CAMBRIDGE
International Examinations

Cambridge IGCSE

Grade thresholds – June 2017

Cambridge IGCSE Additional Mathematics (0606)

Grade thresholds taken for Syllabus 0606 (Additional Mathematics) in the June 2017 examination.

		minimum raw mark required for grade:				
	maximum raw mark available	A	B	C	D	E
Component 11	80	56	41	26	21	15
Component 12	80	58	43	29	24	18
Component 13	80	58	44	29	24	18
Component 21	80	62	47	33	27	22
Component 22	80	55	43	30	25	21
Component 23	80	62	47	33	27	22

Grade A* does not exist at the level of an individual component.

The maximum total mark for this syllabus, after weighting has been applied, is **160**.

The overall thresholds for the different grades were set as follows.

Option	Combination of Components	A*	A	B	C	D	E
AX	11, 21	148	118	88	59	48	37
AY	12, 22	140	113	86	59	49	39
AZ	13, 23	149	120	91	62	51	40

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **May/June 2017**

MARK SCHEME

Maximum Mark: 80

Published

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MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

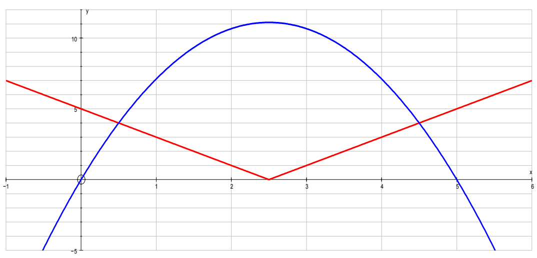
Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Guidance
1(i)	$kx-5=x^2+4x$ $x^2+(4-k)x+5=0$	M1	equating line and curve equation and collecting terms to form an equation of the form $ax^2+bx+c=0$ x terms must be gathered together, maybe implied by later work
	For a tangent $(4-k)^2=20$	DM1	correct use of discriminant
	$k=4+2\sqrt{5}$	A1	Accept $k=4+\sqrt{20}$
	Alternative Gradient of line = k Gradient of curve = $\frac{dy}{dx}=2x+4$ Equating: $k=2x+4$	M1	
	substitution of $k=2x+4$ or $x=\frac{k-4}{2}$ in $kx-5=x^2+4$ and simplify to a quadratic equation in k or x	DM1	
	$k=4+2\sqrt{5}$	A1	Accept $k=4+\sqrt{20}$
1(ii)	Normal gradient = $-\frac{1}{4+2\sqrt{5}}\times\frac{4-2\sqrt{5}}{4-2\sqrt{5}}$	M1	use of negative reciprocal and attempt to rationalise using a form of $a-b\sqrt{5}$ or $a-\sqrt{20}$ or *their* equivalent from (i)
	$=-\frac{4-2\sqrt{5}}{-4}$ oe $=1-\frac{\sqrt{5}}{2}$	A1	$-\frac{4-2\sqrt{5}}{-4}$ oe leading to $1-\frac{\sqrt{5}}{2}$
2	$\text{p}(3)=27+9a+3b-48$	M1	attempt to find $\text{p}(3)$
	$3a+b=9$ oe	A1	
	$\text{p}'(x)=3x^2+2ax+b$ $\text{p}'(1)=3+2a+b$	M1	attempt to differentiate and find $\text{p}'(1)$ must have 2 terms correct
	$2a+b=-3$ oe	A1	
	$a=12,\ b=-27$	A1	for both
3(a)	x^3y^7	B2	**B1** for each term

Question	Answer	Marks	Guidance
3(b)(i)	for $(t-2)^{\frac{3}{2}}=(t-2)^{\frac{1}{2}}(t-2)$ soi	**M1**	
	$(t-2)^{\frac{1}{2}}(4+5(t-2))$	**A1**	
	$(t-2)^{\frac{1}{2}}(5t-6)$	**A1**	
3(b)(ii)	2 and $\frac{6}{5}$	**B1**	**FT** on *their* $(t-2)^{\frac{1}{2}}(5t-6)$, must have 2
4(a)(i)	$f>5$, $f(x)>5$	**B1**	
4(a)(ii)	$\frac{y-5}{3}=e^{-4x}$ or $\frac{x-5}{3}=e^{-4y}$	**B1**	
	$-4x=\ln\left(\frac{y-5}{3}\right)$ or $-4y=\ln\left(\frac{x-5}{3}\right)$	**B1**	
	leading to $f^{-1}(x)=-\frac{1}{4}\ln\left(\frac{x-5}{3}\right)$ or $f^{-1}(x)=\frac{1}{4}\ln\left(\frac{3}{x-5}\right)$ or $f^{-1}(x)=\frac{1}{4}(\ln 3-\ln(x-5))$ or $f^{-1}(x)=-\frac{1}{4}(\ln(x-5)-\ln 3)$	**B1**	
	Domain $x>5$	**B1**	
4(b)	$\ln(x^2+5)=2$	**B1**	
	$x^2+5=e^2$	**B1**	
	$x=1.55$ or better or $\sqrt{e^2-5}$	**B1**	
5(a)(i)	$\overrightarrow{OM}=\overrightarrow{OC}+\frac{1}{2}\left(\overrightarrow{OA}-\overrightarrow{OC}\right)$ oe	**M1**	may be implied by correct answer.
	$\frac{1}{2}(\mathbf{a}+\mathbf{c})$	**A1**	

Question	Answer	Marks	Guidance
5(a)(ii)	$\mathbf{b} = \frac{5}{2}\overrightarrow{OM}$ oe , $\frac{5}{2}$(*their* (i)) or $\overrightarrow{OM} = \frac{2}{3}\left(\mathbf{b} - \overrightarrow{OM}\right)$	**M1**	dealing with ratio correctly to relate **b** or $\overrightarrow{OB}$ to $\overrightarrow{OM}$
	$= \frac{5}{4}(\mathbf{a} + \mathbf{c})$	**A1**	
5(b)(i)	$\lvert -10\mathbf{i} + 24\mathbf{j} \rvert = 26$ $\mathbf{p} = \frac{39}{26}(-10\mathbf{i} + 24\mathbf{j})$	**M1**	magnitude of $-10\mathbf{i} + 24\mathbf{j}$ and use with 39
	$\mathbf{p} = -15\mathbf{i} + 36\mathbf{j}$	**A1**	
5(b)(ii)	If parallel to the y-axis, **i** component is zero	**M1**	realising **i** component is zero
	so $2\mathbf{p} + \mathbf{q} = 12\mathbf{j}$	**DM1**	use of 12
	$\mathbf{q} = 30\mathbf{i} - 60\mathbf{j}$	**A1**	
5(b)(iii)	$\lvert\mathbf{q}\rvert = 30\sqrt{1^2 + (-2)^2}$ or $\sqrt{900} \times \sqrt{5}$	**M1**	attempt at magnitude of *their* **q**
	$\lvert\mathbf{q}\rvert = 30\sqrt{5}$	**A1**	Answer Given: must have full and correct working
6(i)	$\frac{1}{2} \times 12^2 \times \theta = 150$	**M1**	use of sector area
	$\theta = 2.083$, so $\theta = 2.08$ to 2dp	**A1**	
6(ii)	Area of triangle AOB = $\frac{1}{2} \times 12^2 \sin 2.08$	**M1**	correct method for area of triangle
	Area of segment = $150 - \frac{1}{2} \times 12^2 \times \sin 2.08$	**A1**	allow unsimplified, using $\theta = 2.08,\ 2.083$ or $\frac{150}{72}$
	$\sin 1.04 = \frac{\frac{AB}{2}}{12}$	**M1**	correct trigonometric statement using $\theta = 2.08,\ 2.083$ or $\frac{150}{72}$ with attempt to obtain AB
	AB = awrt 20.7	**A1**	
	Shaded area = *their* $AB \times 8$ – *their* segment area	**M1**	execution of a correct ‘plan’(rectangle – segment)
	awrt 78.4 or 78.5	**A1**	

Question	Answer	Marks	Guidance
6(iii)	Arc AB = 25 or 24.96	**B1**	
	Perimeter= 25 + *their* AB + 16	**M1**	correct 'plan' (arc + *their* AB + 2×8)
	awrt 61.7	**A1**	
7	differentiation to obtain answer in the form $p\left(3x^2+8\right)^{\frac{2}{3}}$ or $qx\left(3x^2+8\right)^{\frac{2}{3}}$	**M1**	
	$6x\left(3x^2+8\right)^{\frac{2}{3}}$	**B1**	
	$\frac{dy}{dx}=\frac{5}{3}\times 6x\left(3x^2+8\right)^{\frac{2}{3}}$	**A1**	all correct
	When $\frac{dy}{dx}=0$ only solution is $x=0$	**DM1**	$qx\left(3x^2+8\right)^{\frac{2}{3}}=0$ and attempt to solve
	$x=0$ and $3x^2+8=0$ has no solutions	**A1**	
	Stationary point at $(0,32)$	**A1**	
	correct gradient method with substitution of x values either side of zero or equivalent valid method	**M1**	
	correct conclusion from correct work using a correct $\frac{dy}{dx}$	**A1**	
8(i)		**B5**	**B1** for shape of modulus function **B1** for y intercept = 5 (for modulus graph only) **B1** for x intercept = 2.5 at the V of a modulus graph **B1** for shape of quadratic function for $-1 \leqslant x \leqslant 6$ **B1** for intercepts at $x = 0$ and $x = 5$ for a quadratic graph
8(ii)	$2x-5=\pm 4$	**B1**	one correct answer
	$x=\frac{9}{2}$	**M1**	solution of two different correct linear equations or solution of an equation obtained from squaring both sides or use of symmetry from first solution.
	$x=\frac{1}{2}$	**A1**	second correct solution

Question	Answer	Marks	Guidance
8(iii)	$16\left(\frac{1}{2}\right)^2-80\left(\frac{1}{2}\right)+36=4$ and $16\left(\frac{9}{2}\right)^2-80\left(\frac{9}{2}\right)+36=4$	**B1**	verification using both *x* values or for forming and solving $16x^2-80x+36=0$
8(iv)	using *their* values from (ii) in an equality of the form $a\leqslant x\leqslant b$ or $a<x<b$	**M1**	
	$\frac{1}{2}\leqslant x\leqslant\frac{9}{2}$ cao	**A1**	
9(i)	$5+4\left(\sec^2\left(\frac{x}{3}\right)-1\right)$ leading to given answer	**B1**	use of correct identity
9(ii)	$3\tan\left(\frac{x}{3}\right)\quad(+c)$	**B1**	
9(iii)	attempt to integrate using (i) and/or (ii)	**M1**	
	Area = $\int_{\frac{\pi}{2}}^{\pi}4\sec^2\left(\frac{x}{3}\right)+1\,\mathrm{d}x$	**A1**	all correct
	$\left[12\tan\left(\frac{x}{3}\right)+x\right]_{\frac{\pi}{2}}^{\pi}$	**DM1**	correct method for evaluation using limits in correct order
	$=\left(12\tan\frac{\pi}{3}+\pi\right)-\left(12\tan\frac{\pi}{6}+\frac{\pi}{2}\right)$	**A1**	
	$=8\sqrt{3}+\frac{\pi}{2}$	**A1**	
10(a)	differentiation of a quotient or equivalent product	**M1**	
	correct differentiation of e^{3x}	**B1**	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{3\mathrm{e}^{3x}\left(4x^2+1\right)-8x\mathrm{e}^{3x}}{\left(4x^2+1\right)^2}$ or $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{3\mathrm{e}^{3x}}{4x^2+1}-\frac{8x\mathrm{e}^{3x}}{\left(4x^2+1\right)^2}$	**A1**	everything else correct including brackets where needed, allow unsimplified

Question	Answer	Marks	Guidance
10(b)(i)	one term differentiated correctly	**M1**	
	$\frac{dy}{dx} = -4\sin\left(x+\frac{\pi}{3}\right) + 2\sqrt{3}\cos\left(x+\frac{\pi}{3}\right)$	**A1**	all correct
	When $x = \frac{\pi}{2}$, $\frac{dy}{dx} = -5$	**A1**	
10(b)(ii)	$\frac{dy}{dx} \times \frac{dx}{dt} = \frac{dy}{dt}$ $-5 \times \frac{dx}{dt} = 10$ oe	**M1**	correct use of rates of change
	$\frac{dy}{dt} = -2$	**A1**	**FT** answer to (i)

Cambridge IGCSE

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Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/12**
Paper 1	**May/June 2017**
MARK SCHEME	
Maximum Mark: 80	

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nfww not from wrong working
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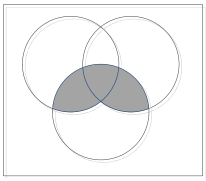
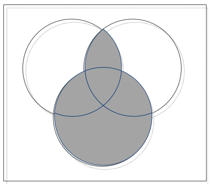
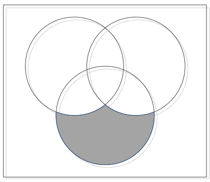
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1	 $(A \cup B) \cap C$  $(A \cap B) \cup C$  $(A' \cap B') \cap C$	**B3**	**B1** for each
2	attempt at differentiating a quotient, must have minus sign and $(x+1)^2$ in the denominator	**M1**	
	for $(5x^2+4)^{-\frac{1}{2}}$	**B1**	
	for $\frac{1}{2}(10x)(5x^2+4)^{-\frac{1}{2}}$	**DB1**	
	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{(x+1)\frac{1}{2}(10x)(5x^2+4)^{-\frac{1}{2}} - (5x^2+4)^{\frac{1}{2}}}{(x+1)^2}$	**A1**	all else correct
	When $x=3$, $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{11}{112}$	**A1**	must be exact
	Alternative $y = (5x^2+4)^{\frac{1}{2}}(x+1)^{-1}$	**M1**	attempt to differentiate a product
	for $(5x^2+4)^{-\frac{1}{2}}$	**B1**	
	for $\frac{1}{2}(10x)(5x^2+4)^{-\frac{1}{2}}$	**DB1**	
	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{2}10x(5x^2+4)^{-\frac{1}{2}}(x+1)^{-1} + (5x^2+4)^{\frac{1}{2}}\left(-(x+1)^{-2}\right)$	**A1**	all else correct
	When $x=3$, $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{11}{112}$	**A1**	A1 must be exact

Question	Answer	Marks	Partial Marks
3(a)	$\mathbf{v} = 3\sqrt{5}\times\frac{1}{\sqrt{5}}(\mathbf{i}-2\mathbf{j})$	**M1**	attempt to find the magnitude of $(\mathbf{i}-2\mathbf{j})$ and use
	$= 3\mathbf{i}-6\mathbf{j}$	**A1**	for $3\mathbf{i}-6\mathbf{j}$ only
3(b)	$\mathbf{w} = 2\cos 30^\circ\,\mathbf{i} + 2\sin 30^\circ\,\mathbf{j}$	**M1**	attempt to use trigonometry correctly to obtain components
	$= \sqrt{3}\mathbf{i}+\mathbf{j}$	**A1**	
4	$3^n - n3^{n-1}\left(\frac{x}{6}\right) + n(n-1)3^{n-2}\left(\frac{x}{6}\right)^2$ $3^n = 81$, so $n = 4$	**B1**	
	$4\times 3^3 \times -\frac{1}{6} = a$	**M1**	for $-n3^{n-1}\left(\frac{x}{6}\right)$, ${}^nC_1 3^{n-1}\left(-\frac{x}{6}\right)$ or $\binom{n}{1}3^{n-1}\left(-\frac{x}{6}\right)$, with/without *their n*
	$a = -18$	**A1**	using *their n* and equating to a to obtain $a = -18$
	$\frac{4\times 3}{2}\times 3^2 \times \frac{1}{36} = b$	**M1**	for $n(n-1)3^{n-2}\left(\frac{x}{6}\right)^2$, ${}^nC_2 3^{n-2}\left(\frac{x}{6}\right)^2$ or $\binom{n}{2}3^{n-2}\left(\frac{x}{6}\right)^2$, with/without *their n*
	$b = \frac{3}{2}$	**A1**	using *their n* and equating to b to obtain $b = \frac{3}{2}$
5(i)	$v = -12\sin 3t$	**B1**	
5(ii)	12	**B1**	**FT** on *their* (i) of the form $k\sin 3t$, must be $\lvert k\rvert$
5(iii)	$a = -36\cos 3t$	**B1**	allow unsimplified
	$3t = \frac{\pi}{2}$, 1.57 or better	**B1**	
	$t = \frac{\pi}{6}$ or 0.524	**B1**	
5(iv)	4 cao	**B1**	may be obtained from knowledge of cosine curve

Question	Answer	Marks	Partial Marks
6(i)	$\frac{1}{\sin\theta}\times\frac{1}{\frac{\cos\theta}{\sin\theta}+\frac{\sin\theta}{\cos\theta}}$	M1	for $\cot\theta=\frac{\cos\theta}{\sin\theta}$, $\tan\theta=\frac{\sin\theta}{\cos\theta}$, $\text{cosec}\,\theta=\frac{1}{\sin\theta}$
	dealing with the fractions correctly	M1	
	$\frac{1}{\sin\theta}\times\frac{\sin\theta\cos\theta}{\cos^2\theta+\sin^2\theta}$	M1	use of identity
	$=\cos\theta$	A1	correct simplification, with all correct
	Alternative 1 $\frac{\text{cosec}\,\theta}{\frac{1}{\tan\theta}\left(1+\tan^2\theta\right)}$	M1	dealing with fractions
	$=\frac{\tan\theta\,\text{cosec}\,\theta}{\sec^2\theta}$	M1	use of appropriate identity
	$=\frac{\sin\theta}{\cos\theta}\times\frac{1}{\sin\theta}\times\cos^2\theta$	M1	for $\cot\theta=\frac{1}{\tan\theta}$, $\tan\theta=\frac{\sin\theta}{\cos\theta}$, $\sec\theta=\frac{1}{\cos\theta}$, $\text{cosec}\,\theta=\frac{1}{\sin\theta}$
	$=\cos\theta$	A1	correct simplification, with all correct
	Alternative 2 $\frac{\text{cosec}\,\theta}{\frac{1}{\cot\theta}\left(\cot^2\theta+1\right)}$	M1	dealing with fractions
	$=\frac{\cot\theta\,\text{cosec}\,\theta}{\text{cosec}^2\theta}$	M1	use of appropriate identity
	$=\frac{\cot\theta}{\text{cosec}\,\theta}$ $=\frac{\cos\theta}{\sin\theta}\times\sin\theta$	M1	for $\cot\theta=\frac{\cos\theta}{\sin\theta}$, $\tan\theta=\frac{\sin\theta}{\cos\theta}$, $\text{cosec}\,\theta=\frac{1}{\sin\theta}$
	$=\cos\theta$	A1	correct simplification, with all correct

Question	Answer	Marks	Partial Marks
6(ii)	$\int_0^a \cos 2\theta \, d\theta = \left[\frac{1}{2}\sin 2\theta\right]_0^a$	B1	
	$\frac{1}{2}\sin 2a = \frac{\sqrt{3}}{4}$	M1	use of $\left[k\sin 2\theta\right]_0^a = \frac{\sqrt{3}}{4}$ to obtain $k\sin 2a = \frac{\sqrt{3}}{4}$
	$2a = \frac{\pi}{3}$	DM1	attempt to solve equation of the form $k\sin 2a = \frac{\sqrt{3}}{4}$, with $-1 \leqslant \frac{\sqrt{3}}{4k} \leqslant 1$, must have a correct order of operations dealing with the double angle
	$a = \frac{\pi}{6}$, 0.167π or better	A1	
7(i)	$\lg y = \lg A + bx$	B1	straight line form, may be implied by correct values of both A and b later
	Gradient = b,	M1	equating gradient to b
	$b = 3$	A1	
	Use of substitution into one of the following $2.2 = \lg A + 0.5b$ $3.7 = \lg A + b$ $158.489 = A \times 10^{0.5b}$ $5011.872 = A \times 10^{b}$ or equivalent valid method leads to $\lg A = 0.7$	M1	
	$A = 5,\ 5.01$ or $10^{0.7}$	A1	
	Alternative 1 $\lg y = \lg A + bx$	B1	straight line form, may be implied by correct work later
	$2.2 = \lg A + 0.5b$	M1	one correct equation
	$3.7 = \lg A + b$	A1	both equations correct
	attempt to solve 2 correct equations	M1	
	leading to $b = 3$ **and** $A = 5,\ 5.01$ or $10^{0.7}$	A1	

Question	Answer	Marks	Partial Marks
7(i)	**Alternative 2** $y = A\left(10^{bx}\right)$ $158.489 = A \times 10^{0.5b}$	**M1**	one correct equation
	$5011.872 = A \times 10^{b}$	**A1**	both correct
	$\dfrac{5011.872}{158.489} = 10^{0.5b}$	**M1**	attempt to solve 2 correct equations
	leading to $b = 3$	**A1**	correct b
	Use of substitution leads to $A = 5,\ 5.01$ or $10^{0.7}$	**A1**	correct A
7(ii)	Substitute A and b correctly into either $y = A\left(10^{0.6b}\right)$, $\lg y = \lg A + 0.6b$ or $\lg y = \lg A + 0.6\lg 10^{b}$ or using $\lg y = 1.8 + 0.7$	**M1**	correct statement using *their A* and *b* **correctly** in either equation or using $\lg y = 3x + 0.7$
	$y = 316$, 315 or $10^{2.5}$	**A1**	
7(iii)	Substitute A and b correctly into either $600 = A\left(10^{bx}\right)$, $\lg 600 = \lg A + bx$ or $\lg 600 = \lg A + x\lg 10^{b}$ or using $\lg 600 = 3x + 0.7$	**M1**	correct statement using *their A* and *b* **correctly** in either equation or using $\lg y = 3x + 0.7$
	$x = 0.693$	**A1**	
8(a)(i)	2520	**B1**	
8(a)(ii)	360	**B1**	
8(a)(iii)	1080	**B1**	
8(a)(iv)	6 or 8 to start with No of ways = $2 \times 5 \times 4 \times 3 \times 2$ = 240	**B1**	
	9 to start with No of ways = $1 \times 5 \times 4 \times 3 \times 3$ = 180	**B1**	
	Total number of ways = 420	**DB1**	Dependent on both previous B marks

Question	Answer	Marks	Partial Marks
8(a)(iv)	**Alternative 1** All numbers > 6000 – all odd numbers > 6000	**B1**	plan and attempt to use, must be using 1080
	1080 – 180 – 480	**B1**	for 180 and 480
	Total number of ways = 420	**DB1**	Dependent on both previous B marks
	Alternative 2 Even numbers > 60000 : Odd numbers > 60000 7 : 11	**B1**	correct ratio
	Total number of ways = $\frac{7}{18}\times 1080$	**B1**	
	= 420	**DB1**	Dependent on both previous B marks
8(b)(i)	480700	**B1**	
8(b)(ii)	26460	**B1**	
8(b)(iii)	With brother and sister ${}^{23}C_5 = 33649$	**B1**	for ${}^{23}C_5$ or ${}^{23}C_5 \times {}^kC_k$
	Without brother and sister ${}^{23}C_7 = 245157$	**B1**	for ${}^{23}C_7$ or ${}^{23}C_7 \times {}^kC_k$
	Total number of ways = 278806	**B1**	for ${}^{23}C_5 + {}^{23}C_7$ and evaluation
9(a)(i)	3×2	**B1**	
9(a)(ii)	correct attempt to multiply the 2 matrices	**M1**	
	$\mathbf{C} = \begin{pmatrix} 6 & -6 \\ 5 & 2 \\ 19 & -8 \end{pmatrix}$	**A2**	–1 for each incorrect element
9(b)(i)	$\mathbf{X}^{-1} = \frac{1}{13}\begin{pmatrix} -7 & 12 \\ -4 & 5 \end{pmatrix}$	**B2**	**B1** for correct use of determinant **B1** for correct matrix
9(b)(ii)	$\begin{pmatrix} x \\ y \end{pmatrix} = \frac{1}{13}\begin{pmatrix} -7 & 12 \\ -4 & 5 \end{pmatrix}\begin{pmatrix} 26 \\ 52 \end{pmatrix}$	**B1**	
	attempt to evaluate using inverse from (i) together with pre-multiplication to obtain a 2×1 matrix	**M1**	
	$x = 34,\ y = 12$	**A2**	**A1** for each
10(i)	0.5	**B1**	for 0.5 from correct work only

Question	Answer	Marks	Partial Marks
10(ii)	$15^2 = 8^2 + 8^2 - (2 \times 8 \times 8 \times \cos AOB)$ $AOB = 2.43075$ rads	**M1**	use of cosine rule (or equivalent) to obtain angle *AOB*.
	$DOC = AOB - 2(their\ AOD)$	**M1**	use of angle *AOD* and symmetry
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better in previous calculations
	Alternative 1 $15 = 2 \times 8 \times \sin\left(\frac{1 + DOC}{2}\right)$	**M1**	use of basic trigonometry
	use of $\frac{1 + 0.5DOC}{2}$	**M1**	may be implied
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better or 1.215 or better in previous calculations
	Alternative 2		
	$15^2 = 8^2 + 8^2 - (2 \times 8 \times 8 \times \cos AOB)$ $AOB = 2.43075$ rads $\angle AOB \times 8 =$ arc AB	**M1**	use of cosine rule (or equivalent) to obtain angle AOB.
	$\frac{\text{arc}AB - 8}{8} = \angle DOC$	**M1**	attempt at *DOC,* must be a complete method with *AOB* found
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better or 1.215 or better in previous calculations
	Alternative 3 Equating 2 different forms for the area of triangle *AOB* $\frac{15\sqrt{31}}{4} = \frac{1}{2} \times 8^2 \sin AOB$, $AOB = 2.43075$ rads	**M1**	using both different forms of the area of triangle *AOB*
	$DOC = AOB - 2(\text{their } AOD)$	**M1**	use of angle *AOD* and symmetry
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better in previous calculations

Question	Answer	Marks	Partial Marks
10(iii)	$\sin\left(\frac{1.43}{2}\right)=\frac{\frac{DC}{2}}{8}$ or $DC^2=8^2+8^2-(2\times8\times8\times\cos1.43)$	**M1**	use of cosine rule or basic trigomoetry to obtain DC
	$DC=10.49$	**A1**	awrt 10.5, may be implied
	Perimeter = $10.49+4+4+15$ = 33.5	**A1**	awrt 33.5
10(iv)	$\frac{1}{2}\times8^2(2.43-\sin2.43)-\frac{1}{2}\times8^2(1.431-\sin1.431)$	**B1**	area of one appropriate sector; allow unsimplified; may be implied by a correct segment
	area of one appropriate triangle, allow unsimplified	**B1**	
	an appropriate segment, allow unsimplified	**B1**	
	= 42.8 (allow awrt 42.8)	**B1**	final answer
	Alternative 1 Area of a trapezium + 2 small segments	**B1**	one appropriate small sector, allow unsimpified (could be doubled)
	Each small segment = $\frac{1}{2}\times8^2(0.5-\sin0.5)$	**B1**	an appropriate triangle, allow unsimplfied (could be doubled)
	Area of trapezium = $\frac{1}{2}(15+10.5)\times(6.041-2.784)$	**B1**	attempt at trapezium, must have a correct attempt at finding the distance between the parallel sides – allow unsimplified
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer
	Alternative 2 Area of 2 small sectors + area of triangle ODC – the area of triangle OAB Area of a small sector = $\frac{1}{2}\times8^2\times\frac{1}{2}$	**B1**	area of small sector, allow unsimplified, (could be doubled)
	Area of triangle ODC = $\frac{1}{2}\times8^2\times\sin1.43$	**B1**	area of triangle ODC, allow unsimplified
	Area of triangle OAB = $\frac{1}{2}\times8^2\times\sin2.43$	**B1**	area of triangle OAB, allow unsimplified
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer

Question	Answer	Marks	Partial Marks
10(iv)	**Alternative 3** Area of rectangle + 2 small triangles + 2 small segments Each small segment = $\frac{1}{2}\times 8^2\left(0.5-\sin 0.5\right)$	**B1**	area of a small segment, allow unsimplified, could be doubled
	$\frac{1}{2}\times\frac{\left(15-10.49\right)}{2}\left(6.041-2.784\right)$	**B1**	area of a small triangle, allow unsimplified, could be doubled
	Area of rectangle = $10.49\times\left(6.041-2.784\right)$	**B1**	allow unsimplified, could be doubled
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer
	Alternative 4 Sector *AOB* – sector *AOD* – sector *COB* – triangle *DOC*	**B1**	area of one appropriate sector; allow unsimplified; may be implied by a correct segment
	$\left(\frac{1}{2}\times 8^2\times 2.43\right)-2\left(\frac{1}{2}\times 8^2\times 0.5\right)-\left(\frac{1}{2}\times 8^2\sin 1.43\right)$ Area = sector *AOB* – segment *DC* – triangle *AOB*	**B1**	area of one appropriate triangle, allow unsimplified
	$\left(\frac{1}{2}\times 8^2\times 2.43\right)-\text{(their segment)}-\left(\frac{1}{2}\times 8^2\sin 2.43\right)$	**B1**	an appropriate segment, allow unsimplified
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer
11(i)	$m\mathrm{e}^{2x-1}$ where m is numeric constant	**M1**	
	$\mathrm{f}\left(x\right)=\frac{1}{2}\mathrm{e}^{2x-1}\quad\left(+c\right)$	**A1**	condone omission of +*c*
	$\frac{7}{2}=\frac{1}{2}+c$	**DM1**	correct attempt to find arbitrary constant
	$\mathrm{f}\left(x\right)=\frac{1}{2}\mathrm{e}^{2x-1}+3$	**A1**	must be an equation
11(ii)	$k\mathrm{e}^{2x-1}$ where *k* is a numeric constant	**M1**	
	$\mathrm{f}''\left(x\right)=2\mathrm{e}^{2x-1}$	**A1**	
	$2x-1=\ln\left(\frac{4}{k}\right)$	**DM1**	attempt to equate to 4 and use logarithms
	$x=\frac{1}{2}+\ln\sqrt{2}$	**A1**	

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2017**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

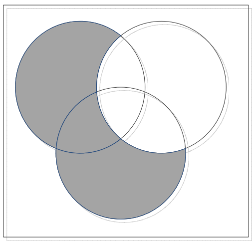
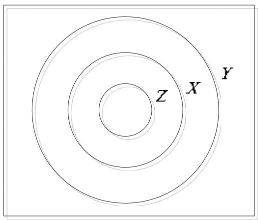
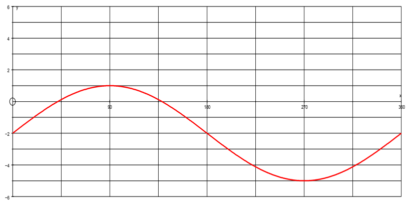
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1(a)		**1**	
1(b)		**1**	
2(i)	4	**1**	
2(ii)	40° or $\frac{2\pi}{9}$ or 0.698 rad	**1**	
3(i)		**3**	**B1** for a complete cycle starting and ending at –2 **B1** for max at $y = 1$ and min at $y = -5$ **B1** for a completely correct graph
3(ii)	5	**1**	**FT** *their* min value for y
4(i)	Area = $\frac{1}{2}\left(3+2\sqrt{5}\right)\left(4+6\sqrt{5}\right)$ $=\frac{1}{2}\left(12+26\sqrt{5}+60\right)$	**M1**	use of correct formula and attempt to expand out the brackets
	$=36+13\sqrt{5}$	**A1**	
4(ii)	$\frac{3+2\sqrt{5}}{2+3\sqrt{5}}$	**B1**	
	$=\frac{3+2\sqrt{5}}{2+3\sqrt{5}}\times\frac{2-3\sqrt{5}}{2-3\sqrt{5}}$	**M1**	
	$=\frac{6-5\sqrt{5}-30}{4-45}$ $=\frac{24+5\sqrt{5}}{41}$	**A1**	for answer

Question	Answer	Marks	Partial Marks
5	When $x = 4,\ y = 5$	**B1**	for y
	$\frac{dy}{dx} = \frac{1}{2} \times 4(4x+9)^{-\frac{1}{2}}$	**B1**	for $2(4x+9)^{-\frac{1}{2}}$, allow unsimplified
	When $x = 4,\ \frac{dy}{dx} = \frac{2}{5}$, so perp grad = $-\frac{5}{2}$	**M1**	obtaining numerical gradient for normal
	Equation of normal $y - 5 = -\frac{5}{2}(x - 4)$ $(2y = 30 - 5x)$	**M1**	for equation of normal
	$A(6,\ 0),\ B(0,\ 15)$	**A2**	**A1** for each
	Midpoint $\left(3,\ \frac{15}{2}\right)$	**B1**	**FT** on *their x*/*y* intercepts
6(a)(i)	dealing with multiplication and addition	**M1**	implied by 2 correct elements
	A + 3**C** = $\begin{pmatrix} -12 & 7 \\ 11 & 7 \end{pmatrix}$	**A1**	
6(a)(ii)	correct attempt to multiply	**M1**	implied by 2 correct elements
	BA = $\begin{pmatrix} 17 & 9 \\ 14 & 18 \\ -3 & -1 \end{pmatrix}$	**A1**	
6(b)(i)	$\mathbf{X}^{-1} = \frac{1}{10}\begin{pmatrix} -2 & 3 \\ -4 & 1 \end{pmatrix}$	**B2**	**B1** for $\frac{1}{10}$, **B1** for $\begin{pmatrix} -2 & 3 \\ -4 & 1 \end{pmatrix}$
6(b)(ii)	$\begin{pmatrix} a & b \\ c & d \end{pmatrix} = \frac{1}{10}\begin{pmatrix} -2 & 3 \\ -4 & 1 \end{pmatrix}\begin{pmatrix} 5 & -10 \\ 15 & 20 \end{pmatrix}$	**M1**	pre-multiplication using matrix from (b)(i)
	$= \begin{pmatrix} 3.5 & 8 \\ -0.5 & 6 \end{pmatrix}$	**A2**	–1 for each incorrect element

Question	Answer	Marks	Partial Marks
7(a)	LHS = $\dfrac{\dfrac{\sin^2\theta}{\cos^2\theta}+\sin^2\theta}{\cos\theta+\dfrac{1}{\cos\theta}}$	M1	for obtaining all in terms of $\sin\theta$ and $\cos\theta$
	$=\dfrac{\dfrac{\sin^2\theta+\sin^2\theta\cos^2\theta}{\cos^2\theta}}{\dfrac{\cos^2\theta+1}{\cos\theta}}$	M1	for simplification using addition of fractions
	$=\dfrac{\sin^2\theta\left(1+\cos^2\theta\right)}{\cos\theta\left(\cos^2\theta+1\right)}$ $=\dfrac{\sin^2\theta}{\cos\theta}$	M1	for factorisation and subsequent cancelling of common term
	$\tan\theta\sin\theta$ = RHS	A1	correct final simplification
	Alternative $\dfrac{\sec^2\theta-1-\cos^2\theta+1}{\cos\theta+\sec\theta}$	M1	use of correct identities
	$=\dfrac{(\sec\theta-\cos\theta)(\sec\theta+\cos\theta)}{(\sec\theta-\cos\theta)}$ $=\sec\theta-\cos\theta$	M1	attempt to factorise and simplify
	$=\dfrac{1-\cos^2\theta}{\cos\theta}$	M1	simplification to obtain terms in $\sin\theta$ and $\cos\theta$ only
	$=\dfrac{\sin^2\theta}{\cos\theta}$ $=\tan\theta\sin\theta$	A1	for final simplification
7(b)	$\sin\phi=\dfrac{x}{3},\ \cos\phi=\dfrac{3}{y}$	M1	for obtaining $\sin\phi$ and $\cos\phi$ in terms of x and y and attempt to use correct identity
	Using $\sin^2\phi+\cos^2\phi=1$ leads to $\dfrac{x^2}{9}+\dfrac{9}{y^2}=1$ and hence $x^2y^2+81=9y^2$	M1	attempt at simplification
	81	A1	

Question	Answer	Marks	Partial Marks
	Alternative method using substitution $\left(9\times\frac{9}{\cos^2\phi}\right)-\left(\frac{9}{\cos^2\phi}\times 9\sin^2\phi\right)$	**M1**	attempt to substitute in for x and y
	$=\left(\frac{81}{\cos^2\phi}\right)-\left(\frac{81\sin^2\phi}{\cos^2\phi}\right)$	**M1**	simplification of fractions
	$=\frac{81\left(1-\sin^2\phi\right)}{\cos^2\phi}$ or $81\left(\sec^2\phi-\tan^2\phi\right)$ leading to 81	**A1**	use of correct identity to obtain 81
8(i)	$\mathrm{p}\left(-\frac{1}{2}\right)=-\frac{2}{8}+\frac{a}{4}-2+b$	**M1**	for attempt at $\mathrm{p}\left(-\frac{1}{2}\right)$
	leading to $a+4b=9$ oe	**A1**	
	$\mathrm{p}(1)=2+a+4+b$ leading to $a+b=-18$ oe	**B1**	
	solution of simultaneous equations	**M1**	
	$a=-27,\ b=9$	**A1**	for both
8(ii)	attempt at factorisation using either long division or observation	**M1**	
	$(2x+1)\left(x^2-14x+9\right)$	**A1**	
8(iii)	attempt to solve q(x) = 0	**M1**	
	$x=7\pm2\sqrt{10},\ -\frac{1}{2}$	**A1**	for all 3 solutions
9(i)	$\left[3e^{5x}+e^{-5x}\right]_{-k}^{k}=6$	**B2**	**B1** for each term integrated correctly
	$\left(3e^{5k}+e^{-5k}\right)-\left(3e^{-5k}+e^{5k}\right)=6$	**M1**	for use of limits with $ae^{5x}+be^{-5x}$
	$2e^{5k}-2e^{-5k}=6$	**A1**	correct unsimplified
	$e^{5k}-e^{-5k}=3$	**A1**	correct simplification to obtain given answer

Question	Answer	Marks	Partial Marks
9(ii)	$y^2 - 3y - 1 = 0$	**M1**	for correct attempt to obtain a quadratic equation in terms of y or e^{5x}
	$y = \frac{3 \pm \sqrt{9+4}}{2}$, $y = e^{5k} = 3.303$ only	**DM1**	for attempt to solve quadratic equation and solve for k
	$k = 0.239$	**A1**	**A0** if more than one solution is given
10(i)	for attempt to differentiate a product	**M1**	
	$\frac{5}{5x+1}$	**B2**	**B1** for $\frac{1}{5x+1}$
	$\frac{dy}{dx} = (10x+2) \times \frac{5}{5x+1} + 10\ln(5x+1)$	**A1**	all else correct
10(ii)	$(10x+2) \times \frac{5}{5x+1} = 10$	**B1**	simplification to obtain 10, allow if seen in (i)
	$10\int \ln(5x+1)\, dx$ $= (10x+2)\ln(5x+1) - 10x$	**M1**	use of result from part (i)
	$\int \ln(5x+1)\, dx$ $= \frac{(5x+1)}{5}\ln(5x+1) - x$	**A1**	
10(iii)	$\left[(x+0.2)\ln(5x+1) - x\right]_0^{\frac{1}{5}}$	**M1**	use of limits in result from (ii)
	$= -\frac{1}{5} + \frac{2}{5}\ln 2 = \frac{-1+\ln 4}{5}$ cao	**A1**	
11(i)	attempt to differentiate	**M1**	
	$\frac{dy}{dx} = 6 - \frac{3}{2}x^{\frac{1}{2}}$	**A1**	
	When $\frac{dy}{dx} = 0$	**M1**	equating to zero and attempt to solve
	$x = 16,\ y = 32$	**A1**	both correct

Question	Answer	Marks	Partial Marks
11(ii)	$\frac{d^2y}{dx^2} = -\frac{3}{4}x^{-\frac{1}{2}}$	**B1**	correct differentiation
	This is negative so a maximum point	**DB1**	correct conclusion
11(iii)	When $x = 4$, $\frac{dy}{dx} = 3$	**B1**	
	$\partial y \approx \frac{dy}{dx} \times h$	**M1**	use of small increases
	$\approx 3h$	**A1**	**FT** *their* (iii)
12(i)	attempt to differentiate	**M1**	
	$6\cos 2t + 6$	**A1**	
12(ii)	$\cos 2t = -1$	**M1**	attempt to equate (i) to zero and solve
	$t = \frac{\pi}{2}$	**A1**	
12(iii)	attempt to integrate	**M1**	
	$x = -\frac{3}{2}\cos 2t + 3t^2 + 2t \quad (+c)$	**A2**	–1 for each error
	When $t = 0,\ x = 0$, so $c = \frac{3}{2}$	**M1**	attempt to find c
	$x = \frac{3}{2} - \frac{3}{2}\cos 2t + 3t^2 + 2t$	**A1**	

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ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2017**

MARK SCHEME

Maximum Mark: 80

Published

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MARK SCHEME NOTES

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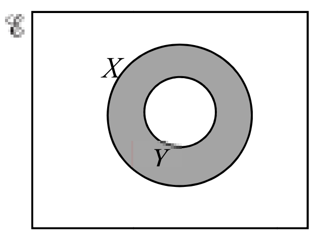
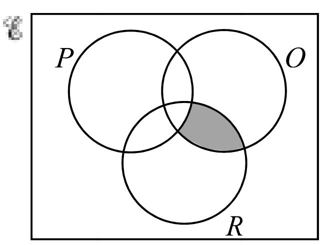
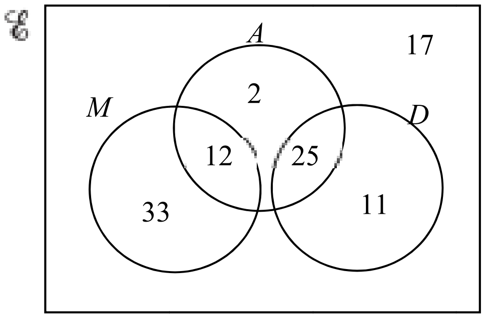
Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Guidance
1	Integrates	**M1**	must be clear attempt to integrate at least one term
	$[y=]x^4+x\,(+c)$	**A1**	Both terms correct
	$17=2^4+2+c$	**DM1**	Substitution of $x=2$, $y=17$ to find c
	$y=x^4+x-1$ cao	**A1**	must have $y=$
2(a)	$2\sqrt{6}\times3\sqrt{3}=6\sqrt{18}$ oe	**M1**	method must be shown – simplifies and combines product
	$18\sqrt{2}$	**A1**	If all over common denominator then consider the product for M1A1
	$9\sqrt{2}$ oe soi leading to final answer of $27\sqrt{2}$	**B1**	
2(b)	$[x=]\dfrac{6+\sqrt{3}}{2-\sqrt{3}}$	**M1**	Expanding and making x subject – condone slips but must be of equivalent difficulty
	$[x=]\dfrac{6+\sqrt{3}}{2-\sqrt{3}}\times\dfrac{2+\sqrt{3}}{2+\sqrt{3}}$ oe and multiplies out numerator and denominator	**M1**	numerator at least 3 terms; $12+2\sqrt{3}+6\sqrt{3}+3$
	$15+8\sqrt{3}$	**A1**	
3(i)	$\dfrac{2x}{x^2+1}$ final answer	**B2**	**B1** for $\dfrac{1}{x^2+1}\times(ax+b)$, a or b must be non-zero
3(ii)	$\delta y = their\left(\dfrac{2(3)}{(3)^2+1}\right)\times h$ or better	**M1**	Substitutes $x=3$ into *their* $\dfrac{dy}{dx}$ **and** multiplies by h
	$\dfrac{6}{10}h$ oe	**A1**	
4(a)(i)	36	**B1**	
4(a)(ii)	7	**B1**	
4(b)	$[y=]5\sin 4x+7$	**B4**	**B1** for each of 5, 4 and 7 and **B1** for sine Accept $a=5$, $b=4$, $c=7$ for **B3**

