1** **1**
		(ii)	$V = \frac{50}{105+50} \times 12$ = 3.87 V	**1** **1**
		(iii)	The p.d across resistor and thermistor is equal so this implies that the resistance across each component is equal. Hence the temperature is 50 °C	**1** **1**
	(b)	**(i)**	p.d across length x = $\frac{x}{l}E$ Since the appliance is parallel to length of x, p.d is the same. Thus p.d across the appliance is x = $\frac{x}{l}E$	**1** **1**
		(Ii)	p.d across appliance = 20 / 100 x 5.0 = 1.0 V current = 1/10.0 = 0.10 A	**1**
		(iii)	ε = 45.0 / 100 x 5.0 = 2.25 V	**1**

6	(a)			The emission of electrons from the surface of a metal when EM radiation [1] of high enough frequency [1] is incident on the surface.	
	(b)	(i)			
	(b)	(ii)	1.	Increasing the intensity while keeping frequency constant increases the number of photons arriving per unit time. [1] Thus, the number of electrons emitted per unit time increases. Hence current increases proportionately. [1]	
	(b)	(ii)	2.	Photons travel at the speed of light. As soon as a photon collides with an electron, its energy is **immediately (and fully) imparted** to it. [1]	
	(c)	(i)	1.	Using gain in KE = loss in EPE, we have $\frac{1}{2} m v^2 = e V$ $\Rightarrow v = \sqrt{(2eV / m)}$ $= \sqrt{(2e \times 625 / 9.11\times10^{-31})}$ $= 1.4817 \times10^{7}$ [1] Since $\lambda_{dB} = h / (mv)$ we have $\lambda_{dB} = 6.63 \times10^{-34} / (9.11\times10^{-31} \times 1.4817 \times10^{7}) = 4.9117 \times10^{-11}$ m [1]	
	(c)	(i)	2.	From the given formula, $d = 1 \times 4.9117\times10^{-11} \div (2 \times \sin 9.96°)$ [1] $= 1.42 \times10^{-10}$ m [1]	
	(c)	(ii)		Rings become larger. [1] P.d. decreases $\rightarrow$ KE / speed of incident electrons on film decreases [1]	

			→ de Broglie wavelength increases [1] → diffraction angle, θ increases [1]	
7	(a)	(i)		3

L / cm	d / cm	log (*L* /cm)	log (*d* /cm)
30	0.40	1.48	-0.40
35	0.60	1.54	-0.22
40	0.90	1.60	-0.046
45	1.30	1.65	0.114
50	1.70	1.70	0.230
55	2.30	1.74	0.362
60	3.00	1.78	0.477
65	3.80	1.81	0.580
70	4.80	1.85	0.681
75	6.00	1.88	0.778

(ii) — 3



1 mark for correct labelling of axis with units

1 mark for plotting of all points

1 mark for best fit line

(iii)

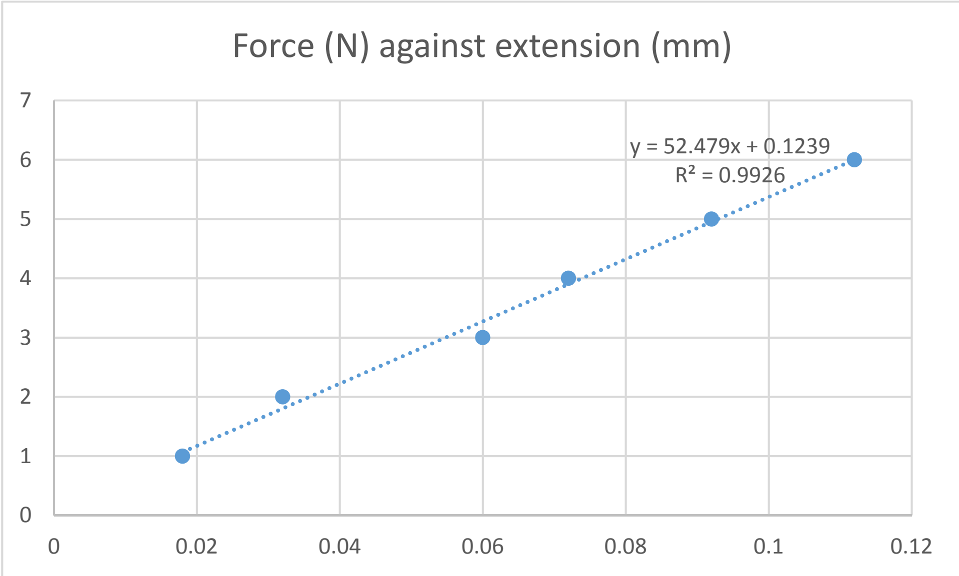
Need to calculate gradient first and use substitution method to find y-intercept. **1**

Values of gradient in the range of 3.0 **1**

log *k* is the y-intercept which is -4.74.

$k = 1.8 \times 10^{-5}$

[Turn over

	(b)	**(i)**	 1 mark for correct labelling of axis with units 1 mark for plotting of all points 1 mark for best fit line	**3**
		(ii)	Gradient = Δy / Δx = 52.5 (within 10% tolerance)	**1** **1**
		(iii)	Y = (*F/ ΔL) (L / A)* = *52.5 [1x10*^{3} */ (5.0 x 10*$^{-5}$)x10^{6}] = 1.05 (1.1) x 10^{3} N mm^{-2}	 **1** **1**
		(iv)	**1.** Steel / concrete/ stone/brick (reject glass, iron –rust, aluminum, plastic, metal-state the type?) **2.** Since material is stiffer than wood, its Y should be greater than that of wood. The graph should have a gradient steeper than that of the wood. Correct graph of steeper gradient (take note of y-intercept of graph, should approach origin)	**1** **1** **1**
	(c)	Moment about X = 0.20 (2.0) + 0.35 (5.0) + 0.80(1.5) = 3.35 (3.4) N m		**1** **1**

Candidate's Name ……………………………………….(   ) CTG ……….

YISHUN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018

PHYSICS **9749/3**

HIGHER 2 12th September 2018

2 hours

Paper 3 Longer Structured Questions

Candidates answer on the Question Paper.
No Additional Materials required.

READ THESE INSTRUCTION FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

Write your answers in the spaces provided on the question paper.
For numerical answers, **all** working should be shown clearly.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Paper 3 (35.0 %)	
Section A	
1	**/8**
2	**/7**
3	**/10**
4	**/10**
5	**/5**
6	**/15**
7	**/5**
Section B	
8	**/20**
9	**/20**
Penalty	
Total	**/80**

This question paper consists of 24 printed pages.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	$T/°C + 273.15$
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle C^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{(x_o^2 - x^2)}$
electric current,	I	=	$A n v q$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided.

1 A vehicle travels from one traffic junction to another. Its acceleration-time (*a*-*t*) graph is shown in Fig. 1.1.

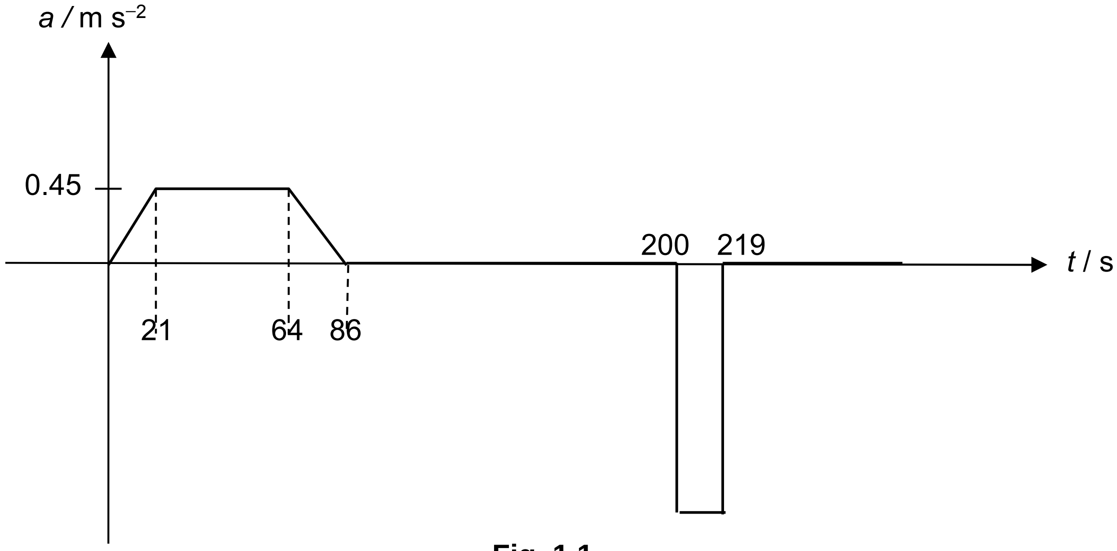


Fig. 1.1

(a) Use Fig. 1.1 to determine the average acceleration of the vehicle over the first 200 s.

average acceleration = …………………… m s^{-2} [2]

(b) Given that the velocity of the vehicle is 0 m s^{-1} at t = 0 s and t = 219 s, determine

(i) the magnitude of its maximum velocity, and

magnitude of maximum velocity = …………………… m s^{-1} [2]

(ii) sketch its corresponding velocity-time (v-t) graph from t = 0 s to t = 219 s in Fig 1.2.

[4]

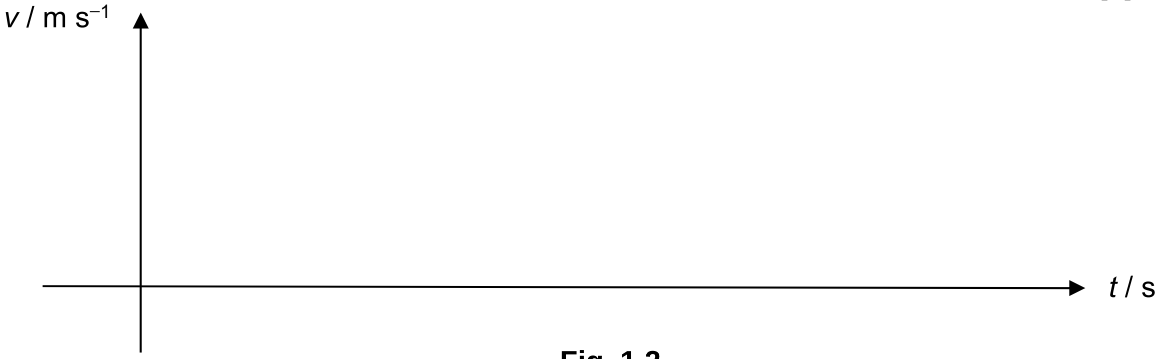


Fig. 1.2

2 Fig. 2.1 shows two men, both with the same mass *m*, weighing themselves using identical weighing scales, at two different locations on the surface of the Earth. Both scales are in good working condition. Man **P** weighs himself at the North pole and has a reading of 589.2 N whereas man **E** weighs himself at the equator and has a reading of 587.4 N. The rotational acceleration of the Earth about an axis through its poles is given as a_c.