Question	Answer	Marks	Guidance
5(i)	$16+32ax+24a^2x^2+8a^3x^3+a^4x^4$	**B2**	**B1** for at most 2 terms incorrect or missing or for correct but unsimplified form **SC1** for $16+32ax+24ax^2+8ax^3+ax^4$ or all terms correct listed
5(ii)	$24a^2=8a^3$ and solves to given answer	**B1**	or verifies that $a = 3$ leads to coeff of 216 for both terms must be from correct terms in (i)
5(iii)	$x = -0.01$ or $ax = -0.03$ soi	**M1**	
	$16 + 32(3)(-0.01) + 24(9)(-0.01)^2$ leading to $16 - 0.96 + 0.0216$ or 15.06…isw	**A1**	Must show clear substitution into their expansion for A1 and reach a value which rounds to 15.1
6(i)	$(\mathbf{M}=)\begin{pmatrix}90 & 10 & 30\\ 0 & 45 & 0\\ 25 & 0 & 15\\ 10 & 0 & 100\end{pmatrix}$	**B1**	columns and/or rows may be interchanged but must be consistent
6(ii)	$(\mathbf{LM}=)\begin{pmatrix}1 & 1 & 1 & 1\end{pmatrix}\begin{pmatrix}90 & 10 & 30\\ 0 & 45 & 0\\ 25 & 0 & 15\\ 10 & 0 & 100\end{pmatrix}=\begin{pmatrix}125 & 55 & 145\end{pmatrix}$	**B1**	Answer must be of correct order and must be consistent with a correct **M**
6(iii)	The total numbers of each type of ticket sold by all 4 cinemas oe	**B1**	
6(iv)	$(\mathbf{N}=)\begin{pmatrix}5\\ 4\\ 3\end{pmatrix}$	**B1**	Calculation not required
	The **total** income of **all** (4) cinemas or other valid comment e.g. **total** income from **all** ticket sales	**B1**	**Total** cost/value of tickets etc.
7(a)		**B2**	**B1** for each
7(b)(i)	$\text{n}(M\cap D)=0$ or $M\cap D=\varnothing$	**B1**	No additional brackets e.g. $M\cap D=\{\varnothing\}$ is **B0**

Question	Answer	Marks	Guidance
7(b)(ii)		**B3**	**B1** correct intersection of circles with 12 and 25 correct **B1** 33, 2, 11 correctly placed **B1FT** 17; must be on the Venn diagram **and** identified as the required answer **FT** on 100– (sum of *their* 5 correctly positioned values)
8(a)	$\left[{}^{30}P_2 =\right]870$	**B1**	
8(b)(i)	${}^2C_1 \times {}^{14}C_{10}$ oe (2 × 1001)	**M1**	Condone $\begin{pmatrix}14\\4\end{pmatrix}$ for $\begin{pmatrix}14\\10\end{pmatrix}$
	2002	**A1**	implies **M1**
8(b)(ii)	$\left({}^2C_1 \times {}^5C_4 \times {}^9C_6\right) + \left({}^2C_1 \times {}^5C_5 \times {}^9C_5\right)$ oe (840 + 252) or ${}^2C_1 \times {}^{14}C_{10} - \left({}^2C_1 \times {}^5C_1 \times {}^9C_9 + {}^2C_1 \times {}^5C_2 \times {}^9C_8 + {}^2C_1 \times {}^5C_3 \times {}^9C_7\right)$ {2002 – (10 + 80 + 720)}	**M3**	**M3** for fully correct method soi **M2** for all necessary products but not summed with no extra products seen soi **M1** for one correct three term product soi
	1092	**A1**	implies **M3**
9(i)	Substitution of $y = 2(1-x)$	**M1**	Must be attempt at full substitution. Condone one sign error in substitution. Condone omission of = 0 or incorrect rhs
	$-3x^2 + 2x + 1 = 0$ oe $\left(3x^2 - 2x - 1 = 0\right)$	**A1**	Terms collected
	Solving *their* quadratic found from eliminating one variable $(3x+1)(1-x)$ or $(3x+1)(x-1)$	**M1**	can be implied by a correct pair of *x* values
	$\left(-\frac{1}{3}, \frac{8}{3}\right)$ oe and $(1, 0)$ oe isw nfww	**A2**	**A1** for each or **A1** for a correct pair of *x*-coordinates or a correct pair of *y*-coordinates

Question	Answer	Marks	Guidance
9(ii)	$[m=]\frac{1}{2}$ cao	**B1**	
	$\left(\frac{1}{3}, \frac{4}{3}\right)$	**B1**	**FT**
	$y - their\frac{4}{3} = their\frac{1}{2}\left(x - their\frac{1}{3}\right)$	**M1**	or $y = their\frac{1}{2}x + c$ and substitutes their midpoint and reaches $c = \ldots$
	$6y - 3x = 7$	**A1**	allow any equivalent form with integer coeffs/constant
10(i)	t: 1, 1.5, 2, 2.5; ln$P$: 1.48, 2.12, 2.76, 3.4(0)	**M1**	allow ln$P$ values to 1 dp rounded or truncated (1.5, 2.1, 2.8, 3.4)
	single ruled line drawn within tolerance at least for t between 1 and 2.5	**A1**	All points within 1 square of line / must **not** pass through origin
10(ii)	$e^{their 3}$	**M1**	
	18 to 22.2	**A1**	
10(iii)	(0, c) with $0.1 \leqslant c \leqslant 0.3$ (0.2)	**B1**	allow $y = c$ condone $c = \ldots$
	m in the range $1.25 \leqslant m \leqslant 1.34$ (1.28)	**B1**	
10(iv)	$\ln P = (their 1.28)t + their 0.2$	**M1**	or $\ln P = (\ln b)t + \ln a$
	$P = e^{(their 1.28)t + their 0.2}$	**M1**	or $\ln b = m = their 1.28$ and $\ln a = c = their 0.2$
	$P = e^{their 0.2}e^{(their 1.28)t}$	**A1**	or $1.10 \leqslant a \leqslant 1.35$ $3.49 \leqslant b \leqslant 3.82$
10(v)	$1000 * e^{their 0.2} \times e^{their 1.28t}$ or $1000 * their\ a \times their\ b^t$	**M1**	A correct relationship e.g. $1.3t * \ln(1000) - 0.2$ where * is = or an inequality sign
	5.3	**A1**	5.2 to 5.5 must be to 1dp

Question	Answer	Marks	Guidance
11(i)	$\frac{\cos x}{\sin x}+\frac{\sin x}{\cos x}=\frac{\cos^2 x+\sin^2 x}{\sin x\cos x}$ oe	B2	**B1** for either $\cot x=\frac{\cos x}{\sin x}$ or $\tan x=\frac{\sin x}{\cos x}$ used **B1** for correctly placing over a common denominator or for splitting into 3 correct terms **not** just for stating or working from both sides
	Valid use of Pythagorean identity e.g. $\cos^2 x+\sin^2 x=1$	B1	
	Simplification to sec*x* (correct solution only)	B1	**not** if working from both sides
11(ii)	$\cos x=\frac{1}{2}$ soi	M1	
	60, 300	A1	Correct pair
	$\cos x=-\frac{1}{2}$ soi	M1	
	120, 240	A1	Correct pair
12(i)	$\left[v=\frac{\mathrm{d}(3t-\cos 5t+1)}{\mathrm{d}t}=\right]3+5\sin 5t$	B2	**B1** for either with no other terms or for both with 1 extra
	their $(3+5\sin 5t)=0$	M1	Must be from an attempt to differentiate
	awrt 0.76	A1	0.7570187525
	awrt 1.13	A1	1.12793684
	substitutes *their t* values into *s* (4.07…, 3.58…)	DM1	must be two values
	0.48 to 0.49 [m]	A1	Final **A1** may imply earlier **A1**s
12(ii)	25cos 5*t*	M1	Differentiating *their v* correctly providing at least 2 terms with one trig function
	–25	A1	Ignore +25 following –25

Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **May/June 2017**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation 'dep' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1	$5x + 3 = 3x - 1$ oe or $5x + 3 = 1 - 3x$ oe	**M1**	
	$x = -2$ and $x = -0.25$ only mark final answer	**A2**	nfww **A1** for $x = -2$ ignoring extras implies M1 if no extras seen If M0 then **SC1** for any correct value with at most one extra value
	Alternative method $(5x+3)^2 = (1-3x)^2$ oe soi	**M1**	
	$16x^2 + 36x + 8 = 0$ oe	**A1**	
	$x = -0.25$, $x = -2$ only; mark final answer	**A1**	
2	**Without using a calculator…** Sufficient evidence must be seen to be convinced that a calculator has not been used. Withhold the mark for any step that is unsupported.		
	deals with the negative index soi	**B1**	e.g. $\left(\frac{3-\sqrt{5}}{1+\sqrt{5}}\right)^2$
	rationalises $\frac{3-\sqrt{5}}{1+\sqrt{5}} \times \frac{1-\sqrt{5}}{1-\sqrt{5}}$ oe	**M1**	allow for $\frac{1+\sqrt{5}}{3-\sqrt{5}} \times \frac{3+\sqrt{5}}{3+\sqrt{5}}$
	multiplies out correctly $\frac{3-4\sqrt{5}+5}{1-5}$ oe	**A1**	allow for $\frac{3+4\sqrt{5}+5}{9-5}$
	squares correct binomial $\left(-2+\sqrt{5}\right)^2 = \left(4-4\sqrt{5}+5\right)$ oe	**A1**	allow for $\left(2+\sqrt{5}\right)^2 = \left(4+4\sqrt{5}+5\right)$
	$9-4\sqrt{5}$ cao	**A1**	dep on all previous marks awarded

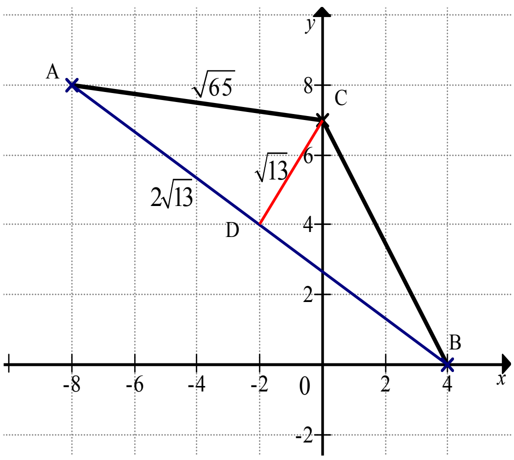
Question	Answer	Marks	Partial Marks
2	**Alternative method 1:** dealing with the negative index soi	B1	
	correctly squaring with at least 3 terms in the numerator and denominator $\frac{3-\sqrt{5}}{1+\sqrt{5}}\times\frac{3-\sqrt{5}}{1+\sqrt{5}}=\frac{9-6\sqrt{5}+5}{1+2\sqrt{5}+5}$ oe	B1	
	rationalising *their* $\left(\frac{14-6\sqrt{5}}{6+2\sqrt{5}}\times\frac{6-2\sqrt{5}}{6-2\sqrt{5}}\right)$ oe	M1	
	multiplying out correctly; at least 3 terms in the numerator but condone a single value for the denominator $\frac{84-64\sqrt{5}+60}{36-20}$ oe	A1	
	$9-4\sqrt{5}$ cao	A1	
	Alternative method 2 dealing with the negative index soi	B1	
	$9-6\sqrt{5}+5=\left(a+b\sqrt{5}\right)\left(1+2\sqrt{5}+5\right)$	M1	
	$14=6a+10b$ $-6=2a+6b$ oe	A1	
	$a=9$ cao	A1	
	$b=-4$ cao	A1	
	Alternative method 3 for dealing with the negative index soi	B1	
	[$3-\sqrt{5}=\left(c+d\sqrt{5}\right)\left(1+\sqrt{5}\right)$ leading to] $c+5d=3$ $c+d=-1$	M1	
	$c=-2$ and $d=1$	A1	
	$\left(-2+\sqrt{5}\right)^2=4-4\sqrt{5}+5$	A1	
	$9-4\sqrt{5}$ cao	A1	

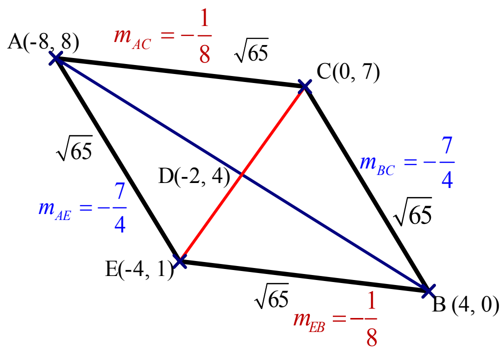
Question	Answer	Marks	Partial Marks
3	Correctly finding a correct linear factor or root	**B1**	from a valid method, e.g. factor theorem used or long division or synthetic division: $\mathrm{f}(2) = 10(2^3) - 21(2^2) + 4 = 0$ or $x-2 \overline{)\,10x^3 - 21x^2 \quad + 4}$ giving quotient $10x^2 - x - 2$: $\underline{10x^3 - 20x^2}$ $-x^2$ $\underline{-x^2 + 2x}$ $-2x + 4$ $\underline{-2x + 4}$ 0 or $\begin{array}{c\|cccc} 2 & 10 & -21 & 0 & 4 \\ & \downarrow & 20 & -2 & -4 \\ \hline & 10 & -1 & -2 & 0 \end{array}$
	correct linear factor stated or implied by, e.g. $(x-2)(10x^2 - x - 2)$	**B1**	$(x-2)$ or $(2x-1)$ or $(5x+2)$ do not allow $\left(x - \frac{1}{2}\right)$ or $\left(x + \frac{2}{5}\right)$
	Correct quadratic factor $(10x^2 - x - 2)$ or $(5x^2 - 8x - 4)$ or $(2x^2 - 5x + 2)$	**B2**	found using any valid method; **B1** for any 2 terms correct
	$(x-2)(2x-1)(5x+2)$ mark final answer	**B1**	must be written as a correct product of all 3 linear factors; only award the final **B1** if **all** previous marks have been awarded
			If quadratic factor is not found but correct remaining linear factors are found using e.g. the factor theorem or long division or synthetic division etc. with correct, sufficient, complete working to justify that no calculator has been used allow: **B1** for correctly finding a correct linear factor or root **B1** for a correct linear factor stated or implied **SC3** for the full, complete and correct working to find the remaining two linear factors and arrive at the correct product of 3 linear factors

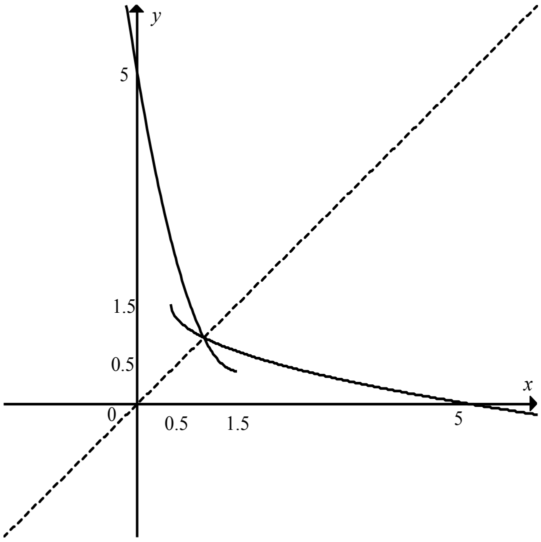
Question	Answer	Marks	Partial Marks
4	$\frac{dy}{dx} = 6x - 7$ soi	**B1**	
	$m_{normal} = -\frac{1}{5}$ soi	**B1**	finds or uses correct gradient of normal
	$m_{tangent} = 5$ soi or $(6x-7)\left(-\frac{1}{5}\right) = -1$ oe	**M1**	uses $m_1 m_2 = -1$ with numerical gradients
	$6x - 7 = 5$ oe $\Rightarrow x = 2$	**A1**	
	$y = 9$	**A1**	
	$k = 47$	**A1**	
	Alternative method $m_{normal} = -\frac{1}{5}$	**B1**	
	$m_{tangent} = 5$	**M1**	
	$3x^2 - 12x + 11 - c = 0$ oe	**A1**	
	solving $3x^2 - 12x + 12 = 0$ oe to find $x = 2$	**A1**	
	$y = 9$	**A1**	
	$k = 47$	**A1**	
5(i)	$\left(their\,2x^4\right)(0.2 - \ln 5x) + 0.4x^5\left(their\,\frac{-5}{5x}\right)$ oe or $their\,0.4x^4 - \left(\left(their\,2x^4\right)\ln 5x + 0.4x^5\left(their\,\frac{5}{5x}\right)\right)$ oe	**M1**	clearly applies correct form of product rule
	$-2x^4 \ln 5x$ isw	**A1**	nfww
5(ii)	$3\ln 5x$ or $\ln 5x + \ln 5x + \ln 5x$	**B1**	

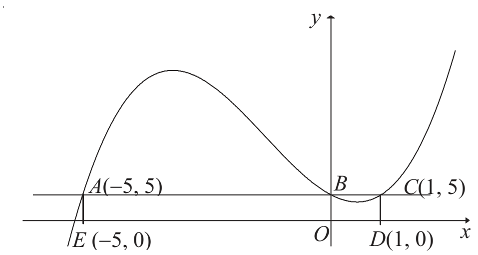
Question	Answer	Marks	Partial Marks
5(iii)	$\frac{3}{-2}\int\left(-2x^4\ln 5x\right)\mathrm{d}x$ oe	M1	**FT** $k = 2$ from (i) allow for $\frac{3}{2}\int\left(2x^4\ln 5x\right)\mathrm{d}x$ or, when $k = -2$, for $\int\left(x^4\ln 5x\right)\mathrm{d}x = -0.2x^5(0.2-\ln 5x)$ or $-\frac{2}{3}\int\left(3x^4\ln 5x\right)\mathrm{d}x = 0.4x^5(0.2-\ln 5x)$ oe or, when FT $k = 2$, for $\int\left(x^4\ln 5x\right)\mathrm{d}x = 0.2x^5(0.2-\ln 5x)$ or $\frac{2}{3}\int\left(3x^4\ln 5x\right)\mathrm{d}x = 0.4x^5(0.2-\ln 5x)$ oe
	$-\frac{3}{2}\left(0.4x^5(0.2-\ln 5x)\right)[+c]$ oe isw cao	A1	nfww; implies M1 An answer of $0.6x^5(0.2-\ln 5x)$ following $k = 2$ from (i) implies M1 A0
6	Uses b^2-4ac	M1	
	$(p-q)^2-4(p)(-q)$	A1	implies **M1**
	$p^2+2pq+q^2$	M1	correctly simplifies
	$(p+q)^2 \geqslant 0$ oe cao isw	A1	
	Alternative method $(px-q)(x+1)$ $[=0]$ or $\frac{-(p-q)\pm\sqrt{(p+q)^2}}{2p}$	M2	or **M1** for $(px+q)(x-1)$ $[=0]$ or $\frac{-(p-q)\pm\sqrt{(p-q)^2-4(p)(-q)}}{2p}$
	$x=\frac{q}{p}$, $x=-1$	A1	
	for conclusion, e.g. p and q are real therefore $\frac{q}{p}$ is real [and –1 is real]	A1	
7(a)(i)	7	B1	
7(a)(ii)	$\frac{1}{7}$ or $\frac{1}{their7}$	B1	**FT** *their* 7 must not be 1 if following through

Question	Answer	Marks	Partial Marks
7(b)	$y = 81^{-\frac{1}{4}}$ or $y = 3^{-1}$ or $y = 9^{-\frac{1}{2}}$ oe	**M1**	Anti-logs
	$y = \frac{1}{3}$ only or 0.333[3….] only	**A1**	nfww; implies the M1; $y =$ …. must be seen at least once If M0 then **SC1** for e.g. $81^{-\frac{1}{4}} = \frac{1}{3}$ as final answer
7(c)	$\frac{2^{5(x^2-1)}}{(2^2)^{x^2}}$ oe or $\frac{4^{\frac{5}{2}(x^2-1)}}{4^{x^2}}$ oe or $\frac{32^{x^2} \times 32^{-1}}{4^{x^2}}$ or $\log 32^{x^2-1} - \log 4^{x^2} = \log 16$ oe	**B1**	converts the terms given left hand side to powers of 2 or 4; may have cross-multiplied or separates the power in the numerator correctly or applies a correct log law
	$2^{3x^2-5} = 16$ oe $\Rightarrow 3x^2 - 5 = 4$ oe or $4^{\frac{3}{2}x^2-\frac{5}{2}} = 16$ oe $\Rightarrow \frac{3}{2}x^2 - \frac{5}{2} = 2$ oe or $\frac{8^{x^2}}{32} = 16$ oe $\Rightarrow x^2 \log 8 = \log 512$ oe or $(x^2 - 1)\log 32 - x^2 \log 4 = \log 16$ oe	**M1**	combines powers and takes logs or equates powers; or brings down all powers for an equation already in logs condone omission of necessary brackets for M1; condone one slip
	$[x =] \pm\sqrt{3}$ isw cao or ± 1.732050... rot to 3 or more figs. isw	**A1**	
8(i)	$y - 8 = -\frac{8}{12}(x - (-8))$ oe isw or $y[-0] = -\frac{8}{12}(x - 4)$ oe isw or $3y = -2x + 8$ oe isw	**B2**	**B1** for $m_{AB} = -\frac{8}{12}$ oe or **M1** for $\frac{8-0}{-8-4}$ oe
8(ii)	$(-8-4)^2 + (8[-0])^2$ oe	**M1**	any valid method
	$\sqrt{208}$ isw or $4\sqrt{13}$ isw or 14.4222051… rot to 3 or more sf	**A1**	implies **M1** provided nfww

Question	Answer	Marks	Partial Marks
8(iii)	[coordinates of D =] (–2, 4) soi	**B1**	If coordinates of D not stated then a calculation for m_{CD} or a relevant length with the coordinates clearly embedded must be shown to imply **B1**
	Gradient methods: $\left[m_{CD} = \frac{7 - their4}{0 - their(-2)} = \right]$ $their\left(\frac{3}{2}\right)$ 	**M1**	or **Length of sides methods:** finds or states $AC^2 = 65$ or $AC = \sqrt{65}$ or $AC^2 = (-8-0)^2 + (8-7)^2$ oe or $AC = \sqrt{(-8-0)^2 + (8-7)^2}$ oe **and** $CD^2 = their13$ or $CD = their\sqrt{13}$ or $CD^2 = (0 - their(-2))^2 + (7 - their4)^2$ oe or $CD = \sqrt{(0 - their(-2))^2 + (7 - their4)^2}$ oe **and** $AD^2 = their52$ or $AD = their2\sqrt{13}$ or $AD^2 = (-8 - their(-2))^2 + (8 - their4)^2$ or $AD = \sqrt{(-8 - their(-2))^2 + (8 - their4)^2}$ or uses a valid method with *their* coordinates of D to find the exact area of the triangle and equates to $\frac{1}{2}(AD)(CD)\sin(ADC)$
	states $\frac{3}{2} \times \left(-\frac{8}{12}\right) = -1$ oe or $\frac{3}{2}$ is the negative reciprocal of $-\frac{2}{3}$ oe or finds the equation of the perpendicular bisector of AB as $y = \frac{3}{2}x + 7$ independently of C and states that C lies on this line.	**A1**	applies Pythagoras to confirm, using integer values, that 65 = 13 + 52 or finds e.g. $AC = \sqrt{65}$ using $\sqrt{(2\sqrt{13})^2 + (\sqrt{13})^2}$ or solves $\frac{1}{2}(2\sqrt{13})(\sqrt{13})\sin ADC = 13$ or $(\sqrt{65})^2 = (2\sqrt{13})^2 + (\sqrt{13})^2 - 2(2\sqrt{13})(\sqrt{13})\cos ADC$ to show ADC is a right angle
8(iv)	$\begin{pmatrix} -4 \\ 1 \end{pmatrix}$ or $-4\mathbf{i} + \mathbf{j}$	**B1**	condone coordinates

Question	Answer	Marks	Partial Marks
8(v)	Full valid method e.g. for **showing** that e.g. $\overrightarrow{CB}=\begin{pmatrix}4\\0\end{pmatrix}-\begin{pmatrix}0\\7\end{pmatrix}=\begin{pmatrix}4\\-7\end{pmatrix}$ or **showing** that e.g. $\overrightarrow{AC}=\begin{pmatrix}0\\7\end{pmatrix}-\begin{pmatrix}-8\\8\end{pmatrix}=\begin{pmatrix}8\\-1\end{pmatrix}$ oe **and** $\overrightarrow{EB}=\begin{pmatrix}4\\0\end{pmatrix}-\begin{pmatrix}-4\\-1\end{pmatrix}=\begin{pmatrix}8\\-1\end{pmatrix}$ oe or comparing gradients of both pairs of opposite sides and showing they are pairwise the same or comparing the lengths of both pairs of opposite sides and showing that they are pairwise the same or showing that length AC = length AE or that the length BC = length BE or comparing the gradients and lengths of a pair of opposite sides or showing that D is the midpoint of CE or showing that length DC = length DE and that C, D and E are collinear	**B2**	**B1** for incomplete method e.g. for **stating** that $\overrightarrow{CB}=\begin{pmatrix}4\\-7\end{pmatrix}$ or $\overrightarrow{AC}=\begin{pmatrix}8\\-1\end{pmatrix}=\overrightarrow{EB}$ or just showing that one pair of opposite sides is parallel or has the same length or just showing that length DC = length DE or just showing that C, D and E are collinear 
9(i)	$2(x-1.5)^2+0.5$ isw	**B3**	or **B3** for $a=2$ and $b=1.5$ and $c=0.5$ provided not from wrong format isw or **B2** for $2(x-1.5)^2+c$ where $c\neq 0.5$ or $a=2$ and $b=1.5$ or **SC2** for $2(x-1.5)+0.5$ or $2\left((x-1.5)^2+\frac{1}{4}\right)$ seen or **B1** for $(x-1.5)^2$ seen or for $b=1.5$ or for $c=0.5$ or **SC1** for 3 correct values seen in incorrect format e.g. $2(x-1.5x)+0.5$ or $2(x^2-1.5)+0.5$

Question	Answer	Marks	Partial Marks
9(ii)		**B3**	**B1** for correct graph for f over correct domain or correct graph for f – 1 over correct domain **B1** for vertex marked for f or f – 1 and intercept marked for f or f – 1 **B1** for idea of symmetry – either symmetrical by eye, ignoring any scale or line $y = x$ drawn and labelled Maximum of 2 marks if not fully correct
9(iii)	$\frac{x-0.5}{2} = (y-1.5)^2$	**M1**	**FT** *their a,b,c*, provided *their a* ≠1 and *a,b,c* are all non-zero constants or $\frac{y-0.5}{2} = (x-1.5)^2$ and reverses variables at some point
	$f^{-1}(x) = 1.5 - \sqrt{\frac{x-0.5}{2}}$ oe	**A1**	must have selected negative square root only; condone $y = ...$ etc.; must be in terms of x
			If M0 then **SC2** for $f^{-1}(x) = \frac{6-\sqrt{8x-4}}{4}$ oe or **SC1** for $f^{-1}(x) = \frac{-(-6) \pm \sqrt{36-4(2)(5-x)}}{2(2)}$ oe
	$x \geqslant \frac{1}{2}$ oe	**B1**	
10(i)	$\sin^{-1}\left(\frac{3}{4}\right)$ soi	**M1**	implied by 0.848[06…]
	0.848[06…] rot to 3 or more figs or 2.29[35…] rot to 3 or more figs	**M1**	implied by a correct answer of acceptable accuracy
	0.544 486... rot to 3 or more figs isw	**A1**	
	1.03 or 1.02630... rot to 4 or more figs isw	**A1**	Maximum 3 marks if extra angles in range; no penalty for extra values outside range $0 \leqslant x \leqslant \frac{\pi}{2}$

Question	Answer	Marks	Partial Marks
10(ii)	Correctly uses $\tan^2 y = \sec^2 y - 1$ and/or $\frac{\sin y}{\cos y}$ **and** $\sin^2 y = 1 - \cos^2 y$	**M1**	for using correct relationship(s) to find an equation in terms of a single trigonometric ratio
	$3\sec^2 y - 14\sec y - 5 = 0$ $\Rightarrow (3\sec y + 1)(\sec y - 5)$ or $5\cos^2 y + 14\cos y - 3 = 0$ $\Rightarrow (5\cos y - 1)(\cos y + 3)$	**DM1**	for factorising or solving their 3-term quadratic dependent on the first M1 being awarded
	$[\cos y = -3]$ $\cos y = \frac{1}{5}$	**A1**	
	78.5 or 78.4630... rot to 2 or more decimal places isw	**A1**	
	281.5 or 281.536.... rot to 2 or more decimal places isw	**A1**	Maximum 4 marks if extra angles in range; no penalty for extra values outside range $0 \leqslant x \leqslant 360$
11(i)	$\frac{x^4}{4} + \frac{4x^3}{3} - \frac{5x^2}{2} + 5x\,[+c]$ isw	**B2**	**B1** for any 3 correct terms
11(ii)	$x^3 + 4x^2 - 5x + 5 = 5$ and rearrange to $x(x^2 + 4x - 5) = 0$ oe soi	**B1**	
	Solves *their* $x^2 + 4x - 5\,[=0]$ soi	**M1**	
	$x = -5$, $x = 1$ soi	**A1**	
	$OEAB = 25$, $OBCD = 5$	**A1**	

Question	Answer	Marks	Partial Marks
11(iii)	Correct or correct **FT** substitution of 0, *their* –5 seen in $\left[\frac{x^4}{4}+\frac{4x^3}{3}-\frac{5x^2}{2}+5x\right]_{their-5}^{0}$	**M1**	dependent on at least **B1** in (i)
	Correct or correct **FT** substitution of *their* 1, 0 seen in $\left[\frac{x^4}{4}+\frac{4x^3}{3}-\frac{5x^2}{2}+5x\right]_{0}^{their1}$	**M1**	dependent on at least **B1** in (i)
	$their\frac{1175}{12}-theirOEAB+theirOBCD-their\frac{49}{12}$ oe	**M1**	for the strategy needed to combine the areas; may be in steps; $97.91\dot{6}-25+5-4.08\dot{3}$
	$\frac{886}{12}$ oe or $73\frac{5}{6}$ oe or $73.8\dot{3}$ rot to 3 or more sig figs	**A1**	all method steps must be seen; not from wrong working If M0 then allow **SC3** for $\int_{-5}^{0}(x^3+4x^2-5x)\,dx-\int_{0}^{1}(x^3+4x^2-5x)\,dx$ oe $=\left[\frac{x^4}{4}+\frac{4x^3}{3}-\frac{5x^2}{2}\right]_{-5}^{0}-\left[\frac{x^4}{4}+\frac{4x^3}{3}-\frac{5x^2}{2}\right]_{0}^{1}$ $=\left[0-\left(\frac{625}{4}-\frac{500}{3}-\frac{125}{2}\right)\right]-\left[\left(\frac{1}{4}+\frac{4}{3}-\frac{5}{2}\right)-0\right]$ $=\frac{443}{6}$ oe or **SC2** for $\int_{their(-5)}^{0}(x^3+4x^2-5x)\,dx-\int_{0}^{their1}(x^3+4x^2-5x)\,dx$ oe $=\left[\frac{x^4}{4}+\frac{4x^3}{3}-\frac{5x^2}{2}\right]_{their(-5)}^{0}-\left[\frac{x^4}{4}+\frac{4x^3}{3}-\frac{5x^2}{2}\right]_{0}^{their1}$ $=[F(0)-F(their(-5))]-[F(their1)-F(0)]$
12(i)	$-6(2x+1)^{-2}$ or $\frac{-6}{(2x+1)^2}$ oe isw	**B1**	Allow $-3(2x+1)^{-2}\times 2$ or $\frac{-3\times 2}{(2x+1)^2}$ oe
	Denominator or $(2x+1)^2$ is positive [and numerator negative therefore $g'(x)$ is always negative] oe	**B1**	**FT** *their* $g'(x)$ of the form $\frac{-k}{(2x+1)^2}$ oe where $k>0$; Allow $(2x+1)^{-2}$ is always positive
12(ii)	$g>0$	**B1**	
12(iii)	$\frac{3k}{2x+1}+3$ oe isw	**B1**	

Question	Answer	Marks	Partial Marks
12(iv)	$\frac{3k}{2(0)+1}+3=5$	**B1**	
	$k=\frac{2}{3}$ isw	**B1**	implies the first **B1**
12(v)	$x>-\frac{1}{2}$	**B1**	

Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/23**
Paper 2	**May/June 2017**
MARK SCHEME	
Maximum Mark: 80	

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1(a)	$\log_7 2.5 = 2x+5$ or $\log_7\left(\frac{2.5}{7^5}\right) = 2x$ or $(2x+5)\log 7 = \log 2.5$	**M1**	correct first anti-logging step
	$[x=]\frac{\log_7 2.5 - 5}{2}$ or $\frac{1}{2}\log_7\left(\frac{2.5}{7^5}\right) = x$ or $x = \frac{1}{2}\left(\frac{\log 2.5}{\log 7} - 5\right)$	**M1**	isolates *x*
	–2.26(4...)	**A1**	
1(b)	$5^2 p^{-3} q^{\frac{5}{4}}$ oe	**B3**	**B1** for each term If B0 then allow **M1** for numerator of $125q^{\frac{3}{2}}$ or denominator of $5p^3q^{\frac{1}{4}}$
2(i)	*B* and *C* with valid reason	**B2**	**B1** for one graph and valid reason or both graphs and no reason
2(ii)	*B* only with valid reason	**B2**	**B1** for graph *B* or valid reason
3	$[m=]\frac{13-5}{1-0.2}$ or 10 soi	**M1**	or $13 = m + c$ and $5 = 0.2m + c$ and subtracting/substituting to solve for *m* or *c,* condone one error
	$Y - 13 = \textit{their }10(X-1)$ or $Y - 5 = \textit{their }10(X - 0.2)$ or $13 = \textit{their }10 + c$ or $5 = \textit{their }10 \times 0.2 + c$	**M1**	or using *their m* or *their c* to find *their c* or *their m*, without further error
	$\sqrt[3]{y} = (\textit{their } m)\frac{1}{x} + (\textit{their } c)$ or $\sqrt[3]{y} = (\textit{their } m)\left(\frac{1}{x} - 1\right) + 13$ or $\sqrt[3]{y} = (\textit{their } m)\left(\frac{1}{x} - 0.2\right) + 5$	**M1**	*their m* and *c* must be validly obtained
	$y = \left(\frac{10}{x} + 3\right)^3$ or $y = \left(10\left(\frac{1}{x} - 1\right) + 13\right)^3$ or $y = \left(10\left(\frac{1}{x} - 0.2\right) + 5\right)^3$ cao, isw	**A1**	

Question	Answer	Marks	Guidance
4(a)(i)	$\begin{pmatrix} -4 \\ 3 \end{pmatrix}$	**B1**	
4(a)(ii)	$\sqrt{11^2+(-15)^2}$ or better	**M1**	
	$\frac{1}{\sqrt{346}}\begin{pmatrix} 11 \\ -15 \end{pmatrix}$	**A1**	
4(b)	$\overrightarrow{OR}=\overrightarrow{OP}+\frac{3}{4}\overrightarrow{PQ}$ soi	**M1**	or $\overrightarrow{OR}=\overrightarrow{OQ}-\frac{1}{4}\overrightarrow{PQ}$ soi
	$\left[\overrightarrow{OR}=\right]\mathbf{p}+\frac{3}{4}(\mathbf{q}-\mathbf{p})$	**M1**	or $\left[\overrightarrow{OR}=\right]\mathbf{q}-\frac{1}{4}(\mathbf{q}-\mathbf{p})$
	$\left[\overrightarrow{OR}=\right]\frac{1}{4}\mathbf{p}+\frac{3}{4}\mathbf{q}$ oe	**A1**	
5(a)	$(9\times8\times7\times6\times1)+(8\times8\times7\times6\times1)$ soi	**M2**	**M1** for one correct product of the sum
	5712	**A1**	
5(b)	${}^9C_4\times{}^5C_4+{}^9C_3\times{}^5C_5$ oe	**M2**	**M1** for one correct product of the sum
	[630 + 84 =] 714	**A1**	
6	$64=2^n$	**M1**	
	$n=6$	**A1**	
	$their\,6(2)^{their(6-1)}\times(-a)=-16b$ oe	**M1**	
	$their\,\frac{6\times(6-1)}{2}(2)^{their(6-2)}\times(-a)^2=100b$ oe	**M1**	
	attempts to solve	**DM1**	dep on both M1 marks being awarded; must have correctly or correct FT eliminated one unknown
	$a=5$	**A1**	
	$b=60$	**A1**	

Question	Answer	Marks	Guidance
7(i)	$k(1+4x)^9$	**M1**	
	$4\times10(1+4x)^9$ or better	**A1**	
	$(1+4x)^{10}(\textit{their} - \sin x) +$ $\cos x\left(\textit{their}\left(4\times10\times(1+4x)^9\right)\right)$	**M1**	clearly applies product rule
	$(1+4x)^{10}(-\sin x)+\cos x\left(4\times10\times(1+4x)^9\right)$	**A1**	all correct
7(ii)	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\mathrm{e}^{4x-5}\right)=4\mathrm{e}^{4x-5}$ soi	**B1**	
	$\frac{\mathrm{d}}{\mathrm{d}x}(\tan x)=\sec^2 x$ soi	**B1**	
	clearly applies correct form of quotient rule $\frac{\tan x\left(\textit{their}\ 4\mathrm{e}^{4x-5}\right)-\mathrm{e}^{4x-5}\left(\textit{their}\sec^2 x\right)}{(\tan x)^2}$	**M1**	or correct form of product rule to $\mathrm{e}^{4x-5}(\tan x)^{-1}$ $4\mathrm{e}^{4x-5}(\tan x)^{-1}+\mathrm{e}^{4x-5}(\tan x)^{-2}\times\sec^2 x$
	$\frac{\tan x\left(4\mathrm{e}^{4x-5}\right)-\mathrm{e}^{4x-5}\left(\sec^2 x\right)}{(\tan x)^2}$ isw	**A1**	all correct
8(i)	$\frac{\pi}{3}$	**B1**	
	6 [cm]	**B1**	
8(ii)	[major arc =]$\left(2\pi-\textit{their}\frac{\pi}{3}\right)\textit{their } r$	**M1**	
	$10\pi+6$ cao	**A1**	
8(iii)	$\frac{1}{2}(\textit{their}6)^2\left(2\pi-\textit{their}\frac{\pi}{3}\right)$	**M1**	$\frac{1}{2}(\textit{their}6)^2\left(\textit{their}\frac{\pi}{3}\right)$
	$\frac{1}{2}(\textit{their}6)^2\sin\left(\textit{their}\frac{\pi}{3}\right)$	**M1**	$\frac{1}{2}(\textit{their}6)^2\sin\left(\textit{their}\frac{\pi}{3}\right)$
	Sector + triangle	**M1**	$\pi\times\textit{their}6^2$ – (Sector – triangle)
	$30\pi+9\sqrt{3}$	**A1**	

Question	Answer	Marks	Guidance
9(i)	$\frac{y}{9}=\sqrt{x-1}$ with attempt to swop x and y at some point or $\frac{x}{9}=\sqrt{y-1}$	**M1**	attempt to swop; may be in later work that contains an error
	$\left[f^{-1}(x)=\right]\left(\frac{x}{9}\right)^2+1$ oe	**A1**	condone $y=$ ... etc; must be a function of x
	$x>0$	**B1**	
9(ii)	f(51)	**M1**	or $\text{fg}(x)=9\sqrt{x^2+1}$
	$9\sqrt{50}$ oe	**A1**	
9(iii)	$\left[\text{gf}(x)=\right]\left(9\sqrt{x-1}\right)^2+2$	**M1**	
	$\left[\text{gf}(x)=\right]81(x-1)+2$ or better	**A1**	
	$\textit{their}\left(81x-79\right)=5x^2+83x-95\rightarrow$ $\textit{their}\left(5x^2+2x-16\,[=0]\right)$	**M1**	provided $\textit{their}(81x-79)$ of the form $ax+b$ for non-zero a and b
	1.6 oe only	**A1**	must disregard other solution
10(a)	$\sin x=0.5$, $\sin x=-0.5$	**M1**	
	$\frac{\pi}{6},\ -\frac{\pi}{6},\ \frac{5\pi}{6},\ -\frac{5\pi}{6}$ oe	**A2**	**A1** for any correct pair of angles if M0 then **SC1** for a correct pair of angles
10(b)	$2y+15=\tan^{-1}\left(\frac{1}{3}\right)$ soi	**M1**	
	18.43(49...) and 198.43(49...)	**M1**	
	1.7, 91.7	**A2**	**A1** for each

Question	Answer	Marks	Guidance
10(c)	Uses $\cot^2 z = \text{cosec}^2 z - 1$ oe	**M1**	for using correct identity or identities to obtain an equation in terms of a single trigonometric ratio
	$2\,\text{cosec}^2 z + 7\,\text{cosec}\, z - 4 = 0 \Rightarrow$ $(2\,\text{cosec}\, z - 1)(\text{cosec}\, z + 4)$	**DM1**	for dealing with quadratic
	$[\sin z = 2\ ]\ \sin z = -\frac{1}{4}$	**M1**	
	194.5, 345.5	**A2**	**A1** for each
11(i)	$5+\sqrt{10x} = \frac{5x+20}{4} \rightarrow \cancel{20} + 4\sqrt{10x} = 5x + \cancel{20}$	**M1**	or better; equates and solves as far as clearing the fraction
	$\left[\frac{x}{\sqrt{x}} = \right]\sqrt{x} = \frac{4\sqrt{10}}{5}$ oe	**M1**	Simplifies as far as $\sqrt{x} = \cdots$
	$x = 6.4$ cao	**A1**	squares and simplifies to 6.4
	$[y =]13$	**B1**	
11(ii)	(area of trapezium =) *their* 57.6	**B1**	**FT** $x = \textit{their}\ 6.4$, $y = \textit{their}\ 13$ using any valid method
	$\int_0^{6.4} \left(5+\sqrt{10x}\right) \mathrm{d}x$	**M1**	
	$\int (10x)^{\frac{1}{2}}\, \mathrm{d}x = k\,(10x)^{\frac{3}{2}}$ or	**M1**	or $\int \sqrt{10}x^{\frac{1}{2}}\, \mathrm{d}x = k\,\sqrt{10}\,(x)^{\frac{3}{2}}$
	$\left[5x + \frac{2(10x)^{\frac{3}{2}}}{3\times 10}\right]$	**A1**	or $\left[5x + \frac{2(10)^{\frac{1}{2}}(x)^{\frac{3}{2}}}{3}\right]$
	$\textit{their}\left[5(6.4) + \frac{2(10\times 6.4)^{\frac{3}{2}}}{3\times 10}\right] - \textit{their}57.6$ oe	**M1**	limits used correctly or correct **FT** and subtraction of trapezium; $\textit{their}\frac{992}{15} - \textit{their}57.6$
	$\frac{128}{15}$ or 8.53 oe	**A1**	allow 8.5333333.... rot to 4 or more sf

Cambridge IGCSE

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Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9272080016

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **May/June 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

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.
The total number of marks for this paper is 80.

This document consists of **12** printed pages.

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[Turn over

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1}a^{n-1}b + \binom{n}{2}a^{n-2}b^2 + \ldots + \binom{n}{r}a^{n-r}b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 The line $y = kx - 5$, where k is a positive constant, is a tangent to the curve $y = x^2 + 4x$ at the point A.

(i) Find the exact value of k. [3]

(ii) Find the gradient of the normal to the curve at the point A, giving your answer in the form $a + b\sqrt{5}$, where a and b are constants. [2]

2 It is given that $\mathrm{p}(x) = x^3 + ax^2 + bx - 48$. When $\mathrm{p}(x)$ is divided by $x - 3$ the remainder is 6. Given that $\mathrm{p}'(1) = 0$, find the value of a and of b. [5]

3 **(a)** Simplify $\sqrt{x^8 y^{10}} \div \sqrt[3]{x^3 y^{-6}}$, giving your answer in the form $x^a y^b$, where a and b are integers. [2]

(b) **(i)** Show that $4(t-2)^{\frac{1}{2}} + 5(t-2)^{\frac{3}{2}}$ can be written in the form $(t-2)^p(qt+r)$, where p, q and r are constants to be found. [3]

(ii) Hence solve the equation $4(t-2)^{\frac{1}{2}} + 5(t-2)^{\frac{3}{2}} = 0$. [1]

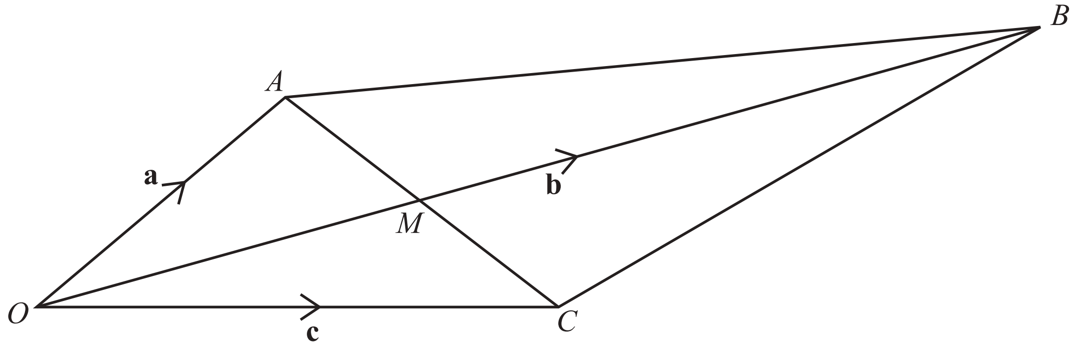
4 **(a)** It is given that $f(x) = 3e^{-4x} + 5$ for $x \in \mathbb{R}$.