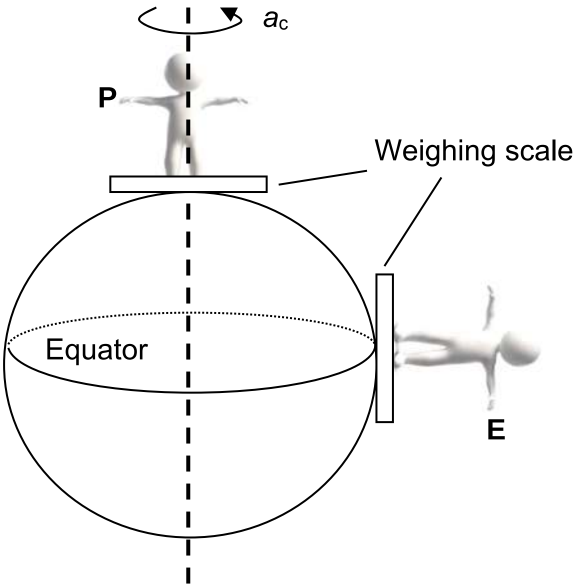


Fig. 2.1

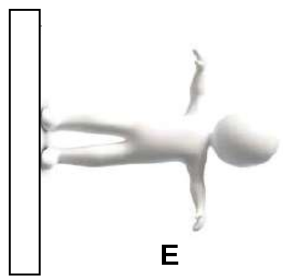


Fig. 2.2

(a) Fig. 2.2 shows an enlarged diagram of man **E** and his weighing scale. On Fig. 2.2, sketch and label all the forces acting on man **E**.

[2]

(b) Hence, or otherwise, explain why the scale readings at **P** and **E** are not the same.

……………………………………………………………………………………………...........

……………………………………………………………………………………………...........

……………………………………………………………………………………………...........

……………………………………………………………………………………………........... [3]

(c) Given that m = 60 kg, deduce a_c.

a_c= …………………… m s^{-2} [2]

3 **(a)** Define *gravitational potential* at a point.

....

.... [1]

(b) Fig. 3.1 shows three equipotential surface centred about the Earth, each with its value indicated.

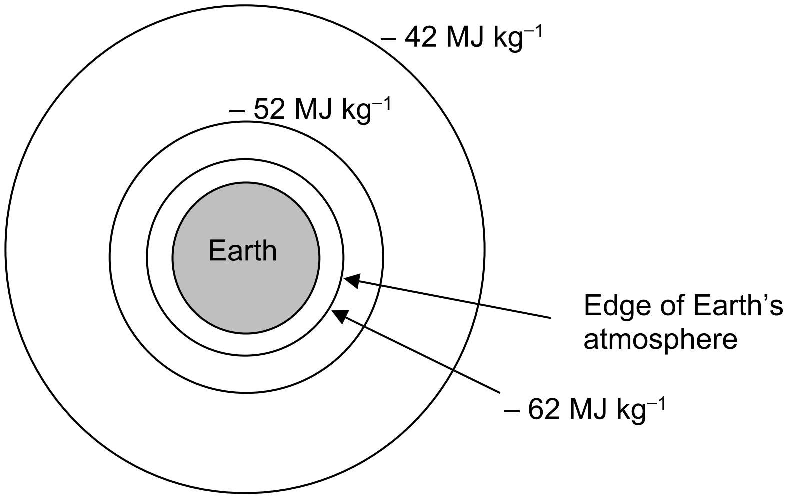


Fig. 3.1

(i) Explain why

1. the spacing between equipotential surfaces are not the same,

....

.... [1]

2. the values of equipotential is negative.

....

....

....

.... [2]

(ii) The potential at the Moon's orbit around the Earth is –1.0 MJ kg^{-1}.
If a spacecraft uses only the gravitational attraction of the Earth to travel from the Moon to the top of the Earth's atmosphere, determine its arrival speed.

arrival speed = ………………….. m s^{-1} [3]

(iii) The gravitational potential at the edge of the Earth's atmosphere is – 61.6 MJ kg^{-1}.
If the radius of the Earth is 6371 km and its mass is 5.97×10^{24} kg , determine the height of this edge of the atmosphere from the Earth's surface.

height = …………………. m [3]

4 **(a)** State the *first law of thermodynamics*.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(b) A diesel engine containing an ideal gas at a pressure of 1.0×10^5 Pa, temperature of 300 K and volume of 10×10^{-4} m^3 undergoes a cyclic process in the sequence as follows:

A the gas is compressed adiabatically (i.e. no net heat transfer) to a pressure of

16×10^5 Pa, temperature of 660 K and volume of 1.4×10^{-4} m^3

B the gas is expanded at constant pressure to a volume of 6.0×10^{-4} m^3

C the gas continued to expand adiabatically to a pressure of 7.8×10^5 Pa to its original volume

D the gas is cooled at constant volume to its original temperature and pressure

(i) Illustrate these changes on the *p*-*V* diagram in Fig. 4.1.

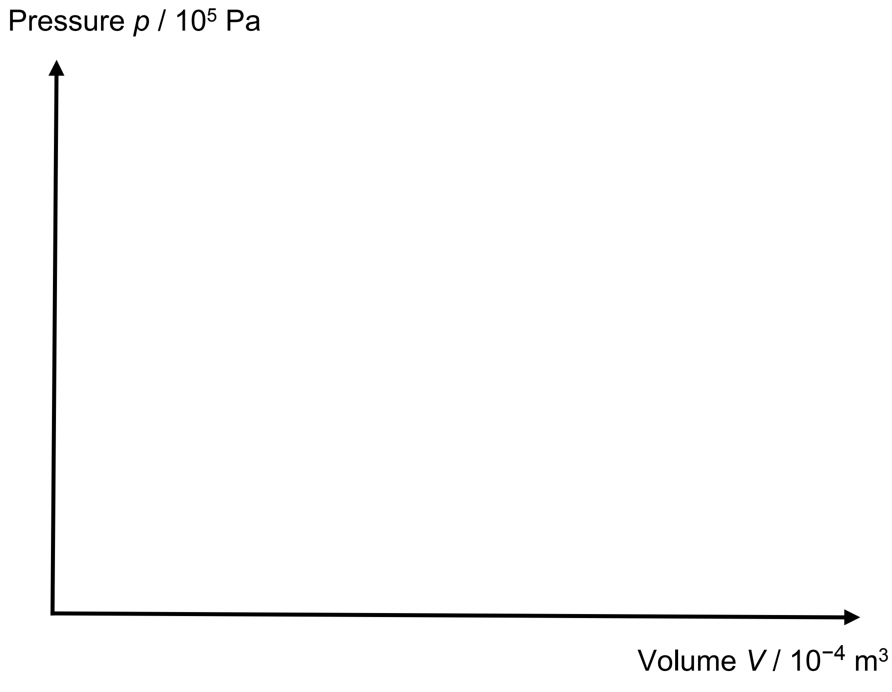


Fig. 4.1 [4]

(ii) Fig. 4.2 shows the changes in internal energy, heat supplied and work done on gas during the cyclic process. Complete Fig. 4.2.

	Heat supplied to gas / J	Work done on gas / J	Increase in internal energy of gas / J
A	0	300	300
B	2580		
C	0	−440	−440
D	−1700		

[3]

Fig 4.2

(iii) Assuming that the efficiency of the diesel engine is defined as ratio of net work done by the gas in the whole cycle to heat supplied to gas during process **B**, calculate the efficiency of this engine.

efficiency of engine = …………………… [2]

5 **(a)** Two point charges of −6.0 μC and +6.0 μC are arranged at points **A** and **B** respectively as shown in Fig. 5.1.

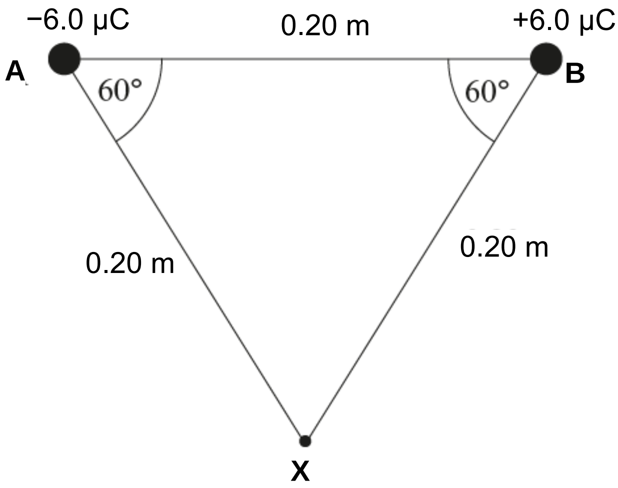


Fig. 5.1

Indicate clearly on Fig. 5.1 the directions of

(i) the electric field at **X** due to charge at **A** (label it E_A), [1]

(ii) the electric field at **X** due to charge at **B** (label it E_B), and [1]

(iii) the resultant (net) electric field at **X** due to both charges (label it E_R). [1]

(b) Determine the magnitude of the resultant electric field at **X**.

electric field strength = ... N C^{-1} [2]

6 Fig. 6.1 shows the main components of a mass spectrometer which are an ion chamber and a velocity selector. The positive ions emerging from the ion chamber, pass through the velocity selector consisting of regions **R** and **S**. A uniform electric field and a uniform magnetic field (indicated by the shaded area) are applied in region **R**. While only a uniform magnetic field (indicated by the shaded area) is applied in region **S**.

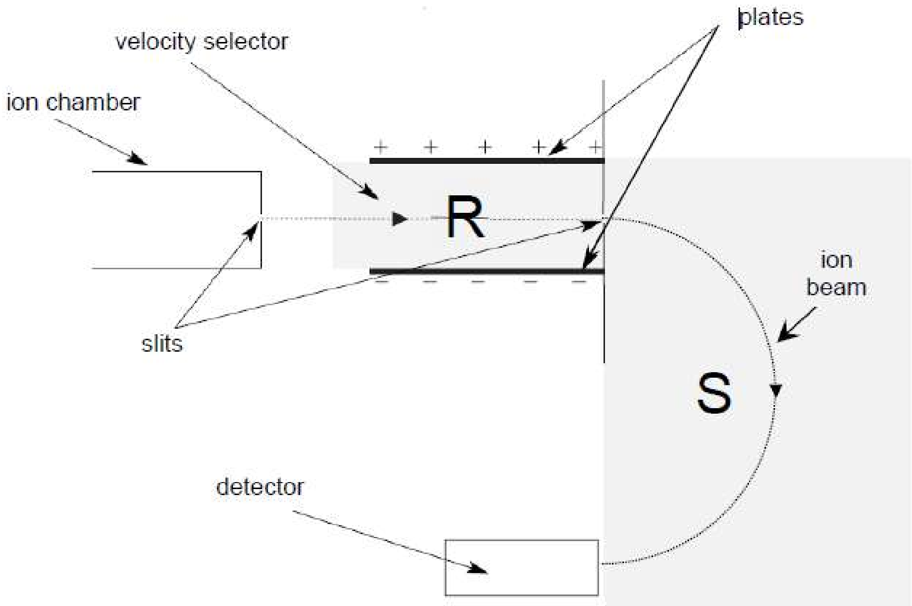


Fig. 6.1

(a) Draw the electric field lines between the plates in the region **R** of the velocity selector in Fig.6.1. [2]

(b) Suggest the purpose of the two slits.

……………………………………………………………………………………………..................

…………………………………………………………………………………………….................. [1]

(c) In the regions **R** and **S**, uniform magnetic fields are applied so that the beam of positive ions is undeflected in **R** and deflected into a circular path in **S**.