(i) State the range of f. [1]

(ii) Find f^{-1} and state its domain. [4]

(b) It is given that $g(x) = x^2 + 5$ and $h(x) = \ln x$ for $x > 0$. Solve $hg(x) = 2$. [3]

5 (a)



The diagram shows a figure $OABC$, where $\overrightarrow{OA} = \mathbf{a}$, $\overrightarrow{OB} = \mathbf{b}$ and $\overrightarrow{OC} = \mathbf{c}$. The lines AC and OB intersect at the point M where M is the midpoint of the line AC.

(i) Find, in terms of **a** and **c**, the vector $\overrightarrow{OM}$. [2]

(ii) Given that $OM : MB = 2:3$, find **b** in terms of **a** and **c**. [2]

(b) Vectors **i** and **j** are unit vectors parallel to the x-axis and y-axis respectively.

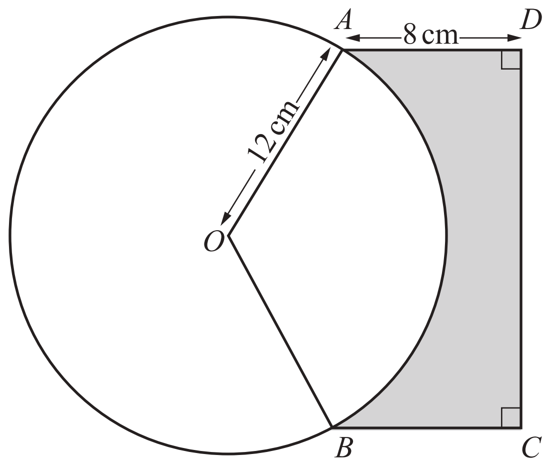
The vector **p** has a magnitude of 39 units and has the same direction as $-10\mathbf{i} + 24\mathbf{j}$.

(i) Find **p** in terms of **i** and **j**. [2]

(ii) Find the vector **q** such that $2\mathbf{p} + \mathbf{q}$ is parallel to the positive y-axis and has a magnitude of 12 units. [3]

(iii) Hence show that $|\mathbf{q}| = k\sqrt{5}$, where k is an integer to be found. [2]

6



The diagram shows a circle, centre O, radius 12 cm. The points A and B lie on the circumference of the circle and form a rectangle with the points C and D. The length of AD is 8 cm and the area of the minor sector AOB is 150 cm^2.

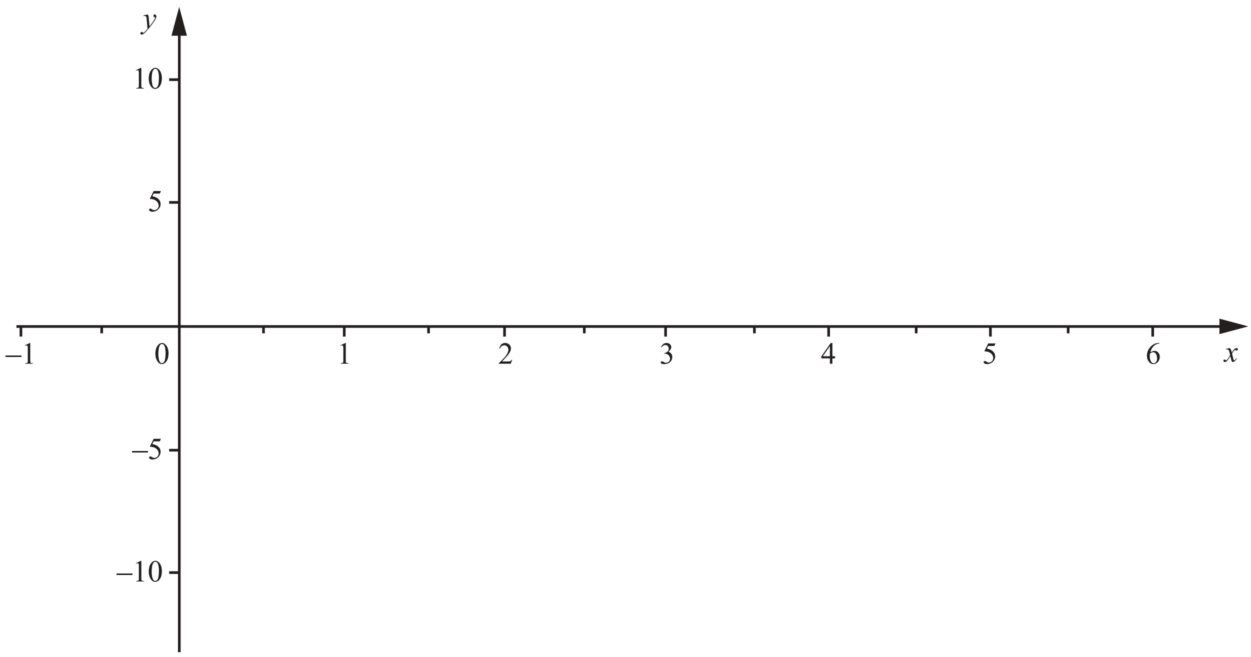
(i) Show that angle AOB is 2.08 radians, correct to 2 decimal places. [2]

(ii) Find the area of the shaded region $ADCB$. [6]

(iii) Find the perimeter of the shaded region $ADCB$. [3]

7 Show that the curve $y = (3x^2 + 8)^{\frac{5}{3}}$ has only one stationary point. Find the coordinates of this stationary point and determine its nature. [8]

8 **(i)** On the axes below sketch the graphs of $y = |2x - 5|$ and $9y = 80x - 16x^2$. [5]



(ii) Solve $|2x - 5| = 4$. [3]

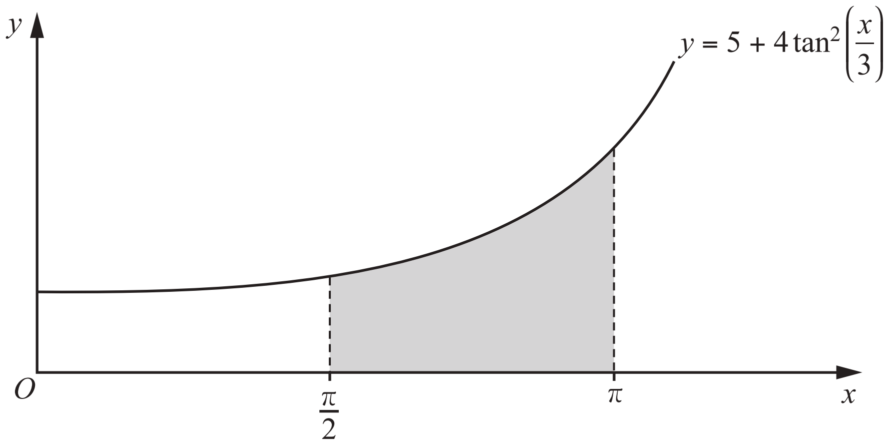
(iii) Hence show that the graphs of $y = |2x - 5|$ and $9y = 80x - 16x^2$ intersect at the points where $y = 4$. [1]

(iv) Hence find the values of x for which $9|2x - 5| \leqslant 80x - 16x^2$. [2]

9 **(i)** Show that $5 + 4\tan^2\left(\frac{x}{3}\right) = 4\sec^2\left(\frac{x}{3}\right) + 1$. [1]

(ii) Given that $\frac{\mathrm{d}}{\mathrm{d}x}\left(\tan\left(\frac{x}{3}\right)\right) = \frac{1}{3}\sec^2\left(\frac{x}{3}\right)$, find $\int \sec^2\left(\frac{x}{3}\right)\mathrm{d}x$. [1]

(iii)



The diagram shows part of the curve $y = 5 + 4\tan^2\left(\frac{x}{3}\right)$. Using the results from parts **(i)** and **(ii)**, find the exact area of the shaded region enclosed by the curve, the x-axis and the lines $x = \frac{\pi}{2}$ and $x = \pi$. [5]

Question 10 is printed on the next page.

10 **(a)** Given that $y = \dfrac{e^{3x}}{4x^2 + 1}$, find $\dfrac{dy}{dx}$. [3]

(b) Variables x, y and t are such that $y = 4\cos\left(x + \dfrac{\pi}{3}\right) + 2\sqrt{3}\sin\left(x + \dfrac{\pi}{3}\right)$ and $\dfrac{dy}{dt} = 10$.

(i) Find the value of $\dfrac{dy}{dx}$ when $x = \dfrac{\pi}{2}$. [3]

(ii) Find the value of $\dfrac{dx}{dt}$ when $x = \dfrac{\pi}{2}$. [2]

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CANDIDATE NAME		
CENTRE NUMBER		CANDIDATE NUMBER

0147311657

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

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Mathematical Formulae

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$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

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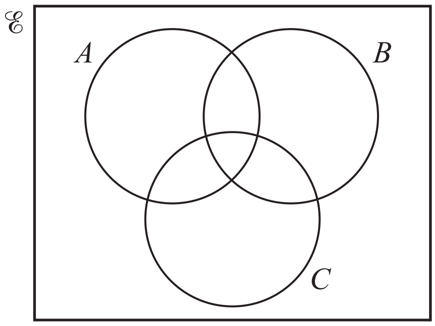
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

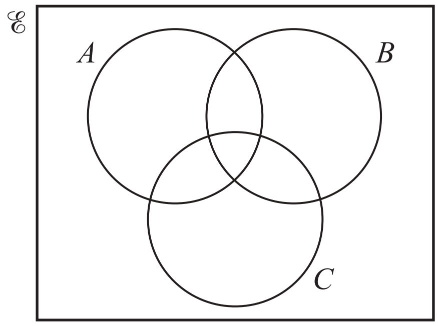
$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

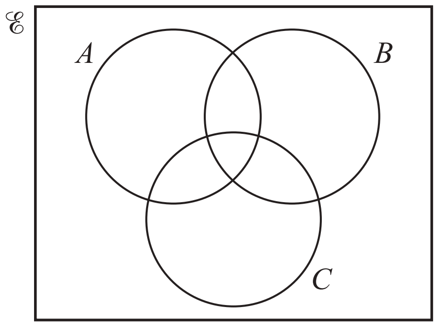
1 On each of the Venn diagrams below, shade the region which represents the given set.



$(A \cup B) \cap C$



$(A \cap B) \cup C$



$(A' \cap B') \cap C$

[3]

2 It is given that $y = \dfrac{(5x^2 + 4)^{\frac{1}{2}}}{x + 1}$. Showing all your working, find the exact value of $\dfrac{dy}{dx}$ when $x = 3$. [5]

3 Vectors **i** and **j** are unit vectors parallel to the x-axis and y-axis respectively.

(a) The vector **v** has a magnitude of $3\sqrt{5}$ units and has the same direction as $\mathbf{i} - 2\mathbf{j}$. Find **v** giving your answer in the form $a\mathbf{i} + b\mathbf{j}$, where a and b are integers. [2]

(b) The velocity vector **w** makes an angle of 30° with the positive x-axis and is such that $|\mathbf{w}| = 2$. Find **w** giving your answer in the form $\sqrt{c}\,\mathbf{i} + d\mathbf{j}$, where c and d are integers. [2]

4 The first 3 terms in the expansion of $\left(3 - \frac{x}{6}\right)^n$ are $81 + ax + bx^2$. Find the value of each of the constants n, a and b. [5]

5 A particle P moves in a straight line, such that its displacement, x m, from a fixed point O, t s after passing O, is given by $x = 4\cos(3t) - 4$.

(i) Find the velocity of P at time t. [1]

(ii) Hence write down the maximum speed of P. [1]

(iii) Find the smallest value of t for which the acceleration of P is zero. [3]

(iv) For the value of t found in part **(iii)**, find the distance of P from O. [1]

6 **(i)** Show that $\dfrac{\operatorname{cosec}\theta}{\cot\theta + \tan\theta} = \cos\theta$. [4]

It is given that $\displaystyle\int_0^a \frac{\operatorname{cosec}2\theta}{\cot 2\theta + \tan 2\theta}\,\mathrm{d}\theta = \frac{\sqrt{3}}{4}$, where $0 < a < \dfrac{\pi}{4}$.

(ii) Using your answer to part **(i)** find the value of a, giving your answer in terms of π. [4]

7 It is given that $y = A(10^{bx})$, where A and b are constants. The straight line graph obtained when $\lg y$ is plotted against x passes through the points $(0.5, 2.2)$ and $(1.0, 3.7)$.

(i) Find the value of A and of b. [5]

Using your values of A and b, find

(ii) the value of y when $x = 0.6$, [2]

(iii) the value of x when $y = 600$. [2]

8 **(a)** A 5-digit number is to be formed from the seven digits 1, 2, 3, 5, 6, 8 and 9. Each digit can only be used once in any 5-digit number. Find the number of different 5-digit numbers that can be formed if

(i) there are no restrictions, [1]

(ii) the number is divisible by 5, [1]

(iii) the number is greater than 60 000, [1]

(iv) the number is greater than 60 000 and even. [3]

(b) Ranjit has 25 friends of whom 15 are boys and 10 are girls. Ranjit wishes to hold a birthday party but can only invite 7 friends. Find the number of different ways these 7 friends can be selected if

(i) there are no restrictions, [1]

(ii) only 2 of the 7 friends are boys, [1]

(iii) the 25 friends include a boy and his sister who cannot be separated. [3]

9 **(a)** Given that $\mathbf{A} = \begin{pmatrix} 3 & 1 \\ -1 & 2 \\ 4 & 5 \end{pmatrix}$, $\mathbf{B} = \begin{pmatrix} 1 & -2 \\ 3 & 0 \end{pmatrix}$ and $\mathbf{C} = \mathbf{AB}$,

(i) state the order of **A**, [1]

(ii) find **C**. [3]

(b) The matrix $\mathbf{X} = \begin{pmatrix} 5 & -12 \\ 4 & -7 \end{pmatrix}$.

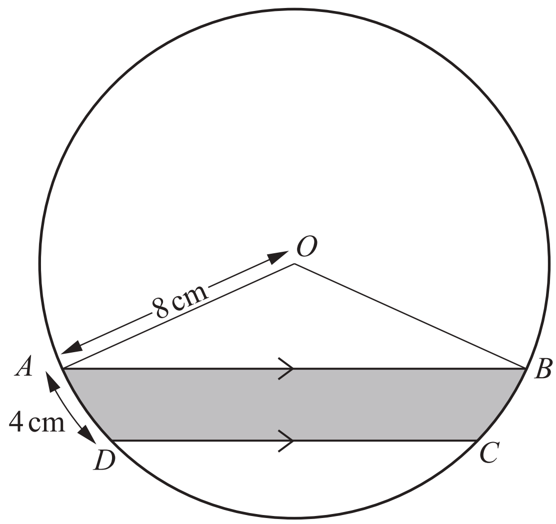
(i) Find $\mathbf{X}^{-1}$. [2]

(ii) Using $\mathbf{X}^{-1}$, find the coordinates of the point of intersection of the lines

$$12y = 5x - 26,$$
$$7y = 4x - 52.$$

[4]

10



The diagram shows a circle, centre O, radius 8 cm. The points A, B, C and D lie on the circumference of the circle such that AB is parallel to DC. The length of the arc AD is 4 cm and the length of the chord AB is 15 cm.

(i) Find, in radians, angle AOD. [1]

(ii) Hence show that angle $DOC = 1.43$ radians, correct to 2 decimal places. [3]

(iii) Find the perimeter of the shaded region. [3]

(iv) Find the area of the shaded region. [4]

Question 11 is printed on the next page.

11 The curve $y = \mathrm{f}(x)$ passes through the point $\left(\frac{1}{2}, \frac{7}{2}\right)$ and is such that $\mathrm{f}'(x) = \mathrm{e}^{2x-1}$.

(i) Find the equation of the curve. [4]

(ii) Find the value of x for which $\mathrm{f}''(x) = 4$, giving your answer in the form $a + b\ln\sqrt{2}$, where a and b are constants. [4]

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8262841617

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

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.
The total number of marks for this paper is 80.

This document consists of **15** printed pages and **1** blank page.

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CAMBRIDGE International Examinations

[Turn over

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a+b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

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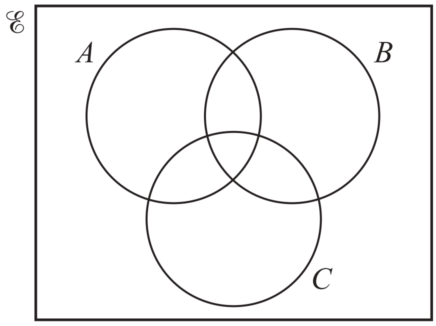
Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

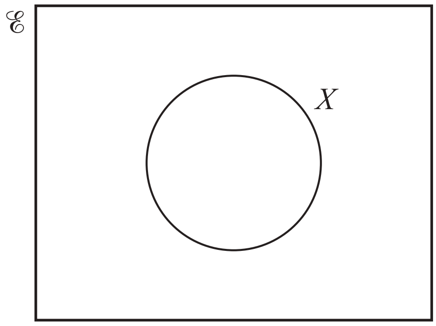
$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 **(a)** On the Venn diagram below, shade the region which represents $(A \cap B') \cup (C \cap B')$. [1]



(b) Complete the Venn diagram below to show the sets Y and Z such that $Z \subset X \subset Y$. [1]

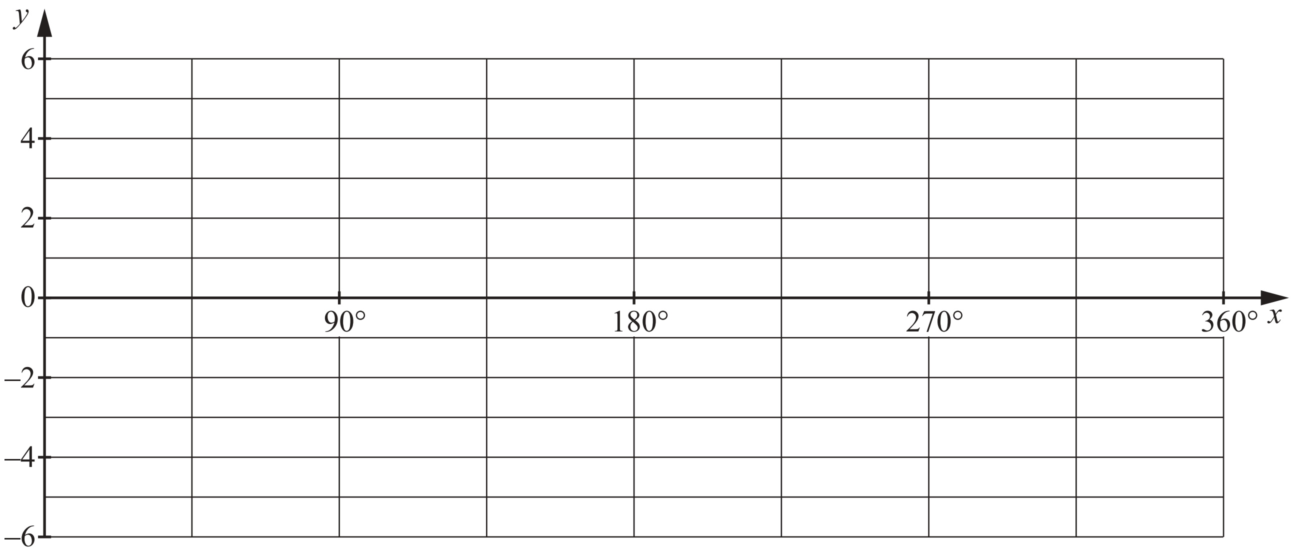


2 Given that $y = 3 + 4\cos 9x$, write down

(i) the amplitude of y, [1]

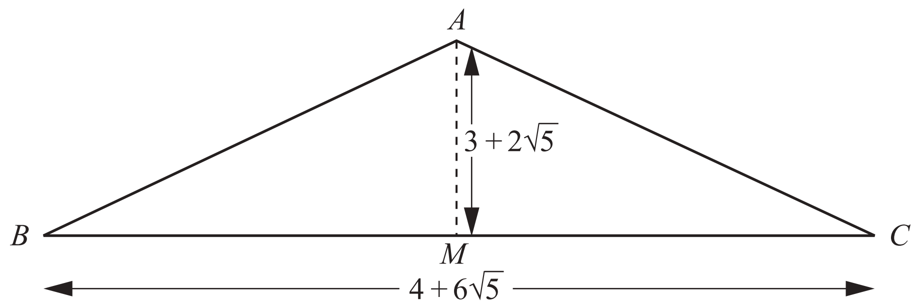
(ii) the period of y. [1]

3 **(i)** On the axes below, sketch the graph of $y = 3\sin x - 2$ for $0° \leqslant \theta \leqslant 360°$. [3]



(ii) Given that $0 \leqslant |3\sin x - 2| \leqslant k$ for $0° \leqslant x \leqslant 360°$, write down the value of k. [1]

4 In this question, all dimensions are in centimetres.



The diagram shows an isosceles triangle ABC, where $AB = AC$. The point M is the mid-point of BC. Given that $AM = 3 + 2\sqrt{5}$ and $BC = 4 + 6\sqrt{5}$, find, **without using a calculator**,

(i) the area of triangle ABC, [2]

(ii) $\tan ABC$, giving your answer in the form $\dfrac{a+b\sqrt{5}}{c}$ where a, b and c are positive integers. [3]

5 The normal to the curve $y = \sqrt{4x + 9}$, at the point where $x = 4$, meets the x- and y-axes at the points A and B. Find the coordinates of the mid-point of the line AB. [7]

6 **(a)** Given that $\mathbf{A} = \begin{pmatrix} 3 & 1 \\ 2 & 4 \end{pmatrix}$, $\mathbf{B} = \begin{pmatrix} 5 & 1 \\ 2 & 4 \\ -1 & 0 \end{pmatrix}$ and $\mathbf{C} = \begin{pmatrix} -5 & 2 \\ 3 & 1 \end{pmatrix}$, find

(i) $\mathbf{A} + 3\mathbf{C}$, [2]

(ii) $\mathbf{BA}$. [2]

(b) **(i)** Given that $\mathbf{X} = \begin{pmatrix} 1 & -3 \\ 4 & -2 \end{pmatrix}$, find $\mathbf{X}^{-1}$. [2]

(ii) Hence find $\mathbf{Y}$, such that $\mathbf{XY} = \begin{pmatrix} 5 & -10 \\ 15 & 20 \end{pmatrix}$. [3]

7 **(a)** Show that $\dfrac{\tan^2\theta + \sin^2\theta}{\cos\theta + \sec\theta} = \tan\theta\sin\theta$. [4]

(b) Given that $x = 3\sin\phi$ and $y = \dfrac{3}{\cos\phi}$, find the numerical value of $9y^2 - x^2y^2$. [3]

8 It is given that $p(x) = 2x^3 + ax^2 + 4x + b$, where a and b are constants. It is given also that $2x + 1$ is a factor of $p(x)$ and that when $p(x)$ is divided by $x - 1$ there is a remainder of -12.

(i) Find the value of a and of b. [5]

(ii) Using your values of a and b, write $p(x)$ in the form $(2x + 1)q(x)$, where $q(x)$ is a quadratic expression. [2]

(iii) Hence find the exact solutions of the equation $p(x) = 0$. [2]

9 It is given that $\int_{-k}^{k}(15e^{5x} - 5e^{-5x})dx = 6$.

(i) Show that $e^{5k} - e^{-5k} = 3$. [5]

(ii) Hence, using the substitution $y = e^{5k}$, or otherwise, find the value of k. [3]

10 It is given that $y = (10x + 2)\ln(5x + 1)$.

(i) Find $\dfrac{dy}{dx}$. [4]

(ii) Hence show that $\int \ln(5x + 1)\,dx = \dfrac{(ax + b)}{5}\ln(5x + 1) - x + c$, where a and b are integers and c is a constant of integration. [3]

(iii) Hence find $\int_0^{\frac{1}{5}} \ln(5x+1)\,dx$, giving your answer in the form $\frac{d+\ln f}{5}$, where d and f are integers. [2]

11 A curve has equation $y = 6x - x\sqrt{x}$.

(i) Find the coordinates of the stationary point of the curve. [4]

(ii) Determine the nature of this stationary point. [2]

(iii) Find the approximate change in y when x increases from 4 to $4 + h$, where h is small. [3]

12 A particle moves in a straight line, such that its velocity, $v\ \mathrm{ms}^{-1}$, t s after passing a fixed point O, is given by $v = 2 + 6t + 3\sin 2t$.

(i) Find the acceleration of the particle at time t. [2]

(ii) Hence find the smallest value of t for which the acceleration of the particle is zero. [2]

(iii) Find the displacement, x m from O, of the particle at time t. [5]

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Cambridge IGCSE

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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6595404132

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
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Answer **all** the questions.
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The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

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.
The total number of marks for this paper is 80.

This document consists of **12** printed pages.

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Mathematical Formulae

1. ALGEBRA

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$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 Find the equation of the curve which passes through the point (2, 17) and for which $\frac{dy}{dx} = 4x^3 + 1$. [4]

2 **Do not use a calculator in this question.**

(a) Show that $\sqrt{24} \times \sqrt{27} + \frac{9\sqrt{30}}{\sqrt{15}}$ can be written in the form $a\sqrt{2}$, where a is an integer. [3]

(b) Solve the equation $\sqrt{3}(1 + x) = 2(x - 3)$, giving your answer in the form $b + c\sqrt{3}$, where b and c are integers. [3]

3 The variables x and y are such that $y = \ln(x^2 + 1)$.

(i) Find an expression for $\frac{dy}{dx}$. [2]

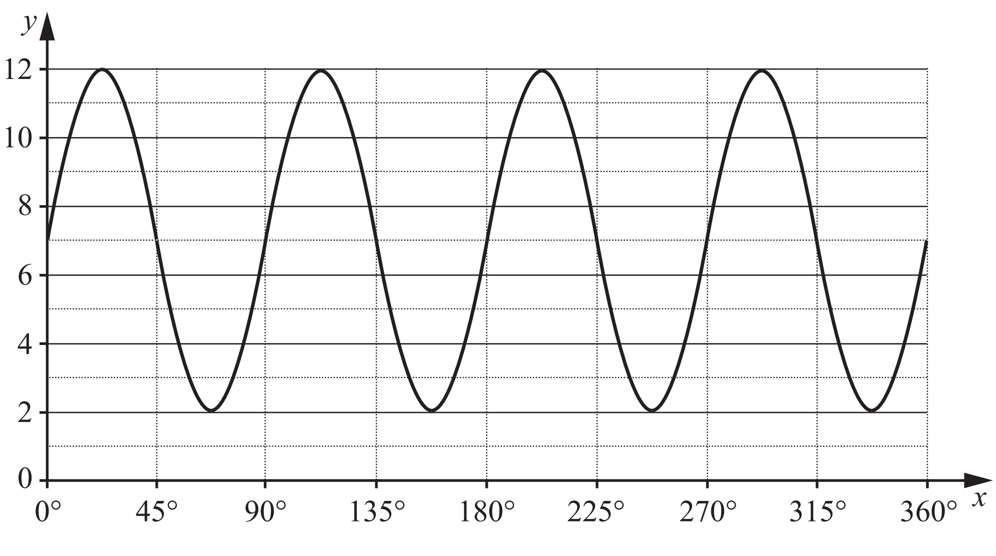
(ii) Hence, find the approximate change in y when x increases from 3 to $3 + h$, where h is small. [2]

4 **(a)** Given that $y = 7\cos 10x - 3$, where the angle x is measured in degrees, state

(i) the period of y, [1]

(ii) the amplitude of y. [1]

(b)



Find the equation of the curve shown, in the form $y = a\,g(bx) + c$, where $g(x)$ is a trigonometric function and a, b and c are integers to be found. [4]

5 **(i)** Given that a is a constant, expand $(2 + ax)^4$, in ascending powers of x, simplifying each term of your expansion. [2]

Given also that the coefficient of x^2 is equal to the coefficient of x^3,

(ii) show that $a = 3$, [1]

(iii) use your expansion to show that the value of 1.97^4 is 15.1 to 1 decimal place. [2]

6 Four cinemas, P, Q, R and S each sell adult, student and child tickets. The number of tickets sold by each cinema on one weekday were

P: 90 adult, 10 student, 30 child
Q: 45 student
R: 25 adult, 15 child
S: 10 adult, 100 child.

(i) Given that $\mathbf{L} = \begin{pmatrix} 1 & 1 & 1 & 1 \end{pmatrix}$, construct a matrix, **M**, of the number of tickets sold, such that the matrix product **LM** can be found. [1]

(ii) Find the matrix product **LM**. [1]

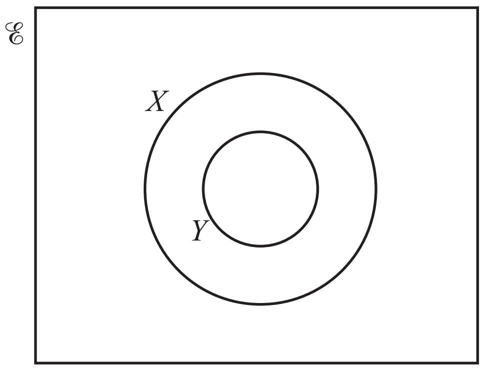
(iii) State what information is represented by the matrix product **LM**. [1]

An adult ticket costs \$5, a student ticket costs \$4 and a child ticket costs \$3.

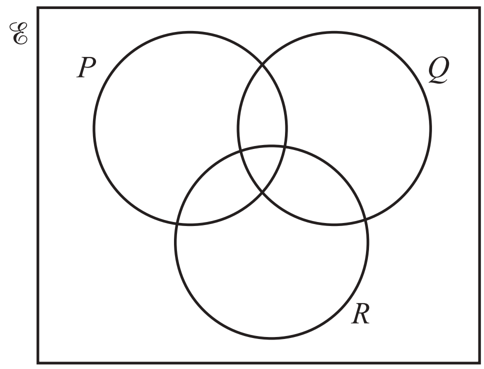
(iv) Construct a matrix, **N**, of the ticket costs, such that the matrix product **LMN** can be found and state what information is represented by the matrix product **LMN**. [2]

7 **(a)** On each of the Venn diagrams below shade the region which represents the given set.

$X \cap Y'$



$P' \cap Q \cap R$



[2]

(b) In a group of students, each student studies at most two of art, music and design. No student studies both music and design.

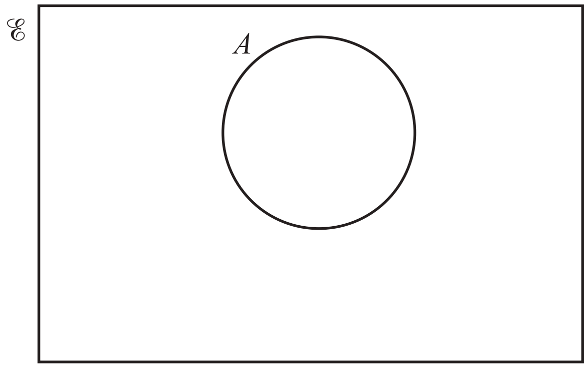
A denotes the set of students who study art,
M denotes the set of students who study music,
D denotes the set of students who study design.

(i) Write the following using set notation.

No student studies both music and design. [1]

There are 100 students in the group. 39 students study art, 45 study music and 36 study design. 12 students study both art and music. 25 students study both art and design.

(ii) Complete the Venn diagram below to represent this information and hence find the number of students in the group who do not study any of these subjects.



[3]

8 **(a)** A football club has 30 players. In how many different ways can a captain and a vice-captain be selected at random from these players? [1]

(b) A team of 11 teachers is to be chosen from 2 mathematics teachers, 5 computing teachers and 9 science teachers. Find the number of different teams that can be chosen if

(i) the team must have exactly 1 mathematics teacher, [2]

(ii) the team must have exactly 1 mathematics teacher and at least 4 computing teachers. [4]

9 The curve $3x^2 + xy - y^2 + 4y - 3 = 0$ and the line $y = 2(1 - x)$ intersect at the points A and B.

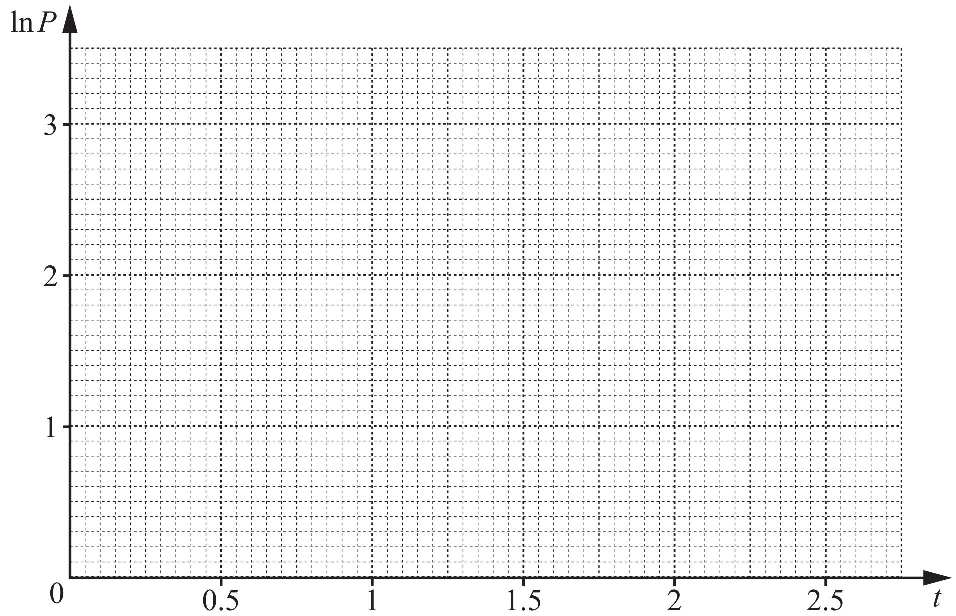
(i) Find the coordinates of A and of B. [5]

(ii) Find the equation of the perpendicular bisector of the line AB, giving your answer in the form $ax + by = c$, where a, b and c are integers. [4]

10 The table shows values of the variables t and P.

t	1	1.5	2	2.5
P	4.39	8.33	15.8	30.0

(i) Draw the graph of $\ln P$ against t on the grid below. [2]



(ii) Use the graph to estimate the value of P when $t = 2.2$. [2]

(iii) Find the gradient of the graph and state the coordinates of the point where the graph meets the vertical axis. [2]

(iv) Using your answers to part **(iii)**, show that $P = ab^t$, where a and b are constants to be found. [3]

(v) Given that your equation in part **(iv)** is valid for values of t up to 10, find the smallest value of t, correct to 1 decimal place, for which P is at least 1000. [2]

11 **(i)** Prove that $\sin x(\cot x + \tan x) = \sec x$. [4]

(ii) Hence solve the equation $|\sin x(\cot x + \tan x)| = 2$ for $0° \leqslant x \leqslant 360°$. [4]

Question 12 is printed on the next page.

12 A particle moves in a straight line so that, t seconds after passing a fixed point O, its displacement, s m, from O is given by

$$s = 1 + 3t - \cos 5t.$$

(i) Find the distance between the particle's first two positions of instantaneous rest. [7]

(ii) Find the acceleration when $t = \pi$. [2]

Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME		
CENTRE NUMBER		CANDIDATE NUMBER

8715888044

ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **May/June 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
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Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
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CAMBRIDGE International Examinations

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

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Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

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$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 Solve $|5x+3|=|1-3x|$. [3]

2 **Without using a calculator**, express $\left(\dfrac{1+\sqrt{5}}{3-\sqrt{5}}\right)^{-2}$ in the form $a+b\sqrt{5}$, where a and b are integers. [5]

3 **Without using a calculator**, factorise the expression $10x^3 - 21x^2 + 4$. [5]

4 The point P lies on the curve $y = 3x^2 - 7x + 11$. The normal to the curve at P has equation $5y + x = k$. Find the coordinates of P and the value of k. [6]

5 **(i)** Show that $\frac{\mathrm{d}}{\mathrm{d}x}[0.4x^5(0.2 - \ln 5x)] = kx^4 \ln 5x$, where k is an integer to be found. [2]

(ii) Express $\ln 125x^3$ in terms of $\ln 5x$. [1]

(iii) Hence find $\int (x^4 \ln 125x^3)\,\mathrm{d}x$. [2]

6 Show that the roots of $px^2 + (p - q)x - q = 0$ are real for all real values of p and q. [4]

7 **(a)** Given that $a^7 = b$, where a and b are positive constants, find,

(i) $\log_a b$, [1]

(ii) $\log_b a$. [1]

(b) Solve the equation $\log_{81} y = -\frac{1}{4}$. [2]

(c) Solve the equation $\frac{32^{x^2 - 1}}{4^{x^2}} = 16$. [3]

8 Solutions to this question by accurate drawing will not be accepted.

The points A and B are $(-8, 8)$ and $(4, 0)$ respectively.

(i) Find the equation of the line AB. [2]

(ii) Calculate the length of AB. [2]

The point C is $(0, 7)$ and D is the mid-point of AB.

(iii) Show that angle ADC is a right angle. [3]

The point E is such that $\overrightarrow{AE} = \begin{pmatrix} 4 \\ -7 \end{pmatrix}$.

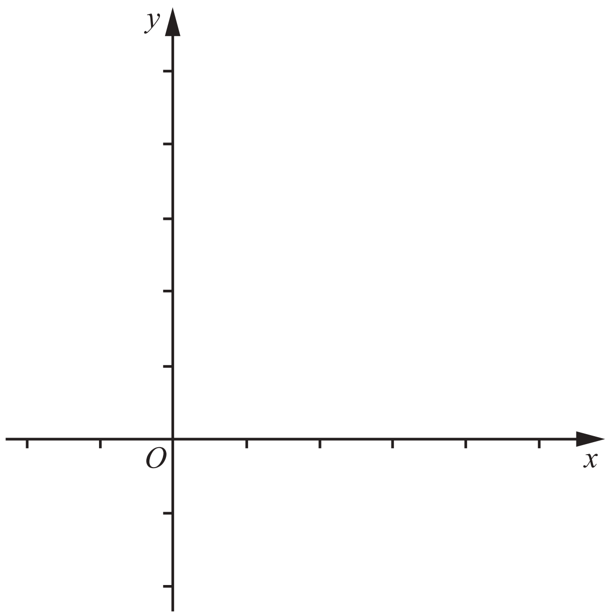
(iv) Write down the position vector of the point E. [1]

(v) Show that $ACBE$ is a parallelogram. [2]

9 A function f is defined, for $x \leqslant \frac{3}{2}$, by $\mathrm{f}(x) = 2x^2 - 6x + 5$.

(i) Express $\mathrm{f}(x)$ in the form $a(x-b)^2 + c$, where a, b and c are constants. [3]

(ii) On the same axes, sketch the graphs of $y = \mathrm{f}(x)$ and $y = \mathrm{f}^{-1}(x)$, showing the geometrical relationship between them. [3]



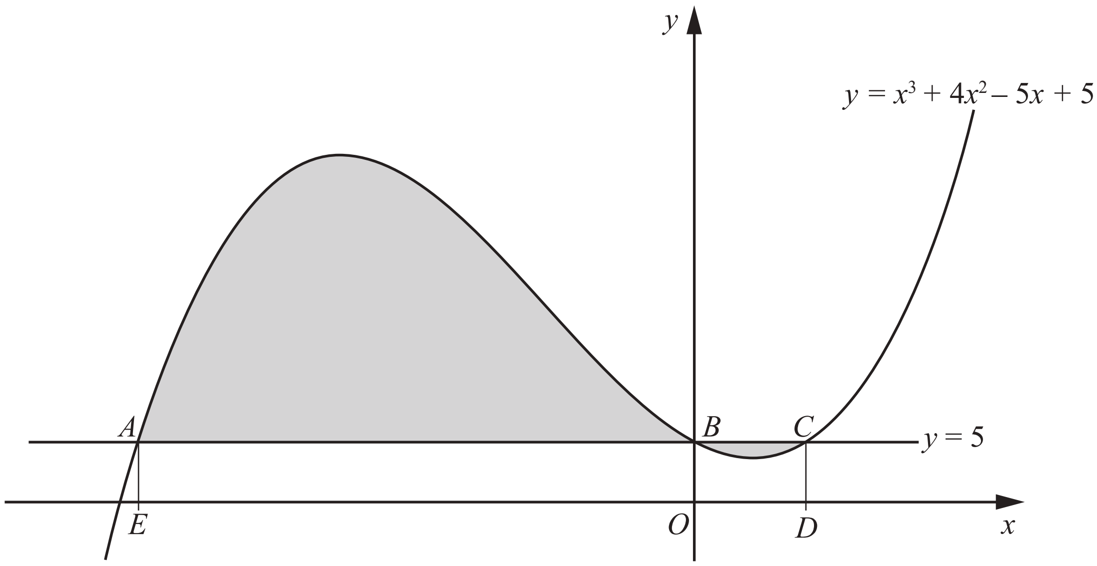
(iii) Using your answer from part **(i)**, find an expression for $\mathrm{f}^{-1}(x)$, stating its domain. [3]

10 Solve the equation

(i) $4\sin\left(3x - \frac{\pi}{4}\right) = 3$ for $0 \leqslant x \leqslant \frac{\pi}{2}$ radians, [4]

(ii) $2\tan^2 y + \sec^2 y = 14\sec y + 3$ for $0° \leqslant y \leqslant 360°$. [5]

11



The diagram shows part of the curve $y = x^3 + 4x^2 - 5x + 5$ and the line $y = 5$. The curve and the line intersect at the points A, B and C. The points D and E are on the x-axis and the lines AE and CD are parallel to the y-axis.

(i) Find $\int (x^3 + 4x^2 - 5x + 5)\,dx$. [2]

(ii) Find the area of each of the rectangles $OEAB$ and $OBCD$. [4]

(iii) Hence calculate the total area of the shaded regions enclosed between the line and the curve. You must show all your working. [4]

Question 12 is printed on the next page.

12 The function g is defined, for $x > -\frac{1}{2}$, by $g(x) = \frac{3}{2x+1}$.

(i) Show that $g'(x)$ is always negative. [2]

(ii) Write down the range of g. [1]

The function h is defined, for all real x, by $h(x) = kx + 3$, where k is a constant.

(iii) Find an expression for $hg(x)$. [1]

(iv) Given that $hg(0) = 5$, find the value of k. [2]

(v) State the domain of hg. [1]

Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7292744436

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **May/June 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

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.
The total number of marks for this paper is 80.

This document consists of **15** printed pages and **1** blank page.