(i) State the direction of the magnetic fields in regions **R** and **S**.

region **R** = ... [1]

region **S** = ... [1]

(ii) Explain why positive ions passing through the second slit have the same velocity regardless of their mass.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….. [3]

(iii) State and explain what happens to the ions that move slower than the ones that pass through the second slit.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(d) A student sets up the apparatus shown in Fig. 6.2(a) and (b) to determine the acceleration of a cart down a ramp. Fig. 6.2(a) shows the set−up from the front view and Fig. 6.2(b) shows the side view of the set−up.

As the cart passes the coils which are suspended, an e.m.f. is induced in each coil. The outputs of the coils are monitored using the voltage sensors connected to a datalogger and computer. The voltage sensors, datalogger and computer are not drawn Fig. 6.2(a) and Fig. 6.2(b). Fig. 6.3 shows the computer printouts after one test.

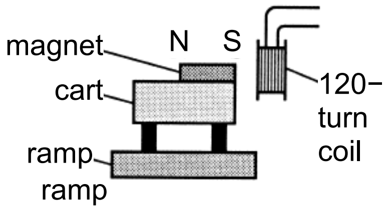

Fig. 6.2(a)

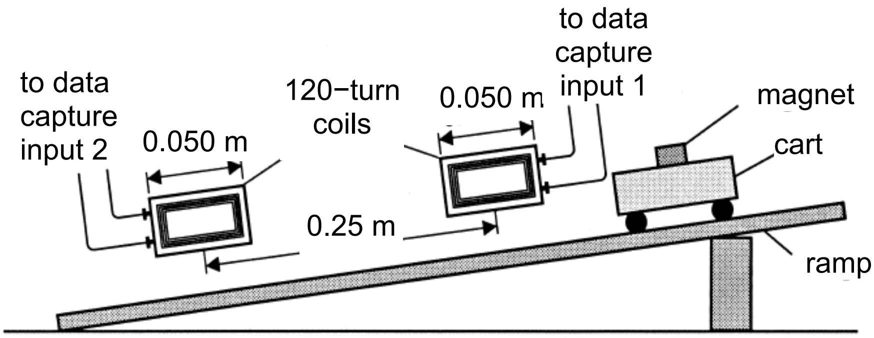

Fig. 6.2(b)

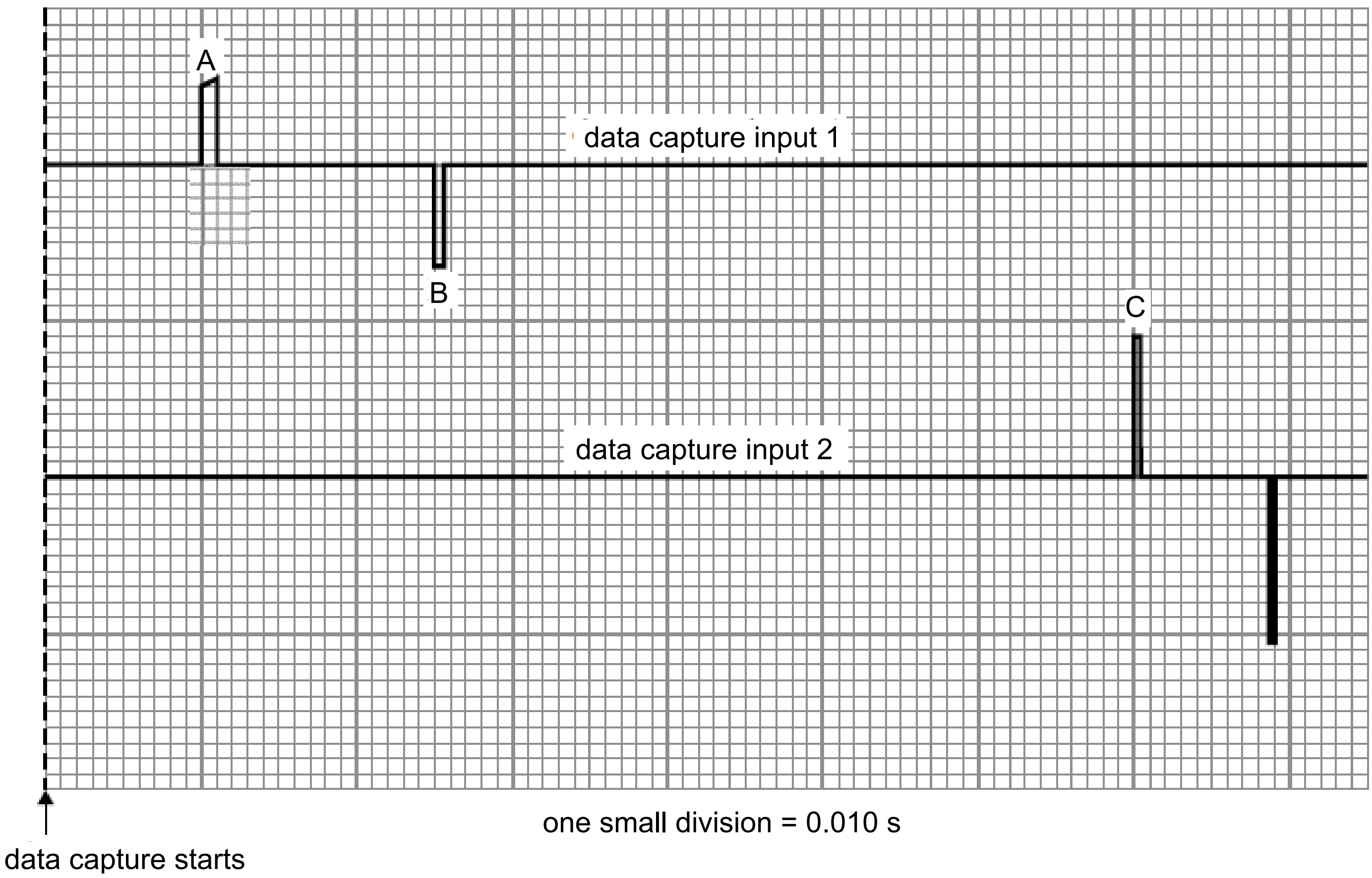

Fig. 6.3

Explain why

(i) e.m.f. is induced in both coils.

………………………………………………………………………………………….........

…………………………………………………………………………………………......... [1]

(ii) pulse **B** is in the opposite direction to pulse **A**,

………………………………………………………………………………………….........

………………………………………………………………………………………….........

………………………………………………………………………………………….........

…………………………………………………………………………………………......... [2]

(iii) the amplitude of pulse **C** is larger than pulse **A**.

………………………………………………………………………………………….........

………………………………………………………………………………………….........

………………………………………………………………………………………….........

…………………………………………………………………………………………......... [2]

7 **(a)** Domestic users in the United Kingdom are supplied with mains electricity at a root-mean-square voltage (r.m.s.) of 230V.

(i) State what is meant by *root-mean-square voltage*.

....

.... [1]

(ii) Calculate the peak power dissipated in a lamp connected to the mains supply when the r.m.s. current is 0.26 A.

peak power =.................................... W [2]

(b) Another alternating voltage is shown in Fig. 7.1.

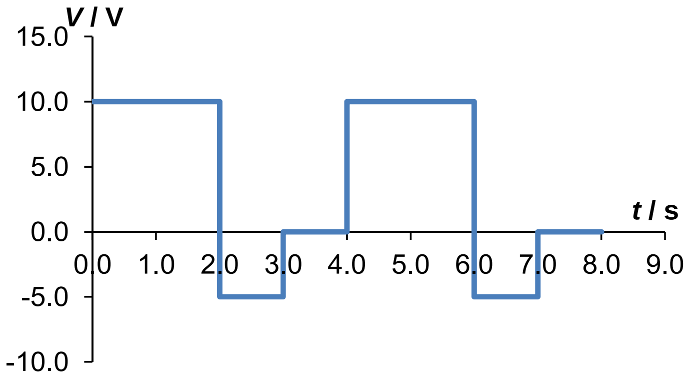

Fig. 7.1

Determine the root-mean-square voltage.

root-mean-square voltage = ...V [2]

Section B

Answer **one** question from this Section in the spaces provided.

8 **(a)** To determine the speed of sound, a student facing a brick wall claps her hands at point **P**, which is a measured distance, *d*, from the brick wall, as shown in Fig. 8.1(a). A microphone at **P** is connected to a timing device, arranged so as to record the time, *t*, between the original clap and its echo. The experiment is carried out for three distances *d*, and the results are plotted as shown in Fig.8.1(b).

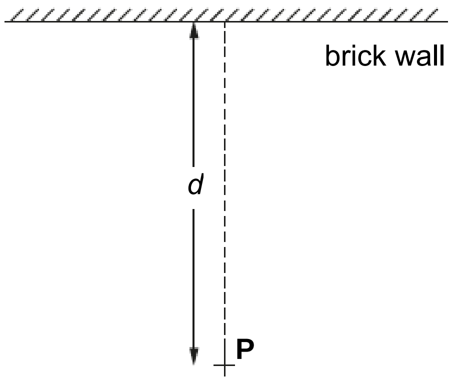

Fig. 8.1(a)

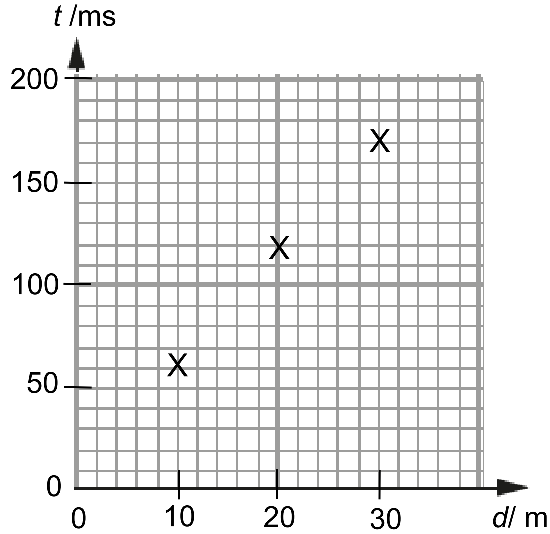

Fig. 8.1(b)

Determine a value for the speed of sound. Explain your working.

speed of sound = ... m s^{-1} [3]

(b) In another experiment, as shown in Fig. 8.2, the student sets up two small loudspeakers, S_1 and S_2, connected to the same signal generator, set to 8 300 Hz.

She moves a microphone along the line AB, and finds maxima of sound at the positions shown by dots along AB, with minima in between.