DC (ST/FC) 129465/2

CAMBRIDGE International Examinations

[Turn over

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1}a^{n-1} b + \binom{n}{2}a^{n-2} b^2 + \ldots + \binom{n}{r}a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

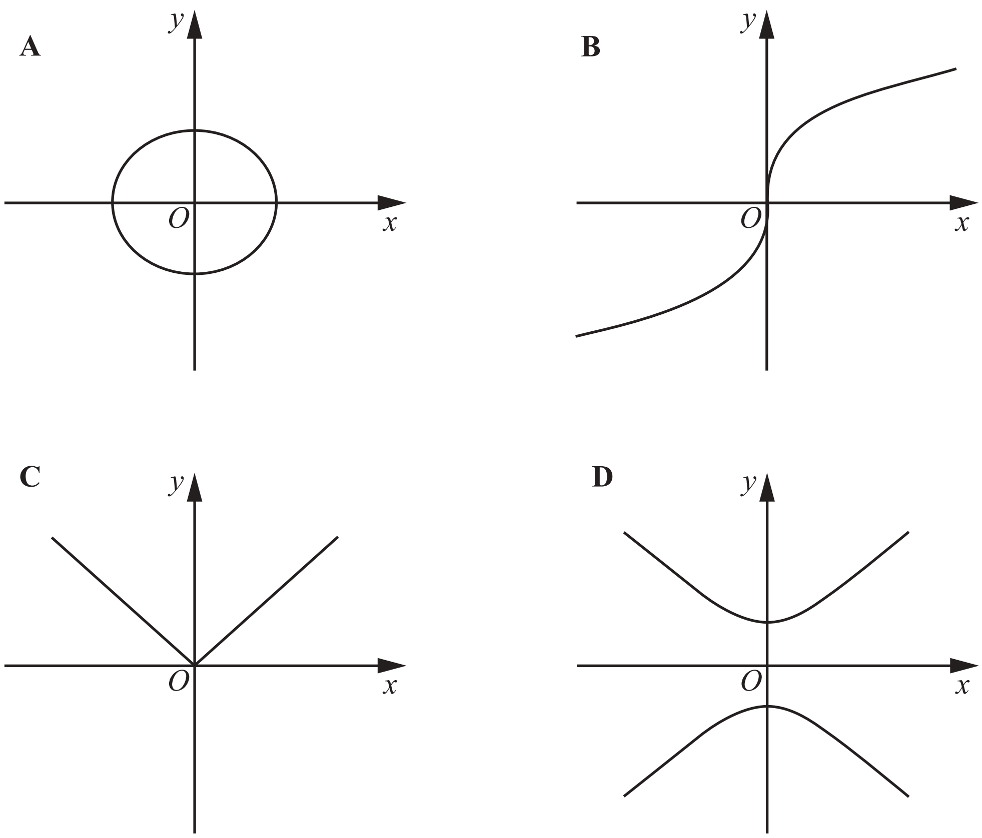
$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 **(a)** Solve the equation $7^{2x+5} = 2.5$, giving your answer correct to 2 decimal places. [3]

(b) Express $\dfrac{(5\sqrt{q})^3}{(625p^{12}q)^{\frac{1}{4}}}$ in the form $5^a p^b q^c$, where a, b and c are constants. [3]

2

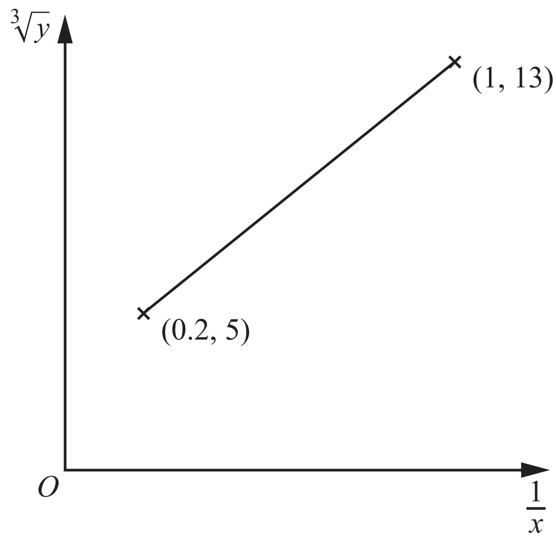


The four graphs above are labelled **A**, **B**, **C** and **D**.

(i) Write down the letter of each graph that represents a function, giving a reason for your choice. [2]

(ii) Write down the letter of each graph that represents a function which has an inverse, giving a reason for your choice. [2]

3



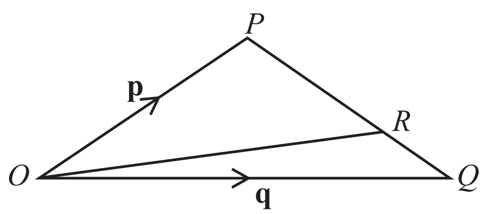
Variables x and y are such that when $\sqrt[3]{y}$ is plotted against $\frac{1}{x}$, a straight line graph passing through the points (0.2, 5) and (1, 13) is obtained. Express y in terms of x. [4]

4 **(a)** Vectors **a**, **b** and **c** are such that $\mathbf{a} = \begin{pmatrix} 5 \\ -6 \end{pmatrix}$, $\mathbf{b} = \begin{pmatrix} 11 \\ -15 \end{pmatrix}$ and $3\mathbf{a} + \mathbf{c} = \mathbf{b}$.

(i) Find **c**. [1]

(ii) Find the unit vector in the direction of **b**. [2]

(b)



In the diagram, $\overrightarrow{OP} = \mathbf{p}$ and $\overrightarrow{OQ} = \mathbf{q}$. The point R lies on PQ such that $PR = 3RQ$. Find $\overrightarrow{OR}$ in terms of **p** and **q**, simplifying your answer. [3]

5 **(a)** How many 5-digit numbers are there that have 5 different digits and are divisible by 5? [3]

(b) A committee of 8 people is to be selected from 9 men and 5 women. Find the number of different committees that can be selected if the committee must have at least 4 women. [3]

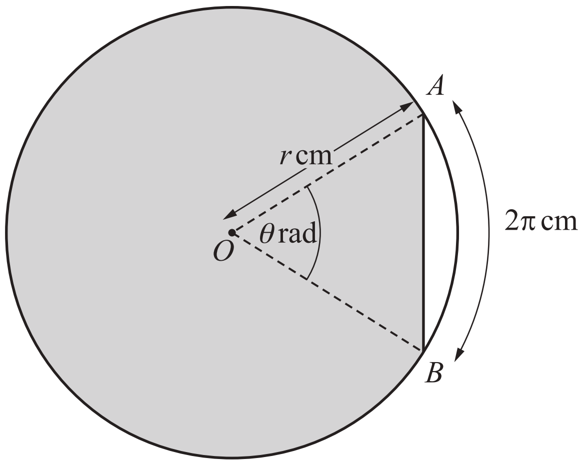
6 The first three terms of the binomial expansion of $(2 - ax)^n$ are $64 - 16bx + 100bx^2$. Find the value of each of the integers n, a and b. [7]

7 Differentiate with respect to x,

(i) $(1+4x)^{10}\cos x$, [4]

(ii) $\dfrac{e^{4x-5}}{\tan x}$. [4]

8



The diagram shows a circle, centre O of radius r cm, and a chord AB. Angle $AOB = \theta$ radians. The length of the major arc AB is 5 times the length of the minor arc AB. The minor arc AB has length 2π cm.

(i) Find the value of θ and of r. [2]

(ii) Calculate the exact perimeter of the shaded segment. [2]

(iii) Calculate the exact area of the shaded segment. [4]

9 The functions f and g are defined, for $x > 1$, by

$$\mathrm{f}(x) = 9\sqrt{x-1},$$
$$\mathrm{g}(x) = x^2 + 2.$$

(i) Find an expression for $\mathrm{f}^{-1}(x)$, stating its domain. [3]

(ii) Find the exact value of fg(7). [2]

(iii) Solve $\mathrm{gf}(x) = 5x^2 + 83x - 95$. [4]

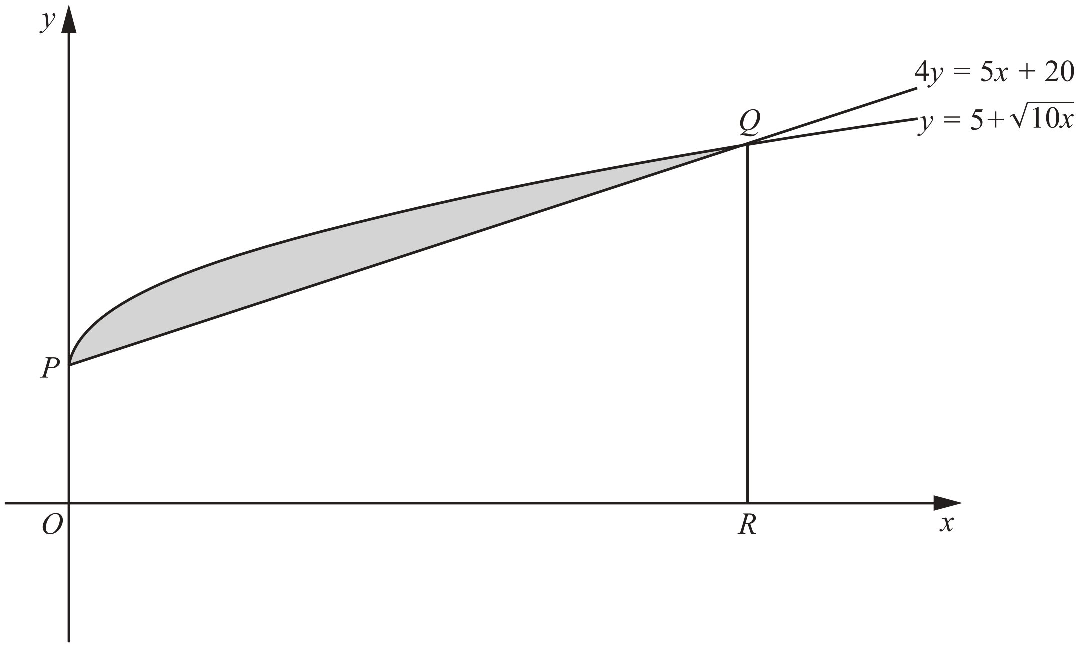
10 Solve the equation

(a) $2|\sin x| = 1$ for $-\pi \leqslant x \leqslant \pi$ radians, [3]

(b) $3\tan(2y + 15°) = 1$ for $0° \leqslant y \leqslant 180°$, [4]

(c) $3\cot^2 z = \operatorname{cosec}^2 z - 7\operatorname{cosec} z + 1$ for $0° \leqslant z \leqslant 360°$. [5]

11



The diagram shows part of the curve $y = 5 + \sqrt{10x}$ and the line $4y = 5x + 20$. The line and curve intersect at the points $P(0, 5)$ and Q. The line QR is parallel to the y-axis.

(i) Find the coordinates of Q. [4]

(ii) Find the area of the shaded region. You must show all your working. [6]

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Cambridge Assessment International Education

Grade thresholds – November 2017

Cambridge IGCSE Additional Mathematics (0606)

Grade thresholds taken for Syllabus 0606 (Additional Mathematics) in the November 2017 examination.

		minimum raw mark required for grade:				
	maximum raw mark available	A	B	C	D	E
Component 11	80	56	42	28	22	17
Component 12	80	56	40	25	20	15
Component 13	80	70	53	35	26	17
Component 21	80	50	38	26	21	16
Component 22	80	59	42	24	19	14
Component 23	80	63	44	26	18	10

Grade A* does not exist at the level of an individual component.

The maximum total mark for this syllabus, after weighting has been applied, is **160**.

The overall thresholds for the different grades were set as follows.

Option	Combination of Components	A*	A	B	C	D	E
AX	11, 21	132	106	80	54	43	33
AY	12, 22	148	115	82	49	39	29
AZ	13, 23	146	133	97	61	44	27

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **October/November 2017**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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MARK SCHEME NOTES

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Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1(i)	$A' \cap B$	**B1**	
1(ii)	$A \cap B \cap C$	**B1**	
1(iii)	$A \cup B$	**B1**	
2(i)	$\mathrm{p}\left(\frac{1}{2}\right) = \frac{a}{8} + \frac{b}{4} - \frac{13}{2} + 4$	**M1**	attempt at $p\left(\frac{1}{2}\right)$
	$\mathrm{p}'(x) = 3ax^2 + 2bx - 13$ $\mathrm{p}'\left(\frac{1}{2}\right) = \frac{3a}{4} + b - 13$	**M1**	attempt at $p'\left(\frac{1}{2}\right)$
	leading to $a + 2b = 20$ and $3a + 4b - 52 = 0$	**A1**	at least one correct equation
	solution of simultaneous equations	**DM1**	
	$a = 12,\ b = 4$	**A1**	for both
2(ii)	$p(-1) = -12 + 4 + 13 + 4$	**M1**	
	9	**A1**	**FT** on *their* integer values of a and b
3(a)	$Tg^{\frac{1}{2}} = 2\pi l^{\frac{1}{2}}$ $T^2 g = 4\pi^2 l$	**B1**	multiplication/dealing with power of $\frac{1}{2}$ or squaring
	$l = \frac{T^2 g}{4\pi^2}$ or $\left(\frac{Tg^{\frac{1}{2}}}{2\pi}\right)^2$	**B1**	for either
3(b)	$y^2 - 4y + 3 = 0$ leading to $y = 1,\ y = 3$	**M1**	reduction to quadratic equation and attempt to solve
	$x^{\frac{1}{3}} = 1,\ \ x^{\frac{1}{3}} = 3$	**DM1**	attempt to solve $x^{\frac{1}{3}} = k$ (positive k)
	$x = 1,\ x = 27$	**A2**	A1 for each

Question	Answer	Marks	Guidance
4(i)	$\frac{1}{2}$	**B1**	
4(ii)	$\lg y = mx^2 + c$ $\lg y = \frac{1}{2}x^2 + 1$	**B2**	–1 for each error
4(iii)	$y = 10^{\left(\frac{x^2}{2}+1\right)}$	**B1**	dealing with lg on *their* (ii)
	$y = 10\left(10^{\frac{x^2}{2}}\right)$	**B2**	B1 for each, dependent on first B1
5(i)	(0, 20)	**B1**	
5(ii)	31.7	**B1**	
5(iii)	$2e^{2x} - 8e^{-2x} \quad (+c)$	**B2**	B1 for each correct term
5(iv)	Area of trapezium = $\frac{1}{2}(20 + 31.7)$ $= 25.86$ or 25.85	**B1**	
	$\left[2e^{2x} - 8e^{-2x}\right]_0^1 = \left(2e^2 - 8e^{-2}\right) - (-6)$	**M1**	substitution of both limits, must have come from integration of the form $ae^{2x} + be^{-2x}$.
	19.7	**A1**	
	Required area = 6.15, 6.16, 6.17	**A1**	
6(a)(i)	$f \geqslant 3$	**B1**	must be using a correct notation
6(a)(ii)	$(4x-1)^2 + 3 = 4$	**M1**	correct order
	solution of resulting quadratic equation	**DM1**	
	$x = 0,\ x = \frac{1}{2}$	**A1**	both required

Question	Answer	Marks	Guidance
6(b)(i)	$xy - 4y = 2x + 1$	M1	'multiplying out'
	$x(y-2) = 4y + 1$ $x = \dfrac{4y+1}{y-2}$	M1	collecting together like terms
	$h^{-1}(x) = \dfrac{4x+1}{x-2}$	A1	correct answer with correct notation
	Range $h^{-1} \neq 4$	B1	must be using a correct notation
6(b)(ii)	$h^2(x) = h\left(\dfrac{2x+1}{x-4}\right)$ $= \dfrac{2\left(\dfrac{2x+1}{x-4}\right)+1}{\left(\dfrac{2x+1}{x-4}\right)-4}$	M1	dealing with h^2 correctly
	dealing with fractions within fractions	M1	
	$= \dfrac{5x-2}{17-2x}$ oe	A1	
7(i)	$\ln(2x+1) - \ln(2x-1)$	B1	
7(ii)	attempt to differentiate	M1	
	$\dfrac{dy}{dx} = \dfrac{2}{2x+1} - \dfrac{2}{2x-1} + 4$	A1	all correct
	attempt to obtain in required form	DM1	
	$= \dfrac{16x^2-8}{4x^2-1}$	A1	A1 all correct
7(iii)	When $\dfrac{dy}{dx} = 0$, $16x^2 - 8 = 0$	M1	setting $\dfrac{dy}{dx} = 0$ and attempt to solve
	$x = \dfrac{1}{\sqrt{2}}$ only	A1	

Question	Answer	Marks	Guidance
7(iv)	$\frac{d^2y}{dx^2} = \frac{32x(4x^2-1)-8x(16x^2-8)}{(4x^2-1)^2}$	**M1**	attempt at second derivative and conclusion or equivalent method
	When $x = \frac{1}{\sqrt{2}}$ $\frac{d^2y}{dx^2}$ is + ve, so minimum	**A1**	
8(a)(i)	${}^8C_6 \times {}^6C_4$	**B1**	either ${}^8C_6$ or ${}^6C_4$
	420	**B1**	
8(a)(ii)	${}^{12}C_8 + {}^{12}C_{10}$	**B2**	B1 for each
	= 561	**B1**	
	Alternate scheme: $1001 - (2 \times {}^{12}C_9)$	**B1 B1**	
	= 561	**B1**	
8(b)(i)	136 080	**B1**	
8(b)(ii)	No of ways ending with 0 - 15 120	**B1**	
	No of ways ending with 5 - 13 440	**B1**	
	Total 28 560	**B1**	
8(b)(iii)	Starting with 6 or 8 - 13 440	**B1**	
	Starting with 7 or 9 - 16 800	**B1**	
	Total = 30 240	**B1**	
9(i)	$\tan\left(\frac{PAQ}{2}\right) = 2.4$	**M1**	valid method
	$PAQ = 2.352(01....)$ $PAQ = 2.35$ correct to 3 sf	**A1**	must see greater than 3 sf then rounding
9(ii)	$PBQ = 0.790$ or 0.792	**B1**	
9(iii)	$(2.352 \times 10) + (0.790 \times 24)$	**M1,A1**	M1 for correct attempt at an arc length A1 for one correct arc length
	= awrt 42.5	**A1**	

Question	Answer	Marks	Guidance
9(iv)	$\left(\left(\frac{1}{2}\times 24^2\times 0.790\right)-\left(\frac{1}{2}\times 24^2\times\sin 0.790\right)\right)$	**B1,B1**	B1 for a correct sector area allow, unsimplified B1 for a correct area of a triangle, allow unsimplified
	$+\left(\left(\frac{1}{2}\times 10^2\times 2.352\right)-\left(\frac{1}{2}\times 10^2\times\sin 2.352\right)\right)$	**B1**	correct plan, dependent on both previous B marks
	$=22.94+82.1$ $=105$	**B1**	
10(a)	$\frac{3}{4}=\sin^2 2x$	**B1**	dealing correctly with cosec
	$\sin 2x=\pm\frac{\sqrt{3}}{2}$ $2x=60,\ 120,\ 240,\ 300$	**M1**	correct method of solution including dealing with $2x$ correctly, may be implied by one correct solution.
	$x=30,\ 60,\ 120,\ 150$	**A2**	A1 for each correct pair
10(b)	$\tan\left(y-\frac{\pi}{4}\right)=\frac{1}{\sqrt{3}}$	**M1**	dealing with order of operations to obtain a first solution
	$y-\frac{\pi}{4}=\frac{\pi}{6},\ \frac{7\pi}{6}$	**M1**	M1 for attempt to obtain a second solution
	$y=\frac{5\pi}{12},\ \frac{17\pi}{12}$	**A2**	A1 for each

Cambridge Assessment International Education
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ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **October/November 2017**

MARK SCHEME

Maximum Mark: 80

Published

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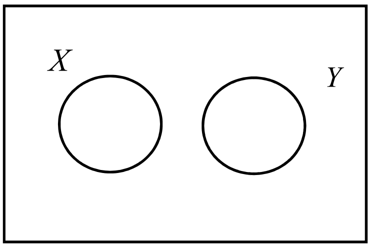
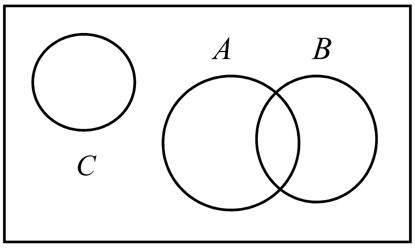
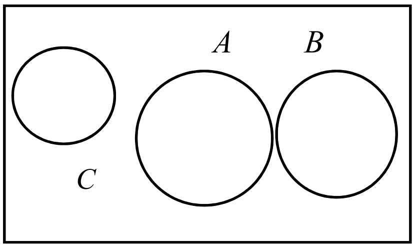
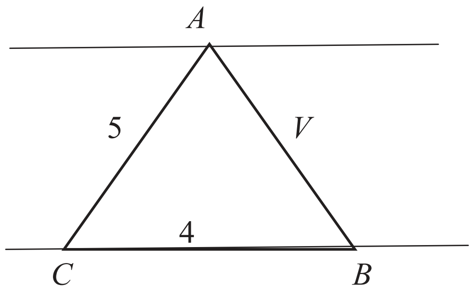
Abbreviations

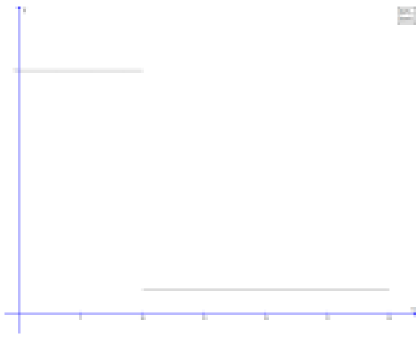
awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Guidance
1(i)		**1**	
1(ii)	Either  Or 	**2**	**B1** for *C* with no intersection with either *A* or *B* (allow if *C* is not represented by a circle) **B1** for all correct, *C* must be represented by a circle
2	$a=4$	**B1**	
	$b=6$	**B1**	
	$c=-2$	**M1, A1**	**M1** for use of $\left(\frac{\pi}{12},\ 2\right)$ to obtain *c*, using *their* values of *a* and of *b*
3(i)	$32-20x^2+5x^4$	**B3**	**B1** for each correct term
3(ii)	$\left(32-20x^2+5x^4\right)\left(\frac{1}{x^2}\text{............}+\frac{9}{x^4}\right)$	**B1**	$\frac{1}{x^2}$ and $\frac{9}{x^4}$
	Independent of *x*: $-20+45$	**M1**	attempt to deal with 2 terms independent of *x*, must be looking at terms in x^2 and $\frac{1}{x^2}$ and terms in x^4 and $\frac{1}{x^4}$
	= 25	**A1**	**FT** *their* answers from (i) (*their* -20×1) + (*their* 5×9)

Question	Answer	Marks	Guidance
4	correct differentiation of $\ln\left(3x^2+2\right)$	B1	
	attempt to differentiate a quotient or a product	M1	
	$\frac{dy}{dx}=\frac{\left(x^2+1\right)\left(\frac{6x}{3x^2+2}\right)-2x\ln\left(3x^2+2\right)}{\left(x^2+1\right)^2}$	A1	all other terms correct.
	When $x=2$, $\frac{dy}{dx}=\frac{5\left(\frac{12}{14}\right)-4\ln 14}{25}$	M1	**M1dep** for substitution and attempt to simplify
	$=\frac{6}{35}-\frac{4}{25}\ln 14$	A2	**A1** for each correct term, must be in simplest form
5(i)	**Either** Gradient $=-0.2$	B1	
	$\lg y=-0.2x+c$	B1	$\lg y=mx+c$ soi
	correct attempt to find c	M1	must have previous B1
	$\lg y=0.42-0.2x$ or $\lg y=\frac{21}{50}-\frac{x}{5}$	A1	line in either form, allow equivalent fractions
	Or $0.3=0.6m+c$	B1	
	$0.2=1.1m+c$	B1	
	attempt to solve for both m and c	M1	must have at least one of the previous B marks
	Leading to $\lg y=0.42-0.2x$ or $\lg y=\frac{21}{50}-\frac{x}{5}$	A1	line in either form, allow equivalent fractions

Question	Answer	Marks	Guidance
5(ii)	**Either** $y = 10^{(0.42-0.2x)}$	**M1**	dealing with the index, using their answer to **(i)**
	$y = 10^{0.42}\left(10^{-0.2x}\right)$ $y = 2.63\left(10^{-0.2x}\right)$	**A2**	**A1** for each
	Or $y = A\left(10^{bx}\right)$ leads to $\lg y = \lg A + bx$ Compare this form with their equation from (i)	**M1**	comparing their answer to **(i)** with $\lg y = \lg A + bx$ may be implied by one correct term from correct work
	$\lg A = 0.42$ so $A = 2.63$	**A1**	
	$b = -0.2$	**A1**	A1 for each
6(i)	$y \in \mathbb{R}$ oe	**B1**	Must have correct notation i.e. no use of x
6(ii)	$y > 3$ oe	**B1**	Must have correct notation i.e. no use of x
6(iii)	$\mathrm{f}^{-1}(x) = \mathrm{e}^x$ or $\mathrm{g}(4) = 35$	**B1**	First B1 may be implied by correct answer or by use of 35
	$\mathrm{f}^{-1}\mathrm{g}(4) = \mathrm{e}^{35}$	**B1**	
6(iv)	$\frac{y-3}{2} = x^2$ or $\frac{x-3}{2} = y^2$	**M1**	valid attempt to obtain the inverse
	$\mathrm{g}^{-1}(x) = \sqrt{\frac{x-3}{2}}$	**A1**	correct form, must be $\mathrm{g}^{-1}(x) =$ or $y =$
	Domain $x > 3$	**B1**	Must have correct notation
7(i)	$\mathrm{p}\left(\frac{1}{2}\right)$: $\frac{a}{8} + 2 + \frac{b}{2} + 5 = 0$	**M1**	substitution of $x = \frac{1}{2}$ and equating to zero (allow unsimplified)
	$\mathrm{p}(-2)$: $-8a + 32 - 2b + 5 = -25$	**M1**	substitution of $x = -2$ and equating to –25 (allow unsimplified)
	leading to $a + 4b + 56 = 0$ $4a + b - 31 = 0$ oe	**M1**	**M1dep** for solution of simultaneous equations to obtain a and b
	$a = 12,\ b = -17$	**A2**	**A1** for each

Question	Answer	Marks	Guidance
7(ii)	$12x^3 + 8x^2 - 17x = 0$ $x = 0$	**B1**	for $x = 0$
	$x = -\frac{1}{3} \pm \frac{\sqrt{55}}{6}$ oe	**B1**	
8			
8(i)	$\angle ABC = 67.4^\circ$	**B1**	
	$\frac{4}{\sin BAC} = \frac{5}{\sin 67.4^\circ}$	**M1**	attempt at the sine rule, using 4 and 5 (or e.g. use of cosine rule followed by sine rule on triangle shown)
	$\angle BAC = 47.6^\circ$	**A1**	may be implied by later work
	Angle required = $180^\circ - 47.6^\circ - 67.4^\circ = 65^\circ$	**A1**	Answer Given
8(ii)	$V^2 = 5^2 + 4^2 - \left(2 \times 5 \times 4 \times \cos 65^\circ\right)$	**M1**	attempt at the cosine rule or sine rule to obtain V – allow if seen in (i)
	$V = 4.91$ or $\frac{4}{\sin BAC} = \frac{V}{\sin 65}$	**A1**	
	Distance to travel: $\frac{120}{\sin 67.4^\circ}$	**M1**	distance to travel – allow if seen in **(i)**
	130 or $\sqrt{120^2 + 50^2}$	**A1**	
	Time taken: $\frac{130}{4.91}$	**M1**	**M1dep** for correct method to find the time, must have both of the previous M marks
	26.5	**A1**	

Question	Answer	Marks	Guidance
	Alternative method $AC = \frac{120}{\cos 25}$ oe	**M1**	correct attempt at AC
	$= 132.4$	**A1**	Allow 132
	Speed for this distance = 5	**M1A1**	**M1dep A1** for speed, it must be 5 exactly for A1, must have first M mark
	Time taken $= \frac{132.4}{5}$	**M1**	**M1dep** for a correct method to find the time, must have both of the previous M marks
	= 26.5	**A1**	
9(a)		**B3**	**B1** for line joining $(0,5)$ and $(10,5)$ **B1** for a line joining $(10,0.5)$ and $(30,0.5)$ **B1** all correct with **no solid** line joining $(10,5)$ to $(10,0.5)$
9(b)(i)	3	**B1**	
9(b)(ii)	$\frac{dv}{dt} = -15e^{-5t} + \frac{3}{2}$	**M1**	attempt to differentiate, must be in the form $ae^{-5t} + b$
	When $\frac{dv}{dt} = 0$, $e^{-5t} = 0.1$	**M1**	**M1dep** for equating to zero and attempt to solve, must be of the form $ae^{-5t} = b,\ b > 0$ to obtain an equation in the form $-5t = k$ where k is a logarithm or < 0
	$t = 0.461$	**A1**	

Question	Answer	Marks	Guidance
9(b)(iii)	**Either** attempt to integrate, must be in the form $ce^{-5t}+dt^2$	M1	
	$s=-\frac{3}{5}e^{-5t}+\frac{3}{4}t^2 \quad (+c)$	A1	
	When $t=0,\ s=0$ so $c=\frac{3}{5}$	M1	**M1dep** for attempt to find c and substitute $t=0.5$
	$s=0.738$	A1	
	Or attempt to integrate, must be in the form $ce^{-5t}+dt^2$	M1	
	$\left[-\frac{3}{5}e^{-5t}+\frac{3}{4}t^2\right]_0^{0.5}$	A1	
	correct use of limits	M1	**M1dep**
	leading to $s=0.738$	A1	
10(i)	$5\angle BAC=6.2,\ \angle BAC=1.24$	B1	
10(ii)	$\sin 0.62=\frac{BD}{5}$, $BD=2.905, 2.91$	B1	valid method to find *BD*
	Arc *BFC*: $\pi\times BD \quad (=9.13)$	M1	attempt to find arc length *BFC*, using *their BD*
	Perimeter: $9.13+6.2=15.3$	A1	
10(iii)	Area: $\left(\frac{1}{2}\times\pi\times 2.91^2\right)-\left(\left(\frac{1}{2}\times 5^2\times 1.24\right)-\left(\frac{1}{2}\times 5^2\times\sin 1.24\right)\right)$	B3	**B1** for area of semi circle (= 13.3) **B1** for area of sector (= 15.5) **B1** for area of triangle (= 11.8)
	$9.58\leqslant$ Area $\leqslant 9.62$	B1	final answer

Question	Answer	Marks	Guidance
11(a)	$\tan\left(\phi+35^{\circ}\right)=\frac{2}{5}$	M1	dealing correctly with cot and an attempt at solution of $\tan\left(\phi+35\right)=c$, order must be correct, to obtain a value for $\phi+35$
	$\phi+35^{\circ}=21.8^{\circ},\ 201.8^{\circ},\ 381.8^{\circ}$	M1	**M1dep** for an attempt at a second solution in the range, (180° + *their* first solution in the range oe)
	$\phi=166.8^{\circ},\ \ 346.8^{\circ}$	A2	**A1** for each
11(b)(i)	**Either** $\dfrac{\frac{1}{\cos\theta}}{\frac{\cos\theta}{\sin\theta}+\frac{\sin\theta}{\cos\theta}}$	M1	expressing all terms in terms of $\sin\theta$ and $\cos\theta$ where necessary
	$=\frac{1}{\cos\theta}\left(\frac{\sin\theta\cos\theta}{\cos^2\theta+\sin^2\theta}\right)$	M1	dealing with the fractions correctly to get $\frac{\sin^2\theta+\cos^2\theta}{\sin\theta\cos\theta}$ in denominator or as in left hand column
	$=\frac{\sin\theta}{(1)}$	A1	use of identity, together with a complete and correct solution, withhold A1 for incorrect use of brackets
	Or $\dfrac{\sec\theta}{\frac{1}{\tan\theta}+\tan\theta}$ $=\dfrac{\sec\theta}{\frac{1+\tan^2\theta}{\tan\theta}}$	M1	dealing with fractions in the denominator correctly to get $\frac{1+\tan^2\theta}{\tan\theta}$ in the denominator, allow $\tan\theta$ taken to the numerator
	$=\frac{\sec\theta\tan\theta}{\sec^2\theta}$	M1	use of the identity to get $\sec^2\theta$
	$=\frac{\tan\theta}{\sec\theta}\ \ =\frac{\sin\theta}{\cos\theta}\times\cos\theta\ \ =\sin\theta$	A1	expressing all terms in terms of $\sin\theta$ and $\cos\theta$ and simplification to the given answer, withhold A1 for incorrect use of brackets

Question	Answer	Marks	Guidance
11(b)(ii)	$\sin 3\theta = -\frac{\sqrt{3}}{2}$	**M1**	correct attempt to solve for θ, order must be correct, may be implied by one correct solution
	$3\theta = -\frac{2\pi}{3},\ -\frac{\pi}{3},\ \frac{4\pi}{3}$ $\theta = -\frac{2\pi}{9},\ -\frac{\pi}{9},\ \frac{4\pi}{9}$	**A3**	**A1** for each

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2017**

MARK SCHEME

Maximum Mark: 80

Published

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MARK SCHEME NOTES

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Types of mark

M Method marks, awarded for a valid method applied to the problem.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1	Using $\tan^2\theta+1=\sec^2\theta$ to obtain $y=2(\tan^2\theta+1)$ or $(x+5)^2=\sec^2\theta-1$ $(x+5)^2+1=\frac{y}{2}$	**M1**	use of correct identity
	$y=2((x+5)^2+1)$ oe	**A1**	
2	$\frac{dy}{dx}=10e^{5x}+3$ an attempt at integration in form $ae^{5x}+bx$	**M1**	
	$y=\frac{10}{5}e^{5x}+3x\quad(+c)$	**A1**	condone omission of c
	attempt to find c using $x=0, y=9$	**M1**	**M1dep**
	$y=2e^{5x}+3x+7$	**A1**	
3	$9<4k(k-4)$ $4k^2-16k-9$	**M1**	use of the discriminant with correct values
	$(2k-9)(2k+1)$	**M1**	**M1dep** for solution of *their* quadratic to obtain critical values
	Critical values $\frac{9}{2},\quad -\frac{1}{2}$	**A1**	
	$k<-\frac{1}{2},\ k>\frac{9}{2}$	**A1**	
4	$a=3$	**B1**	
	$b=8$	**B1**	
	$\frac{5}{2}=3\cos\left(8\times\frac{\pi}{12}\right)+c$	**M1**	substitution of $x=\frac{\pi}{12}$ and $y=\frac{5}{2}$ to find c
	$c=4$	**A1**	
5(i)	$\frac{5}{14}(7x-10)^{\frac{2}{5}}$	**B2**	**B1** for $k(7x-10)^{\frac{2}{5}}$

Question	Answer	Marks	Guidance
5(ii)	$\frac{5}{14}\left[(7x-10)^{\frac{2}{5}}\right]_6^a = \frac{25}{14}$ $\frac{5}{14}(7a-10)^{\frac{2}{5}} - \frac{5}{14}(7\times 6-10)^{\frac{2}{5}} = \frac{25}{14}$ $(7a-10)^{\frac{2}{5}} - 4 = 5$	**M1**	correct application of limits for $k(7x-10)^{\frac{2}{5}}$
	$a = \frac{9^{\frac{5}{2}}+10}{7}$	**M1**	**M1dep** for evaluation of $(7\times 6-10)^{\frac{2}{5}}$ and correct order of operations to find a, including dealing with power.
	$a = \frac{253}{7}$ or $36\frac{1}{7}$	**A1**	
6(i)	Gradient = $\frac{2.4-0.9}{0.2-0.8}$ $(=-2.5)$	**B1**	
	$\ln y = -\frac{5}{2}x^2 + c$	**M1**	straight line form and correct substitutions to find c
	$\ln y = -\frac{5}{2}x^2 + 2.9$ oe	**A1**	
	<u>Alternative method</u> $2.4 = p(0.2) + q$ $0.9 = p(0.8) + q$	**B1**	
	Correct method of solution to find p and q from two correct equations	**M1**	**M1dep**
	$\ln y = -\frac{5}{2}x^2 + 2.9$	**A1**	
6(ii)	$y = e^{\left(-\frac{5}{2}x^2+2.9\right)}$	**M1**	dealing with ln
	$y = e^{-\frac{5}{2}x^2} \times e^{2.9}$	**M1**	**M1dep** for dealing with the index
	$y = 18.2z^{-\frac{5}{2}}$	**A1**	

Question	Answer	Marks	Guidance
7(i)	$64-48x^2+15x^4$	**B3**	**B1** for each correct term in final line of response
7(ii)	$\left(64-48x^2+15x^4\right)\left(\frac{1}{x^2}+2+x^2\right)$	**B1**	**B1**for $\frac{1}{x^2}+2+x^2$ oe
	at least two correctly obtained products leading to terms in x^2	**M1**	
	Term in x^2 : $64+15-96$	**A1**	**FT** for correct evaluation of *their* 64 + (2 × *their*–48) + *their* 15
	$=-17$	**A1**	
8(i)	attempt to differentiate a product	**M1**	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=\left((x-4)\times\frac{5}{3}\times3(3x-1)^{\frac{2}{3}}\right)+(3x-1)^{\frac{5}{3}}$	**A2**	**A1** for $(+)\left((x-4)\times\frac{5}{3}\times3(3x-1)^{\frac{2}{3}}\right)$ **A1** for $(+)(3x-1)^{\frac{5}{3}}$
	$=(3x-1)^{\frac{2}{3}}\left((5x-20)+(3x-1)\right)$	**M1**	use of $(3x-1)^{\frac{5}{3}}=(3x-1)^{\frac{2}{3}}(3x-1)$
	$=(3x-1)^{\frac{2}{3}}(8x-21)$	**A1**	
8(ii)	When $x=3$, $\frac{\mathrm{d}y}{\mathrm{d}x}=8^{\frac{2}{3}}\times3$	**M1**	$(3\times3-1)^{\frac{2}{3}}\times k$ or $(9-1)^{\frac{2}{3}}\times k$ or $4\times k$ (where k is any number)
	$\partial y=8^{\frac{2}{3}}\times3\times h$	**M1**	**M1dep** for *their* $\left((9-1)^{\frac{2}{3}}\times k\right)\times h$
	$\partial y=12h$	**A1**	
9(a)(i)	720	**B1**	
9(a)(ii)	240	**B1**	
9(a)(iii)	$k\times4!\ \times2$ or $240-k\times4!\ \times2$ or correct equivalents with no extra terms added or subtracted	**B1**	
	$4\times4!\ \times p$ or correct equivalents with no extra terms added or subtracted	**B1**	
	192	**B1**	

Question	Answer	Marks	Guidance
9(b)(i)	6435	**B1**	
9(b)(ii)	With twins: ${}^{13}C_6$ or 1716 Without twins: ${}^{13}C_8$ or 1287	**B2**	**B1** for ${}^{13}C_6$ or 1716 or ${}^{13}C_8$ or 1287 **B1** for (${}^{13}C_6$ and ${}^{13}C_8$) or (1716 and 1287) with no multiples and no extra terms
	Total: 1716 + 1287 = 3003	**B1**	3003 from a correct method
10(a)	matrix multiplication, must have at least 2 correct elements	**M1**	
	$\mathbf{AB} = \begin{pmatrix} 13 & 8 \\ 2a-5b & 3a+4b \end{pmatrix}$	**A1**	
	$2a-5b=18$ $3a+4b=4$	**M1**	formation and solution of simultaneous equations
	leading to $a=4,\ b=-2$	**A1**	
	Alternate scheme $\mathbf{AB} = \begin{pmatrix} 13 & 8 \\ 18 & 4 \end{pmatrix}$ $\mathbf{ABB}^{-1} = \begin{pmatrix} 13 & 8 \\ 18 & 4 \end{pmatrix} \mathbf{B}^{-1}$	**M1**	Correct plan
	Correct inverse	**B1**	
	$\mathbf{A} = \begin{pmatrix} 4 & -1 \\ a & b \end{pmatrix} = \frac{1}{23}\begin{pmatrix} 13 & 8 \\ 18 & 4 \end{pmatrix}\begin{pmatrix} 4 & -3 \\ 5 & 2 \end{pmatrix}$	**M1**	Correct order and method of multiplication with at least two correct elements
	leading to $a=4,\ b=-2$	**A1**	
10(b)(i)	$-\frac{1}{17}\begin{pmatrix} 1 & 5 \\ 4 & 3 \end{pmatrix}$ oe	**B2**	**B1** for $-\frac{1}{17}$ **B1** for $\begin{pmatrix} 1 & 5 \\ 4 & 3 \end{pmatrix}$
10(b)(ii)	$\mathbf{Z} = -\frac{1}{17}\begin{pmatrix} 1 & 5 \\ 4 & 3 \end{pmatrix}\begin{pmatrix} -1 & 2 \\ 4 & 0 \end{pmatrix}$	**M1**	pre-multiplication with two elements correct
	$= -\frac{1}{17}\begin{pmatrix} 19 & 2 \\ 8 & 8 \end{pmatrix}$ oe	**A2**	**A1** for four correct of $-\frac{1}{17}$, 19, 2, 8, 8

Question	Answer	Marks	Guidance
11(i)	1.48	**B1**	
11(ii)	$\frac{1}{2}\times 10^2 \times \theta = 21.8$	**M1**	correct use of sector area
	$\theta = 0.436$	**A1**	
11(iii)	$\angle BOC = \frac{2\pi - 1.48 - 0.436}{2} \quad (= 2.18(4))$	**B1**	2.18(4) or unsimplified
	$BC = 20\sin\left(\frac{1}{2}\angle BOC\right)$ or $BC = \frac{10\times \sin BOC}{\sin\left(\frac{\pi - BOC}{2}\right)}$ or $BC = \sqrt{(200 - 200\cos BOC}$ $BC = 17.7(5)$	**M2**	**M1** for a complete correct method to find *BC* using *their* angle *BOC* **M1** for a correct plan using 14.8, *their BC* and 10 × *their* answer to (ii)
	Perimeter = $14.8 + (2\times 17.7(5)) + 4.36$ $= 54.7$ or 54.6	**A1**	awrt 54.7 or awrt 54.6

Question	Answer	Marks	Guidance
11(iv)	Area = $\left(\frac{1}{2}\times 10^2\times 1.48\right)+21.8+2\left(\frac{1}{2}\times 10^2\sin 2.18(4)\right)$	**B2**	**B1** for $\left(\frac{1}{2}\times 10^2\times 1.48\right)+21.8$ **B1** for $2\left(\frac{1}{2}\times 10^2\sin 2.18(4)\right)$
	= 178	**B1**	awrt 178 from correct working
	<u>Alternative method 1</u> Segment area $=\frac{1}{2}\left(10^2\left(2.18-\sin 2.18\right)\right)$	**B1**	**B1** for $2\times\frac{1}{2}\left(10^2\left(2.18(4)-\sin 2.18(4)\right)\right)$
	Area required = $100\pi-2\times\frac{1}{2}\left(10^2\left(2.18(4)-\sin 2.18(4)\right)\right)$	**B1**	
	= 178	**B1**	awrt 178 from correct working
	<u>Alternative method 2</u> Area of trapezium = $\frac{1}{2}\left(\left(13.5+4.33\right)\left(17.1\right)\right)$	**B1**	correct area of trapezium *ABCD* (allow unsimplified)
	Area of segments = $\frac{1}{2}\left(10^2\left(1.48-\sin 1.48\right)\right)$ **+** $\frac{1}{2}\left(10^2\left(0.436-\sin 0.436\right)\right)$	**B1**	correct area of both segments (allow unsimplified)
	= 178	**B1**	awrt 178 from correct working

Question	Answer	Marks	Guidance
12(i)	$2x^2+5x-12=0$ or $y^2+3y-28=0$	M1	attempt to get in terms of one variable
	$(2x-3)(x+4)=0$ or $(y+7)(y-4)=0$	M1	**M1dep** for solution of a three term quadratic
	leading to $x=-4,\ y=-7$ and $x=\frac{3}{2},\ y=4$	A2	**A1** for each 'pair'
	Midpoint $M\left(\frac{\frac{3}{2}-4}{2},\frac{4+(-7)}{2}\right)\left(=\left(-\frac{5}{4},-\frac{3}{2}\right)\right)$	A1	correctly obtained midpoint
	Gradient of $PQ=2$	B1	may be implied
	Perp gradient = $-\frac{1}{2}$	M1	$\frac{-1}{\textit{their}\text{ gradient of }PQ}$
	Perp bisector: $y+\frac{3}{2}=-\frac{1}{2}\left(x+\frac{5}{4}\right)$	M1	**M1dep** for equation of perp bisector using *their* perp gradient and *their* midpoint. (unsimplified)
	$y=-\frac{1}{2}(-10)-\frac{17}{8}=\frac{23}{8}$ or $\frac{23}{8}=-\frac{1}{2}x-\frac{17}{8}\rightarrow x=-10$	A1	all correct so far and for verification using a correct equation

Question	Answer	Marks	Guidance
12(ii)	Area $= \frac{1}{2}\times\left(\frac{17}{8}+1\right)\times\frac{5}{4}$	M1	finding *R*, *S* and *RS*
	correct method for finding area	M1	**M1dep**
	$= \frac{125}{64}$ or 1.95 or $1\frac{61}{64}$	A1	
	<u>Alternative method 1</u> Area $= \frac{1}{2}\times\frac{\sqrt{125}}{4}\times\frac{\sqrt{125}}{8}$	M1	finding *R*, *S*, *RM* and *MS*
	correct method for finding area	M1	**M1dep**
	$= \frac{125}{64}$ or 1.95 or $1\frac{61}{64}$	A1	
	<u>Alternative method 2</u> Area $= \frac{1}{2}\begin{vmatrix} 0 & 0 & \frac{-5}{4} & 0 \\ 1 & \frac{-17}{8} & \frac{-3}{2} & 1 \end{vmatrix}$	M1	finding *R* and *S* to obtain *their* $\frac{1}{2}\begin{vmatrix} 0 & 0 & \frac{-5}{4} & 0 \\ 1 & \frac{-17}{8} & \frac{-3}{2} & 1 \end{vmatrix}$
	$= \frac{1}{2}\left\lvert -\frac{5}{4}-\frac{85}{32}\right\rvert$ oe	M1	**M1dep** for correct method of evaluation
	$= \frac{125}{64}$ or 1.95 or $1\frac{61}{64}$	A1	

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ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2017**

MARK SCHEME

Maximum Mark: 80

Published

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awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Guidance
1	$x^2 - 6x - 7(>0)$	**B1**	
	$(x-7)(x+1)(>0)$	**M1**	
	Critical values 7 and –1	**A1**	
	$x > 7$ or $x < -1$	**A1**	
2	$\dfrac{(1+\sin\theta)-(1-\sin\theta)}{(1-\sin\theta)(1+\sin\theta)}$	**M1**	Dealing with fractions
	$=\dfrac{2\sin\theta}{(1-\sin^2\theta)}$	**A1**	Simplification
	$=\dfrac{2\sin\theta}{\cos^2\theta}$	**M1**	Use of identity (seen anywhere)
	$=2\tan\theta\sec\theta$	**M1**	Use of $\tan\theta=\dfrac{\sin\theta}{\cos\theta}$ and $\sec\theta=\dfrac{1}{\cos\theta}$ (seen anywhere)
3	$2=\log_5 25$	**B1**	
	$\log_5 25+\log_5(x-7)=\log_5 25(x-7)$ $10x+5=25(x-7)$	**M1**	
	$180=15x$	**M1**	Equate, clear brackets and collect terms.
	$12=x$	**A1**	

Question	Answer	Marks	Guidance
4	$x-2\left(4-\sqrt{3}x\right)=5\sqrt{3}$	M1	Eliminate y
	$x=\dfrac{5\sqrt{3}+8}{2\sqrt{3}+1}$	A1	
	$x=\dfrac{\left(5\sqrt{3}+8\right)\left(2\sqrt{3}-1\right)}{\left(2\sqrt{3}+1\right)\left(2\sqrt{3}-1\right)}$	M1	Multiply by $\left(a\sqrt{b}+c\right)$ as appropriate
	$x=2+\sqrt{3}$	A1	
	$y=1-2\sqrt{3}$	A1	
	Alternative method $\sqrt{3}\left(5\sqrt{3}+2y\right)+y=4$	M1	Eliminate x
	$y=\dfrac{-11}{\left(2\sqrt{3}+1\right)}$	A1	
	$y=\dfrac{-11\left(2\sqrt{3}-1\right)}{\left(2\sqrt{3}+1\right)\left(2\sqrt{3}-1\right)}$	M1	Multiply by $\left(a\sqrt{b}+c\right)$ as appropriate
	$y=1-2\sqrt{3}$	A1	
	$x=2+\sqrt{3}$	A1	
5(i)	$\dfrac{\mathrm{d}}{\mathrm{d}x}\left(\dfrac{5}{3x+2}\right)=-5\left(3x+2\right)^{-2}\times 3$	M1	$-5\left(3x+2\right)^{-2}$
		A1	$\times 3$
5(ii)	$\int\dfrac{30}{\left(3x+2\right)^2}\,\mathrm{d}x=\left[\dfrac{-10}{\left(3x+2\right)}\right]$	M1	$\dfrac{1}{\left(3x+2\right)}$
		A1	$\times -10$
5(iii)	$\left[\dfrac{-10}{\left(3x+2\right)}\right]_1^2=-\dfrac{10}{8}+\dfrac{10}{5}$	M1	Insert limits and subtract
	$=\dfrac{3}{4}$	A1	
6(i)	$2q+3p=13$	B1	

Question	Answer	Marks	Guidance
6(ii)	Multiply matrices correctly	**M1**	
	$2p + pq = 12$	**A1**	
6(iii)	$4p + p(13 - 3p) = 24$	**M1**	Eliminate q
	$3p^2 - 17p + 24 = 0$	**A1**	
	$(3p - 8)(p - 3) = 0$	**M1**	Solve
	$p = 3,\ q = 2$	**A1**	
7	$\frac{dy}{dx} = 3x^2 - \frac{1}{x^2}(+C)$	**B2**	**B1** for $3x^2$ **B1** for $-\frac{1}{x^2}$.
	$x = 1,\ \frac{dy}{dx} = 1 \to C = -1$	**B1**	
	$y = x^3 + \frac{1}{x} - x + D$ $x = 1,\ y = 3 \to D = 2$	**B2**	**B1** for two correct terms in x
	$y = x^3 + \frac{1}{x} - x + 2$	**B1**	
8	$z^2 = a^2 + 3(a+3)^2 + 2a(a+3)\sqrt{3}$ $= 79 + b\sqrt{3}$	**M1**	
	$a^2 + 3(a+3)^2 = 79$ and $2a(a+3) = b$	**A1**	**FT** Equate correctly to obtain both eqns
	$a^2 + 3a^2 + 18a + 27 = 79$ $4a^2 + 18a - 52 = 0$	**M1**	Expand and simplify to obtain 3 term quadratic
	$(a - 2)(4a + 26) = 0$	**M1**	
	$a = 2, \quad b = 20$	**A2**	**A1** for each
9(i)	$1 + 4x + 6x^2 + 4x^3 + x^4$	**B1**	
9(ii)	$1296 - 864x + 216x^2 - 24x^3 + x^4$	**B2**	Minus 1 each error.
9(iii)	$1295 - 868x + 210x^2 - 28x^3 = 175$	**M1**	Subtract and equate to 1
	$28x^3 - 210x^2 + 868x - 1120 = 0$	**A1**	

Question	Answer	Marks	Guidance
9(iv)	$28(2)^3 - 210(2)^2 + 868(2) - 1120$	**M1**	Inserts $x = 2$
	$= 224 - 840 + 1736 - 1120 = 0$ $(x-2)$ is a factor	**A1**	
	$(x-2)(28x^2 - 154x + 560)$	**M1A1**	**M1** for 28 and 560 seen oe **A1** for –154
	$b^2 - 4ac < 0$ shown	**B1**	
10(i)	$\mathbf{r}_A = (2\mathbf{i} + 4\mathbf{j}) + t(\mathbf{i} + \mathbf{j})$	**B1**	
10(ii)	$\mathbf{r}_B = (10\mathbf{i} + 14\mathbf{j}) + t(-2\mathbf{i} - 3\mathbf{j})$	**B1**	
10(iii)	$\mathbf{r}_B - \mathbf{r}_A = (8\mathbf{i} + 10\mathbf{j}) + t(-3\mathbf{i} - 4\mathbf{j})$	**M1**	
	$X^2 = (8-3t)^2 + (10-4t)^2$	**M1A1**	
10(iv)	Differentiate	**M1**	
	$\frac{dX^2}{dt} = 2(8-3t)(-3) + 2(10-4t)(-4)$ oe	**A1**	
	$\frac{dX^2}{dt} = 0 \rightarrow t = 2.56$ $\rightarrow X = 0.4$	**B2**	**B1** for value of t **B1** for value of X .
11(i)	$x^2 - 2x + (kx+3)^2 = 8$	**M1**	Eliminate y
	$(1+k^2)x^2 + (6k-2)x + 1 = 0$	**A1**	
	$b^2 - 4ac = 0 \rightarrow (6k-2)^2 - 4(1+k^2) = 0$	**M1**	
	$k = \frac{3}{4}$	**A1**	Answer given
11(ii)	$x = \frac{-b}{2a} \rightarrow x = \frac{-2.5}{2 \times 1.5625}$	**M1**	
	$= -0.8$	**A1**	
	$y = 0.75 \times -0.8 + 3 = 2.4$	**A1**	**FT**

Question	Answer	Marks	Guidance
11(iii)	Eqn of PQ $\frac{y-2.4}{x+0.8}=\frac{-4}{3}$	**M1**	
	$\rightarrow 3y=4-4x$	**A1**	
12(i)	$\frac{\mathrm{d}(\cos x)^{-1}}{\mathrm{d}x}=\frac{1}{\cos^2 x}\times\sin x$	**M1**	$\frac{1}{\cos^2 x}$
		A1	$\times\sin x$
12(ii)	$\frac{\mathrm{d}y}{\mathrm{d}x}=\sec^2 x+\frac{4\sin x}{\cos^2 x}$	**B1**	$\sec^2 x$
		B1	$\frac{4\sin x}{\cos^2 x}$
12(iii)	$\frac{1}{\cos^2 x}+\frac{4}{\cos x}\times\frac{\sin x}{\cos x}=4$	**M1**	Equate *their* (i) to 4 and multiply by $\cos^2 x$
	$\rightarrow 1+4\sin x=4\cos^2 x$	**M1**	Use of identity and simplify
	$4\sin^2 x+4\sin x-3=0$	**A1**	
	$(2\sin x-1)(2\sin x+3)=0$	**M1**	Solve
	$x=\frac{\pi}{6},\ \frac{5\pi}{6}$	**A2**	**A1** for each

Cambridge IGCSE

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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **October/November 2017**

MARK SCHEME

Maximum Mark: 80

Published

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Types of mark

M	Method marks, awarded for a valid method applied to the problem.
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Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1	$z^2 = 7 + 4\sqrt{3}$	B1	Accept $4 + 3 + 4\sqrt{3}$
	$a\left(7 + 4\sqrt{3}\right) + b\left(2 + \sqrt{3}\right) = 1 + \sqrt{3}$	M1	Equate both $\sqrt{3}$ terms and constant terms to obtain two equations in a and b.
	$7a + 2b = 1$ $4a + b = 1$	A1	Both correct. Accept equation with a multiple of $\sqrt{3}$
	Attempt to solve a pair of linear simultaneous eqns to $a =$ or $b =$	M1	**M1dep**
	$a = 1$ and $b = -3$	A1	
2	$2x^{1.5} + 6x^{-0.5} = x\left(x^{0.5} + 5x^{-0.5}\right)$	M1	Attempt to multiply by $x^{0.5} + 5x^{-0.5}$ or $x^{0.5}$ or divide by $x^{0.5}$
	$2x^{1.5} + 6x^{-0.5} = x^{1.5} + 5x^{0.5}$ or $x^{1.5} - 5x^{0.5} + 6x^{-0.5} = 0$ or $\dfrac{2x^2 + 6}{x + 5} = x$ or $\dfrac{2x + \frac{6}{x}}{1 + \frac{5}{x}} = x$	A1	Simplified numerical powers
	$x^2 - 5x + 6 = 0$	M1	**M1dep** obtain a three term quadratic. Allow errors in signs and coefficients but not powers
	$\left(x - 3\right)\left(x - 2\right) = 0$	M1	Solve a three term quadratic
	$x = 3$ or 2 only	A1	
3	Correctly obtain a value of $x = 2$	B1	Inequality not required
	Correctly obtain a value of $x = -\dfrac{1}{2}$	B1	Inequality not required
	$x > 2$ and $x < -\dfrac{1}{2}$	B1	**B1dep** mark final answer(s). Allow $2 < x < -\dfrac{1}{2}$

Question	Answer	Marks	Partial Marks
4	$x+4=y^2$	**B1**	
	$7y-x=16$ $7y-16+4=y^2$	**B1**	allow 2^4 for 16
	$y^2-7y+12 \to (y-3)(y-4)(=0)$ or $x^2-17x+60 \to (x-5)(x-12)(=0)$	**M1**	**Attempt** to eliminate x or y to obtain a three term quadratic.
	Solve a three term quadratic	**M1**	**M1dep**
	$\to y=3,\ x=5$ or $y=4\ x=12$	**A1**	Allow for values seen even if correct pairs not clear.
5(i)	${}^{10}C_4=210$	**B1**	
5(ii)	2 Mystery 2 others = ${}^5C_2 \times {}^5C_2$ =100 3 Mystery 1 other = ${}^5C_3 \times {}^5C_1$ = 50 4 Mystery = ${}^5C_4$ =5 Total 155	**B3**	**B1** for one combination, unsimplifiied **B1** for second combination, unsimplifiied **B1** for third combination, unsimplifiied and total
	Alternative Method All – 0 Mystery – 1 Mystery	**B1**	All minus 0 or 1 or both
	$=210-{}^5C_4-{}^5C_1\times{}^5C_3$	**B1**	**B1dep** 1Mystery and 0 mystery unsimplified
	$=210-5-5\times10=155$	**B1**	**B1dep** final answer
5(iii)	2M1C1R = ${}^5C_2\times{}^3C_1\times{}^2C_1=60$ 1M2C1R = ${}^5C_1\times{}^3C_2\times{}^2C_1=30$ 1M1C2R $={}^5C_1\times{}^3C_1\times{}^2C_2$ $=15$ Total 105	**B3**	**B1** for one combination, unsimplifiied **B1** for second combination, unsimplifiied **B1** for third combination, unsimplifiied and total
6(i)	$\pi x^2h=500 \to h=\frac{500}{\pi x^2}$	**B1**	Ignore units Condone r for x
6(ii)	$A=2\pi x^2+2\pi xh$	**M1**	Correct expression for A and insert for *their h*.
	$=2\pi x^2+2\pi x\times\frac{500}{\pi x^2}\ =\ 2\pi x^2+\frac{1000}{x}$	**A1**	Answer given Condone r for x.

Question	Answer	Marks	Partial Marks
6(iii)	Differentiate: at least one power reduced by 1	**M1**	
	$\frac{dA}{dx} = 4\pi x - \frac{1000}{x^2}$	**A1**	
	$\frac{dA}{dx} = 0 \rightarrow x = \sqrt[3]{\frac{1000}{4\pi}}$ isw or $(x = 4.3(0))$	**A1**	
	$A = 2\pi(4.3)^2 + \frac{1000}{4.3} = 349\,\text{cm}^2$	**A1**	awrt 349
	$\frac{d^2A}{dx^2} = 4\pi + \frac{2000}{x^3}$ (>0) or a positive value $(\rightarrow \text{min})$	**B1**	Correct second differential (need not be evaluated) and conclusion. or Examine correct gradient either side of $x = 4.3$ and conclusion
7(i)	(Gradient or $\frac{dy}{dx}$) $= \frac{3x-1}{\sqrt{x}}$	**B1**	Gradient = Negative reciprocal. Can be implied.
	$= 3x^{\frac{1}{2}} - x^{-\frac{1}{2}}$	**B1**	± One correct term
	$y = 2x^{\frac{3}{2}} - 2x^{\frac{1}{2}}\,(+C)$	**M1**	at least 1 fractional power increased by1.
	$-10 = 2 - 2 + C \rightarrow C = -10$	**A1**	one term correct with simplified coefficients
	$y = 2x^{\frac{3}{2}} - 2x^{\frac{1}{2}} - 10$	**A1**	For *C* from correct working.
7(ii)	$x = 4 \rightarrow y = 16 - 4 - 10 = 2$	**B1**	
	$\rightarrow \frac{dy}{dx} = 6 - \frac{1}{2} = 5.5$	**B1**	
	Eqn with *their* grad and point (4, ...)	**M1**	
	Eqn of tangent: $\frac{y-2}{x-4} = 5.5 \rightarrow y = 5.5x - 20$ oe	**A1**	Must be in the form $y = mx + c$ but accept $2y = 11x - 40$
8(i)	$2\mathbf{A} = \begin{pmatrix} 4 & 2 \\ 8 & 6 \end{pmatrix}$	**B1**	
	$(2\mathbf{A})^{-1} = \frac{1}{8}\begin{pmatrix} 6 & -2 \\ -8 & 4 \end{pmatrix}$	**B2**	**B1** for $\begin{pmatrix} 6 & -2 \\ -8 & 4 \end{pmatrix}$ **B1** for $\frac{1}{8}$

Question	Answer	Marks	Partial Marks
8(ii)	$4x+2y=-5$ $8x+6y=-9$	**B1**	
	Pre multiply $\begin{pmatrix}-5\\-9\end{pmatrix}$ by a 2×2 matrix.	**M1**	Allow recovery
	$\begin{pmatrix}x\\y\end{pmatrix}=\frac{1}{8}\begin{pmatrix}6 & -2\\-8 & 4\end{pmatrix}\begin{pmatrix}-5\\-9\end{pmatrix}$	**M1**	Pre multiply *their* $\begin{pmatrix}-5\\-9\end{pmatrix}$ by *their* answer to (i)
	$\begin{pmatrix}x\\y\end{pmatrix}=\frac{1}{8}\begin{pmatrix}-12\\4\end{pmatrix}=\begin{pmatrix}-1.5\\0.5\end{pmatrix}$	**A2**	**A1** for x value **A1** for y value oe Allow both unsimplified
9(i)	$\frac{\mathrm{d}}{\mathrm{d}x}(x\ln x)=x\times\frac{1}{x}+\ln x$ isw	**M1A1**	Product rule. One correct term + another term. Allow unsimplified.
9(ii)	$\int 1+\ln x\,\mathrm{d}x=x\ln x$	**M1**	Correct use of (i) and must be dealing with 2 terms. soi
	$\int \ln x\,dx=x\ln x-x+(C)$	**A1**	Correct answer with no working is fine.
9(iii)	$\int_k^{2k}\ln x\,\mathrm{d}x=[2k\ln 2k-2k]-[k\ln k-k]$ $=k(2\ln 2k-\ln k-1)$	**M1**	Insert limits and subtract correctly using *their* result from (ii) which must contain an ln function
	$=k\left(\ln(2k)^2-\ln k-1\right)$	**M1**	Uses $n\ln a=\ln a^n$ somewhere oe
	$=k\left(\ln\left(\frac{4k^2}{k}\right)-1\right)$	**M1**	Uses $\ln a-\ln b=\ln\left(\frac{a}{b}\right)$ or $\ln a+\ln b=\ln ab$ somewhere
	$=k(\ln 4k-1)$	**A1**	Answer given Correct completion.

Question	Answer	Marks	Partial Marks
10(i)	$c=1 \to 6(1)^3-7(1)^2+1=0 \to (c-1)$ is a factor.	**B1**	Or correct division. Finding or using one correct factor.
	Attempt to factorise or use long division to obtain $6c^2\ldots\pm1$ or $6c^2\pm c\ldots$ respectively	**M1**	
	$(c-1)(6c^2-c-1)=0$	**A1**	
	$(c-1)(2c-1)(3c+1)=0$	**A1**	
	$c=1,\ \frac{1}{2},-\frac{1}{3}$	**A1**	**FT** From three different linear factors
10(ii)	$\frac{dy}{dx}=\sec^2 x+6\cos x$	**B2**	**B1** for each term
10(iii)	$\frac{1}{\cos^2 x}+6\cos x=7$	**B1**	**B1dep** Replaces $\sec^2 x$ by $\frac{1}{\cos^2 x}$
	$\to 6\cos^3 x-7\cos^2 x+1=0$	**B1**	**B1dep** Answer given so all steps must be correct.
10(iv)	$\cos x=1,\ \frac{1}{2},\ -\frac{1}{3}.$ $\to x=0,\ 1.05\left(\text{or } \frac{\pi}{3}\right),\ 1.91$	**A2**	**A1** for 2 values awrt **A1** for third value and no others in range. No credit for answers in degrees
11(i)	$y=0 \to (x-4)(x+1)=0$	**M1**	Solve
	$\to A$ is $(4,0)$ nfww	**A1**	Indication somewhere that $x=4$ when $y=0$
11(ii)	$4+3x-x^2=mx+8$ $x^2+(m-3)x+4=0$	**M1**	Eliminate y.
	$b^2-4ac(=0) \to (m-3)^2=16$	**M1**	**M1dep** Use of discriminant
	$m=-1$	**A1**	Do not award if $m=7$ is not discarded
11(iii)	Obtain quadratic $x^2+(m-3)x+4=0$ using *their* m and attempt to solve.	**M1**	Working must be seen for any marks to be awarded. Must not be awarded if m is not obtained correctly
	Point B (2, 6)	**A1**	

Question	Answer	Marks	Partial Marks
11(iv)	Area under curve $=\int_2^4 \left(4+3x-x^2\right)\mathrm{d}x$ Integrate powers increased in at least 2 terms	**M1**	
	$=\left[4x+\frac{3}{2}x^2-\frac{1}{3}x^3\right]_2^4$	**A1**	
	$=\left[16+24-\frac{64}{3}\right]-\left[8+6-\frac{8}{3}\right]$ $=7\frac{1}{3}$	**M1**	**M1dep** Insert limits of *their* 2 and 4 and subtract in correct order. May be implied by $18\frac{2}{3}-\ldots$
	Intercept is (8,0) so area of triangle = $\frac{6\times 6}{2}=18$	**M1**	Area of triangle using *their* $B=\frac{(their 8-x_B)}{2}\times y_B$ or Attempt to find other suitable areas to result in a complete method.
	Shaded area $=18-7\frac{1}{3}=10\frac{2}{3}$	**A1**	Accept 10.7. Must not be awarded if point B is not obtained correctly.

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ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **October/November 2017**

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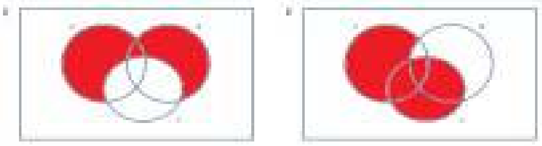
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Guidance
1(a)		**B2**	**B1** for each
1(b)	$n(P')$ = 18	**B1**	
	$n((Q \cup R) \cap P)$ = 11	**B1**	
	$n(Q' \cup P)$ = 29	**B1**	
2	$3x-1=5+x$ $x=3$	**B1**	
	$3x-1=-5-x$ oe	**M1**	M1 not earned if incorrect equation(s) present
	$x=-1$	**A1**	
3	$\frac{p(\sqrt{3}+1)+(\sqrt{3}-1)}{(\sqrt{3}-1)(\sqrt{3}+1)}=q+3\sqrt{3}$	**M1**	on LHS take common denominator or rationalise each term or multiply throughout
	$p(\sqrt{3}+1)+(\sqrt{3}-1)=2q+6\sqrt{3}$ oe	**A1**	correct eqn with no surds in denominators of LHS
	equate surd/non surd parts	**M1**	equate and solve for p or q ($\neq 0$)
	$p=5$ and $q=2$	**A1**	
4	$\log_3 3=1$ or $\log_3 9=2$	**B1**	implied by one correct equation
	$x+1=3y$	**B1**	
	$x-y=9$	**B1**	
	solve correct equations for x or y	**M1**	
	$x=14$ and $y=5$	**A1**	
5(i)	$\overrightarrow{OX}=\lambda(1.5\mathbf{b}+3\mathbf{a})$	**B1**	
5(ii)	$\overrightarrow{AB}=\mathbf{b}-\mathbf{a}$ or $\overrightarrow{BA}=\mathbf{a}-\mathbf{b}$	**B1**	
	$\overrightarrow{OX}=\mathbf{a}+\mu(\mathbf{b}-\mathbf{a})$	**B1**	
5(iii)	$1.5\lambda=\mu$ or $3\lambda=1-\mu$	**M1**	$\overrightarrow{OX}=\overrightarrow{OX}$ and equate for **a** or **b**
	$\mu=\frac{1}{3}$ $\lambda=\frac{2}{9}$	**A2**	**A1** for each

Question	Answer	Marks	Guidance
5(iv)	$\frac{AX}{XB}=\frac{1}{2}$	B1	Accept 1 : 2 but not $\frac{1}{2}:1$
5(v)	$\frac{OX}{XD}=\frac{2}{7}$	B1	Accept 2 : 7 but not $\frac{2}{7}:1$
6(i)	$f^2 = f(f)$ used algebraic $([(x+2)^2+1]+2)^2+1$	M1	numerical or algebraic
	17	A1	
6(ii)	$x=\frac{y-2}{2y-1}$	M1	change x and y
	$2xy-x=y-2 \to y(2x-1)=x-2$	M1	**M1dep** multiply, collect y terms, factorise
	$y=\frac{x-2}{2x-1}$ $[=g(x)]$	A1	correct completion
6(iii)	$gf(x)=\frac{[(x+2)^2+1]-2}{2[(x+2)^2+1]-1}$ oe	B1	
	$\frac{(x+2)^2-1}{2(x+2)^2+1}=\frac{8}{19}$ $3(x+2)^2=27$ oe $3x^2+12x-15=0$	M1	*their* gf = $\frac{8}{19}$ and simplify to quadratic equation
	solve quadratic	M1	**M1dep** Must be of equivalent form
	$x=1$ $x=-5$	A1	
7(i)	$v=0 \to \cos 2t=\frac{1}{3}$	M1	set $v=0$ and solve for $\cos 2t$
	$\to t=0.615$ or 0.616	A1	
7(ii)	$s=\frac{3}{2}\sin 2t-t$ $(+c)$	M1A1	**M1** for $\sin 2t$ and $\pm t$
	$t=\frac{\pi}{4}\to$ $s=1.5-\frac{\pi}{4}$ $(=0.715)$	A1	
7(iii)	$a=-6\sin 2t$	M1A1	**M1** for $-\sin 2t$
	$t=0.615 \to a=-5.66$ or -5.65 or $-2\sqrt{8}$	A1	condone substitution of degrees

Question	Answer	Marks	Guidance
8(i)	$\cos\alpha = \frac{1}{3}$ oe	**M1**	
	$\alpha = 70.5°$	**A1**	
8(ii)	speed $= \sqrt{3^2 - 1^2}$	**M1**	Pythagoras/trig ratio/cosine rule
	$\sqrt{8}$ or $2\sqrt{2}$ or $2.83\ \text{m s}^{-1}$	**A1**	
8(iii)	time $= \frac{50}{their\sqrt{8}}$	**M1**	
	$\frac{25\sqrt{2}}{2}$ or 17.7s	**A1**	
8(iv)	*their* 8(iii) seen	**B1**	
	$BC = 10\sqrt{2}$ or 14.1 m or 14.2 m	**B1**	
9(i)	$\frac{d}{dx}(\ln x) = \frac{1}{x}$ and $\frac{d}{dx}x^3 = 3x^2$ or $\frac{d}{dx}x^{-3} = -3x^{-4}$	**B1**	seen
	Substitution of *their* derivatives into quotient rule	**M1**	
	$\frac{d}{dx}\left(\frac{\ln x}{x^3}\right) = \frac{x^3 \times \frac{1}{x} - 3x^2 \ln x}{x^6}$ oe	**A1**	correct completion
9(ii)	$\frac{dy}{dx} = 0 \rightarrow 1 - 3\ln x = 0$ $\ln x = \frac{1}{3}$	**M1**	equate given $\frac{dy}{dx}$ to zero and solve for $\ln x$ or x
	$x = e^{\frac{1}{3}}$	**A1**	seen
	$y = \frac{1}{3e}$	**A1**	seen
9(iii)	$\frac{\ln x}{x^3} = \int \frac{1 - 3\ln x}{x^4}\,dx$ oe	**M1**	use given statement in (i)
	$\int \frac{1}{x^4}\,dx = \frac{-1}{3x^3}$	**B1**	seen anywhere
	$\int \frac{\ln x}{x^4}\,dx = -\frac{1}{9x^3} - \frac{\ln x}{3x^3}$ (+C) oe	**A2**	**A1** for each term

Question	Answer	Marks	Guidance
10(a)	LHS $= \dfrac{\sin^2 x + (1+\cos x)^2}{\sin x(1+\cos x)}$	B1	correct addition of fractions
	$= \dfrac{1+2\cos x+1}{\sin x(1+\cos x)}$	B1	expansion and use of identity
	$= \dfrac{2(1+\cos x)}{\sin x(1+\cos x)} = 2\operatorname{cosec} x$	B1	factorisation and completion
10(b)(i)	$\operatorname{cosec}^2 y - 1 + \operatorname{cosec} y - 5 = 0$ $\operatorname{cosec}^2 y + \operatorname{cosec} y - 6 = 0$	M1	use of identity for $\cot^2 y$ to obtain quadratic in cosec$y$
	$(\operatorname{cosec} y - 2)(\operatorname{cosec} y + 3) = 0$	M1	solve 3 term quadratic for cosec$y$
	$\sin y = \dfrac{1}{2}$, $\sin y = -\dfrac{1}{3}$	M1	obtain values for sin$y$
	$y = 30°, 150°, 199.5°, 340.5°$	A2	**A1** for 2 values
10(b)(ii)	$2z + \dfrac{\pi}{4} = \dfrac{5\pi}{6}$ or $\dfrac{7\pi}{6}$ (2.6…, 3.6…)	M2	**M1** equate to $\dfrac{5\pi}{6}$ **M1** equate to $\dfrac{7\pi}{6}$
	$z = \dfrac{7\pi}{24}$ or $\dfrac{11\pi}{24}$ (0.916, 1.44)	A2	**A1** for 1 value
11(i)	Other root $= 4$	B1	
	$f(x) = (x-3)(x-3)(x-4)$ $= x^3 - 10x^2 + 33x - 36$	M1	multiply out $(x-3)(x-3)(x \pm p)$
	$a = -10$ $b = 33$	A2	**A1** for each Can be implied by correct cubic
11(ii)	$x = 6,\ x = 6,\ x = 1$ $x = 2,\ x = 2,\ x = 9$ $x = 1,\ x = 1,\ x = 36$	B4	**B1** for each of first two sets **B2** for third set

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

1404301964

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **October/November 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
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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.
The total number of marks for this paper is 80.

This document consists of **16** printed pages.

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Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}\,.$$

Binomial Theorem

$$(a+b)^n = a^n + \binom{n}{1} a^{n-1}\, b + \binom{n}{2} a^{n-2}\, b^2 + \ldots + \binom{n}{r} a^{n-r}\, b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$.

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

Formulae for ΔABC

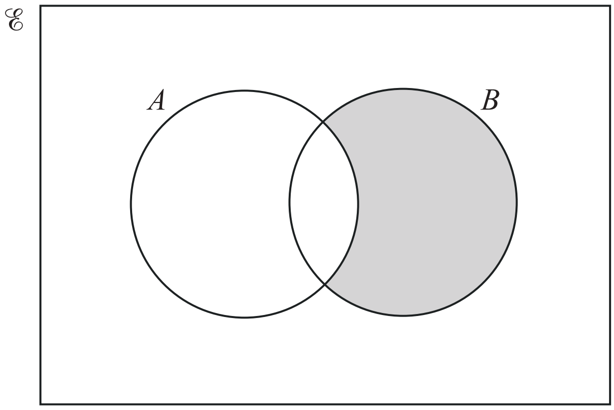
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2}\, bc \sin A$$

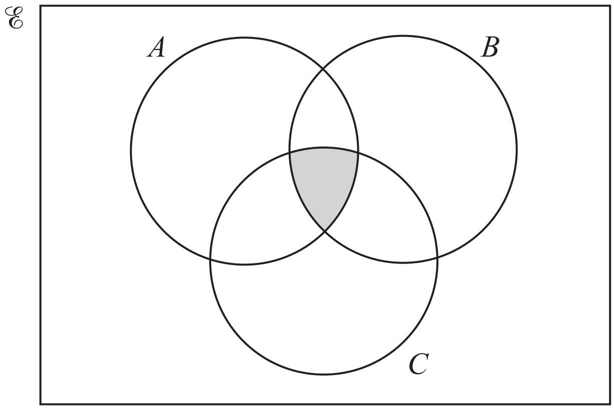
1 Express in set notation the shaded regions shown in the Venn diagrams below.

(i)



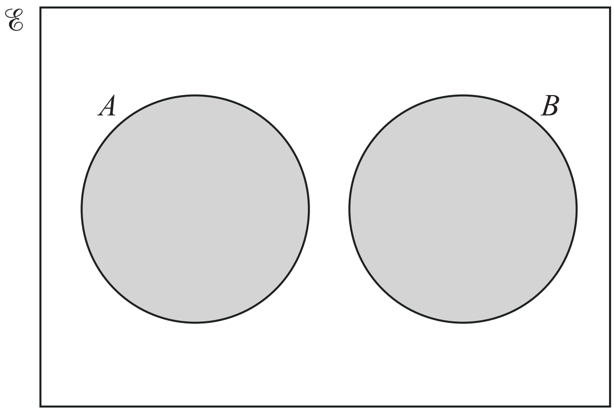
.... [1]

(ii)



.... [1]

(iii)



.... [1]

2 The polynomial $p(x)$ is $ax^3 + bx^2 - 13x + 4$, where a and b are integers. Given that $2x - 1$ is a factor of $p(x)$ and also a factor of $p'(x)$,

(i) find the value of a and of b. [5]

Using your values of a and b,

(ii) find the remainder when $p(x)$ is divided by $x + 1$. [2]

3 **(a)** Given that $T = 2\pi l^{\frac{1}{2}} g^{-\frac{1}{2}}$, express l in terms of T, g and π. [2]

(b) By using the substitution $y = x^{\frac{1}{3}}$, or otherwise, solve $x^{\frac{2}{3}} - 4x^{\frac{1}{3}} + 3 = 0$. [4]

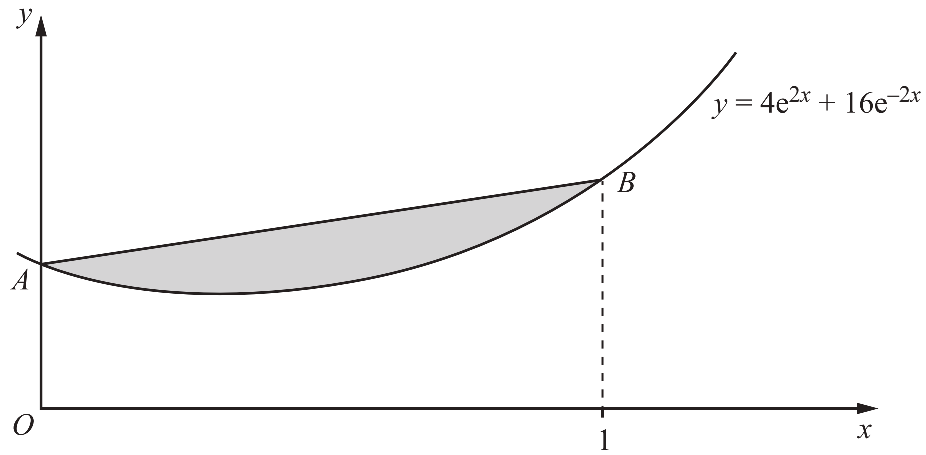
4 When $\lg y$ is plotted against x^2 a straight line is obtained which passes through the points (4, 3) and (12, 7).

(i) Find the gradient of the line. [1]

(ii) Use your answer to part **(i)** to express $\lg y$ in terms of x. [2]

(iii) Hence express y in terms of x, giving your answer in the form $y = A\left(10^{bx^2}\right)$ where A and b are constants. [3]

5



The diagram shows part of the graph of $y = 4e^{2x} + 16e^{-2x}$ meeting the y-axis at the point A and the line $x = 1$ at the point B.

(i) Find the coordinates of A. [1]

(ii) Find the y-coordinate of B. [1]

(iii) Find $\int (4e^{2x} + 16e^{-2x})\,dx$. [2]

(iv) Hence find the area of the shaded region enclosed by the curve and the line AB. You must show all your working. [4]

6 **(a)** Functions f and g are such that, for $x \in \mathbb{R}$,

$$f(x) = x^2 + 3,$$

$$g(x) = 4x - 1.$$

(i) State the range of f. [1]

(ii) Solve $fg(x) = 4$. [3]

(b) A function h is such that $\mathrm{h}(x) = \dfrac{2x+1}{x-4}$ for $x \in \mathbb{R},\ x \neq 4$.

(i) Find $\mathrm{h}^{-1}(x)$ and state its range. [4]

(ii) Find $\mathrm{h}^{2}(x)$, giving your answer in its simplest form. [3]

7 **(i)** Write $\ln\left(\dfrac{2x+1}{2x-1}\right)$ as the difference of two logarithms. [1]

A curve has equation $y = \ln\left(\dfrac{2x+1}{2x-1}\right) + 4x$ for $x > \dfrac{1}{2}$.

(ii) Using your answer to part **(i)** show that $\dfrac{dy}{dx} = \dfrac{ax^2+b}{4x^2-1}$, where a and b are integers. [4]

(iii) Hence find the x-coordinate of the stationary point on the curve. [2]

(iv) Determine the nature of this stationary point. [2]

8 **(a)** 10 people are to be chosen, to receive concert tickets, from a group of 8 men and 6 women.

(i) Find the number of different ways the 10 people can be chosen if 6 of them are men and 4 of them are women. [2]

The group of 8 men and 6 women contains a man and his wife.

(ii) Find the number of different ways the 10 people can be chosen if both the man and his wife are chosen or neither of them is chosen. [3]

(b) Freddie has forgotten the 6-digit code that he uses to lock his briefcase. He knows that he did not repeat any digit and that he did not start his code with a zero.

(i) Find the number of different 6-digit numbers he could have chosen. [1]

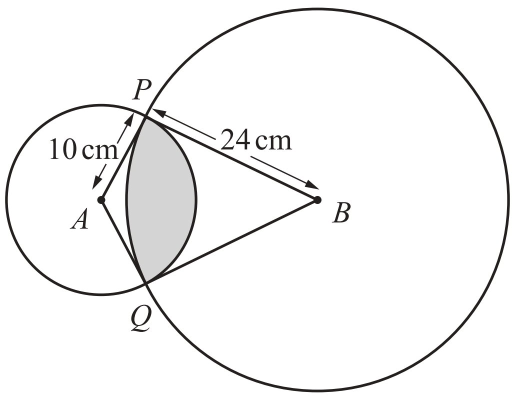
Freddie also remembers that his 6-digit code is divisible by 5.

(ii) Find the number of different 6-digit numbers he could have chosen. [3]

Freddie decides to choose a new 6-digit code for his briefcase once he has opened it. He plans to have the 6-digit number divisible by 2 and greater than 600 000, again with no repetitions of digits.

(iii) Find the number of different 6-digit numbers he can choose. [3]

9



The diagram shows a circle, centre A, radius 10 cm, intersecting a circle, centre B, radius 24 cm. The two circles intersect at the points P and Q. The radii AP and AQ are tangents to the circle with centre B. The radii BP and BQ are tangents to the circle with centre A.

(i) Show that angle PAQ is 2.35 radians, correct to 3 significant figures. [2]

(ii) Find angle PBQ in radians. [1]

(iii) Find the perimeter of the shaded region. [3]

(iv) Find the area of the shaded region. [4]

Question 10 is printed on the next page.

10 **(a)** Solve $3\operatorname{cosec} 2x - 4\sin 2x = 0$ for $0° \leqslant x \leqslant 180°$. [4]

(b) Solve $3\tan\left(y - \frac{\pi}{4}\right) = \sqrt{3}$ for $0 \leqslant y \leqslant 2\pi$ radians, giving your answers in terms of π. [4]

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CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

4541912001

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **October/November 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

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Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1}a^{n-1} b + \binom{n}{2}a^{n-2} b^2 + \ldots + \binom{n}{r}a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$.

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

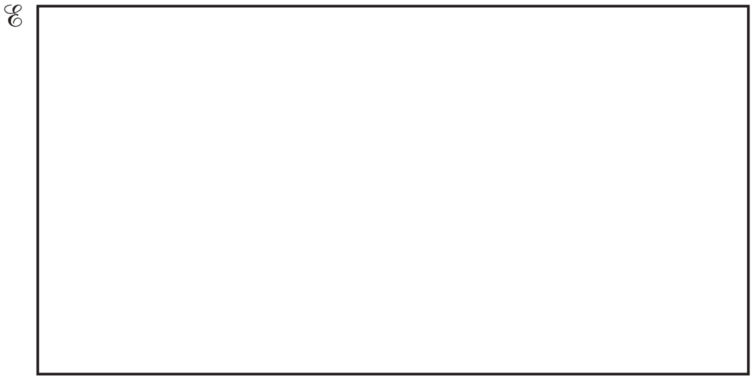
Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

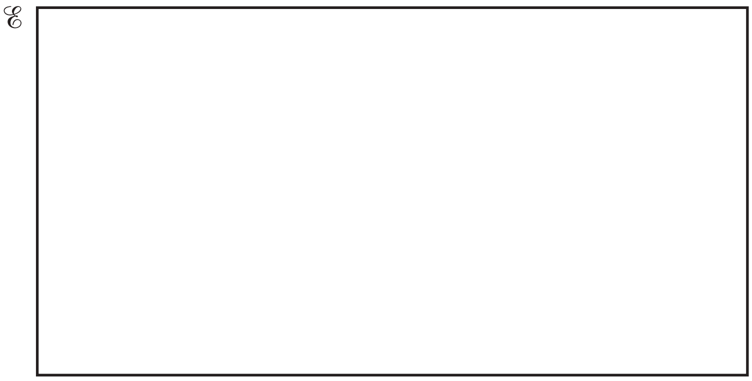
$$\Delta = \frac{1}{2} bc \sin A$$

1 **(i)** On the Venn diagram below, draw sets X and Y such that $\mathrm{n}(X \cap Y) = 0$.



[1]

(ii) On the Venn diagram below, draw sets A, B and C such that $C \subset (A \cup B)'$.



[2]

2 The graph of $y = a\sin(bx) + c$ has an amplitude of 4, a period of $\frac{\pi}{3}$ and passes through the point $\left(\frac{\pi}{12},\ 2\right)$. Find the value of each of the constants a, b and c. [4]

3 **(i)** Find, in ascending powers of x, the first 3 terms in the expansion of $\left(2 - \frac{x^2}{4}\right)^5$. [3]

(ii) Hence find the term independent of x in the expansion of $\left(2 - \frac{x^2}{4}\right)^5 \left(\frac{1}{x} - \frac{3}{x^2}\right)^2$. [3]

4 Given that $y = \dfrac{\ln(3x^2 + 2)}{x^2 + 1}$, find the value of $\dfrac{dy}{dx}$ when $x = 2$, giving your answer as $a + b\ln 14$, where a and b are fractions in their simplest form. [6]

5 When $\lg y$ is plotted against x, a straight line is obtained which passes through the points (0.6, 0.3) and (1.1, 0.2).

(i) Find $\lg y$ in terms of x. [4]

(ii) Find y in terms of x, giving your answer in the form $y = A(10^{bx})$, where A and b are constants. [3]

6 Functions f and g are defined, for $x > 0$, by

$$f(x) = \ln x,$$
$$g(x) = 2x^2 + 3.$$

(i) Write down the range of f. [1]

(ii) Write down the range of g. [1]

(iii) Find the exact value of $f^{-1}g(4)$. [2]

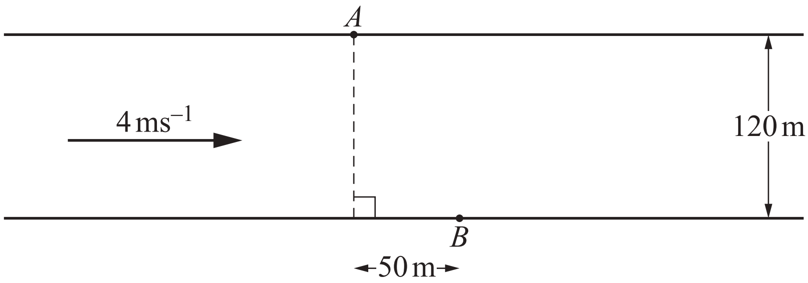
(iv) Find $g^{-1}(x)$ and state its domain. [3]

7 A polynomial $p(x)$ is $ax^3 + 8x^2 + bx + 5$, where a and b are integers. It is given that $2x - 1$ is a factor of $p(x)$ and that a remainder of –25 is obtained when $p(x)$ is divided by $x + 2$.