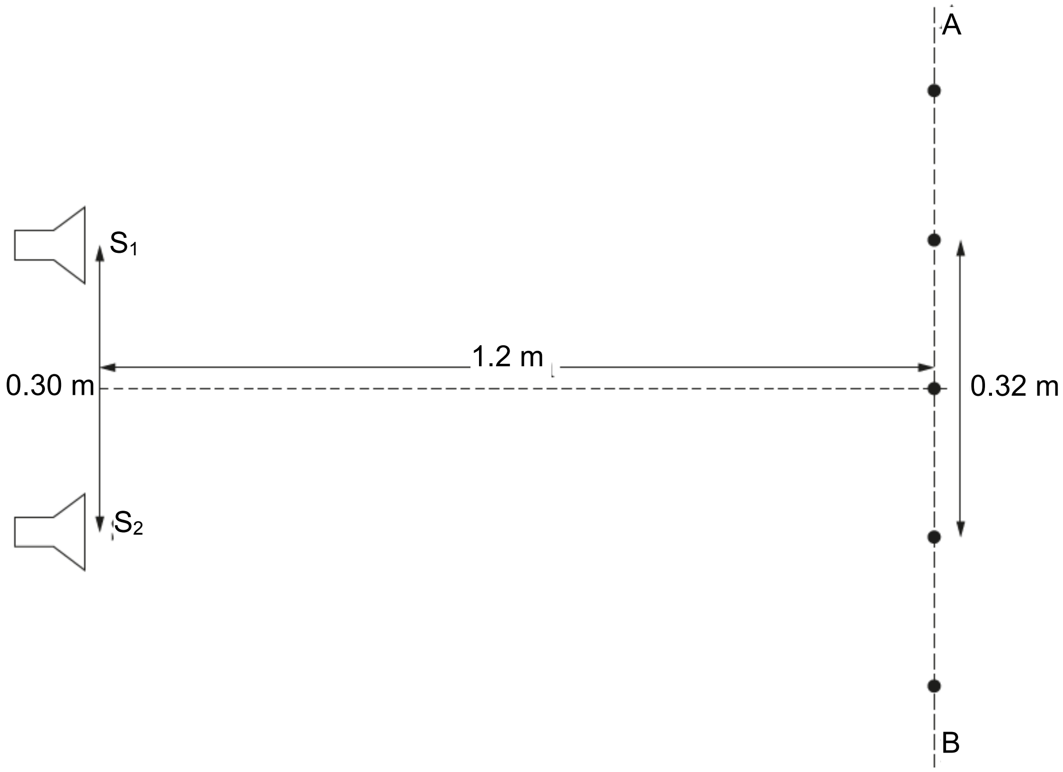

Fig. 8.2

(i) Determine the wavelength of the sound produced from S_1 and S_2.

wavelength = ... m [2]

(ii) Hence, calculate the speed of sound from this experiment.

speed of sound = ... m s^{-1} [1]

(iii) **1.** Label with a letter 'M' on one of the dots along the line AB for which the path difference is $S_2M - S_1M = 2\lambda$. [1]

2. Explain why 'M' is a maxima.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(iv) When the signal generator is set to 300 Hz, the student does not find a succession of maxima and minima as the microphone is moved along the line AB. Explain why this happens.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [3]

(c) Fig. 8.3 shows an arrangement used to analyse the light emitted by a source. The light source emits a range of wavelengths from 500 nm to 700 nm. The light is incident on a diffraction grating that has 10000 lines per metre. The diffracted pattern is formed on the screen placed at a distance away from the grating. OX is the line that indicates the direction of the undiffracted light.

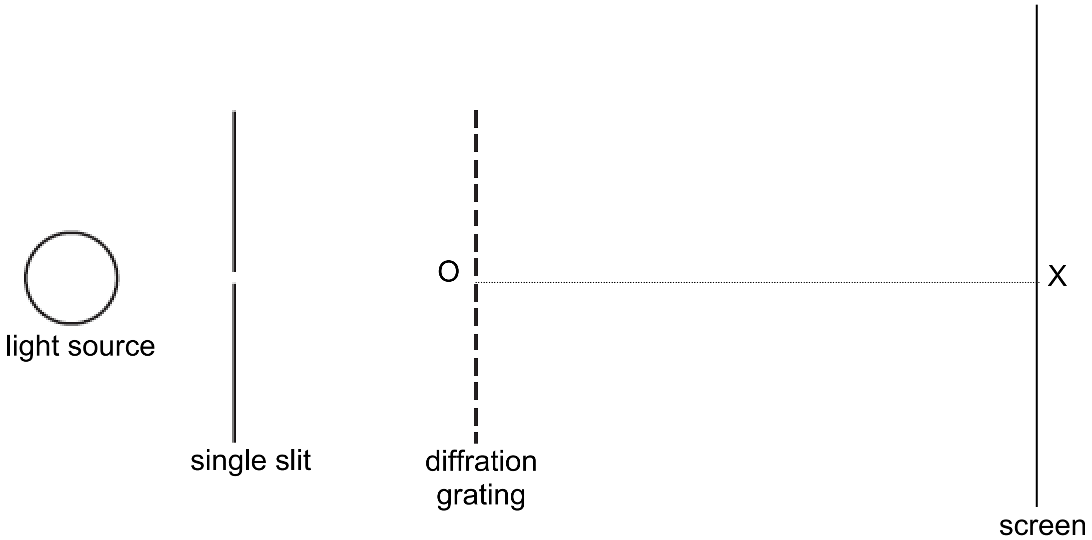

Fig. 8.3

(i) Calculate the angle from OX at which the first order maximum for the light of wavelengh of 500 nm is formed.

angle from OX = ... ° [2]

(ii) Calculate the maximum angular separation of the first order spectrum on the same side of OX.

maximum angular separation = ... ° [2]

(iii) Calculate the maximum linear separation of the first order spectrum if the screen is placed at 2.0 m from the diffraction grating.

maximum linear separation = ... m [2]

(iv) The single slit is initially illuminated by light from a point source that is 0.020 m from the slit.

State and explain how the intensity of light incident on the single slit changes when the light source is moved to a position 0.050 m from the slit.

………………………………………………………………………………………….......

………………………………………………………………………………………….......

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………………………………………………………………………………………….........

…………………………………………………………………………………………......... [3]

9 **(a)** Fig. 9.1 shows the first three energy levels of copper.

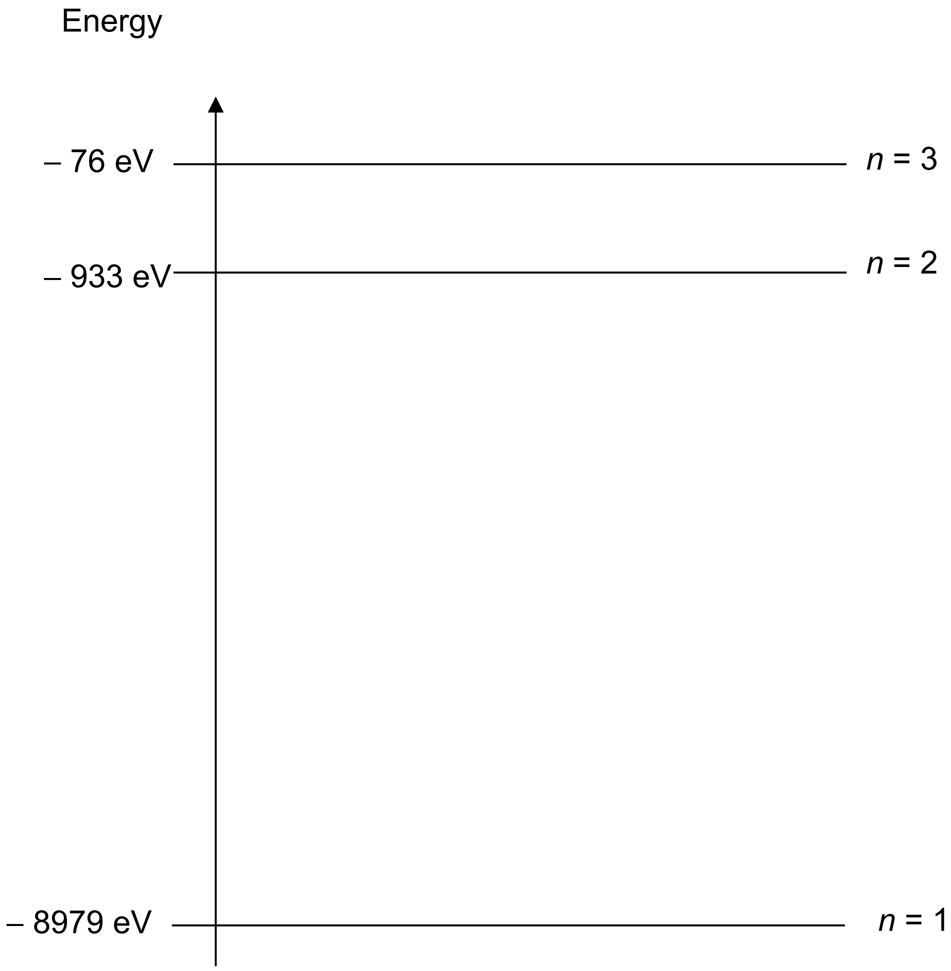


Fig. 9.1

In a particular experimental X-ray tube, a copper target is used. Electrons in the tube are accelerated by a potential difference of 10 kV before entering the target. X-rays then emerge from the target.

(i) Determine

1. the minimum wavelength of the X-ray photons.

minimum wavelength = ………………….. m [3]

2. the wavelength corresponding to the K-alpha characteristic line.

wavelength = ……………… m [2]

(ii) Sketch the X-ray spectrum of copper on Fig. 9.2 below. Use the answers in **(a)(i)** to label two important values of wavelength on your spectrum.

Fig. 9.2

[3]

(b) The diameter of a nucleus is of the order of magnitude of 10^{-15} m. Show, using the uncertainty principle, that an electron does not exist inside the nucleus.

[3]

(c) The decay of a calcium-45 nucleus (chemical symbol: Ca; Z = 20) releases a scandium-45 (chemical symbol: Sc; Z = 21) nucleus. Write a nuclear equation to deduce the type of decay that takes place.

type of decay = …………………………… [2]

(d) Radon-219 is a naturally radioactive element, a member of the noble gas family found in soil. Data for the α-decay of Radon-219 to form Polonium-215 are given in Fig. 9.3 below.

Nucleus	*Mass of nucleus / u*
Radon-219	219.009523
Polonium-215	214.999469
Helium-4	4.002603

Fig. 9.3

Determine the energy released during the decay.

energy released = …………………….. MeV [3]

(e) Bismuth-210 undergoes β-decay. The emitted β-particles have a range of energies up to a maximum of 1.17 MeV.

Using conservation laws, explain why this range of energies leads to the suggestion that, apart from the β-particle, another particle must be emitted by the Bismuth-210 nucleus.