(i) Find the value of a and of b. [5]

(ii) Using your values of a and b, find the exact solutions of $p(x) = 5$. [2]

8

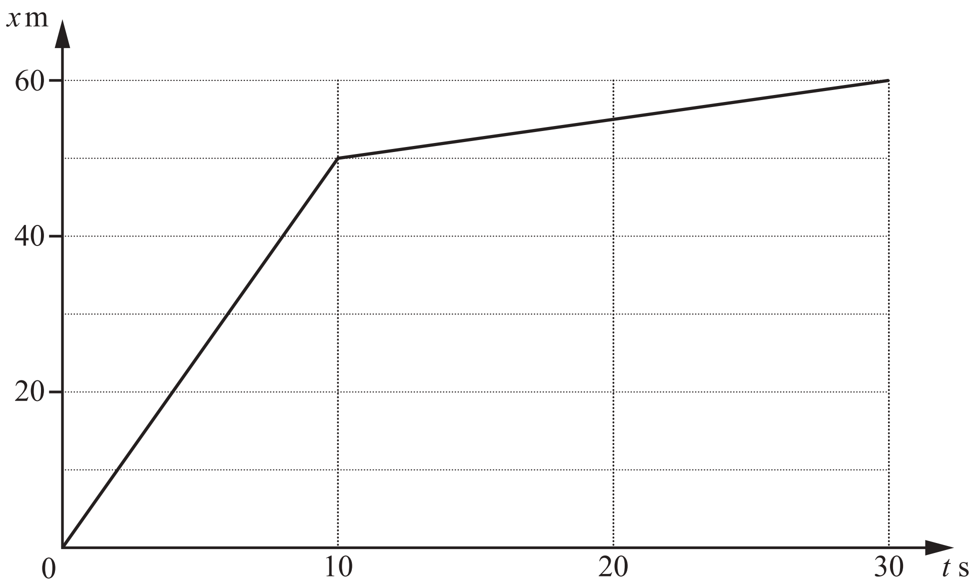


The diagram shows a river which is 120 m wide and is flowing at $4\,\text{ms}^{-1}$. Points A and B are on opposite sides of the river such that B is 50 m downstream from A. A man needs to cross the river from A to B in a boat which can travel at $5\,\text{ms}^{-1}$ in still water.

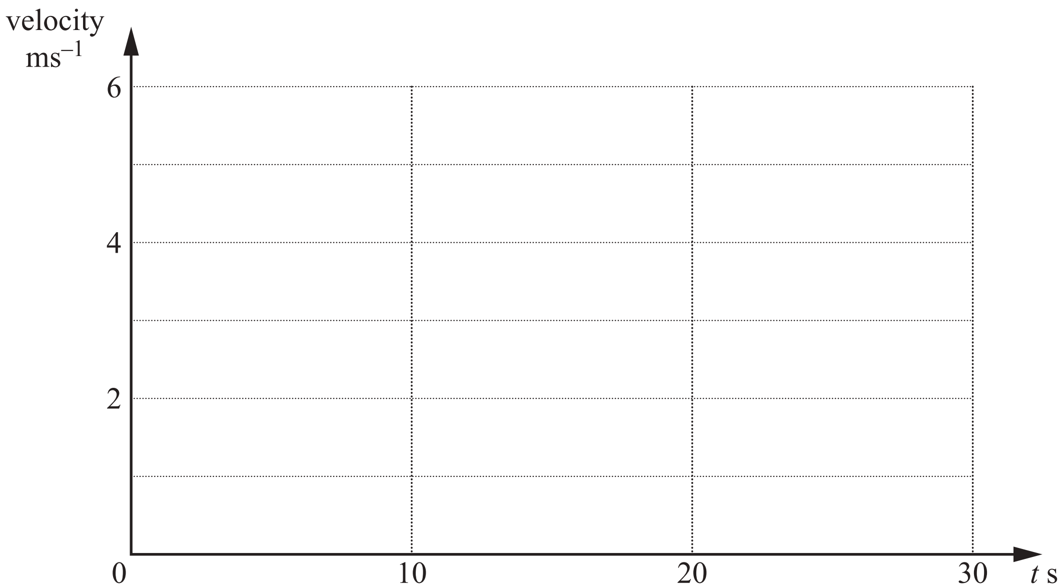
(i) Show that the man must point his boat upstream at an angle of approximately 65° to the bank. [4]

(ii) Find the time the man takes to cross the river from A to B. [6]

9 **(a)**



The diagram shows the displacement-time graph of a particle P which moves in a straight line such that, t s after leaving a fixed point O, its displacement from O is x m. On the axes below, draw the velocity-time graph of P.



[3]

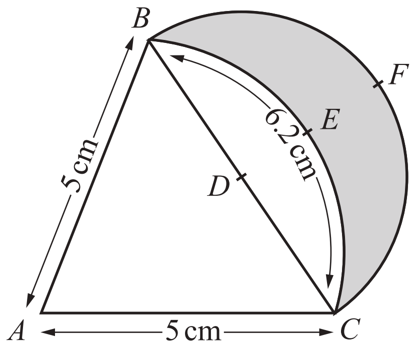
(b) A particle Q moves in a straight line such that its velocity, v ms^{-1}, t s after passing through a fixed point O, is given by $v = 3e^{-5t} + \frac{3t}{2}$, for $t \geqslant 0$.

(i) Find the velocity of Q when $t = 0$. [1]

(ii) Find the value of t when the acceleration of Q is zero. [3]

(iii) Find the distance of Q from O when $t = 0.5$. [4]

10



The diagram shows an isosceles triangle ABC, where $AB = AC = 5$ cm. The arc BEC is part of the circle centre A and has length 6.2 cm. The point D is the midpoint of the line BC. The arc BFC is a semi-circle centre D.

(i) Show that angle BAC is 1.24 radians. [1]

(ii) Find the perimeter of the shaded region. [3]

(iii) Find the area of the shaded region. [4]

11 **(a)** Solve $2\cot(\phi + 35^\circ) = 5$ for $0^\circ \leqslant \phi \leqslant 360^\circ$. [4]

Question 11(b) is printed on the next page.

(b) **(i)** Show that $\dfrac{\sec\theta}{\cot\theta+\tan\theta}=\sin\theta$. [3]

(ii) Hence solve $\dfrac{\sec 3\theta}{\cot 3\theta+\tan 3\theta}=-\dfrac{\sqrt{3}}{2}$ for $-\dfrac{\pi}{2}\leqslant\theta\leqslant\dfrac{\pi}{2}$, giving your answers in terms of π. [4]

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CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

6581423218

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

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The total number of marks for this paper is 80.

This document consists of **15** printed pages and **1** blank page.

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Mathematical Formulae

1. ALGEBRA

Quadratic Equation

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$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

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$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 Given that $y = 2\sec^2\theta$ and $x = \tan\theta - 5$, express y in terms of x. [2]

2 A curve is such that its gradient at the point (x, y) is given by $10e^{5x} + 3$. Given that the curve passes though the point (0, 9), find the equation of the curve. [4]

3 Find the set of values of k for which the equation $kx^2 + 3x - 4 + k = 0$ has no real roots. [4]

4 The graph of $y = a\cos(bx) + c$ has an amplitude of 3, a period of $\frac{\pi}{4}$ and passes through the point $\left(\frac{\pi}{12}, \frac{5}{2}\right)$. Find the value of each of the constants a, b and c. [4]

5 **(i)** Find $\int (7x-10)^{-\frac{3}{5}}\,\mathrm{d}x$. [2]

(ii) Given that $\int_6^a (7x-10)^{-\frac{3}{5}}\,\mathrm{d}x = \frac{25}{14}$, find the exact value of a. [3]

6 When $\ln y$ is plotted against x^2 a straight line is obtained which passes through the points (0.2, 2.4) and (0.8, 0.9).

(i) Express $\ln y$ in the form $px^2 + q$, where p and q are constants. [3]

(ii) Hence express y in terms of z, where $z = e^{x^2}$. [3]

7 **(i)** Find, in ascending powers of x, the first 3 terms in the expansion of $\left(2-\frac{x^2}{4}\right)^6$. Give each term in its simplest form. [3]

(ii) Hence find the coefficient of x^2 in the expansion of $\left(2-\frac{x^2}{4}\right)^6\left(\frac{1}{x}+x\right)^2$. [4]

8 It is given that $y = (x-4)(3x-1)^{\frac{5}{3}}$.

(i) Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = (3x-1)^{\frac{2}{3}}(Ax+B)$, where A and B are integers to be found. [5]

(ii) Hence find, in terms of h, where h is small, the approximate change in y when x increases from 3 to $3 + h$. [3]

9 **(a)** A 6-digit number is to be formed using the digits 1, 3, 5, 6, 8, 9. Each of these digits may be used only once in any 6-digit number. Find how many different 6-digit numbers can be formed if

(i) there are no restrictions, [1]

(ii) the number formed is even, [1]

(iii) the number formed is even and greater than 300 000. [3]

(b) Ruby wants to have a party for her friends. She can only invite 8 of her 15 friends.

(i) Find the number of different ways she can choose her friends for the party if there are no restrictions. [1]

Two of her 15 friends are twins who cannot be separated.

(ii) Find the number of different ways she can now choose her friends for the party. [3]

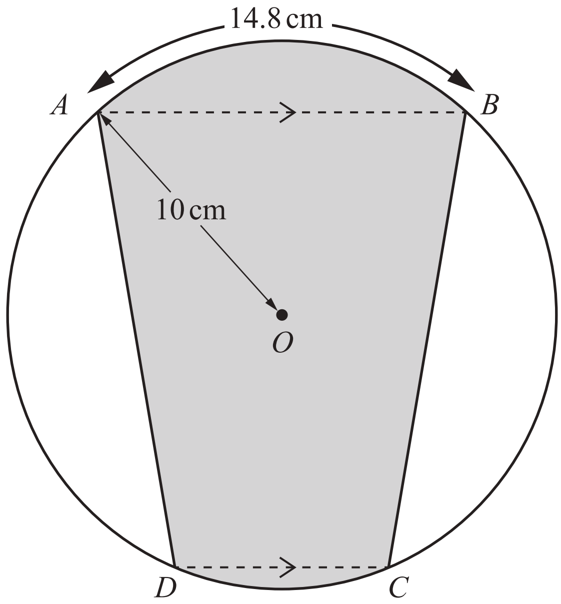
10 **(a)** Given that $\mathbf{A} = \begin{pmatrix} 4 & -1 \\ a & b \end{pmatrix}$, $\mathbf{B} = \begin{pmatrix} 2 & 3 \\ -5 & 4 \end{pmatrix}$ and $\mathbf{AB} = \begin{pmatrix} 13 & 8 \\ 18 & 4 \end{pmatrix}$, find the value of a and of b. [4]

(b) It is given that $\mathbf{X} = \begin{pmatrix} 3 & -5 \\ -4 & 1 \end{pmatrix}$, $\mathbf{Y} = \begin{pmatrix} -1 & 2 \\ 4 & 0 \end{pmatrix}$ and $\mathbf{XZ} = \mathbf{Y}$.

(i) Find $\mathbf{X}^{-1}$. [2]

(ii) Hence find **Z**. [3]

11



The diagram shows a circle, centre O, radius 10 cm. The points A, B, C and D lie on the circumference of the circle such that AB is parallel to DC. The length of the minor arc AB is 14.8 cm. The area of the minor sector ODC is 21.8 cm^2.

(i) Write down, in radians, angle AOB. [1]

(ii) Find, in radians, angle DOC. [2]

(iii) Find the perimeter of the shaded region. [4]

(iv) Find the area of the shaded region. [3]

12 The line $y = 2x + 1$ intersects the curve $xy = 14 - 2y$ at the points P and Q. The midpoint of the line PQ is the point M.

(i) Show that the point $\left(-10, \frac{23}{8}\right)$ lies on the perpendicular bisector of PQ. [9]

The line PQ intersects the y-axis at the point R. The perpendicular bisector of PQ intersects the y-axis at the point S.

(ii) Find the area of the triangle RSM. [3]

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Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7690408726

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

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.
The total number of marks for this paper is 80.

This document consists of **15** printed pages and **1** blank page.

DC (CW) 135370/2

CAMBRIDGE International Examinations

[Turn over

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1}a^{n-1} b + \binom{n}{2}a^{n-2} b^2 + \ldots + \binom{n}{r}a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 Solve the inequality $(x-1)(x-5) > 12$. [4]

2 Show that $\dfrac{1}{1-\sin\theta} - \dfrac{1}{1+\sin\theta} = 2\tan\theta\sec\theta$. [4]

3 Solve the equation $\log_5(10x+5) = 2 + \log_5(x-7)$. [4]

4 Solve the following simultaneous equations for x and y, giving each answer in its simplest surd form.

$$\sqrt{3}x + y = 4$$

$$x - 2y = 5\sqrt{3}$$

[5]

5 **(i)** Find $\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{5}{3x+2}\right)$. [2]

(ii) Use your answer to part **(i)** to find $\int \frac{30}{(3x+2)^2}\,\mathrm{d}x$. [2]

(iii) Hence evaluate $\int_1^2 \frac{30}{(3x+2)^2}\,\mathrm{d}x$. [2]

6 It is given that $\mathbf{M} = \begin{pmatrix} 2 & p \\ -3 & q \end{pmatrix}$ where p and q are integers.

(i) If $\det \mathbf{M} = 13$, find an equation connecting p and q. [1]

(ii) Given also that $\mathbf{M}^2 = \begin{pmatrix} 4-3p & 12 \\ -6-3q & -3p+q^2 \end{pmatrix}$, find a second equation connecting p and q. [2]

(iii) Find the value of p and of q. [4]

7 Find y in terms of x, given that $\frac{d^2y}{dx^2} = 6x + \frac{2}{x^3}$ and that when $x = 1$, $y = 3$ and $\frac{dy}{dx} = 1$. [6]

8 Given that $z = a + (a+3)\sqrt{3}$ and $z^2 = 79 + b\sqrt{3}$, find the value of each of the integers a and b. [6]

9 **(i)** Expand $(1 + x)^4$, simplifying all coefficients. [1]

(ii) Expand $(6 - x)^4$, simplifying all coefficients. [2]

(iii) Hence express $(6 - x)^4 - (1 + x)^4 = 175$ in the form $ax^3 + bx^2 + cx + d = 0$, where a, b, c and d are integers. [2]

(iv) Show that $x = 2$ is a solution of the equation in part **(iii)** and show that this equation has no other real roots. [5]

10 In this question $\mathbf{i}$ is a unit vector due east and $\mathbf{j}$ is a unit vector due north. Units of length and velocity are metres and metres per second respectively.

The initial position vectors of particles A and B, relative to a fixed point O, are $2\mathbf{i} + 4\mathbf{j}$ and $10\mathbf{i} + 14\mathbf{j}$ respectively. Particles A and B start moving at the same time. A moves with constant velocity $\mathbf{i} + \mathbf{j}$ and B moves with constant velocity $-2\mathbf{i} - 3\mathbf{j}$. Find

(i) the position vector of A after t seconds, [1]

(ii) the position vector of B after t seconds. [1]

It is given that X is the distance between A and B after t seconds.

(iii) Show that $X^2 = (8 - 3t)^2 + (10 - 4t)^2$. [3]

(iv) Find the value of t for which $(8-3t)^2+(10-4t)^2$ has a stationary value and the corresponding value of X. [4]

11 The line $y = kx + 3$, where k is a positive constant, is a tangent to the curve $x^2 - 2x + y^2 = 8$ at the point P.

(i) Find the value of k. [4]

(ii) Find the coordinates of P. [3]

(iii) Find the equation of the normal to the curve at P. [2]

12 **(i)** Differentiate $(\cos x)^{-1}$ with respect to x. [2]

(ii) Hence find $\frac{dy}{dx}$ given that $y = \tan x + 4(\cos x)^{-1}$. [2]

(iii) Using your answer to part **(ii)** find the values of x in the range $0 \leqslant x \leqslant 2\pi$ such that $\frac{dy}{dx} = 4$. [6]

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Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

8047669716

ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **October/November 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

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CAMBRIDGE
International Examinations

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

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Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1}a^{n-1} b + \binom{n}{2}a^{n-2} b^2 + \ldots + \binom{n}{r}a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

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Identities

$$\sin^2 A + \cos^2 A = 1$$

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Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 If $z = 2 + \sqrt{3}$ find the integers a and b such that $az^2 + bz = 1 + \sqrt{3}$. [5]

2 Solve the equation $\dfrac{2x^{1.5} + 6x^{-0.5}}{x^{0.5} + 5x^{-0.5}} = x$. [5]

3 Solve the inequality $|3x - 1| > 3 + x$. [3]

4 Solve the simultaneous equations

$$\log_2(x+4) = 2\log_2 y,$$

$$\log_2(7y - x) = 4.$$

[5]

5 Naomi is going on holiday and intends to read 4 books during her time away. She selects these books from 5 mystery, 3 crime and 2 romance books. Find the number of ways in which she can make her selection in each of the following cases.

(i) There are no restrictions. [1]

(ii) She selects at least 2 mystery books. [3]

(iii) She selects at least 1 book of each type. [3]

6 The volume of a closed cylinder of base radius x cm and height h cm is $500\,\text{cm}^3$.

(i) Express h in terms of x. [1]

(ii) Show that the total surface area of the cylinder is given by $A = 2\pi x^2 + \frac{1000}{x}\,\text{cm}^2$. [2]

(iii) Given that x can vary, find the stationary value of A and show that this value is a minimum. [5]

7 The gradient of the normal to a curve at the point with coordinates (x, y) is given by $\frac{\sqrt{x}}{1-3x}$.

(i) Find the equation of the curve, given that the curve passes through the point $(1, -10)$. [5]

(ii) Find, in the form $y = mx + c$, the equation of the tangent to the curve at the point where $x = 4$. [4]

8 The matrix **A** is $\begin{pmatrix} 2 & 1 \\ 4 & 3 \end{pmatrix}$.

(i) Find $(2\mathbf{A})^{-1}$. [3]

(ii) Hence solve the simultaneous equations

$$2y + 4x + 5 = 0,$$

$$6y + 8x + 9 = 0.$$

[4]

9 **(i)** Find $\frac{\mathrm{d}}{\mathrm{d}x}(x \ln x)$. [2]

(ii) Hence find $\int \ln x \, \mathrm{d}x$. [2]

(iii) Hence, given that $k > 0$, show that $\int_k^{2k} \ln x \, dx = k(\ln 4k - 1)$. [4]

10 **(i)** **Without using a calculator**, solve the equation $6c^3 - 7c^2 + 1 = 0$. [5]

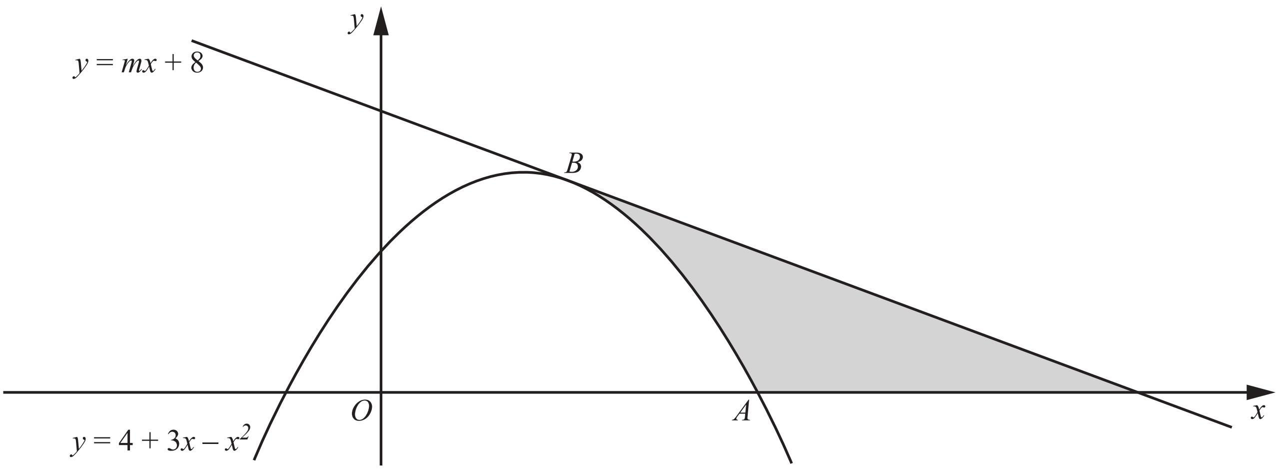
It is given that $y = \tan x + 6\sin x$.

(ii) Find $\frac{dy}{dx}$. [2]

(iii) If $\dfrac{dy}{dx} = 7$ show that $6\cos^3 x - 7\cos^2 x + 1 = 0$. [2]

(iv) Hence solve the equation $\dfrac{dy}{dx} = 7$ for $0 \leqslant x \leqslant \pi$ radians. [2]

11



The diagram shows the curve $y = 4 + 3x - x^2$ intersecting the positive x-axis at the point A. The line $y = mx + 8$ is a tangent to the curve at the point B. Find

(i) the coordinates of A, [2]

(ii) the value of m, [3]

(iii) the coordinates of B, [2]

(iv) the area of the shaded region, showing all your working. [5]

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Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7407739830

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **October/November 2017**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

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The total number of marks for this paper is 80.

This document consists of **16** printed pages.

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CAMBRIDGE
International Examinations

Mathematical Formulae

1. ALGEBRA

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$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

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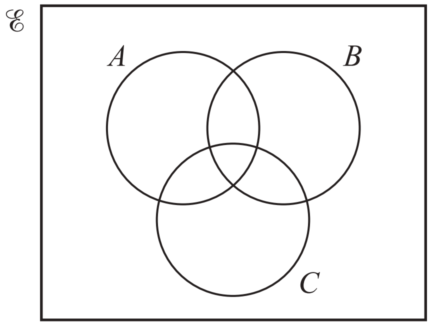
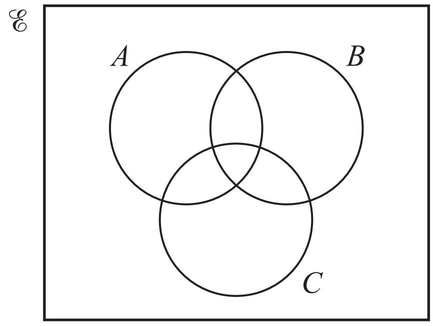
$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 **(a)** On each of the diagrams below, shade the region which represents the given set.



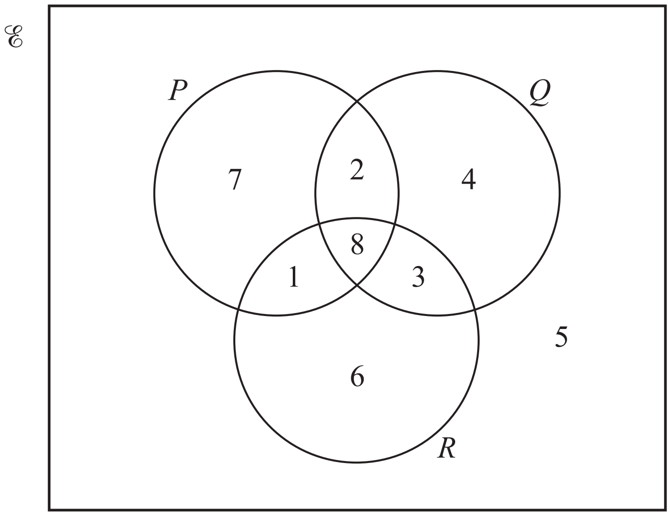
$(A \cup B) \cap C'$



$(A \cap B') \cup C$

[2]

(b)



The Venn diagram shows the number of elements in each of its subsets.

Complete the following.

$n(P') =$ ....

$n((Q \cup R) \cap P) =$ ....

$n(Q' \cup P) =$ .... [3]

2 Solve the equation $|3x - 1| = |5 + x|$. [3]

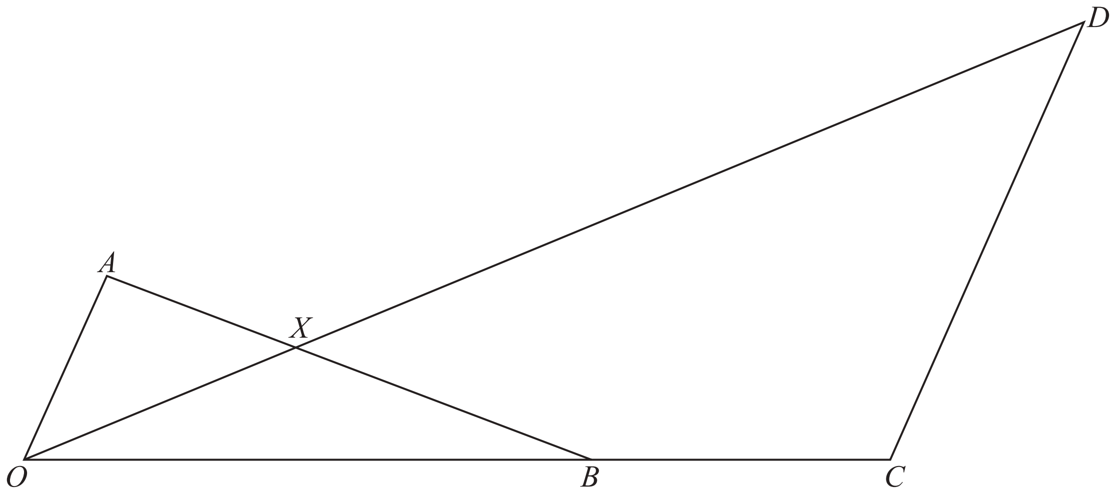
3 Find integers p and q such that $\dfrac{p}{\sqrt{3} - 1} + \dfrac{1}{\sqrt{3} + 1} = q + 3\sqrt{3}$. [4]

4 Solve the simultaneous equations

$$\log_3(x+1) = 1 + \log_3 y,$$
$$\log_3(x-y) = 2.$$

[5]

5



The diagram shows points O, A, B, C, D and X. The position vectors of A, B and C relative to O are $\overrightarrow{OA} = \mathbf{a}$, $\overrightarrow{OB} = \mathbf{b}$ and $\overrightarrow{OC} = \frac{3}{2}\mathbf{b}$. The vector $\overrightarrow{CD} = 3\mathbf{a}$.

(i) If $\overrightarrow{OX} = \lambda\overrightarrow{OD}$ express $\overrightarrow{OX}$ in terms of λ, **a** and **b**. [1]

(ii) If $\overrightarrow{AX} = \mu\overrightarrow{AB}$ express $\overrightarrow{OX}$ in terms of μ, **a** and **b**. [2]

(iii) Use your two expressions for $\overrightarrow{OX}$ to find the value of λ and of μ. [3]

(iv) Find the ratio $\frac{AX}{XB}$. [1]

(v) Find the ratio $\frac{OX}{XD}$. [1]

6 The functions f and g are defined for real values of *x* by

$$f(x) = (x+2)^2 + 1,$$

$$g(x) = \frac{x-2}{2x-1},\ x \neq \frac{1}{2}.$$

(i) Find $f^2(-3)$. [2]

(ii) Show that $g^{-1}(x) = g(x)$. [3]

(iii) Solve $gf(x) = \frac{8}{19}$. [4]

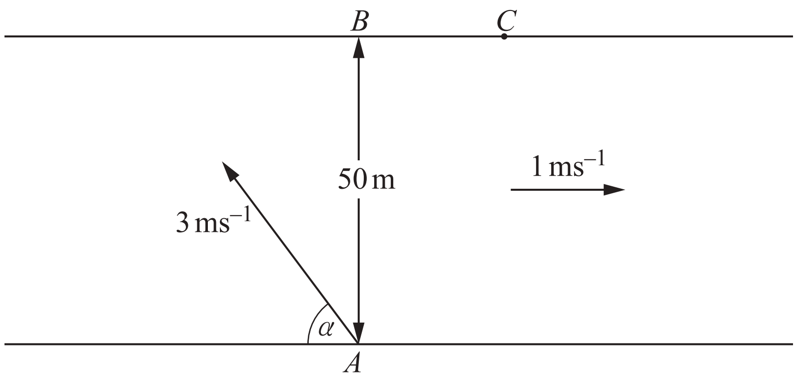
7 A particle moving in a straight line passes through a fixed point O. Its velocity, v ms^{-1}, t s after passing through O, is given by $v = 3\cos 2t - 1$ for $t \geqslant 0$.

(i) Find the value of t when the particle is first at rest. [2]

(ii) Find the displacement from O of the particle when $t = \frac{\pi}{4}$. [3]

(iii) Find the acceleration of the particle when it is first at rest. [3]

8



A man, who can row a boat at $3\,\mathrm{ms}^{-1}$ in still water, wants to cross a river from A to B as shown in the diagram. AB is perpendicular to both banks of the river. The river, which is 50 m wide, is flowing at $1\,\mathrm{ms}^{-1}$ in the direction shown. The man points his boat at an angle $\alpha°$ to the bank. Find

(i) the angle α, [2]

(ii) the resultant speed of the boat from A to B, [2]

(iii) the time taken for the boat to travel from A to B. [2]

On another occasion the man points the boat in the same direction but the river speed has increased to $1.8\,\mathrm{ms}^{-1}$ and as a result he lands at the point C.

(iv) State the time taken for the boat to travel from A to C and hence find the distance BC. [2]

9 **(i)** Show that $\dfrac{\mathrm{d}}{\mathrm{d}x}\left(\dfrac{\ln x}{x^3}\right) = \dfrac{1 - 3\ln x}{x^4}$. [3]

(ii) Find the exact coordinates of the stationary point of the curve $y = \dfrac{\ln x}{x^3}$. [3]

(iii) Use the result from part **(i)** to find $\int \left(\frac{\ln x}{x^4} \right) \mathrm{d}x$. [4]

10 **(a)** Show that $\dfrac{\sin x}{1+\cos x}+\dfrac{1+\cos x}{\sin x}=2\operatorname{cosec} x$. [3]

(b) Solve the following equations.

(i) $\cot^2 y+\operatorname{cosec} y-5=0$ for $0° \leqslant y \leqslant 360°$ [5]

(ii) $\cos\left(2z+\frac{\pi}{4}\right)=-\frac{\sqrt{3}}{2}$ for $0 \leqslant z \leqslant \pi$ radians [4]

Question 11 is printed on the next page.

11 The cubic equation $x^3 + ax^2 + bx - 36 = 0$ has a repeated positive integer root.

(i) If the repeated root is $x = 3$ find the other positive root and the value of a and of b. [4]

(ii) There are other possible values of a and b for which the cubic equation has a repeated positive integer root. In each case state all three integer roots of the equation. [4]

Cambridge Assessment International Education

Grade thresholds – June 2018

Cambridge IGCSE™ Additional Mathematics (0606)

Grade thresholds taken for Syllabus 0606 (Additional Mathematics) in the June 2018 examination.

		minimum raw mark required for grade:				
	maximum raw mark available	A	B	C	D	E
Component 11	80	64	47	31	25	19
Component 12	80	57	43	30	24	18
Component 13	80	64	47	31	25	19
Component 21	80	59	45	31	25	20
Component 22	80	62	51	39	33	27
Component 23	80	59	45	31	25	20

Grade A* does not exist at the level of an individual component.

The maximum total mark for this syllabus, after weighting has been applied, is **160**.

The overall thresholds for the different grades were set as follows.

Option	Combination of Components	A*	A	B	C	D	E
AX	11, 21	145	123	92	62	50	39
AY	12, 22	141	119	94	69	57	45
AZ	13, 23	145	123	92	62	50	39

Cambridge IGCSE

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **May/June 2018**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2018 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

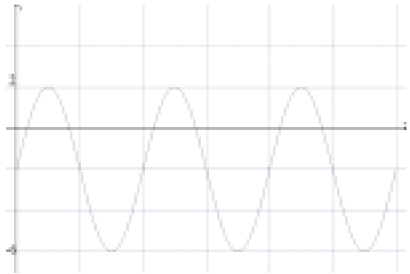
B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1	Substitution and simplification to obtain a 3 term quadratic in one variable	**M1**	substitution of $y = x + 4$ or $x = y - 4$ and simplification to 3 terms.
	$x^2 - 2x - 8 = 0$ or $2x^2 - 4x - 16 = 0$ or $y^2 - 10y + 16 = 0$ or $y^2 - 10y + 16 = 0$	**A1**	correct equation of the form $ax^2 + bx + c = 0$ or $ay^2 + by + c = 0$
	Solution of quadratic equation	**M1**	**M1 dep**
	$x = 4,\ y = 8$ $x = -2,\ y = 2$	**A2**	**A1** for each pair
2	Midpoint $\left(\frac{5}{2}, -1\right)$	**B1**	
	Gradient of line $= -\frac{8}{3}$	**B1**	
	Gradient of perp $= \frac{3}{8}$	**M1**	
	Equation of perp bisector: $y + 1 = \frac{3}{8}\left(x - \frac{5}{2}\right)$	**M1**	**M1 dep** Using *their* perpendicular gradient and *their* midpoint
	$6x - 16y - 31 = 0$ or $-6x + 16y + 31 = 0$	**A1**	
3	<table><tr><th>A</th><th>B</th><th>C</th><th>D</th></tr><tr><td></td><td>✓</td><td></td><td></td></tr><tr><td></td><td></td><td>✓</td><td>✓</td></tr><tr><td></td><td></td><td>✓</td><td></td></tr><tr><td>✓</td><td></td><td></td><td></td></tr></table>	**4**	**B1** for either each row correct or each column correct – mark to candidate's advantage.
4(i)	$b = 4$	**B1**	
	$c = 6$	**B1**	
	$2 = a + 4\sin\frac{\pi}{2}$	**M1**	Evaluation of a using *their* b and *their* c and the given point.
	$a = -2$	**A1**	

Question	Answer	Marks	Partial Marks
4(ii)		3	**B1** for $-6 \leqslant y \leqslant 2$ **B1** for 3 complete cycles **B1** for all correct
5(i)	The number of bacteria at the start of the experiment	**B1**	
5(ii)	$20\,000 = 800e^{kt}$ so $\frac{20\,000}{800} = e^{2k}$ or $\ln 20\,000 = \ln 800 + \ln(e^{2k})$	**M1**	use of given equation and attempt to solve for e^{2k} or use logs correctly
	$2k = \ln 25$	**M1**	correct method to obtain $2k$
	1.61	**A1**	
5(iii)	$P = 800e^{3\ln 5}$	**M1**	Substitution of $t = 3$ in formula using *their k*
	$= 100\,000$	**A1**	answer in range 99800 to 100200
6(a)	$\left(\frac{\log_3 p}{\log_3 2} \times \log_3 2\right) + \log_3 q$ or $\log_3 2^{\log_2 p} + \log_3 q$	**B1**	
	$\log_3 p + \log_3 q$ or $\log_3(2^{\log_2 p} \times q)$	**B1**	**B1 dep**
	$\log_3 pq$	**B1**	**B1 dep**
6(b)	$(\log_a 5 - 1)(\log_a 5 - 3) = 0$	**M1**	solution of quadratic equation
	$\log_a 5 = 1,\ a = 5$ $\log_a 5 = 3,\ a = \sqrt[3]{5}$ or 1.71 or $5^{\frac{1}{3}}$	**A2**	**A1** for $a = 5$ **A1** for $a = \sqrt[3]{5}$ or 1.71or $5^{\frac{1}{3}}$
7(i)	$\frac{1}{2}\begin{pmatrix} 3 & 2 \\ 5 & 4 \end{pmatrix}$	2	**B1** for $\frac{1}{2}$ **B1** for $\begin{pmatrix} 3 & 2 \\ 5 & 4 \end{pmatrix}$

Question	Answer	Marks	Partial Marks
7(ii)	$4x-2y=\frac{5}{2}$ $-5x+3y=\frac{7}{2}$	**B1**	Relating solution of these equations to matrix in **(i)** B1 for adapted equation or $\begin{pmatrix}2.5\\3.5\end{pmatrix}$ or $2\begin{pmatrix}x\\y\end{pmatrix}$
	$\begin{pmatrix}x\\y\end{pmatrix}=\frac{1}{2}\begin{pmatrix}3&2\\5&4\end{pmatrix}\begin{pmatrix}2.5\\3.5\end{pmatrix}$ or $2\begin{pmatrix}x\\y\end{pmatrix}=\frac{1}{2}\begin{pmatrix}3&2\\5&4\end{pmatrix}\begin{pmatrix}5\\7\end{pmatrix}$	**M1**	Correct method for pre-multiplication by *their* inverse matrix.
	$\begin{pmatrix}x\\y\end{pmatrix}=\begin{pmatrix}7.25\\13.25\end{pmatrix}$ or $\begin{pmatrix}\frac{29}{4}\\\frac{53}{4}\end{pmatrix}$ $x=7.25,\ y=13.25$	**A2**	**A1** for each. Condone in matrix form.
8(a)	$3(2\mathbf{i}-5\mathbf{j})-4(\mathbf{i}-3\mathbf{j})$	**M1**	For expansion and collection of terms
	$3\mathbf{p}-4\mathbf{q}=2\mathbf{i}-3\mathbf{j}$	**A1**	
	Magnitude of their $2\mathbf{i}-3\mathbf{j}$ $\sqrt{2^2+(-3)^2}$	**M1**	For method to find magnitude
	Unit vector = $\frac{2\mathbf{i}-3\mathbf{j}}{\sqrt{13}}$	**A1**	
8(b)(i)	$v^2=2.73^2+1.25^2$	**B1**	Correct use of Pythagoras
	$v=3.00$	**B1**	
8(b)(ii)	$\tan\theta=\frac{1.25}{2.73}$ oe	**M1**	Use of a trig funtion to obtain a relevant angle
	Angle to AB= 24.6° or 0.429 radians	**A1**	
9(i)	$256x^8-64x^6+7x^4$	**3**	**B1** for each term

Question	Answer	Marks	Partial Marks
9(ii)	$\frac{1}{x^4}+\frac{2}{x^2}+1$	B1	
	$\left(256x^8-64x^6+7x^4\right)\left(\frac{1}{x^4}+\frac{2}{x^2}+1\right)$ $\left(256\times1-64\times2+7\times1\right)x^4$	M1	**M1** for three correctly obtained products leading to terms in x^4 using *their* $256x^8-64x^6+7x^4$ and *their* $\frac{1}{x^4}+\frac{2}{x^2}+1$
	Coefficient of x^4 is $256-128+7$ = 135	A1	
10(a)	$\frac{5+6\sqrt{5}}{6+\sqrt{5}}\times\frac{6-\sqrt{5}}{6-\sqrt{5}}$	M1	for rationalisation
	$=\frac{30-5\sqrt{5}+36\sqrt{5}-30}{31}$	M1	**M1dep** for expanding the numerator to obtain four terms.
	$=\frac{31\sqrt{5}}{31}=\sqrt{5}$	A1	**A1** for $\sqrt{5}$ from correct working
10(b)	$\sqrt{3}\times\left(\sqrt{2}\right)^6\times\sqrt{2}=\sqrt{6}\times2^3$		
	$8\sqrt{6}$	B2	**B1** for $\sqrt{6}$ from $\sqrt{3}\times\sqrt{2}$ **B1** for 8 from $\left(\sqrt{2}\right)^6$ or 2^3

Question	Answer	Marks	Partial Marks
10(c)	**EITHER**: $x^2+\sqrt{2}x-4=0$	**B1**	3 term quadratic equation equated to zero
	$x=\dfrac{-\sqrt{2}\pm\sqrt{18}}{2}$	**M1**	use of the quadratic formula
	for use of $\sqrt{18}=3\sqrt{2}$	**M1**	**M1 dep**
	$\sqrt{2},\quad -2\sqrt{2}$	**A1**	For both from full working
	OR: $x^2+\sqrt{2}x-4=0$	**B1**	
	$\left(x+\dfrac{\sqrt{2}}{2}\right)^2=4+\dfrac{1}{2}$ $x=\pm\dfrac{3}{\sqrt{2}}-\dfrac{\sqrt{2}}{2}$	**M1**	Correct use of completing the square method
	$x=-\dfrac{4}{\sqrt{2}},\ \dfrac{2}{\sqrt{2}}$	**M1**	**M1dep** for dealing with $\sqrt{2}$ in denominator
	$x=\sqrt{2},\quad -2\sqrt{2}$	**A1**	
11(i)	$\dfrac{dy}{dx}=16-\dfrac{54}{x^3}$	**M1**	for $\dfrac{dy}{dx}=16\pm\dfrac{p}{x^3}$
	Equating to zero and obtaining x^3	**M1**	**M1dep**
	$x=\dfrac{3}{2},\ y=36$	**A2**	**A1** for each

Question	Answer	Marks	Partial Marks
11(ii)	**EITHER**: When $x=1,\ y=43$ When $x=3,\ y=51$	**B1**	**B1** for both
	$\left(\frac{1}{2}(43+51)\times 2\right)-\int_1^3 16x+\frac{27}{x^2}\,dx$		
	Area of trapezium = $\left(\frac{1}{2}(43+51)\times 2\right)$ oe	**B1**	**FT** from *their P* and *their Q*
	Integration to find area under curve	**M1**	for $\left[px^2+\frac{q}{x}\right]$
	$=\left[8x^2-\frac{27}{x}\right]$	**A1**	Integration correct
	$=\left[8\times 3^2-\frac{27}{3}\right]-\left[8\times 1^2-\frac{27}{1}\right]$	**M1**	**M1dep** for application of limits
	Required area = 94 – 82 =12	**A1**	
	OR: When $x=1,\ y=43$ When $x=3,\ y=51$	**B1**	**B1** for both
	Equation of *PQ*: $y=4x+39$	**B1**	Equation of line **FT** from *their P* and *their Q*
	Integration of their $4x+39-16x-\frac{27}{x^2}$	**M1**	for $\left[px+qx^2+\frac{r}{x}\right]$
	$=\left[39x-6x^2+\frac{27}{x}\right]$	**A1**	All correct
	$=\left[39\times 3-6\times 3^2+\frac{27}{3}\right]-\left[39\times 1-6\times 1^2+\frac{27}{1}\right]$	**M1**	**M1dep** for application of limits
	Required area = 72 – 60 = 12	**A1**	

Question	Answer	Marks	Partial Marks
12	$\frac{dy}{dx} = (2x-5)^{\frac{1}{2}} \quad (+c)$	M1	for $k(2x-5)^{\frac{1}{2}}$,
	for $(2x-5)^{\frac{1}{2}}$	A1	
	Substitution to obtain arbitrary constant	M1	**M1 dep** Using $\frac{dy}{dx} = 6$ when $x = \frac{9}{2}$
	$\left(\frac{dy}{dx}\right) = (2x-5)^{\frac{1}{2}} + 4$	A1	for correct $\frac{dy}{dx}$
	Integration of *their* $k(2x-5)^{\frac{1}{2}} + c$	M1	**M1 dep** on first M1 for integration of $k(2x-5)^{\frac{1}{2}}$ to obtain $m(2x-5)^{\frac{3}{2}}$
	$y = \frac{1}{3}(2x-5)^{\frac{3}{2}} + 4x \quad (+d)$	A1	for $\frac{1}{3}(2x-5)^{\frac{3}{2}} + 4x$ **FT** *their* (non -zero) constant
	Finding constant	M1	**M1 dep** for obtaining arbitrary constant for $m(2x-5)^{\frac{3}{2}} + nx + d$ using $x = \frac{9}{2}, \quad y = \frac{2}{3}$
	$y = \frac{1}{3}(2x-5)^{\frac{3}{2}} + 4x - 20$	A1	for correct equation

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ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2018**

MARK SCHEME

Maximum Mark: 80

Published

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Cambridge Assessment International Education

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- the specific skills defined in the mark scheme or in the generic level descriptors for the question
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GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

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- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
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GENERIC MARKING PRINCIPLE 4:

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GENERIC MARKING PRINCIPLE 5:

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GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