……

……

……

……

……

……

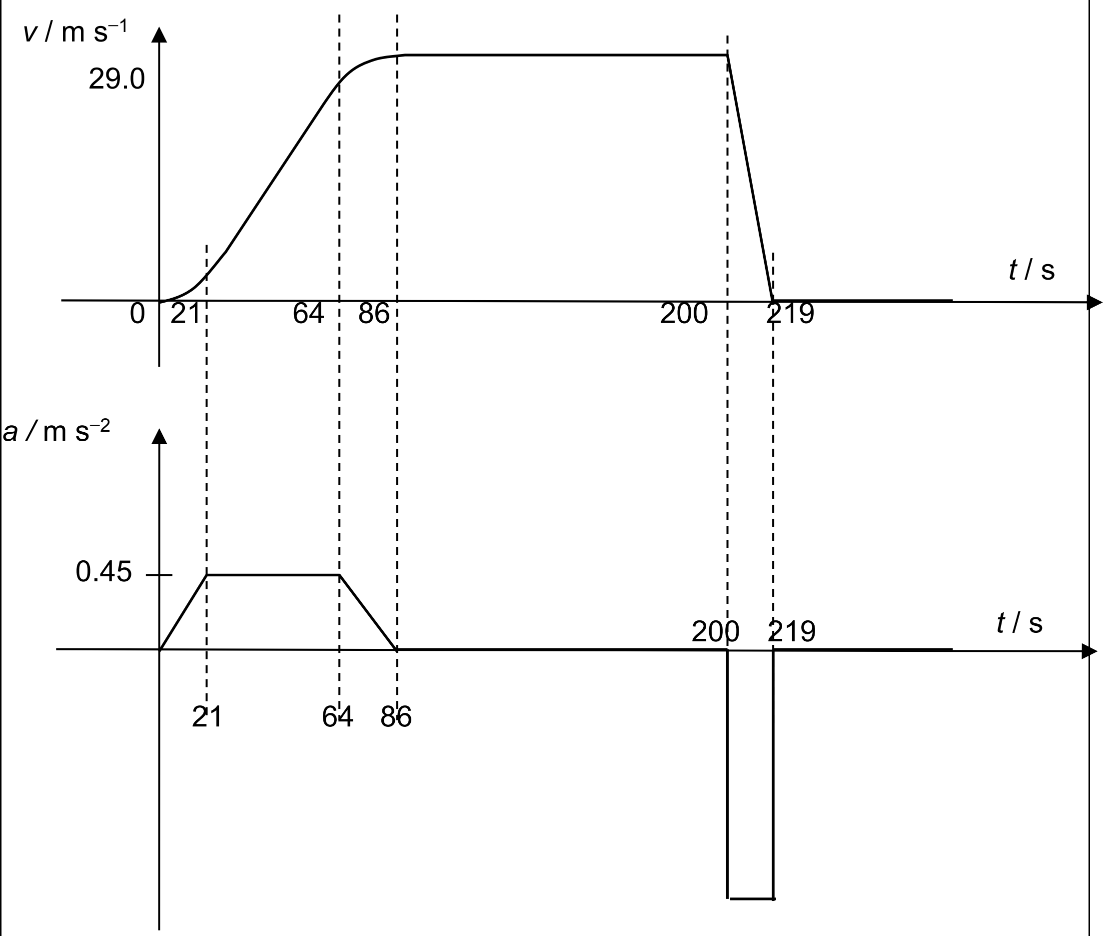
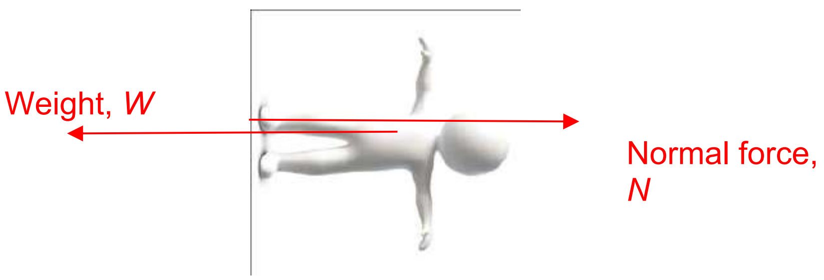
……

……

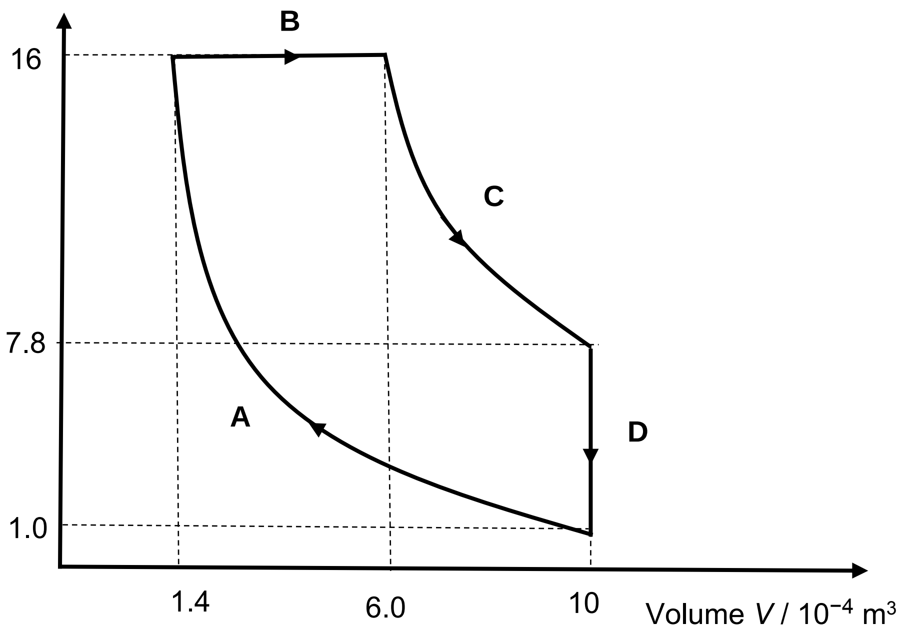
…… [4]

\- End of Paper -

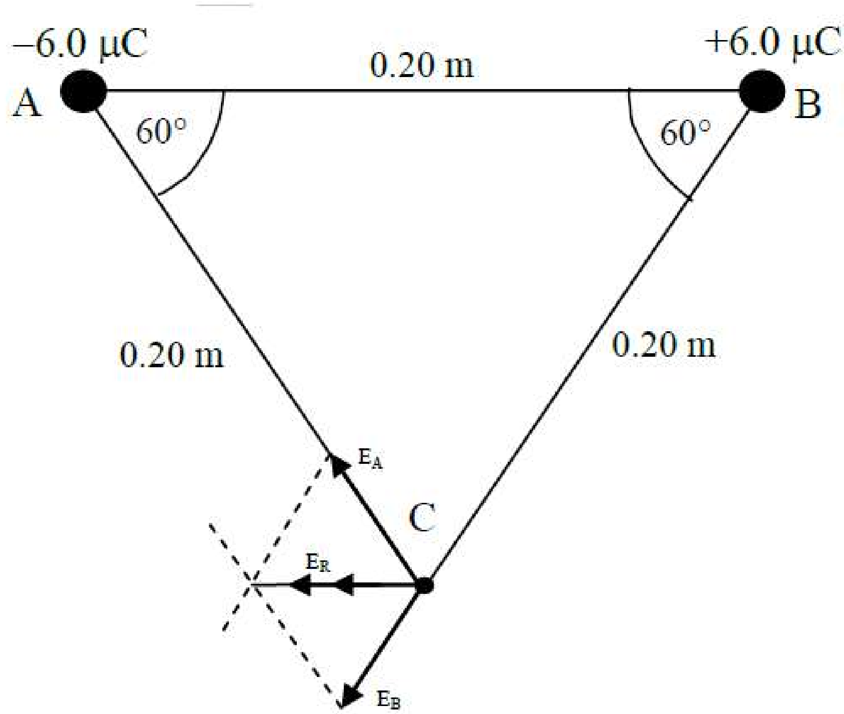
Suggested Solution
Section A

1	**(a)**		Δv = area under *a-t* graph $= ½ (21)(0.45) + (43)(0.45) + ½ (22)(0.45)$ $= 29$ $< a > = \Delta v / \Delta t$ $= 29 / 200$ $= 0.15\ (0.145)\ \text{m s}^{-2}$	**1** **1**
	(b)	**(i)**	v_{max} = area under *a-t* graph (from $t = 0$ to $t = 86$ s) $= ½ (86 + 43) (0.45)$ $= 29.0\ \text{m s}^{-1}$	**1** **1**
		(ii)	 	
2	**(a)**		[1] for the correct pair of forces [1] for length of W > N  	

	(b)	The scale reads the normal force. The normal force of man **P** is equal to his weight, whereas the normal force of man **E** is the difference between his weight and the centripetal force as man **E** is undergoing circular motion.	**1** **1** **1**
	(c)	$589.2 – 587.4 = 60\ a_c$ $a_c = 0.030\ \text{m s}^{-2}$	**1** **1**
3	**(a)**	Gravitational potential at a point is the work done <u>per unit mass</u> in bringing a <u>small test mass</u> from <u>infinity to that point</u>.	**1**
	(b) (i)	**1.** The gravitational field is non uniform. Accept: Gravitational potential varies inversely proportional to the distance from the centre of Earth to a point.	**1**
	(b) (i)	**2.** Gravitional potential is taken to be zero at infinitiy. The gravitational forces are attractive and thus negative work has to be done by an external force to bring the mass from infinity to that point at constant speed.	**1** **1**
	(b) (ii)	By Priniciple of Conservation of Mechanical Energy, $GPE_i + KE_i = GPE_f + KE_f$ $m\Phi_m + 0 = m\Phi_E + ½ mv^2$ [1] $v^2 = 2 (\Phi_m - \Phi_E)$ $v = \{2[-1.0 – (-62.0)]\}^{0.5}$ [1] $= 1.1 \times 10^4\ \text{m s}^{-1}$ [1]	
	(b) (iii)	Since gravitational potential, $\phi = – GM / r$, $– 61.6 \times 10^6 = – (6.67 \times 10^{-11}) (5.97 \times 10^{24}) / (6371 \times 10^3 + h)$ where h is the height of the upper edge of the atmosphere correct substitution of ϕ , G , M [1] $r = r_E + h$ [1] Thus, $h = 9.3 \times 10^4$ m (93.3 km) [1]	

4	(a)	The INCREASE in the internal energy of a system is equal to the sum of heat supplied TO the system and the work done ON the system.		1
	(b)	(i)		4
		(ii)	see table below	3
		(iii)	Net work done on gas = 300 + (-740) + (-440) + 0 = - 880 J Heat supplied to gas during B = 2580 J Ratio = 880 / 2580 = 0.34	1 1

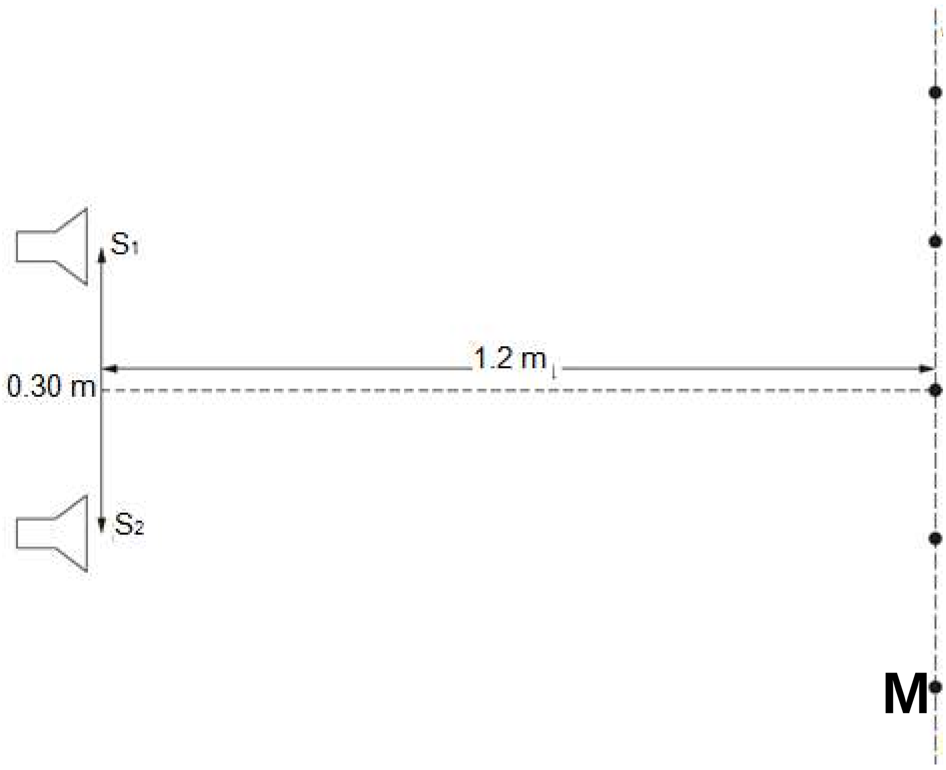
	Heat supplied to gas / J	Work done on gas / J	Increase in internal energy of gas / J
A	0	300	300
B	2580	-740	1840
C	0	-440	-440
D	-1700	0	-1700

5	(a)		1 1 1
	(b)	$E_R = \frac{1}{4\pi\varepsilon_o}\frac{6\times10^{-6}}{0.2^2}\cos 60^\circ$ x 2 $= 1.35\times10^6\ NC^{-1}$ Right substitution.	1 1

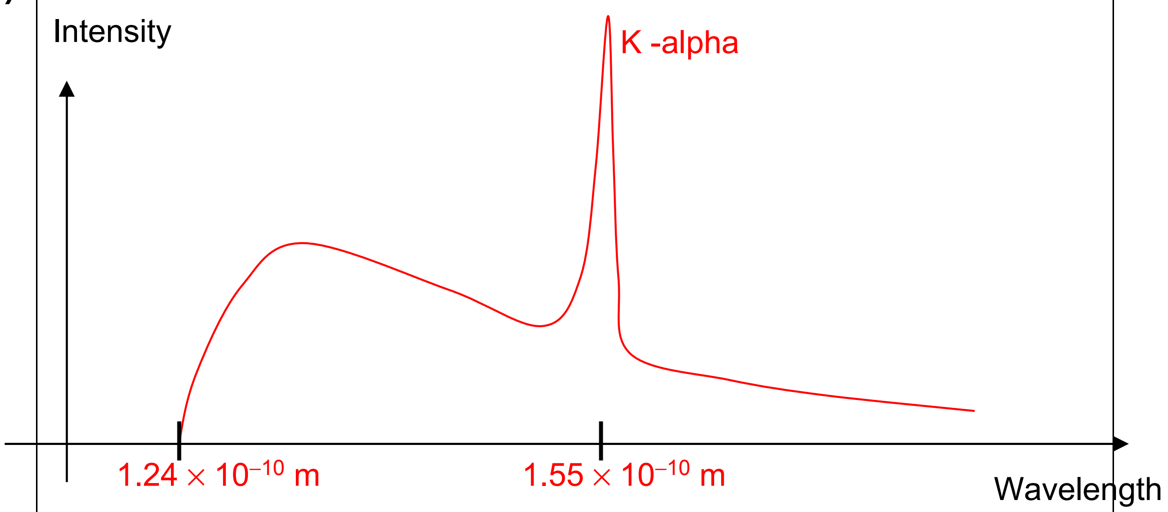
6	(a)	good attempt at evenly spaced parallel lines, and downward arrow.		1 1
	(b)	To produce a fine/ narrow beam /ions parallel to each other		1
	(c)	(i)	*(region R) into page* *(region S) out of page*	1 1
		(ii)	Electric force is downward with the magnetic force is directed upward. Electric force is equal to *qE* while magnetic force is equal to *Bqv*. They are equal to each other which gives v = E/B and mass is not included in the relation.	1 1 1
		(iii)	It will hit below the slit nearer to the bottom plate. Since electric force is greater than the magnetic force.	1 1
	(d)	(i)	There is a change in magnetic flux linkage though the coil as the cart approaches and leaves the coil.	1

	(d)	**(ii)**	The direction of the induced e.m.f. is such that the current would flow to oppose the change producing it. As the cart passes A, the flux linkage is increasing and as the cart passes B, magnetic flux linkage is decreasing so e.m.f. induced is in opposite direction.	**1** **1**
	(d)	**(iii)**	The cart has accelerated between A and C/ moves faster/ more KE at C. The change of magnetic flux linkage takes place within a shorter time frame, hence rate of change of magnetic flux is greater. This induced e.m.f. is greater.	**1** **1**
7	**(a)**	**(I)**	effective direct voltage that produces the same heating effect as the alternating voltage.	**1**
		(ii)	Vo = 325.269 V Peak P = 325.269 x 0.26 $\sqrt{2}$ =120 W	**1** **1**
	(b)	$\langle V^2 \rangle = \frac{(10)^2(2.0)+(5^2)(1.0)}{4.0}$ = 56.25 V V_{rms} = 7.5 V		**1** **1**

Section B

8	**(a)**	Calculate speed for *d* = 10, 20, 30 m: Velocity $v_1 = 10 \times \mathbf{2} / 60 \times 10^{-3} = 333.33333$ m s^{-1} $v_2 = 20 \times \mathbf{2} / 120 \times 10^{-3} = 333.33333$ m s^{-1} $v_3 = 30 \times \mathbf{2} / 170 \times 10^{-3} = 352.94$ m s^{-1} Explanation: The value of *d* is multiplied by 2 (or half the *t*) because the sound travels from the source to wall and back again to source. Find the average. : $v_{ave} = 339.87 = 340$ m s^{-1} [Alternatively, students can solve via drawing a BFL, determining its gradient, equating the gradient value to 2/*v* and then find *v*. Drawing a BFL is akin to taking average.]			 **1** **1** **1**
	(b)	**(i)**	Use $\lambda = ax/D$ With *x* = 0.16 m, …. $\lambda = 0.040$ m		 **1** **1**
	(b)	**(ii)**	$v = f\lambda = 8300 \times 0.040$ $= 332$ m s^{-1}		 **1**
		(iii)	**1.**		**1**

			2. The path difference is equal to an integer number of wavelengths (and sources are in phase) OR Waves from S_1 and S_2 arrive in phase at **M** [“Constructive interefence” as the sole answer will not gain any credit. This is just paraphrasing the question]	**1**
		(iv)	Calculate that λ = 1.1 m Use $\lambda = ax/D$ to calculate x = 4.4 m The first order maximum is found at 4.4 m which is too far away from the central fringe. (The length of the screen AB appears to be slightly greater than 0.64 m only. So there is a central maxima, but the next maxima is 4.4 m away, and the first minima is 2.2 m away, so no succession of maxima and minima).	**1** **1** **1**
	(c)	**(i)**	$d = 1.0 \times 10^{-4}$ m $n\lambda = d \sin\theta$ With n = 1, θ = 0.286°	**1** **1**
		(ii)	For λ = 700 nm, n = 1, we have θ_{700} = 0.4011° Thus $\Delta\theta = \theta_{700} - \theta_{500}$ = 0.4011 – 0.2865 = 0.115°	**1** **1**
		(iii)	Let y be the distance of the maxima from **X**, as measured along the screen. Then y_{700} = 2.0 tan 0.4011° and y_{500} = 2.0 tan 0.2865°. Thus, linear separation = $y_{700} - y_{500}$ = 0.00400 m	 **1** **1**
		(iv)	lower intensity (because energy spreads) use or statement of inverse square law ($I \propto 1/r^2$) ratio of the initial intensity to the final intensity = $(0.02/0.05)^2$ = 0.16 or intensity falls by factor of 6.25	**1** **1** **1**

9	**(a)**	**(i)**	1. Using $e V_{acc} = h c / \lambda_{min}$, [1] we have $\lambda_{min} = (6.63 \times 10^{-34}) (3.0 \times 10^{8}) / (1.60 \times 10^{-19} \times 10 \times 10^{3})$ [1] $= 1.24 \times 10^{-10}$ m [1]	
		(i)	2. Using $\Delta E_{(2\rightarrow1)} = h c / \lambda$, we have $\lambda = (6.63 \times 10^{-34}) (3.0 \times 10^{8}) / [(-933) - (-8979)] \times 1.60 \times 10^{-19}$ [1] $= 1.55 \times 10^{-10}$ m [1]	
	(a)	**(ii)**	 Shape [1] Minimum wavelength labelled [1] K-alpha wavelength labelled [1]	
	(b)		Using formula $\Delta p_x \Delta x \geq h$, $\Delta p_x \geq 6.63 \times 10^{-34} / (1 \times 10^{-15}) = 6.63 \times 10^{-19}$ [1] $\Delta v \geq 6.63 \times 10^{-19} / (9.11 \times 10^{-31}) = 7.3 \times 10^{11}$ m s^{-1} [1] Thus, Δv > c, which is impossible [1]	
	(c)		$^{45}_{20}Ca \rightarrow ^{45}_{21}Sc + ^{0}_{-1}e$ [1] (Negative) beta decay [1]	

	(d)	Mass difference = 219.009523 – (214.999469 + 4.002603) [1] = 0.007451 u Energy released = $(0.007451 \times 1.66 \times 10^{-27})(3 \times 10^{8})^2$ [1] $= 1.1132 \times 10^{-12}$ J = 6.96 MeV [1]	
	(e)	Without a second emitted particle, all β-particles would have the same energy [1] Range of β-particle energy values means range of momenta (speeds) [1] For COM and COE [1], there must be another particle to share the momentum and energy [1]	

2018 JC2 H2 Physics Preliminary Examination

Suggested Solutions to Prelim Paper 4

Question 1 [12 marks]

1	(a)	(i)	MMO Record of maximum height (30 to 60 mm) to the nearest mm.	1
		(ii)	ACE Curve of correct trend (decreasing rate of rise), passes through origin (label) Maximum value with distinct flat part	1 1
	(b)	(i)	ACE Correct calculation of 0.75 *H* to 2 or 3 sf, with unit.	1
		(ii)	MMO Record of time to rise : 30 s ≥ time ≥ 10 s, to nearest 0.01 s, with unit.	1
		(iii)	ACE Correct calculation of rate in mm s^{-1}, using data in part (b)(i) & (ii), to correct no. of sf.	1
	(c)		ACE Each valid point awarded one mark for improvement • Stated method for measuring heights eg mark 5 to 10 different distances on the strips • Use distances at *H*/5 to *H*/10 intervals • Use reasonable time intervals of 2 to 4 seconds • Repeat timing (with several strips) for each distance and average • Repeat distance measurement for each time • Use coloured water (e.g add copper sulphate)	2
	(d)		ACE Each one valid point is awarded one mark for method • Measure time to reach each mark/different height (*h* < 0.75*H*) **OR** measure heights at different times (*t* < 30s) • Plot graph of *h* against *t* and compare shape of graphs	1 1
	(e)		ACE Need to know the amount/volume/mass of water absorbed	1
			Using a mass balance, measure the mass of paper or mass of water in beaker before and mass after and subtract	1
			OR measure the volume of water before and after and subtract Replace beaker with measuring cylinder	
			Total	**12**

Question 2 [11 marks]