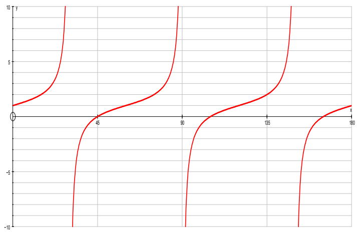
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1(i)	$\frac{\pi}{3}$ or 60°	B1	
1(ii)		3	**B1** for 3 asymptotes at $x = 30^\circ$, 90° and 150°; the curve must approach but not cross all 3 of the asymptotes and be in the 1st and 4th quadrants **B1** for starting at $(0, 1)$ and finishing at $(180, 1)$ **B1** for all correct
2	For an attempt to obtain an equation in *x* only	M1	
	$9x^2 - (k+1)x + 4 = 0$	A1	correct 3 term equation
	$(k+1)^2 - (4 \times 9 \times 4)$	M1	**M1dep** for correct use of $b^2 - 4ac$ oe
	Critical values $k = 11$, $k = -13$	A1	
	$-13 < k < 11$	A1	For the correct range
3	$e^y = ax^2 + b$	B1	may be implied, $b \neq 0$
	either $3 = 5a + b$ $1 = 3a + b$ or Gradient = 1, so $a = 1$	M1	correct attempt to find *a* or *b* by use of simultaneous equations or finding the gradient and equating it to *a*
	Coefficient of x^2 is 1	A1	
	Intercept is –2	A1	
	$y = \ln(x^2 - 2)$	A1	For correct form
4(i)	$3 = \ln(5t + 3)$ $e^3 = 5t + 3$ or better	B1	
	$t = 3.42$	B1	
4(ii)	$\frac{dx}{dt} = \frac{5}{5t+3}$	M1	for $\frac{k_1}{5t+3}$
	When $t = 0$, $\frac{dx}{dt} = \frac{5}{3}$, 1.67 or better	A1	all correct

Question	Answer	Marks	Partial Marks
4(iii)	If $t > 0$ each term in $\frac{k_1}{5t+3} > 0$ so never negative oe	B1	**dep** on **M1** in **(ii)** **FT** on *their* $\frac{k_1}{5t+3}$, provided $k_1 > 0$
4(iv)	$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = \frac{k_2}{(5t+3)^2}$	M1	
	$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\frac{25}{(5t+3)^2}$ When $t = 0$, $\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\frac{25}{9}$ or -2.78	A1	all correct
5(i)	$a = 243,\ b = -45,\ c = \frac{10}{3}$	3	**B1** for each coefficient, must be simplified
5(ii)	$\left(243 - \frac{45}{x} + \frac{10}{3x^2}\right)\left(4 + 36x + 81x^2\right)$	B1	For $\left(4 + 36x + 81x^2\right)$
	for having 3 terms independent of x	M1	
	Independent term is $972 - 1620 + 270 = -378$	A1	
6	attempt to differentiate quotient or equivalent product	M1	
	$\frac{\mathrm{d}}{\mathrm{d}x}(2x-1)^{\frac{1}{2}} = (2x-1)^{-\frac{1}{2}}$ for a quotient $\frac{\mathrm{d}}{\mathrm{d}x}(2x-1)^{-\frac{1}{2}} = -(2x-1)^{-\frac{3}{2}}$ for a product	B1	
	either $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\sqrt{2x-1} - (x+2)\left[(2x-1)^{-\frac{1}{2}}\right]}{\left(\sqrt{2x-1}\right)^2}$ or $\frac{\mathrm{d}y}{\mathrm{d}x} = (2x-1)^{-\frac{1}{2}} - (x+2)\left[(2x-1)^{-\frac{3}{2}}\right]$	A1	All other terms correct
	When $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$, $2x - 1 = x + 2$	M1	equate to zero and attempt to solve
	$x = 3$	A1	
	$y = \sqrt{5}$, $\frac{5}{\sqrt{5}}$, 2.24	A1	

Question	Answer	Marks	Partial Marks
7(i)	1000	**B1**	
7(ii)	$2000 = 1000e^{\frac{t}{4}}$	**B1**	
	$t = 4\ln 2,\ \ \ln 16$	**M1**	For $4\ln k$ or $\ln k^4,\ k > 0$
	2.77	**A1**	
7(iii)	$B = 1000e^2$ $= 7389,\ 7390$	**B1**	
8(a)	$3\left(1-\sin^2\theta\right)+4\sin\theta = 4$	**M1**	use of correct identity
	$\left(3\sin\theta-1\right)\left(\sin\theta-1\right)=0$ $\sin\theta = \frac{1}{3},\ \ \sin\theta = 1$	**M1**	For attempt to solve a 3 term quadratic equation in $\sin\theta$ to obtain $\sin\theta =$
	$\theta = 19.5^\circ,\ \ 160.5^\circ$	**A1**	
	90°	**A1**	
8(b)	$\tan 2\phi = \sqrt{3}$ $2\phi = \frac{\pi}{3},\ -\frac{2\pi}{3}$	**M1**	obtaining an equation in $\tan 2\phi$ and correct attempt to solve for one solution to reach $2\phi = k$
	for one correct solution $\phi = \frac{\pi}{6}$, or 0.524	**A1**	
	for attempt at a second solution	**M1**	
	$\phi = -\frac{\pi}{3}$, or -1.05	**A1**	for a correct second solution and no other solutions within the range
9(a)(i)	1000	**B1**	
9(a)(ii)	for use of power rule	**M1**	
	for addition or subtraction rule	**M1**	**dep** on previous **M1**
	$\lg\frac{1000a}{b^2}$	**A1**	Allow $\lg\frac{10^3 a}{b^2}$
9(b)(i)	$x^2 - 5x + 6 = 0$	**M1**	For attempt to obtain a quadratic equation and solve
	$x = 3,\ x = 2$	**A1**	for both

Question	Answer	Marks	Partial Marks
9b(ii)	$(\log_4 a)^2 - 5\log_4 a + 6 = 0$	**M1**	For the connection with **(i)** and attempt to deal with at least one logarithm correctly, either $4^{their 3}$ or $4^{their 2}$
	$a = 64$	**A1**	
	$a = 16$	**A1**	
10(i)	$AC^2 = (4\sqrt{3} - 5)^2 + (4\sqrt{3} + 5)^2$	**M1**	For attempt to use the cosine rule
	$-2(4\sqrt{3} - 5)(4\sqrt{3} + 5)\cos 60^\circ$	**A1**	For all correct unsimplified
	$AC^2 = 123$	**M1**	**M1 dep** for attempt to evaluate without use of calculator
	$AC = \sqrt{123}$	**A1**	
	ALTERNATIVE METHOD		
	Taking *D* as the foot of the perpendicular from *A*: Find *AD*, *BD*, *DC* $AC^2 = AD^2 + DC^2$	**M1**	For a complete method to get AC^2
	$AC^2 = \left(\frac{12 - 5\sqrt{3}}{2}\right)^2 + \left(\frac{15 + 4\sqrt{3}}{2}\right)^2$	**A1**	For all correct unsimplified
	$AC^2 = 123$	**M1**	**M1dep** for attempt to evaluate without use of calculator
	$AC = \sqrt{123}$	**A1**	

Question	Answer	Marks	Partial Marks
10(ii)	$\frac{AC}{\sin 60^\circ} = \frac{4\sqrt{3}-5}{\sin ACB}$ or $\sin ACB = \frac{AD}{AC}$	**M1**	For attempt at the sine rule or trigonometry involving right-angled triangles
	For attempt at cosec	**M1**	**dep** on first **M** mark $\text{cosec}ACB = \frac{2\sqrt{123}}{\sqrt{3}\left(4\sqrt{3}-5\right)}$ or $\frac{2\sqrt{41}}{\left(4\sqrt{3}-5\right)}$ oe
	$\text{cosec } ACB = \frac{2}{\sqrt{3}} \frac{\sqrt{123}}{\left(4\sqrt{3}-5\right)} \times \frac{4\sqrt{3}+5}{4\sqrt{3}+5}$	**M1**	**dep** on previous **M** mark for a statement involving rationalisation using $a\sqrt{3}+b$
	$= \frac{2\sqrt{41}}{23}\left(4\sqrt{3}+5\right)$	**A1**	For rationalisation using $\frac{4\sqrt{3}+5}{4\sqrt{3}+5}$ oe and simplification
	ALTERNATIVE METHOD		
	$\frac{1}{2}\left(4\sqrt{3}-5\right)\left(4\sqrt{3}+5\right)\sin 60 \quad = \frac{23\sqrt{3}}{4}$	**M1**	Area of *ABC*
	$\frac{1}{2}\sqrt{123}\left(4\sqrt{3}+5\right)\sin ACB \quad = \frac{23\sqrt{3}}{4}$	**M1**	For attempt at a second area of *ABC* and equating to first area
	For attempt at cosec	**M1**	**dep** on first 2 **M** marks
	$= \frac{2\sqrt{41}}{23}\left(4\sqrt{3}+5\right)$	**A1**	Need to be convinced no calculator is being used in simplification

Question	Answer	Marks	Partial Marks
11	When $x = 0,\ y = \frac{1}{2}$	**B1**	For $y = \frac{1}{2}$
	$\frac{dy}{dx} = \frac{1}{2}e^{4x}$	**B1**	
	$\frac{dy}{dx} = \frac{1}{2}$, Gradient of normal = –2	**B1**	**FT** on *their* $\frac{dy}{dx}$, must be numeric
	either: Normal $y - \frac{1}{2} = -2x$ or: Gradient of normal = $-\frac{OA}{OB}$	**M1**	For an attempt at a normal equation passing through *their* $\left(0, \frac{1}{2}\right)$ and a substitution of $y = 0$
	When $y = 0,\ x = \frac{1}{4}$	**A1**	
	EITHER: $\int_0^{\frac{1}{4}} \frac{1}{8}e^{4x} + \frac{3}{8}dx$	**M1**	For attempt to integrate to obtain $k_1e^{4x} + \frac{3}{8}x,\ k_1 \neq \frac{1}{8},\ k_1 \neq \frac{1}{2}$
	$\left[\frac{1}{32}e^{4x} + \frac{3x}{8}\right]_0^{\frac{1}{4}}$	**A1**	For correct integration
	Use of limits	**M1**	**M1dep**
	For area of triangle $= \frac{1}{16}$	**B1**	**FT** on *their* $x = \frac{1}{4}$
	$= \frac{e}{32}$	**A1**	final answer in correct form
	OR: $\int_0^{\frac{1}{4}} \frac{1}{8}e^{4x} + \frac{3}{8} - \frac{1}{2} + 2x\ dx$	**M1**	For attempt at subtraction and attempt to integrate to obtain $k_1e^{4x} + \frac{3}{8}x + k_2x + k_3x^2,\ k_1 \neq \frac{1}{8}$
	$\left[\frac{1}{32}e^{4x} - \frac{1}{8}x + x^2\right]_0^{\frac{1}{4}}$	**A2**	–1 for each error for integration
	for use of limits	**M1**	**M1dep**
	$= \frac{e}{32}$	**A1**	final answer in correct form

Question	Answer	Marks	Partial Marks
12(a)	$p = \frac{1}{4}$	**B1**	
	$p + q - 4q + 6 = 4$	**B1**	**FT** on *their p*
	$q = \frac{3}{4}$	**B1**	
12(b)	$\left(x^{\frac{1}{3}} + 3\right)\left(x^{\frac{1}{3}} + 1\right) = 0$	**M1**	For attempt to factorise and solve, or solve using the quadratic formula oe, a quadratic in $x^{\frac{1}{3}}$ or u
	$x^{\frac{1}{3}} = -1$ or $u = -1$ $x^{\frac{1}{3}} = -3$ or $u = -3$	**A1**	For both
	$x = -1$	**A1**	
	$x = -27$	**A1**	

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ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2018**

MARK SCHEME

Maximum Mark: 80

Published

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MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

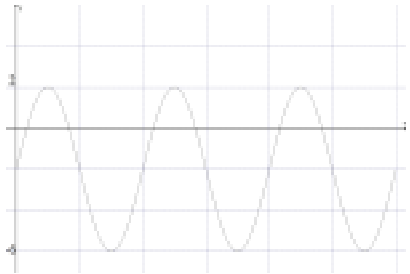
B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Partial Marks</th></tr>
<tr><td rowspan="4">1</td><td>Substitution and simplification to obtain a 3 term quadratic in one variable</td><td>M1</td><td>substitution of $y = x + 4$ or $x = y - 4$ and simplification to 3 terms.</td></tr>
<tr><td>$x^2 - 2x - 8 = 0$ or $2x^2 - 4x - 16 = 0$
or
$y^2 - 10y + 16 = 0$ or $y^2 - 10y + 16 = 0$</td><td>A1</td><td>correct equation of the form
$ax^2 + bx + c = 0$ or $ay^2 + by + c = 0$</td></tr>
<tr><td>Solution of quadratic equation</td><td>M1</td><td>**M1 dep**</td></tr>
<tr><td>$x = 4,\ y = 8$
$x = -2,\ y = 2$</td><td>A2</td><td>**A1** for each pair</td></tr>
<tr><td rowspan="5">2</td><td>Midpoint $\left(\frac{5}{2}, -1\right)$</td><td>B1</td><td></td></tr>
<tr><td>Gradient of line $= -\frac{8}{3}$</td><td>B1</td><td></td></tr>
<tr><td>Gradient of perp $= \frac{3}{8}$</td><td>M1</td><td></td></tr>
<tr><td>Equation of perp bisector:
$y + 1 = \frac{3}{8}\left(x - \frac{5}{2}\right)$</td><td>M1</td><td>**M1 dep** Using *their* perpendicular gradient and *their* midpoint</td></tr>
<tr><td>$6x - 16y - 31 = 0$ or
$-6x + 16y + 31 = 0$</td><td>A1</td><td></td></tr>
<tr><td>3</td><td><table><tr><th>A</th><th>B</th><th>C</th><th>D</th></tr><tr><td></td><td>✓</td><td></td><td></td></tr><tr><td></td><td></td><td>✓</td><td>✓</td></tr><tr><td></td><td></td><td>✓</td><td></td></tr><tr><td>✓</td><td></td><td></td><td></td></tr></table></td><td>4</td><td>**B1** for either each row correct or each column correct – mark to candidate's advantage.</td></tr>
<tr><td rowspan="4">4(i)</td><td>$b = 4$</td><td>B1</td><td></td></tr>
<tr><td>$c = 6$</td><td>B1</td><td></td></tr>
<tr><td>$2 = a + 4\sin\frac{\pi}{2}$</td><td>M1</td><td>Evaluation of a using *their* b and *their* c and the given point.</td></tr>
<tr><td>$a = -2$</td><td>A1</td><td></td></tr>
</table>

Question	Answer	Marks	Partial Marks
4(ii)		3	**B1** for $-6 \leqslant y \leqslant 2$ **B1** for 3 complete cycles **B1** for all correct
5(i)	The number of bacteria at the start of the experiment	**B1**	
5(ii)	$20\,000 = 800e^{kt}$ so $\dfrac{20\,000}{800} = e^{2k}$ or $\ln 20\,000 = \ln 800 + \ln(e^{2k})$	**M1**	use of given equation and attempt to solve for e^{2k} or use logs correctly
	$2k = \ln 25$	**M1**	correct method to obtain $2k$
	1.61	**A1**	
5(iii)	$P = 800e^{3\ln 5}$	**M1**	Substitution of $t = 3$ in formula using *their k*
	$= 100\,000$	**A1**	answer in range 99800 to 100200
6(a)	$\left(\dfrac{\log_3 p}{\log_3 2} \times \log_3 2\right) + \log_3 q$ or $\log_3 2^{\log_2 p} + \log_3 q$	**B1**	
	$\log_3 p + \log_3 q$ or $\log_3(2^{\log_2 p} \times q)$	**B1**	**B1 dep**
	$\log_3 pq$	**B1**	**B1 dep**
6(b)	$(\log_a 5 - 1)(\log_a 5 - 3) = 0$	**M1**	solution of quadratic equation
	$\log_a 5 = 1,\ a = 5$ $\log_a 5 = 3,\ a = \sqrt[3]{5}$ or 1.71 or $5^{\frac{1}{3}}$	**A2**	**A1** for $a = 5$ **A1** for $a = \sqrt[3]{5}$ or 1.71or $5^{\frac{1}{3}}$
7(i)	$\dfrac{1}{2}\begin{pmatrix} 3 & 2 \\ 5 & 4 \end{pmatrix}$	2	**B1** for $\dfrac{1}{2}$ **B1** for $\begin{pmatrix} 3 & 2 \\ 5 & 4 \end{pmatrix}$

Question	Answer	Marks	Partial Marks
7(ii)	$4x-2y=\frac{5}{2}$ $-5x+3y=\frac{7}{2}$	**B1**	Relating solution of these equations to matrix in **(i)** B1 for adapted equation or $\begin{pmatrix}2.5\\3.5\end{pmatrix}$ or $2\begin{pmatrix}x\\y\end{pmatrix}$
	$\begin{pmatrix}x\\y\end{pmatrix}=\frac{1}{2}\begin{pmatrix}3&2\\5&4\end{pmatrix}\begin{pmatrix}2.5\\3.5\end{pmatrix}$ or $2\begin{pmatrix}x\\y\end{pmatrix}=\frac{1}{2}\begin{pmatrix}3&2\\5&4\end{pmatrix}\begin{pmatrix}5\\7\end{pmatrix}$	**M1**	Correct method for pre-multiplication by *their* inverse matrix.
	$\begin{pmatrix}x\\y\end{pmatrix}=\begin{pmatrix}7.25\\13.25\end{pmatrix}$ or $\begin{pmatrix}\frac{29}{4}\\\frac{53}{4}\end{pmatrix}$ $x=7.25,\ y=13.25$	**A2**	**A1** for each. Condone in matrix form.
8(a)	$3(2\mathbf{i}-5\mathbf{j})-4(\mathbf{i}-3\mathbf{j})$	**M1**	For expansion and collection of terms
	$3\mathbf{p}-4\mathbf{q}=2\mathbf{i}-3\mathbf{j}$	**A1**	
	Magnitude of their $2\mathbf{i}-3\mathbf{j}$ $\sqrt{2^2+(-3)^2}$	**M1**	For method to find magnitude
	Unit vector = $\frac{2\mathbf{i}-3\mathbf{j}}{\sqrt{13}}$	**A1**	
8(b)(i)	$v^2=2.73^2+1.25^2$	**B1**	Correct use of Pythagoras
	$v=3.00$	**B1**	
8(b)(ii)	$\tan\theta=\frac{1.25}{2.73}$ oe	**M1**	Use of a trig funtion to obtain a relevant angle
	Angle to AB= 24.6° or 0.429 radians	**A1**	
9(i)	$256x^8-64x^6+7x^4$	**3**	**B1** for each term

Question	Answer	Marks	Partial Marks
9(ii)	$\frac{1}{x^4}+\frac{2}{x^2}+1$	**B1**	
	$\left(256x^8-64x^6+7x^4\right)\left(\frac{1}{x^4}+\frac{2}{x^2}+1\right)$ $\left(256\times1-64\times2+7\times1\right)x^4$	**M1**	**M1** for three correctly obtained products leading to terms in x^4 using *their* $256x^8-64x^6+7x^4$ and *their* $\frac{1}{x^4}+\frac{2}{x^2}+1$
	Coefficient of x^4 is $256-128+7$ = 135	**A1**	
10(a)	$\frac{5+6\sqrt{5}}{6+\sqrt{5}}\times\frac{6-\sqrt{5}}{6-\sqrt{5}}$	**M1**	for rationalisation
	$=\frac{30-5\sqrt{5}+36\sqrt{5}-30}{31}$	**M1**	**M1dep** for expanding the numerator to obtain four terms.
	$=\frac{31\sqrt{5}}{31}=\sqrt{5}$	**A1**	**A1** for $\sqrt{5}$ from correct working
10(b)	$\sqrt{3}\times\left(\sqrt{2}\right)^6\times\sqrt{2}=\sqrt{6}\times2^3$		
	$8\sqrt{6}$	**B2**	**B1** for $\sqrt{6}$ from $\sqrt{3}\times\sqrt{2}$ **B1** for 8 from $\left(\sqrt{2}\right)^6$ or 2^3

Question	Answer	Marks	Partial Marks
10(c)	**EITHER**: $x^2+\sqrt{2}x-4=0$	**B1**	3 term quadratic equation equated to zero
	$x=\dfrac{-\sqrt{2}\pm\sqrt{18}}{2}$	**M1**	use of the quadratic formula
	for use of $\sqrt{18}=3\sqrt{2}$	**M1**	**M1 dep**
	$\sqrt{2},\quad -2\sqrt{2}$	**A1**	For both from full working
	OR: $x^2+\sqrt{2}x-4=0$	**B1**	
	$\left(x+\dfrac{\sqrt{2}}{2}\right)^2=4+\dfrac{1}{2}$ $x=\pm\dfrac{3}{\sqrt{2}}-\dfrac{\sqrt{2}}{2}$	**M1**	Correct use of completing the square method
	$x=-\dfrac{4}{\sqrt{2}},\ \dfrac{2}{\sqrt{2}}$	**M1**	**M1dep** for dealing with $\sqrt{2}$ in denominator
	$x=\sqrt{2},\quad -2\sqrt{2}$	**A1**	
11(i)	$\dfrac{dy}{dx}=16-\dfrac{54}{x^3}$	**M1**	for $\dfrac{dy}{dx}=16\pm\dfrac{p}{x^3}$
	Equating to zero and obtaining x^3	**M1**	**M1dep**
	$x=\dfrac{3}{2},\ y=36$	**A2**	**A1** for each

Question	Answer	Marks	Partial Marks
11(ii)	**EITHER**: When $x=1,\ y=43$ When $x=3,\ y=51$	**B1**	**B1** for both
	$\left(\frac{1}{2}(43+51)\times 2\right)-\int_1^3 16x+\frac{27}{x^2}\,\mathrm{d}x$		
	Area of trapezium = $\left(\frac{1}{2}(43+51)\times 2\right)$ oe	**B1**	**FT** from *their P* and *their Q*
	Integration to find area under curve	**M1**	for $\left[px^2+\frac{q}{x}\right]$
	$=\left[8x^2-\frac{27}{x}\right]$	**A1**	Integration correct
	$=\left[8\times 3^2-\frac{27}{3}\right]-\left[8\times 1^2-\frac{27}{1}\right]$	**M1**	**M1dep** for application of limits
	Required area $=94-82$ $=12$	**A1**	
	OR: When $x=1,\ y=43$ When $x=3,\ y=51$	**B1**	**B1** for both
	Equation of *PQ*: $y=4x+39$	**B1**	Equation of line **FT** from *their P* and *their Q*
	Integration of their $4x+39-16x-\frac{27}{x^2}$	**M1**	for $\left[px+qx^2+\frac{r}{x}\right]$
	$=\left[39x-6x^2+\frac{27}{x}\right]$	**A1**	All correct
	$=\left[39\times 3-6\times 3^2+\frac{27}{3}\right]$ $-\left[39\times 1-6\times 1^2+\frac{27}{1}\right]$	**M1**	**M1dep** for application of limits
	Required area $=72-60$ $=12$	**A1**	

Question	Answer	Marks	Partial Marks
12	$\frac{dy}{dx} = (2x-5)^{\frac{1}{2}} \quad (+c)$	M1	for $k(2x-5)^{\frac{1}{2}}$,
	for $(2x-5)^{\frac{1}{2}}$	A1	
	Substitution to obtain arbitrary constant	M1	**M1 dep** Using $\frac{dy}{dx} = 6$ when $x = \frac{9}{2}$
	$\left(\frac{dy}{dx}\right) = (2x-5)^{\frac{1}{2}} + 4$	A1	for correct $\frac{dy}{dx}$
	Integration of *their* $k(2x-5)^{\frac{1}{2}} + c$	M1	**M1 dep** on first M1 for integration of $k(2x-5)^{\frac{1}{2}}$ to obtain $m(2x-5)^{\frac{3}{2}}$
	$y = \frac{1}{3}(2x-5)^{\frac{3}{2}} + 4x \quad (+d)$	A1	for $\frac{1}{3}(2x-5)^{\frac{3}{2}} + 4x$ **FT** *their* (non -zero) constant
	Finding constant	M1	**M1 dep** for obtaining arbitrary constant for $m(2x-5)^{\frac{3}{2}} + nx + d$ using $x = \frac{9}{2}$, $y = \frac{2}{3}$
	$y = \frac{1}{3}(2x-5)^{\frac{3}{2}} + 4x - 20$	A1	for correct equation

Cambridge IGCSE

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2018**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2018 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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dep dependent
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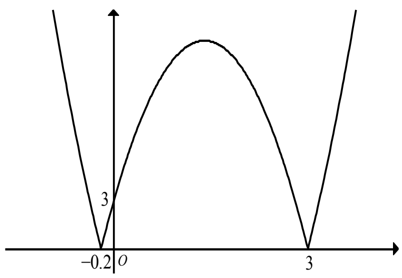
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1(i)(a)	*A* is not a [proper] subset of *B* oe	**B1**	
1(i)(b)	*A* and *C* are mutually exclusive oe or *A* intersection *C* is the empty set oe	**B1**	
1(ii)(a)	$\text{n}\left(A \cup B\right) = 3$	**B1**	
1(ii)(b)	$x \in \left(A \cap C'\right)$ oe	**B1**	
2(i)	$k \times \frac{1}{3x-1}$	**M1**	
	$3 \times \frac{1}{3x-1}$	**A1**	
2(ii)	$x = \frac{11}{15}$ soi	**B1**	
	$0.125 \approx \textit{their} \left.\frac{\text{d}y}{\text{d}x}\right\|_{x=\textit{their}\frac{11}{15}} \times \delta x$ oe	**M1**	
	0.05 nfww	**A1**	
3(i)	$\left({}^{12}P_7 =\right) 3\,991\,680$	**B1**	
3(ii)	$(4 \times {}^{11}P_6 =)\ 1\,330\,560$	**B1**	
3(iii)	4! × 4! × 2 oe	**M2**	**M1** for 4! × 4! oe only or ${}^4P_4 \times {}^4P_3$ oe only
	1152	**A1**	

Question	Answer	Marks	Partial Marks
4(i)	$2(-4)^3+3(-4)^2-4a-12=0$ with one correct interim step leading to $a=-23$	**B1**	Note: = 0 must be seen or may be implied by e.g. $-92=4a$ or $92=-4a$ or convincingly showing that $2(-4)^3+3(-4)^2-4(-23)-12=0$ or correct synthetic division at least as far as $\begin{array}{r\|rrrr} -4 & 2 & 3 & a & -12 \\ & & -8 & 20 & -4a-80 \\ \hline & 2 & -5 & a+20 & 0 \end{array}$ then $a=-23$ or correct long division to, e.g. verify –23, at least as far as $x+4\overline{)2x^3+3x^2-23x-12}$ giving quotient $2x^2-5x-3$: $\underline{2x^3+8x^2}$ $-5x^2-23x$ $-\underline{5x^2-20x}$ $-3x-12$ $\underline{-3x-12}$ 0
	$p(1)=2+3-23\ -12$ $b=-30$	**B1**	
4(ii)	finds a correct quadratic factor e.g. $(2x^2-5x-3)$	**B2**	**B1** for quadratic factor with 2 correct terms OR **B1** for finding $(x-3)$ using factor theorem **B1** for convincingly finding $(2x+1)$ as third factor
	Product of three linear factors $(2x+1)(x-3)(x+4)$	**M1**	
	$x=-\frac{1}{2},\ x=3,\ x=-4$ nfww	**A1**	If **M0** then **SC1** if quadratic factorised correctly but does not show full factorisation but does give all 3 solutions correctly
5(i)	Putting $y=f(x)$, changing subject to x and swopping x and y or vice versa	**M1**	
	$f^{-1}(x)=\frac{1}{2}\left(\frac{1}{x}+5\right)$ or $\frac{5x+1}{2x}$ oe isw	**A1**	
5(ii)	$x>0$ oe	**B1**	

Question	Answer	Marks	Partial Marks
5(iii)	$\dfrac{1}{2\left(\dfrac{1}{2x-5}\right)-5}$	**B1**	
	$\dfrac{1}{\dfrac{2-5(2x-5)}{2x-5}}$ oe	**M1**	**FT** if expression of equivalent difficulty e.g. $\dfrac{1}{\left(\dfrac{1}{2x-5}\right)-5}$
	Completes to $\dfrac{2x-5}{-10x+27}$ oe final answer	**A1**	
6(i)	$16x = 40$ oe	**M1**	
	$x = 2.5$ oe (radians)	**A1**	
6(ii)	$\frac{1}{2}(16)^2(2.5)$ oe	**M1**	
	320	**A1**	
6(iii)	$\frac{1}{2}r^2(\textit{their}2.5) = (\textit{their}320) - 140$ oe	**M1**	**FT** provided *their* 320 > 140
	correct simplification to $r^2 = \ldots$	**M1**	**dep** on first **M1**
	12	**A1**	
7(i)	$4\tan x + 4x\sec^2 x$ isw	**B2**	Fully correct **B1** for one correct term as part of e.g. a sum of 2 terms
7(ii)	$\dfrac{d}{dx}\left(e^{3x+1}\right) = 3e^{3x+1}$	**B1**	
	$\dfrac{(x^2-1)(\textit{their}3e^{3x+1}) - \textit{their}(2x)e^{3x+1}}{(x^2-1)^2}$	**M1**	
	$\dfrac{(x^2-1)(3e^{3x+1}) - 2xe^{3x+1}}{(x^2-1)^2}$ oe isw	**A1**	
8(i)	Takes logs of both sides	**M1**	
	$\ln y = \ln a + n\ln x$ or $\lg y = \lg a + n\lg x$	**A1**	

Question	Answer	Marks	Partial Marks
8(ii)	$n =$ –0.2 to –0.3 nfww	**B1**	
	attempts to equate *y*-intercept to ln *a* or forms *their* ln equation with *their* gradient and a point on the line or uses two points on the line to form a pair of simultaneous equations	**M1**	
	$a = e^{4.7}$ isw or 110 or 109.9[47…]	**A1**	maximum of 2 marks if no coordinates stated
8(iii)	use of ln(50) and ln$x$ = 3 to 3.2	**M1**	or for $\frac{50}{theira} = x^{their\ n}$ or better or for $\ln 50 = \ln(theira) + (their\ n)\ln x$ oe
	awrt 22 or 23 to 2 significant figures	**A1**	implies **M1**
9(i)	$5\left(x - \frac{7}{5}\right)^2 - \frac{64}{5}$	**B3**	**B1** for each of p, q, r correct in correct format; allow correct equivalent values. If **B0**, then **SC2** for $5\left(x - \frac{7}{5}\right) - \frac{64}{5}$ or **SC1** for correct values but incorrect format
9(ii)		**B4**	**B2** for fully correct shape in correct position or **B1** for fully correct shape translated parallel to the *x*-axis **B1** for *y*-intercept at (0, 3) marked on graph **B1** for roots marked on graph at –0.2 and 3
9(iii)	$0 < k < \left\lvert their\left(-\frac{64}{5}\right)\right\rvert$	**B2**	**FT** *their* **(i)** **B1** for any inequality using *their* $\frac{64}{5}$ or max *y* value is *their* 12.8soi
10(i)	$v = \frac{ds}{dt} = -3\sin 3t$	**B1**	
	When $v = 0$, $t = \frac{\pi}{3}$	**B1**	

Question	Answer	Marks	Partial Marks
10(ii)	Finding s when $t=\frac{\pi}{4}$ and $t=\frac{\pi}{2}$	**M1**	
	Finding s when $t = \textit{their}\frac{\pi}{3}$ and correct plan	**M1**	Using *their* **(i)** correctly
	1.29 nfww	**A1**	
10(iii)	$a=\frac{\mathrm{d}v}{\mathrm{d}t}=-9\cos 3t$	**B1**	
	9	**B1**	**FT** *their* $k\cos 3t$
11(a)	$10\left(1-\sin^2 x\right)+3\sin x=9$	**M1**	
	Solves $10\sin^2 x-3\sin x-1=0$ oe	**M1**	**dep** on first **M1** Solves *their* three term quadratic in $\sin x$
	$\sin x=\frac{1}{2},\ \sin x=-\frac{1}{5}$	**A1**	
	30º, 150º and 191.5º, 348.5º awrt	**A2**	**A1** for any two correct solutions
11(b)	$3\frac{\sin 2y}{\cos 2y}=4\sin 2y$ oe	**M1**	
	Solves $3\sin 2y-4\sin 2y\cos 2y\,[=0]$	**M1**	**dep** on first **M1**
	$\sin 2y=0\ \ \cos 2y=\frac{3}{4}$	**A1**	
	Any two of π, 0.72273…, 5.56045… nfww	**A1**	
	$\frac{\pi}{2}$, 0.361, 2.78 awrt nfww	**A1**	**SC**: cancels out sin2y after **M1M0** allow **SC1** for 0.72273… and 5.56045... and **SC1**for 0.361 and 2.78
12(i)	$\tan 30=\frac{h}{x/2}$ oe	**M1**	
	Correct completion to given answer	**A1**	
	$V=5\sqrt{3}\,h^2$ isw	**B1**	

Question	Answer	Marks	Partial Marks
12(ii)(a)	$\frac{\mathrm{d}V}{\mathrm{d}h} = their 10\sqrt{3}\,h$ or $\frac{5\sqrt{3}}{2}$	**B1**	**FT** $their\,V = k\,h^2$
	$\frac{\mathrm{d}h}{\mathrm{d}t} = \frac{\mathrm{d}h}{\mathrm{d}V} \times \frac{\mathrm{d}V}{\mathrm{d}t}$ soi	**M1**	
	$\frac{\mathrm{d}h}{\mathrm{d}t} = \frac{1}{their\left(\frac{\mathrm{d}V}{\mathrm{d}h}\right)} \times 0.5$	**M1**	
	0.115 or 0.11547 to 0.1155 oe	**A1**	
12(ii)(b)	$\left(\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{\mathrm{d}x}{\mathrm{d}h} \times \frac{\mathrm{d}h}{\mathrm{d}t} =\right) 2\sqrt{3} \times their \frac{1}{5\sqrt{3}}$	**M1**	
	$\frac{2}{5}$	**A1**	

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/22**

Paper 1 **May/June 2018**

MARK SCHEME

Maximum Mark: 80

Published

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Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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Cambridge International is publishing the mark schemes for the May/June 2018 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method marks, awarded for a valid method applied to the problem.

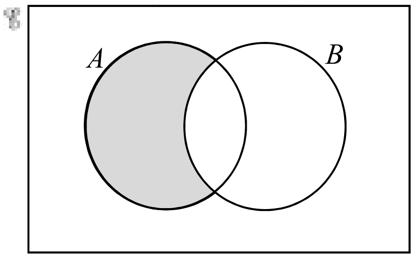
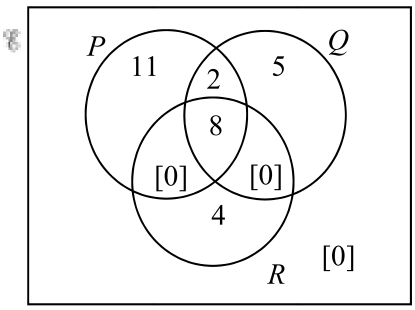
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

B Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

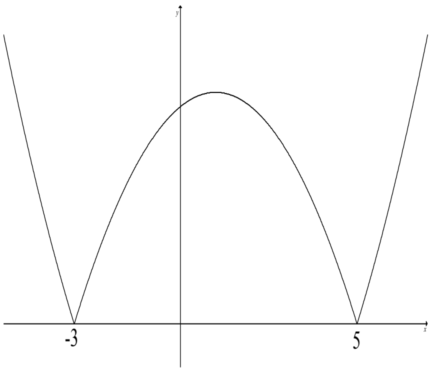
awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1(i)	Uses $\cot\theta = \dfrac{\cos\theta}{\sin\theta}$ $\dfrac{\cos^2\theta + \sin^2\theta}{\sin\theta}$ Uses $\cos^2\theta + \sin^2\theta = 1$ Completes to $\dfrac{1}{\sin\theta} = \operatorname{cosec}\theta$	B3	**B1** for using $\cot\theta = \dfrac{\cos\theta}{\sin\theta}$ oe or $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ oe at some stage **B1** for use of $\cos^2\theta + \sin^2\theta = 1$ oe **B1** for common denominator of $\sin\theta$ oe either in a compound fraction or in two partial fractions or for writing $\dfrac{1-\sin^2\theta}{\sin\theta}$ as $\dfrac{1}{\sin\theta} - \dfrac{\sin^2\theta}{\sin\theta}$ oe **Maximum of 2 marks if not fully correct or does not complete to cosecθ**
1(ii)	$\sin\theta = \dfrac{1}{4}$	M1	
	14.5° or 14.47[751…] rot to 4 or more figures isw	A1	Not from wrong working
2(a)	 	B1	
2(b)	 	B3	**B1** for 8 correctly placed and all the empty regions correct **B1** for 11, 2, 5 correctly placed **B1** for 4 correctly placed **maximum of 2 marks if fully correct but other values such as 30, 21 and/or 15 present within the diagram**
	their 12	B1	**STRICT FT** *their* Venn diagram

Question	Answer	Marks	Partial Marks
3	p(–3) = 0 or p(2) = –15 stated or implied	**M1**	
	–54 + 9a + 72 + b = 0 or better	**A1**	finds one correct equation; implies **M1**
	16 + 4a – 48 + b = –15 or better	**A1**	finds another correct equation; implies **M1**
	Solves a pair of simultaneous equations in a and b	**M1**	**dep** on first **M1** condone one sign or arithmetic error in *their* solution; as far as finding one unknown
	a = –7, b = 45	**A1**	
	60 cao	**A1**	
4	Eliminates one of the unknowns	**M1**	
	Simplifies to a correct 3-term quadratic: $2x^2 + 4x - 16$ [= 0] oe or $2y^2 - 6y - 36$ [= 0] oe	**A1**	
	Factorises or solves $(x+4)(x-2)=0$ oe or $(y+3)(y-6)=0$ oe	**M1**	**FT** *their* 3-term quadratic in x or y;
	(2, 6) and (–4, –3) oe	**A2**	Not from wrong working **A1** for either (2, 6) or (–4, –3) or **A1** for x = 2 and x = –4 or y = 6 and y = –3
5(a)	${}^7P_4$ or 7 × 6 × 5 × 4 oe	**M1**	
	840	**A1**	
5(b)(i)	20	**B1**	
5(b)(ii)	${}^5C_1 \times {}^4C_1 \times {}^2C_1$ or 5 × 4 × 2 oe	**M1**	
	40	**A1**	
5(b)(iii)	${}^5C_3 + {}^4C_3$ oe	**M1**	
	14	**A1**	

Question	Answer	Marks	Partial Marks
6(i)	(Arc length =) 1.5×5 oe soi	**M1**	implied by 7.5
	(DE =) 10sin(0.75) oe soi	**M1**	implied by awrt 6.82
	34.3 or answer in range 34.31 to 34.32	**A1**	
6(ii)	(Area sector =) $\frac{1}{2} \times 5^2 \times 1.5$ oe	**M1**	implied by 18.75
	(Area triangle =) $\frac{1}{2} \times 5^2 \times \sin(1.5)$ oe	**M1**	implied by awrt 12.47
	31.2 or answer in range 31.21 to 31.22	**A1**	
7(i)	$\lvert their(\mathbf{a}+\mathbf{c})\rvert = \sqrt{their(5^2+14^2)}$	**M1**	
	$\sqrt{221}$	**A1**	mark final answer
7(ii)	[$(2+m)\mathbf{i} + (3-5m)\mathbf{j}$ therefore] *their* $(2+m) = 0$	**M1**	for attempting to form $\mathbf{a} + m\mathbf{b}$ and equate the scalar of the **i** component to 0
	$m = -2$ only	**A1**	implies **M1**
7(iii)	[$(2n-1)\mathbf{i} + (3n+5)\mathbf{j} = 3\mathbf{i} + 11\mathbf{j}$ or $n(2\mathbf{i}+3\mathbf{j}) = (3\mathbf{i}+11\mathbf{j}) + (\mathbf{i}-5\mathbf{j})$ oe leading to] $2n-1=3$ or $3n+5=11$ oe, soi	**M1**	
	$n = 2$ only	**A1**	implies **M1**

Question	Answer	Marks	Partial Marks
8(a)	$\begin{pmatrix} -2 & 6 \\ 1 & 12 \end{pmatrix}$	B2	**B1** for a 2 by 2 matrix with 2 or 3 correct elements
	$their\left[\dfrac{1}{-30}\begin{pmatrix} 12 & -6 \\ -1 & -2 \end{pmatrix}\right]$ oe isw	B2	**FT** *their* non-singular **BA** **B1 FT** for either $\dfrac{1}{their(-30)}\begin{pmatrix} & \\ & \end{pmatrix}$ or $\ldots \times their\begin{pmatrix} 12 & -6 \\ -1 & -2 \end{pmatrix}$ If *their* **BA** is singular, **B0** then **SC1** for $\ldots \times their\begin{pmatrix} 12 & -6 \\ -1 & -2 \end{pmatrix}$ OR **Alternative method $\mathbf{A}^{-1}\mathbf{B}^{-1}$:** **B2** for $\mathbf{A}^{-1} = \dfrac{1}{-5}\begin{pmatrix} -3 & 1 \\ -1 & 2 \end{pmatrix}$ isw or $\mathbf{B}^{-1} = \dfrac{1}{6}\begin{pmatrix} -5 & 2 \\ -3 & 0 \end{pmatrix}$ isw or **B1** for a multiplier of $\dfrac{1}{-5}$ or for $\begin{pmatrix} -3 & 1 \\ -1 & 2 \end{pmatrix}$ or for a multipler of $\dfrac{1}{6}$ or for $\begin{pmatrix} -5 & 2 \\ -3 & 0 \end{pmatrix}$ **B2 FT** for $\mathbf{A}^{-1}\,\mathbf{B}^{-1} = their\dfrac{1}{-30} \times their\begin{pmatrix} 12 & -6 \\ -1 & -2 \end{pmatrix}$ or **B1 FT** for a 2 by 2 matrix with 2 or 3 correct elements **Maximum of 3 marks if not fully correct**
8(b)(i)	2×3	B1	
8(b)(ii)	$\begin{pmatrix} 2 & -\dfrac{1}{2} \end{pmatrix}$ oe isw	B2	**B1** for each correct element; must be in a 1 by 2 matrix or **M1** for a full method as far as finding values for the two elements

Question	Answer	Marks	Partial Marks
9(i)	$\frac{d}{dx}\left(\sqrt{\sin x}\right)=\frac{1}{2}(\sin x)^{-\frac{1}{2}}(\cos x)$ oe	**B2**	**B1** for $\frac{1}{2}(\sin x)^{-\frac{1}{2}}\times ...$ or for $\frac{1}{2}(\sin x)^{-\frac{1}{2}}$ or for $\frac{1}{2}(...)^{-\frac{1}{2}}\times\cos x$ or for $\textit{their}\,\frac{1}{2}(\sin x)^{\left(\textit{their}\,\frac{1}{2}\right)-1}\times\cos x$
	$\textit{their}\left(4x^3\right)\sqrt{\sin x}$ $+x^4\left(\textit{their}\,\frac{1}{2}(\sin x)^{-\frac{1}{2}}(\cos x)\right)$ oe	**M1**	Applies correct form of product rule
	$4x^3\sqrt{\sin x}+x^4\left(\frac{1}{2}(\sin x)^{-\frac{1}{2}}(\cos x)\right)$ oe isw	**A1**	Not from wrong working
9(ii)	$\int\left(4x^3\sqrt{\sin x}\right)dx$ $+\int\left(x^4\times\frac{1}{2}(\sin x)^{-\frac{1}{2}}(\cos x)\right)dx$ $=x^4\sqrt{\sin x}$ oe	**M1**	or $\int x\,dx+2\int\left(\frac{x^4\cos x}{2\sqrt{\sin x}}+4x^3\sqrt{\sin x}\right)dx$ oe **FT** *their* **(i)**
	$\frac{x^2}{2}+2x^4\sqrt{\sin x}$ [+c]	**A2**	**A1** for $\int x\,dx+2x^4\sqrt{\sin x}$
10(a)(i)	 	**B2**	**B1** for correct shape **B1** for roots marked on the graph or seen nearby provided graph drawn and one root is negative and one is positive
10(a)(ii)	Any correct domain	**B1**	
10(b)(i)	$\frac{4}{3x-1}$	**B1**	mark final answer