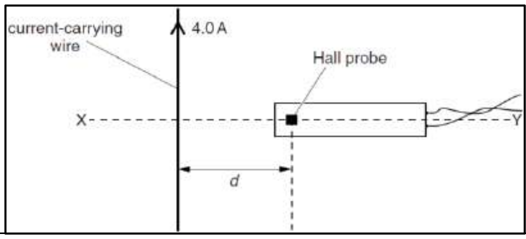
2	(a)	(ii)	MMO Evidence of repeated readings. All raw values of *d* to 0.01mm (using micrometer screw gauge) with unit and in the range 0.25 mm to 0.45 mm.	1
		(iii)	ACE Correct calculation of *A* with consistent unit and power of tens.	1
	(b)	(iii)	MMO Value of *L* with appropriate unit in the range 10.0 cm ≤ *L* ≤ 20.0 cm	1
		(iv)	ACE Percentage uncertainty in *L* based on absolute uncertainty of 2 mm to 8 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if workings is clearly shown. Correct method of calculation to obtain percentage uncertainty.	1
	(c)	(i)	ACE Correct calculation of *C.* Correct units for *C.* Accept e.c.f	 1 1
	(d)	(ii)	Repeated raw values of *t* given to nearest 0.01 s *Nt* ≥ 20.00 s *T* calculated with units, range 0.5 s ≤ *T* ≤ 2.0 s	1
	(e)	(ii)	ACE Second values of *L* and *C* Second value of *T* Quality : if $d_1 > d_2$, then second value of *T* > first value of *T*	 1 1
	(f)	(i)	ACE Two values of *k* calculated correctly. Accept e.c.f	 1
		(ii)	ACE Sensible comment relating to the calculated values of *k*, testing against a criterion specified by the candidate.	 1
			Total	**11**

Question 3 [20 marks]

3	(a)		MMO Use of half metre rule to measure value of *D* to the nearest 0.1 cm Repeated measurements of *D.*	 1 1
	(e)	(i)	MMO *f* and *L* measured to the correct precision with unit.	1
		(ii)	ACE Uncertainty in *L* is range of 0.2 cm to 0.5 cm Percentage uncertainty in L correctly calculated and given in 1 or 2 s.f.	 1
	(f)		MMO Data Collection ≥ 6 sets of readings: 2 5 sets of readings: 1 ≤ 4 sets of readings: 0 PDO Each column heading must contain a physical quantity and an appropriate unit. There must be some distinguishing mark (solidus) between quantity and unit : For example: *L*/cm , *f*/Hz or *f*(Hz), $\frac{1}{f}/s$, PDO *Consistency in number of decimal places for raw data:* *L* expressed to nearest mm. *f* expressed to nearest integer PDO The significant figures for each of the calculated value of *1/f* should reflect the number of significant figures in the raw data. *ACE* *Processed data: 1/f ca*lculated correctly.	 2 1 1 1 1
	(g)		ACE Linearising equation and deriving expressions that equate gradient of graph to *v* and y-intercept of graph to *b*.	 1
			Plotting of Graph: PDO Axes: Sensible scales must be used. No awkward scale allowed. Scales must be chosen such that the plotted points occupy more than half the grid in both x and y directions. Axes must be labelled with correct quantity and appropriate unit. PDO Plotting of points: All collected data points must be plotted correctly on the graph grid. (Accuracy up to half a small square in both the x and y directions).	 1 1 1

			PDO Best fit line: Assessed best fit line if and only if at least 5 out of 6 of the plotted points are non-anomalous. Judge by scatter of points about the plotted line. Fair scatter of points on either side of the line	
			ACE Calculation of gradient and *v* Gradient – hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Check for $\Delta y / \Delta x$ (i.e. do not allow $\Delta x / \Delta y$). Value of *v* calculated correctly with units.	1 1
			ACE Y-intercept: *b* Y-intercept must be read off accurately to within half a small square and OR determined from $y = mx + c$. The coordinates (x,y) of a data point on the best fit line must be substituted correctly.	1
	(h)		MMO Presence of anomalous point: Circle the anomalous point/points on the graph. Comment that there is anomalous point (x,y) on the graph which deviates from the general trend of best fit line. OR No anomalous point: Comment: There is no anomalous point on the graph as no point deviates from the general trend of best fit line. Note: Comments must be valid with reference to the plotted best fit line before mark can be awarded.	1
	(i)		ACE Possible Errors (relevant points with appropriate elaboration): • Positioning bottom of rule on water surface • Sound from other experiments • Top of rule not touching tube during measurements • Uncertainty in determining the position of tube	1
	(j)		ACE Possible Improvements (relevant points with appropriate elaboration): • Use another stand and clamp to clamp rule • Screen off other experiments or perform a greater distance apart • Use a set square • Use a sound sensor+ datalogger+ PC (OR CRO + microphone)	1
			Total	**20**

Question 4 [12 marks]

Independent Variable	I and B	stated clearly – 1
Dependent variable	V_H	
Variables to be controlled	type of conducting material, thickness / area of conductor	1
Diagram	Circuit with e.m.f. source to supply I through conductor Source of B-field producing field in vertical direction	1 1
Measurement of IV	ammeter (milliammeter) for I, along direction of I Hall probe for B For reference: this diagram is taken from the lecture notes on planning: 	1 1
Measurement of DV	Voltmeter (millivoltmeter), across faces **C** and **D**	1
Analysis	Graph to be plotted. Statement on how to obtain one of the constants.	1
	Graph to be plotted. Statement on how to obtain the other two constants.	1
Safety	Any reasonable precaution	1
Reliability	Helmholtz coils are used to generate a uniform B-field	Any two – 1 mark each
	The type of conducting material used in the experiment should be the same	
	Initial testing of range of V_H	
	Start with large R value and decrease gradually so as to not damage the circuit elements	
	Calibration of Hall probe with known B	

Suggested answer

Independent variable:

- The magnetic flux density B acting on a pair of opposite faces of the conductor.
- The current I being passed through another pair of opposite faces.

Dependant variable:

- The Hall voltage, V_H, across the third pair of opposite faces.

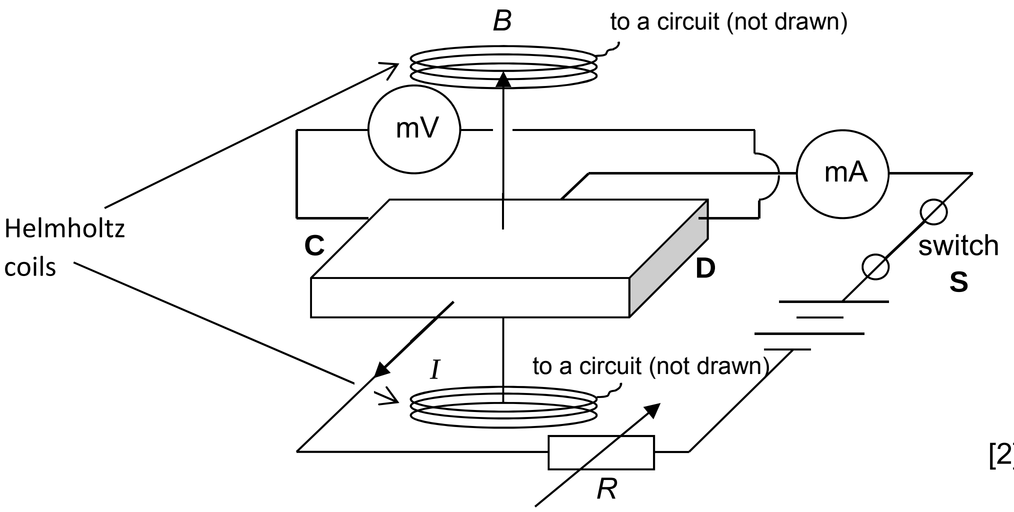
[1]

Variables to be controlled:

- The material of the conductor
- The thickness of the conductor

Combined with reliability #2 [1]

Diagram:



[2]

Procedure:

1. Set up the apparatus as shown.
2. With **S** closed, read off the milliammeter and record the current, I flowing through the conductor. [1]
3. Read off the millivoltmeter and record the voltage, V_H across faces **C** and **D**. [1]
4. Repeat steps 2 to 3 by varying I until there are six different values. This is done by adjusting R.
5. Tabulate the values of V_H and I. Then plot a graph of lg V_H against lg I. Let this be graph 1.

6. At a particular fixed setting of R, repeat step 2. Let this value be I_o.
7. Place a hall probe directly above the conductor's top face and record the magnetic flux density, B. [1]

8. Repeat steps 3 and 7 by varying B until there are six different values. This is done by varying the current flowing through both Helmholtz coils.

9. Tabulate the values of V_H and B. Then plot a graph of lg V_H against lg B. Let this be graph 2.

Analysis:

Given $V_H = k I^m B^n$, we have

$\lg V_H = \lg k + m \lg I + n \lg B$

Graph 1: lg V_H against lg I

Then, the gradient = m (found) [1]

Graph 2: lg V_H against lg B with value of $I = I_o$

Then, the gradient = n (found) and

the y-intercept, $c = \lg k + m \lg I_o$. Thus, $k = 10^{c - m \lg I_o}$ (found) [1]

Safety:

Perform the experiment in a dry area to avoid any short-circuit. [1]

Reliability:

1. Use Helmholtz coils to generate the magnetic field so that the region where the conductor is located has a uniform magnetic field.

2. Keep using the same conductor throughout the experiment so that the material and thickness remains the same. (combined with variables to be controlled)

3. The first reading in step 2 of the procedure should be done at a high setting of R so that a small current is passed through the circuit. This avoids damaging the circuit elements.

4. The Hall probe reading should be taken at different locations around the conductor. If the readings are similar but not exactly the same, the average B should be computed and used in the graph plotting.

5. Before using the Hall probe in the experiment, obtain a calibration curve for the probe. This is done by placing the probe in B-fields of known values, so that a graph of B vs probe reading can be plotted. This graph is the calibration curve. With the curve, we can then read off the B value from the probe reading.

Any two: [1] each

Candidate’s name ……………………………………………… CTG ………………

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2018

PHYSICS **9749/04**

HIGHER 2 **14th August 2018**

2 hours 30 minutes

Paper 4 Practical Test

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner’s Use	
1	**/12**
2	**/11**
3	**/20**
4	**/12**
Total	
	/ 55

For Examiner's Use

1 You are going to investigate the rate at which kitchen paper absorbs water.

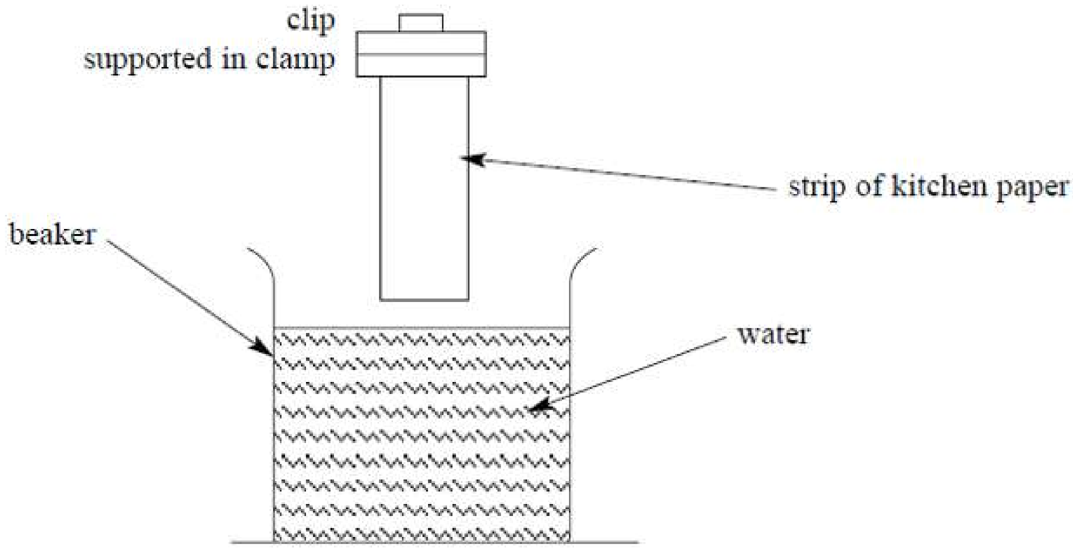


Fig. 1.1

(a) Set up the arrangement shown in Fig 1.1. Mount a strip of the paper so that its lower edge is initially about 5 mm above the water surface and parallel to it.

(i) Add water to the beaker until the water touches the bottom edge of the paper strip.

Observe what happens for about 30 s and record the maximum height *H*, above the bottom edge of the strip that the water reaches.

H = ………………………….. mm [1]

(ii) Sketch on the axes below, a graph to show the variation of height reached by the water in the paper with time.

[2]

[Turn over

For Examiner's Use

(b) **(i)** Calculate $h = 0.75\,H$, where H is the measurement you made in part **(a)(i)**.

h = ………………………………… [1]

(ii) On a new dry strip, draw a line of distance, h, above the bottom edge of the strip.

Repeat the procedure in part **(a)**, start timing at the instant the water touches the bottom edge of the paper.

Measure and record the time, t, for the water to reach the line you have drawn.

t = ………………….. [1]

(iii) Calculate R, the average rate of change of height.

R = ………………….. mm s^{-1} [1]

(c) Suggest two improvements that could be made for this experiment.

1.……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

2.……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

For Examiner's Use

(d) Describe briefly how you would proceed to verify whether the graph you have sketched in part **(a)(ii)** is correct.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

(e) The purpose of kitchen paper is to soak up as much liquid as possible.

State another quantity which could be measured to provide a more reliable test than the height to which the water rises. Describe briefly how you would make the measurement.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

For Examiner's Use

2 In this experiment, you will investigate the movement of a loaded wire.

(a) **(i)** Take the **shorter** of the two wires.

(ii) Measure and record the diameter *d* of the wire.

d = ………………………… [1]

(iii) Calculate the cross-sectional area *A* of the wire.

A = ………………………… [1]

(b) **(i)** Secure the hook of the mass hanger to one end of the wire, leaving at least 20 cm of excess wire. The wire may be wrapped around the hook several times.

(ii) Set up the apparatus as shown in Fig. 2.1.

The length *L* of the wire between the clip and the hook of the mass hanger should be approximately 15 cm.

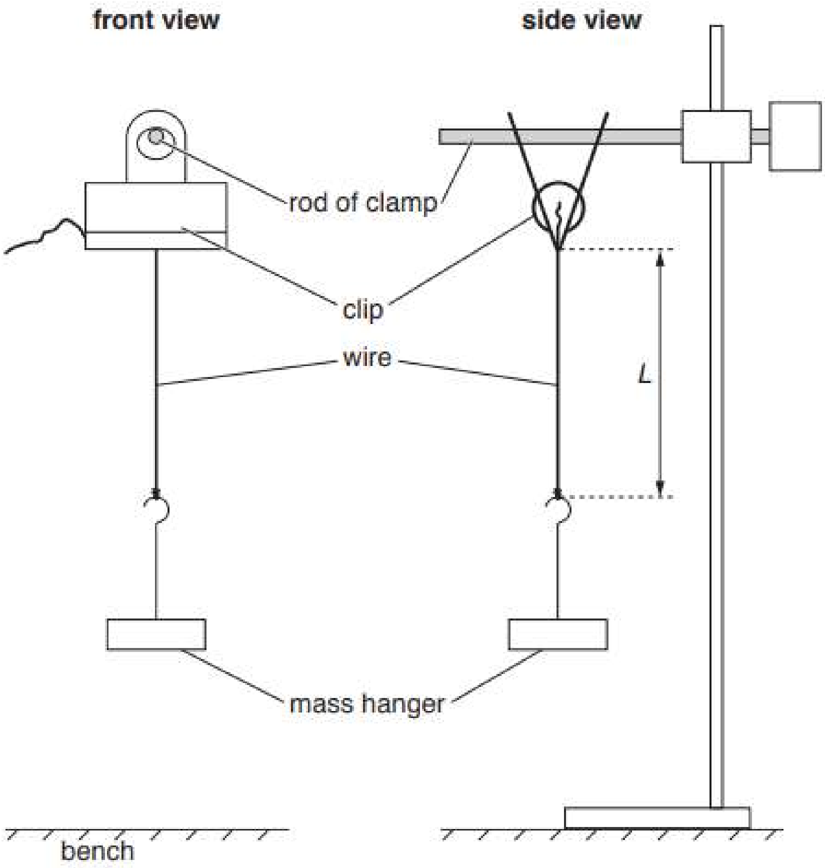


Fig. 2.1

For Examiner's Use

(iii) Measure and record *L*.

L = ……………………….. [1]

(iv) Estimate the percentage uncertainty in your value of *L*.

percentage uncertainty = …………………….. [1]

(c) Calculate *C* where

$$C = \frac{\sqrt{L}}{A}$$

C = …………………………… [2]

(d) **(i)** Twist the mass hanger through approximately 180°.

Release the mass hanger. The mass hanger will oscillate as shown in Fig. 2.2

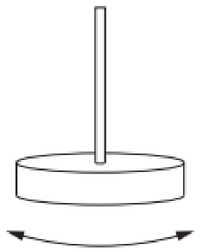


Fig. 2.2

(ii) Take measurements to determine *T*, the period of the oscillations.

Record *T*.

T =…………………………… [1]

For Examiner's Use

(iii) Remove the wire from the mass hanger.

(e) **(i)** Take the **longer** wire. Repeat **(a)(ii)** and **(a)(iii)**.

d = ……………………………

A = ……………………………

(ii) Secure the hook of the mass hanger to one of the wire leaving 40 cm of excess wire.

Repeat (**b)(ii), (b)(iii), (c)** and **(d)** for a value of L of approximately 30 cm.

L = ………………………….

C = ……………………….

T = ………………………. [2]

(f) It is suggested that the relationship between T and C is

$$T = kC$$

where k is a constant.

(i) Using your data, calculate two values of k.

first value of k =…………………

second value of k = ………………... [1]

For Examiner's Use

(ii) Explain whether your results from **(f)(i)** support the suggested relationship.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

For Examiner's Use

3 In this experiment, you will investigate resonance produced by a standing wave in a tube.

(a) Measure and record the internal diameter, *D* of the tube.

D = ………………………… [2]

(b) Set up the apparatus as shown in Fig. 3.1. The measuring cylinder should be placed inside the tray provided. Lower the tube into the water so that the length of tube above the water surface is as short as possible.

(c) Sound a tuning fork by hitting it **gently** onto the block of wood. Then hold the tuning fork above the top of the tube as shown in Fig. 3.1.

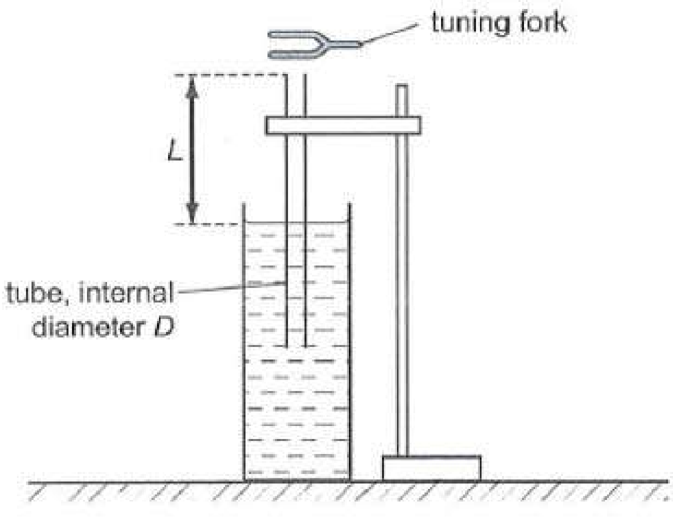


Fig. 3.1

(d) Keeping the tuning fork above the top of the tube, raise the tube gradually until a **maximum loudness** is heard. You may need to sound the tuning fork more than once.

(e) **(i)** Record the frequency *f* of the tuning fork and the length *L* of tube above the water surface.

f = ………………….

L = …………………. [1]

(ii) Estimate the percentage uncertainty in *L.*

percentage uncertainty = ……………………. [1]

For Examiner's Use

(f) Repeat steps **(c)**, **(d)** and **(e) (i)** to obtain further sets of readings for *f* and *L*.

[6]

(g) Theory suggests that *f* and *L* are related by the expression

$$L=\frac{v}{4f}+b$$

where *v* and *b* are constants.

Plot a suitable graph to determine the constants *v* and *b*. [3]

v =…………………………… [2]

b =…..………………………. [2]

For Examiner's Use

[Turn over

For Examiner's Use

(h) Comment on any anomalous data or results that you may have obtained. Explain your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(i) State one significant source of error in this experiment.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(j) Suggest an improvement that could be made to the experiment to address the source of error identified in **(i)**. You may suggest the use of other apparatus or a different procedure.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

For Examiner's Use

4 Fig. 4.1 shows an electrical conductor in the shape of a cuboid. When the conductor is exposed to a magnetic field acting perpendicular to a pair of opposing faces and then electrical current is passed through another pair of opposing faces as shown, a potential difference naturally appears across the remaining pair of opposing faces, i.e. faces **C** and **D** below.

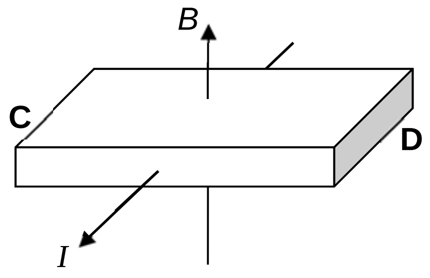


Fig. 4.1

This naturally-occurring potential difference is called the Hall voltage, V_H , which depends on the magnitude of current I and strength of magnetic field B. The relation between the quantities may be written in the form

$$V_H = k\, I^{\,m}\, B^{\,n}$$

Design an experiment to determine the values of the constants k, m and n.

You are provided with a number of electrical conductors, all in the shape of cuboids. You may also use any of the other equipment usually found in a physics laboratory.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account, you should pay particular attention to

(a) the identification and control of variables,
(b) the equipment you would use,
(c) the procedure to be followed,
(d) how the values of k, m and n are determined,
(e) any precautions that can improve the accuracy and safety of the experiment.

[12]

For Examiner's Use

Diagram:

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

For Examiner's Use

--- End of paper ---