Question	Answer	Marks	Partial Marks
10(b)(ii)	Correct method for finding inverse function e.g. swopping variables **and** changing subject or vice versa; or indicates $(\text{hg})^{-1}(x) = \text{g}^{-1}\text{h}^{-1}(x)$ and finds $\text{g}^{-1}(x) = \frac{x+1}{3}$ and $\text{h}^{-1}(x) = \frac{4}{x}$	**M1**	**FT** only if *their*hg(x) of the form $\frac{a}{bx+c}$ where *a, b* and *c* are integers
	$\left[(\text{hg})^{-1}(x) =\right] \frac{1}{3}\left(\frac{4}{x}+1\right)$ oe isw or $\left[(\text{hg})^{-1}(x) =\right] \frac{4+x}{3x}$ oe isw	**A1**	**FT** *their* $(\text{hg})^{-1}(x) = \frac{a-cx}{bx}$ oe If **M0** then **SC1** for *their* hg(x) of the form $y = \frac{a}{x} + b$ oe leading to *their* $(\text{hg})^{-1}(x)$ of the form $y = \frac{a}{x-b}$ isw
10(c)	*a* cao	**B1**	
11(a)	$\frac{(2x-1)^{\frac{4}{3}}}{\frac{4}{3}\times 2}$ $[+c]$ oe isw	**B2**	**B1** for $k \times \frac{(2x-1)^{\left(\frac{1}{3}+1\right)}}{\left(\frac{1}{3}+1\right)}$ where $k \neq 0$
11(b)(i)	$k\cos 4x\,[+c]$ where $k < 0$ or $k = \frac{1}{4}$	**M1**	
	$-\frac{1}{4}\cos 4x\,[+c]$	**A1**	
11(b)(ii)	Sight of correct substitution of limits: $-\frac{1}{4}\cos\frac{4\pi}{4} - \left(-\frac{1}{4}\cos\frac{4\pi}{8}\right)$ oe	**M1**	**FT** *their* $k\cos 4x$ from **(b)(i)** **dep** on **M1** awarded in **(b)(i)**
	$\frac{1}{4}$	**A1**	does **not** imply **M1**

Question	Answer	Marks	Partial Marks
11(c)	$\int e^{\frac{x}{3}}\,dx = ke^{\frac{x}{3}}$ $[+c]$	**M1**	k any non-zero constant
	$k = 3$	**A1**	
	Sight of correct substitution of limits: $\textit{their}\, ke^{\frac{\ln 8}{3}} - \textit{their}\, ke^{0}$ oe	**M1**	**dep** on first **M1**
	Shows how to deal with the power of the first term e.g. $\frac{\ln 8}{3} = \ln 8^{\frac{1}{3}}$ or $\frac{\ln 8}{3} = \ln 2$ or $3\left(\sqrt[3]{8}\right)$ seen	**B1**	
	6 – 3 = 3	**A1**	Not from wrong working
12(i)	$\tan\frac{\pi}{12} = \frac{r}{h}$ oe	**M1**	
	$r = h(2-\sqrt{3})$ or $r = h\tan\frac{\pi}{12}$ oe	**A1**	
	$[V=]\frac{1}{3}\pi\left(2-\sqrt{3}\right)^2 h^2 \times h$ oe	**M1**	Correctly uses *their* expression for r in terms of h in formula for volume of a cone dependent on finding an expression connecting r and h
	$[V=]\frac{\pi\left(4-4\sqrt{3}+3\right)h^3}{3}$ oe correctly leading to $[V=]\frac{\pi\left(7-4\sqrt{3}\right)h^3}{3}$ **AG**	**A1**	
12(ii)	Correct derivative of V e.g. $\frac{3\pi\left(7-4\sqrt{3}\right)h^2}{3}$ oe isw	**B1**	
	$\frac{dh}{dt} = \frac{dh}{dV} \times \frac{dV}{dt}$ soi	**B1**	
	$\frac{1}{\textit{their}\left(\frac{dV}{dh}\right)\Big\vert_{h=5}} \times 30$	**M1**	if correct implies **B1 B1;** if incorrect, a correct **FT** statement implies the second **B1**
	5.32	**A1**	

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ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **May/June 2018**

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oe	or equivalent
rot	rounded or truncated
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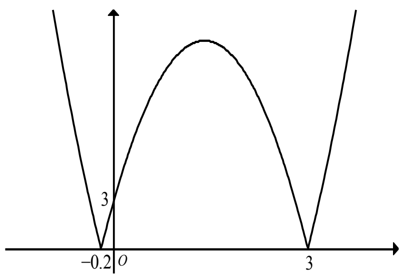
soi	seen or implied

Question	Answer	Marks	Partial Marks
1(i)(a)	*A* is not a [proper] subset of *B* oe	**B1**	
1(i)(b)	*A* and *C* are mutually exclusive oe or *A* intersection *C* is the empty set oe	**B1**	
1(ii)(a)	$\text{n}\left(A \cup B\right) = 3$	**B1**	
1(ii)(b)	$x \in \left(A \cap C'\right)$ oe	**B1**	
2(i)	$k \times \frac{1}{3x-1}$	**M1**	
	$3 \times \frac{1}{3x-1}$	**A1**	
2(ii)	$x = \frac{11}{15}$ soi	**B1**	
	$0.125 \approx \textit{their} \left.\frac{\text{d}y}{\text{d}x}\right\vert_{x=\textit{their}\frac{11}{15}} \times \delta x$ oe	**M1**	
	0.05 nfww	**A1**	
3(i)	$\left({}^{12}P_7 =\right) 3\,991\,680$	**B1**	
3(ii)	$(4 \times {}^{11}P_6 =)\ 1\,330\,560$	**B1**	
3(iii)	4! × 4! × 2 oe	**M2**	**M1** for 4! × 4! oe only or ${}^4P_4 \times {}^4P_3$ oe only
	1152	**A1**	

Question	Answer	Marks	Partial Marks
4(i)	$2(-4)^3+3(-4)^2-4a-12=0$ with one correct interim step leading to $a = -23$	**B1**	Note: = 0 must be seen or may be implied by e.g. $-92 = 4a$ or $92 = -4a$ or convincingly showing that $2(-4)^3+3(-4)^2-4(-23)-12=0$ or correct synthetic division at least as far as $\begin{array}{r\|rrrr} -4 & 2 & 3 & a & -12 \\ & & -8 & 20 & -4a-80 \\ \hline & 2 & -5 & a+20 & 0 \end{array}$ then $a = -23$ or correct long division to, e.g. verify –23, at least as far as $\begin{array}{r} 2x^2-5x-3 \\ x+4\overline{)2x^3+3x^2-23x-12} \\ \underline{2x^3+8x^2} \\ -5x^2-23x \\ \underline{-5x^2-20x} \\ -3x-12 \\ \underline{-3x-12} \\ 0 \end{array}$
	$p(1)=2+3-23-12$ $b = -30$	**B1**	
4(ii)	finds a correct quadratic factor e.g. $(2x^2 - 5x - 3)$	**B2**	**B1** for quadratic factor with 2 correct terms OR **B1** for finding $(x - 3)$ using factor theorem **B1** for convincingly finding $(2x + 1)$ as third factor
	Product of three linear factors $(2x + 1)(x - 3)(x + 4)$	**M1**	
	$x = -\frac{1}{2},\ x = 3,\ x = -4$ nfww	**A1**	If **M0** then **SC1** if quadratic factorised correctly but does not show full factorisation but does give all 3 solutions correctly
5(i)	Putting $y = f(x)$, changing subject to x and swopping x and y or vice versa	**M1**	
	$f^{-1}(x)=\frac{1}{2}\left(\frac{1}{x}+5\right)$ or $\frac{5x+1}{2x}$ oe isw	**A1**	
5(ii)	$x > 0$ oe	**B1**	

Question	Answer	Marks	Partial Marks
5(iii)	$\dfrac{1}{2\left(\dfrac{1}{2x-5}\right)-5}$	B1	
	$\dfrac{1}{\dfrac{2-5(2x-5)}{2x-5}}$ oe	M1	**FT** if expression of equivalent difficulty e.g. $\dfrac{1}{\left(\dfrac{1}{2x-5}\right)-5}$
	Completes to $\dfrac{2x-5}{-10x+27}$ oe final answer	A1	
6(i)	$16x = 40$ oe	M1	
	$x = 2.5$ oe (radians)	A1	
6(ii)	$\frac{1}{2}(16)^2(2.5)$ oe	M1	
	320	A1	
6(iii)	$\frac{1}{2}r^2(their2.5) = (their320) - 140$ oe	M1	**FT** provided *their* 320 > 140
	correct simplification to $r^2 = \ldots$	M1	**dep** on first **M1**
	12	A1	
7(i)	$4\tan x + 4x\sec^2 x$ isw	B2	Fully correct **B1** for one correct term as part of e.g. a sum of 2 terms
7(ii)	$\frac{d}{dx}(e^{3x+1}) = 3e^{3x+1}$	B1	
	$\dfrac{(x^2-1)(their3e^{3x+1}) - their(2x)e^{3x+1}}{(x^2-1)^2}$	M1	
	$\dfrac{(x^2-1)(3e^{3x+1}) - 2xe^{3x+1}}{(x^2-1)^2}$ oe isw	A1	
8(i)	Takes logs of both sides	M1	
	$\ln y = \ln a + n\ln x$ or $\lg y = \lg a + n\lg x$	A1	

Question	Answer	Marks	Partial Marks
8(ii)	$n =$ –0.2 to –0.3 nfww	**B1**	
	attempts to equate *y*-intercept to ln *a* or forms *their* ln equation with *their* gradient and a point on the line or uses two points on the line to form a pair of simultaneous equations	**M1**	
	$a = \mathrm{e}^{4.7}$ isw or 110 or 109.9[47…]	**A1**	maximum of 2 marks if no coordinates stated
8(iii)	use of ln(50) and ln*x* = 3 to 3.2	**M1**	or for $\frac{50}{\mathit{theira}} = x^{\mathit{their}\ n}$ or better or for $\ln 50 = \ln(\mathit{theira}) + (\mathit{their}\ n)\ln x$ oe
	awrt 22 or 23 to 2 significant figures	**A1**	implies **M1**
9(i)	$5\left(x - \frac{7}{5}\right)^2 - \frac{64}{5}$	**B3**	**B1** for each of *p*, *q*, *r* correct in correct format; allow correct equivalent values. If **B0**, then **SC2** for $5\left(x - \frac{7}{5}\right) - \frac{64}{5}$ or **SC1** for correct values but incorrect format
9(ii)		**B4**	**B2** for fully correct shape in correct position or **B1** for fully correct shape translated parallel to the *x*-axis **B1** for *y*-intercept at (0, 3) marked on graph **B1** for roots marked on graph at –0.2 and 3
9(iii)	$0 < k < \left\lvert \mathit{their}\left(-\frac{64}{5}\right)\right\rvert$	**B2**	**FT** *their* **(i)** **B1** for any inequality using *their* $\frac{64}{5}$ or max *y* value is *their* 12.8soi
10(i)	$v = \frac{\mathrm{d}s}{\mathrm{d}t} = -3\sin 3t$	**B1**	
	When $v = 0$, $t = \frac{\pi}{3}$	**B1**	

Question	Answer	Marks	Partial Marks
10(ii)	Finding s when $t=\frac{\pi}{4}$ and $t=\frac{\pi}{2}$	**M1**	
	Finding s when $t = \textit{their}\frac{\pi}{3}$ and correct plan	**M1**	Using *their* **(i)** correctly
	1.29 nfww	**A1**	
10(iii)	$a=\frac{\mathrm{d}v}{\mathrm{d}t}=-9\cos 3t$	**B1**	
	9	**B1**	**FT** *their* $k\cos 3t$
11(a)	$10\left(1-\sin^2 x\right)+3\sin x=9$	**M1**	
	Solves $10\sin^2 x-3\sin x-1=0$ oe	**M1**	**dep** on first **M1** Solves *their* three term quadratic in $\sin x$
	$\sin x=\frac{1}{2},\ \sin x=-\frac{1}{5}$	**A1**	
	30º, 150º and 191.5º, 348.5º awrt	**A2**	**A1** for any two correct solutions
11(b)	$3\frac{\sin 2y}{\cos 2y}=4\sin 2y$ oe	**M1**	
	Solves $3\sin 2y-4\sin 2y\cos 2y\,[=0]$	**M1**	**dep** on first **M1**
	$\sin 2y=0\ \ \cos 2y=\frac{3}{4}$	**A1**	
	Any two of π, 0.72273…, 5.56045… nfww	**A1**	
	$\frac{\pi}{2}$, 0.361, 2.78 awrt nfww	**A1**	**SC**: cancels out sin2y after **M1M0** allow **SC1** for 0.72273… and 5.56045... and **SC1** for 0.361 and 2.78
12(i)	$\tan 30=\frac{h}{x/2}$ oe	**M1**	
	Correct completion to given answer	**A1**	
	$V=5\sqrt{3}\,h^2$ isw	**B1**	

Question	Answer	Marks	Partial Marks
12(ii)(a)	$\frac{\mathrm{d}V}{\mathrm{d}h} = \textit{their}\,10\sqrt{3}\,h$ or $\frac{5\sqrt{3}}{2}$	**B1**	**FT** $\textit{their}\,V = k\,h^2$
	$\frac{\mathrm{d}h}{\mathrm{d}t} = \frac{\mathrm{d}h}{\mathrm{d}V} \times \frac{\mathrm{d}V}{\mathrm{d}t}$ soi	**M1**	
	$\frac{\mathrm{d}h}{\mathrm{d}t} = \frac{1}{\textit{their}\left(\frac{\mathrm{d}V}{\mathrm{d}h}\right)} \times 0.5$	**M1**	
	0.115 or 0.11547 to 0.1155 oe	**A1**	
12(ii)(b)	$\left(\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{\mathrm{d}x}{\mathrm{d}h} \times \frac{\mathrm{d}h}{\mathrm{d}t} =\right) 2\sqrt{3} \times \textit{their}\,\frac{1}{5\sqrt{3}}$	**M1**	
	$\frac{2}{5}$	**A1**	

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3936138431

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **May/June 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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The total number of marks for this paper is 80.

This document consists of **16** printed pages.

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International Examinations

[Turn over

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a+b)^n = a^n + \binom{n}{1}a^{n-1}b + \binom{n}{2}a^{n-2}b^2 + \ldots + \binom{n}{r}a^{n-r}b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

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Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\text{cosec}^2 A = 1 + \cot^2 A$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 Solve the equations

$$y - x = 4,$$

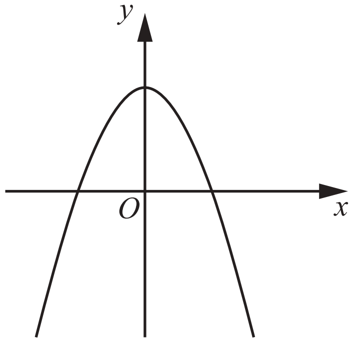
$$x^2 + y^2 - 8x - 4y - 16 = 0.$$

[5]

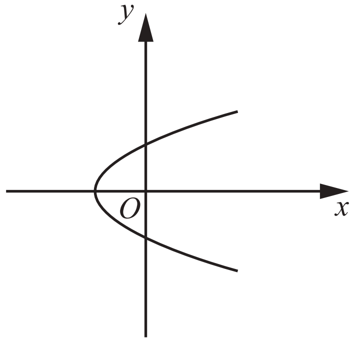
2 Find the equation of the perpendicular bisector of the line joining the points (1, 3) and (4, −5). Give your answer in the form $ax + by + c = 0$, where a, b and c are integers. [5]

3 Diagrams **A** to **D** show four different graphs. In each case the whole graph is shown and the scales on the two axes are the same.

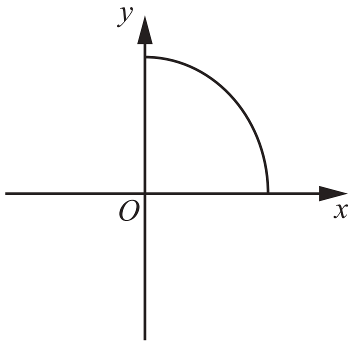
A



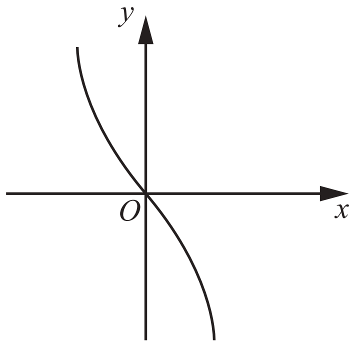
B



C



D

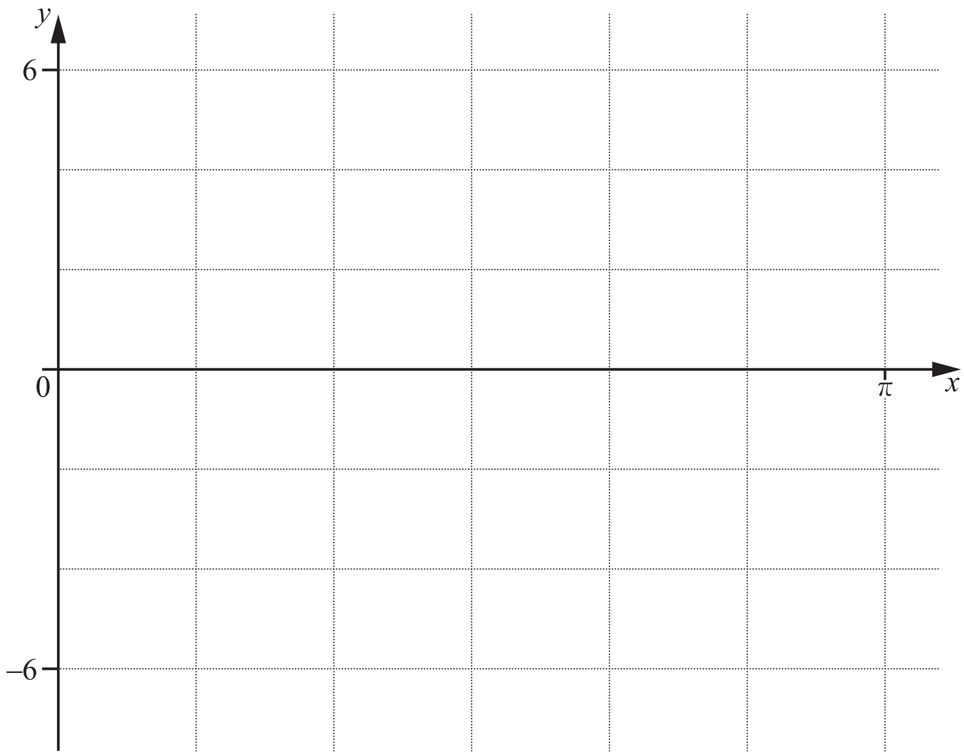


Place ticks in the boxes in the table to indicate which descriptions, if any, apply to each graph. There may be more than one tick in any row or column of the table. [4]

	A	**B**	**C**	**D**
Not a function				
One-one function				
A function that is its own inverse				
A function with no inverse				

4 **(i)** The curve $y = a + b\sin cx$ has an amplitude of 4 and a period of $\frac{\pi}{3}$. Given that the curve passes through the point $\left(\frac{\pi}{12}, 2\right)$, find the value of each of the constants a, b and c. [4]

(ii) Using your values of a, b and c, sketch the graph of $y = a + b\sin cx$ for $0 \leqslant x \leqslant \pi$ radians. [3]



5 The population, P, of a certain bacterium t days after the start of an experiment is modelled by $P = 800e^{kt}$, where k is a constant.

(i) State what the figure 800 represents in this experiment. [1]

(ii) Given that the population is 20 000 two days after the start of the experiment, calculate the value of k. [3]

(iii) Calculate the population three days after the start of the experiment. [2]

6 **(a)** Write $(\log_2 p)(\log_3 2) + \log_3 q$ as a single logarithm to base 3. [3]

(b) Given that $(\log_a 5)^2 - 4\log_a 5 + 3 = 0$, find the possible values of a. [3]

7 **(i)** Find the inverse of the matrix $\begin{pmatrix} 4 & -2 \\ -5 & 3 \end{pmatrix}$. [2]

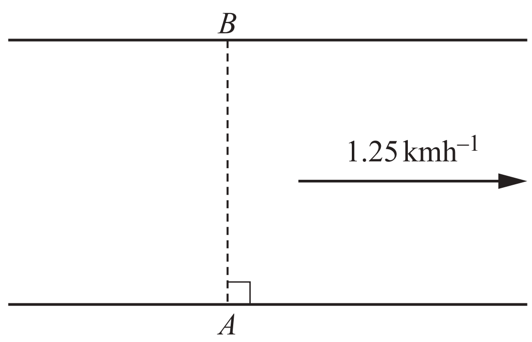
(ii) Hence solve the simultaneous equations

$$8x - 4y - 5 = 0,$$
$$-10x + 6y - 7 = 0.$$

[4]

8 **(a)** Given that $\mathbf{p} = 2\mathbf{i} - 5\mathbf{j}$ and $\mathbf{q} = \mathbf{i} - 3\mathbf{j}$, find the unit vector in the direction of $3\mathbf{p} - 4\mathbf{q}$. [4]

(b)



A river flows between parallel banks at a speed of $1.25\,\text{kmh}^{-1}$. A boy standing at point A on one bank sends a toy boat across the river to his father standing directly opposite at point B. The toy boat, which can travel at $v\,\text{kmh}^{-1}$ in still water, crosses the river with resultant speed $2.73\,\text{kmh}^{-1}$ along the line AB.

(i) Calculate the value of v. [2]

The direction in which the boy points the boat makes an angle θ with the line AB.

(ii) Find the value of θ. [2]

9 **(i)** Find the first 3 terms in the expansion of $\left(2x - \frac{1}{16x}\right)^8$ in descending powers of x. [3]

(ii) Hence find the coefficient of x^4 in the expansion of $\left(2x - \frac{1}{16x}\right)^8 \left(\frac{1}{x^2} + 1\right)^2$. [3]

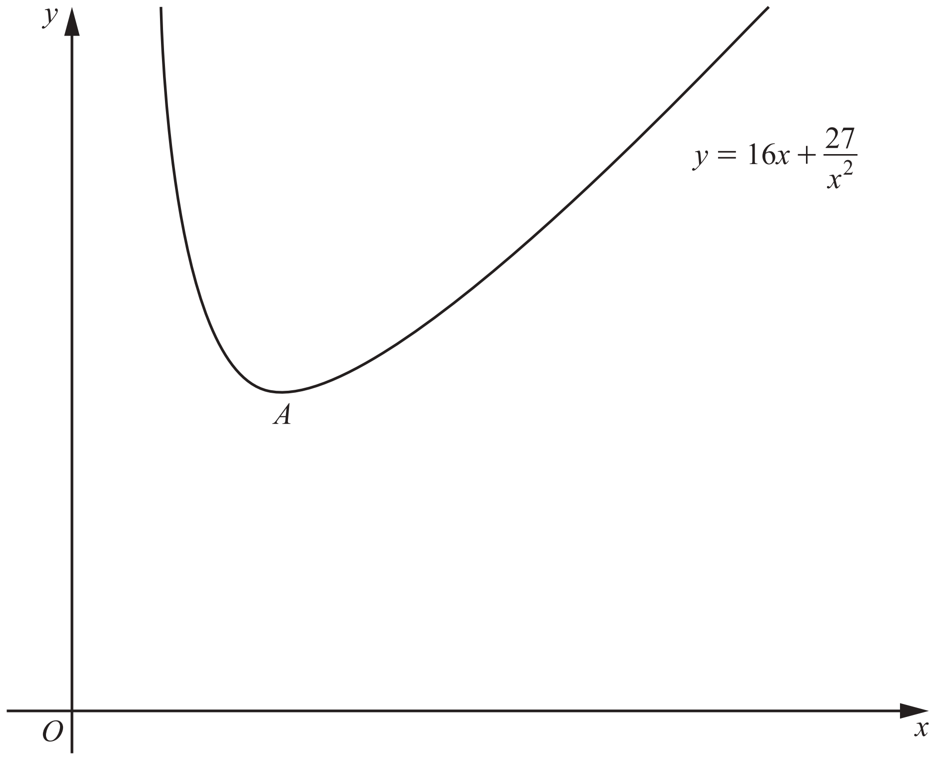
10 Do not use a calculator in this question.

(a) Simplify $\dfrac{5+6\sqrt{5}}{6+\sqrt{5}}$. [3]

(b) Show that $3^{0.5} \times (\sqrt{2})^7$ can be written in the form $a\sqrt{b}$, where a and b are integers and $a > b$. [2]

(c) Solve the equation $x + \sqrt{2} = \dfrac{4}{x}$, giving your answers in simplest surd form. [4]

11



The diagram shows part of the graph of $y = 16x + \frac{27}{x^2}$, which has a minimum at A.

(i) Find the coordinates of A. [4]

The points P and Q lie on the curve $y = 16x + \dfrac{27}{x^2}$ and have x-coordinates 1 and 3 respectively.

(ii) Find the area enclosed by the curve and the line PQ. You must show all your working. [6]

Question 12 is printed on the next page.

12 A curve is such that $\frac{d^2y}{dx^2} = (2x-5)^{-\frac{1}{2}}$. Given that the curve has a gradient of 6 at the point $\left(\frac{9}{2}, \frac{2}{3}\right)$, find the equation of the curve. [8]

Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

1239049889

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

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This document consists of **16** printed pages.

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Mathematical Formulae

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$$(a + b)^n = a^n + \binom{n}{1}a^{n-1} b + \binom{n}{2}a^{n-2} b^2 + \ldots + \binom{n}{r}a^{n-r} b^r + \ldots + b^n,$$

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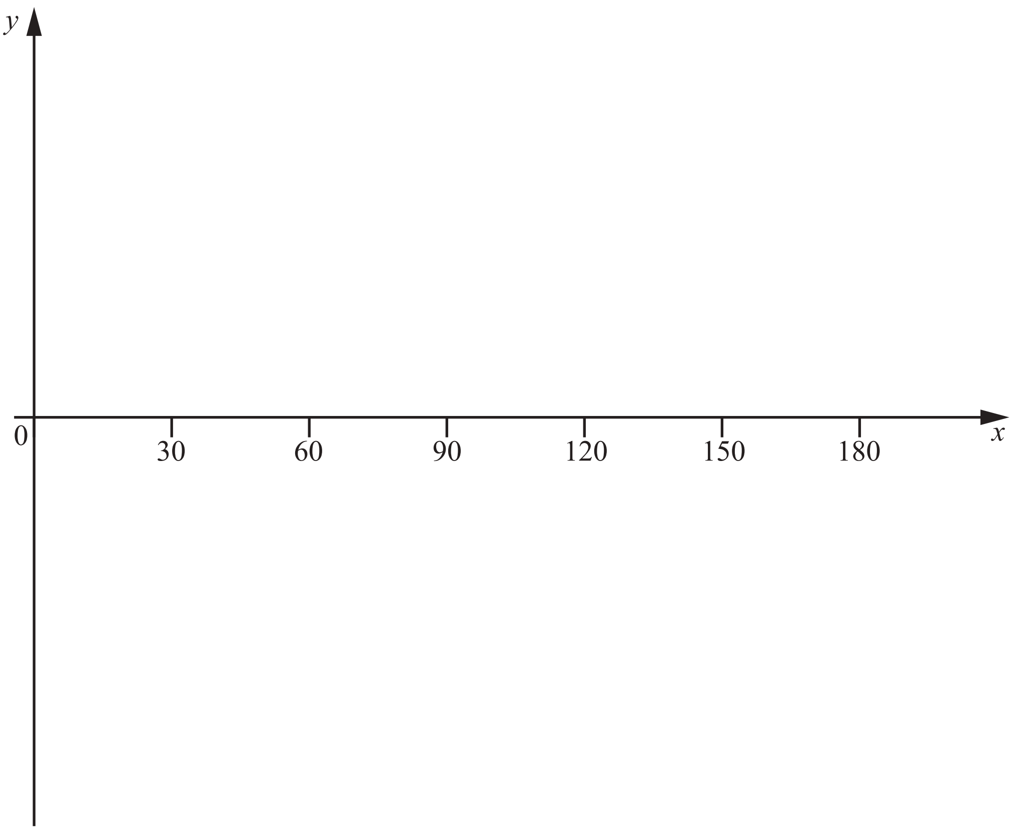
$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 It is given that $y = 1 + \tan 3x$.

(i) State the period of y. [1]

(ii) On the axes below, sketch the graph of $y = 1 + \tan 3x$ for $0° \leqslant x° \leqslant 180°$. [3]



2 Find the values of k for which the line $y = 1 - 2kx$ does not meet the curve $y = 9x^2 - (3k + 1)x + 5$. [5]

3 The variables x and y are such that when e^y is plotted against x^2, a straight line graph passing through the points (5, 3) and (3, 1) is obtained. Find y in terms of x. [5]

4 A particle P moves so that its displacement, x metres from a fixed point O, at time t seconds, is given by $x = \ln(5t + 3)$.

(i) Find the value of t when the displacement of P is 3m. [2]

(ii) Find the velocity of P when $t = 0$. [2]

(iii) Explain why, after passing through O, the velocity of P is never negative. [1]

(iv) Find the acceleration of P when $t = 0$. [2]

5 **(i)** The first three terms in the expansion of $\left(3-\frac{1}{9x}\right)^5$ can be written as $a+\frac{b}{x}+\frac{c}{x^2}$. Find the value of each of the constants a, b and c. [3]

(ii) Use your values of a, b and c to find the term independent of x in the expansion of

$$\left(3-\frac{1}{9x}\right)^5(2+9x)^2.$$ [3]

6 Find the coordinates of the stationary point of the curve $y = \dfrac{x+2}{\sqrt{2x-1}}$. [6]

7 A population, B, of a particular bacterium, t hours after measurements began, is given by $B = 1000e^{\frac{t}{4}}$.

(i) Find the value of B when $t = 0$. [1]

(ii) Find the time taken for B to double in size. [3]

(iii) Find the value of B when $t = 8$. [1]

8 **(a)** Solve $3\cos^2\theta + 4\sin\theta = 4$ for $0° \leqslant \theta \leqslant 180°$. [4]

(b) Solve $\sin 2\phi = \sqrt{3}\cos 2\phi$ for $-\frac{\pi}{2} \leqslant \phi \leqslant \frac{\pi}{2}$ radians. [4]

9 **(a)** **(i)** Solve $\lg x = 3$. [1]

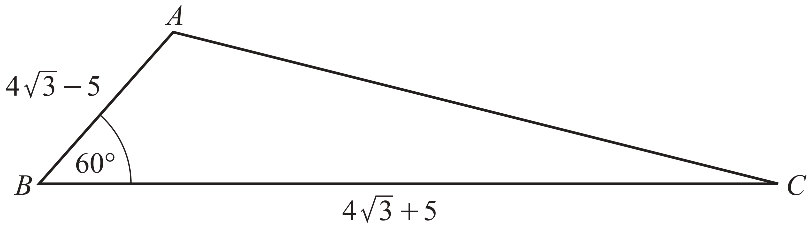
(ii) Write $\lg a - 2\lg b + 3$ as a single logarithm. [3]

(b) **(i)** Solve $x - 5 + \frac{6}{x} = 0$. [2]

(ii) Hence, showing all your working, find the values of a such that $\log_4 a - 5 + 6\log_a 4 = 0$. [3]

10 Do not use a calculator in this question.

All lengths in this question are in centimetres.



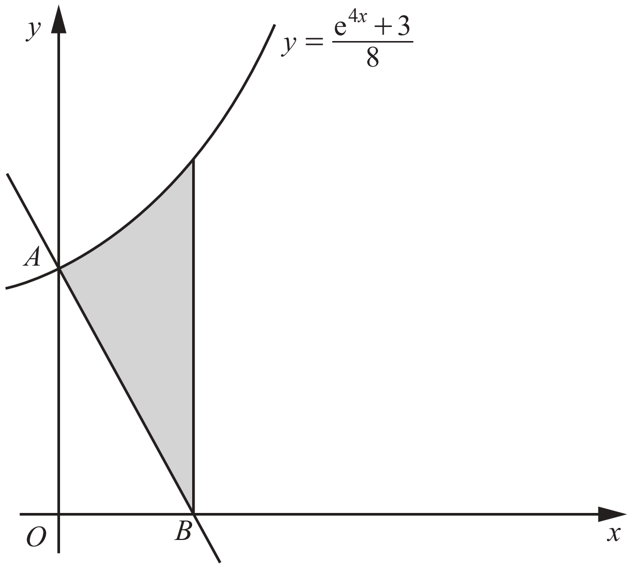
The diagram shows the triangle ABC, where $AB = 4\sqrt{3} - 5$, $BC = 4\sqrt{3} + 5$ and angle $ABC = 60°$.

It is known that $\sin 60° = \frac{\sqrt{3}}{2}$, $\cos 60° = \frac{1}{2}$, $\tan 60° = \sqrt{3}$.

(i) Find the exact value of AC. [4]

(ii) Hence show that $\operatorname{cosec} ACB = \dfrac{2\sqrt{p}}{q}(4\sqrt{3}+5)$, where p and q are integers. [4]

11



The diagram shows the graph of the curve $y = \frac{e^{4x}+3}{8}$. The curve meets the y-axis at the point A.

The normal to the curve at A meets the x-axis at the point B. Find the area of the shaded region enclosed by the curve, the line AB and the line through B parallel to the y-axis. Give your answer in the form $\frac{e}{a}$, where a is a constant. You must show all your working.

[10]

Question 12 is printed on the next page.

12 Do not use a calculator in this question.

(a) Given that $\dfrac{6^p \times 8^{p+2} \times 3^q}{9^{2q-3}}$ is equal to $2^7 \times 3^4$, find the value of each of the constants p and q. [3]

(b) Using the substitution $u = x^{\frac{1}{3}}$, or otherwise, solve $4x^{\frac{1}{3}} + x^{\frac{2}{3}} + 3 = 0$. [4]

Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5006741950

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

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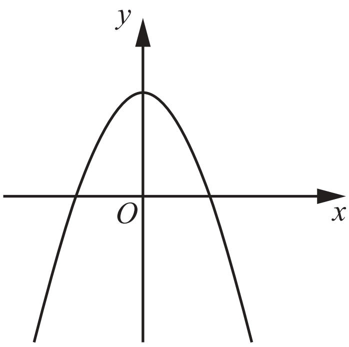
[5]

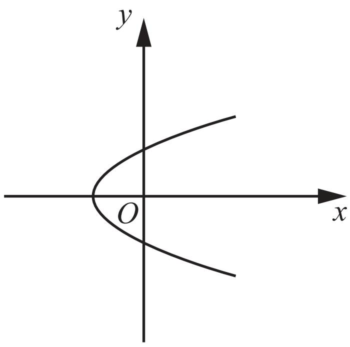
2 Find the equation of the perpendicular bisector of the line joining the points (1, 3) and (4, −5). Give your answer in the form $ax + by + c = 0$, where a, b and c are integers. [5]

3 Diagrams **A** to **D** show four different graphs. In each case the whole graph is shown and the scales on the two axes are the same.

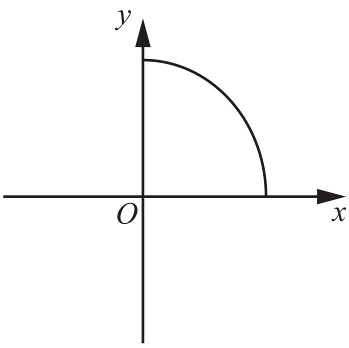
A



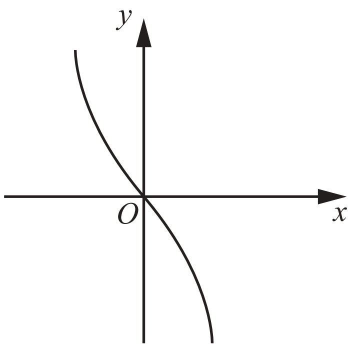
B



C



D



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A function with no inverse				

4 **(i)** The curve $y = a + b\sin cx$ has an amplitude of 4 and a period of $\frac{\pi}{3}$. Given that the curve passes through the point $\left(\frac{\pi}{12}, 2\right)$, find the value of each of the constants a, b and c. [4]

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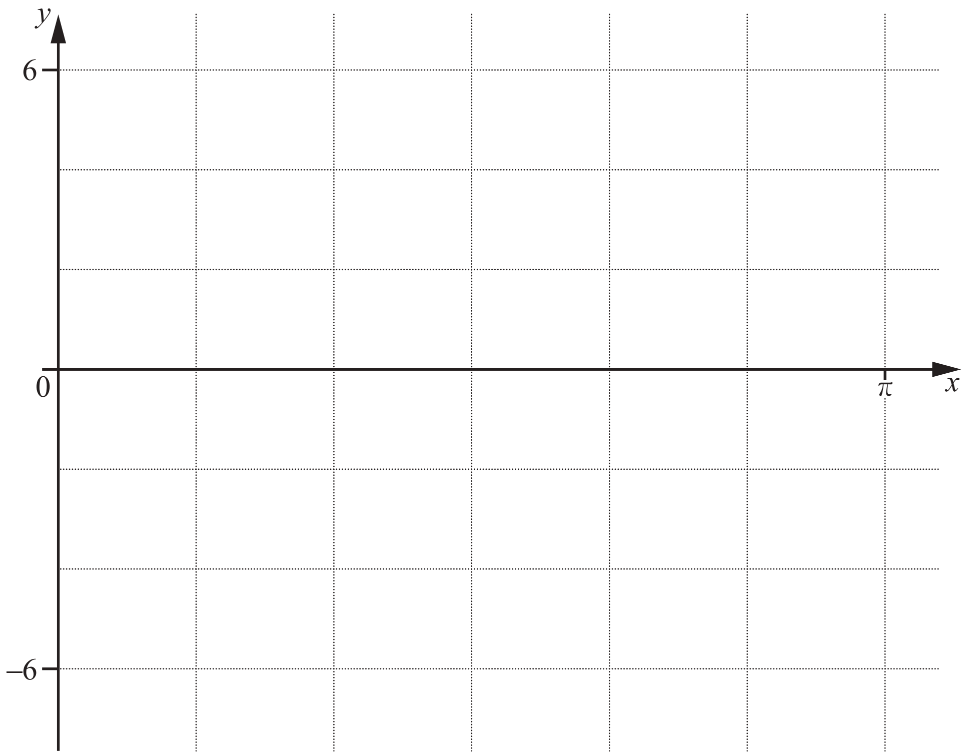

5 The population, P, of a certain bacterium t days after the start of an experiment is modelled by $P = 800e^{kt}$, where k is a constant.

(i) State what the figure 800 represents in this experiment. [1]

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7 **(i)** Find the inverse of the matrix $\begin{pmatrix} 4 & -2 \\ -5 & 3 \end{pmatrix}$. [2]

(ii) Hence solve the simultaneous equations

$$8x - 4y - 5 = 0,$$
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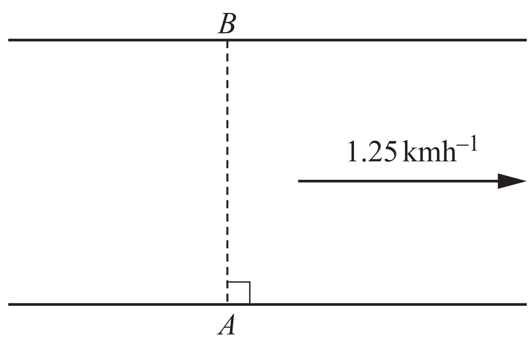
(b)



A river flows between parallel banks at a speed of $1.25\,\text{kmh}^{-1}$. A boy standing at point A on one bank sends a toy boat across the river to his father standing directly opposite at point B. The toy boat, which can travel at $v\,\text{kmh}^{-1}$ in still water, crosses the river with resultant speed $2.73\,\text{kmh}^{-1}$ along the line AB.

(i) Calculate the value of v. [2]

The direction in which the boy points the boat makes an angle θ with the line AB.

(ii) Find the value of θ. [2]

9 **(i)** Find the first 3 terms in the expansion of $\left(2x - \frac{1}{16x}\right)^8$ in descending powers of x. [3]

(ii) Hence find the coefficient of x^4 in the expansion of $\left(2x - \frac{1}{16x}\right)^8 \left(\frac{1}{x^2} + 1\right)^2$. [3]

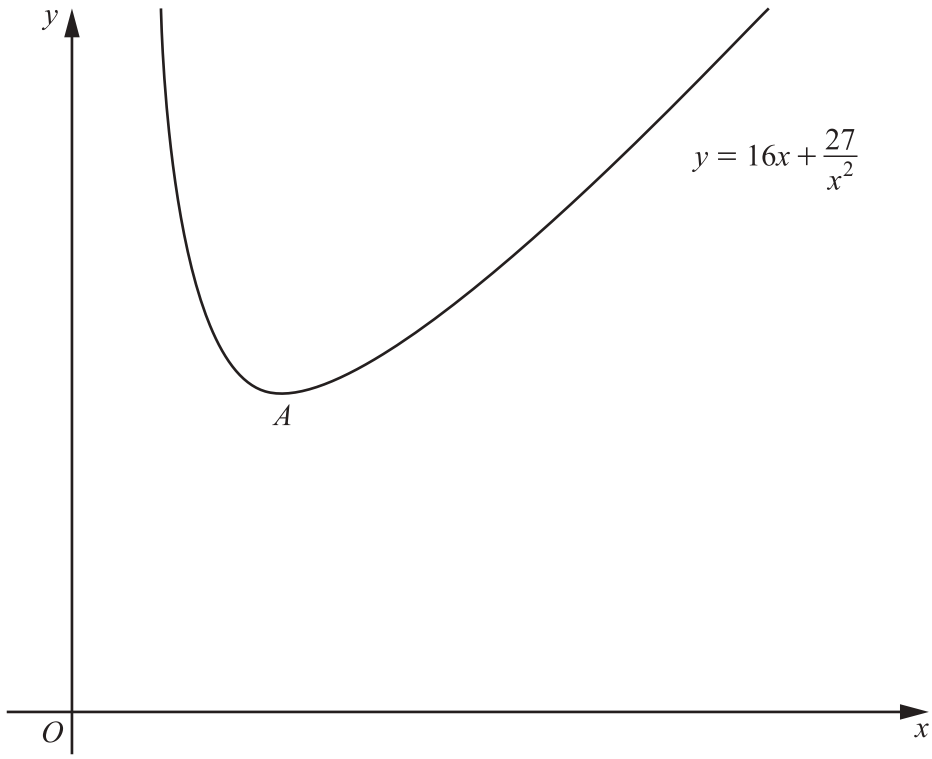
10 Do not use a calculator in this question.

(a) Simplify $\dfrac{5+6\sqrt{5}}{6+\sqrt{5}}$. [3]

(b) Show that $3^{0.5}\times(\sqrt{2})^7$ can be written in the form $a\sqrt{b}$, where a and b are integers and $a > b$. [2]

(c) Solve the equation $x+\sqrt{2}=\dfrac{4}{x}$, giving your answers in simplest surd form. [4]

11



The diagram shows part of the graph of $y = 16x + \dfrac{27}{x^2}$, which has a minimum at A.

(i) Find the coordinates of A. [4]

The points P and Q lie on the curve $y = 16x + \dfrac{27}{x^2}$ and have x-coordinates 1 and 3 respectively.

(ii) Find the area enclosed by the curve and the line PQ. You must show all your working. [6]

Question 12 is printed on the next page.

12 A curve is such that $\frac{d^2y}{dx^2} = (2x - 5)^{-\frac{1}{2}}$. Given that the curve has a gradient of 6 at the point $\left(\frac{9}{2}, \frac{2}{3}\right)$, find the equation of the curve. [8]

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

6234149436

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 80.

This document consists of **15** printed pages and **1** blank page.

DC (NF/SW) 145871/1

CAMBRIDGE International Examinations

[Turn over

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

2. TRIGONOMETRY

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$$\sin^2 A + \cos^2 A = 1$$

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$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 A, B and C are subsets of the same universal set.

(i) Write each of the following statements in words.

(a) $A \not\subset B$ [1]

(b) $A \cap C = \varnothing$ [1]

(ii) Write each of the following statements in set notation.

(a) There are 3 elements in set A or B or both. [1]

(b) x is an element of A but it is not an element of C. [1]

2 The variables x and y are such that $y = \ln(3x - 1)$ for $x > \frac{1}{3}$.

(i) Find $\frac{dy}{dx}$. [2]

(ii) Hence find the approximate change in x when y increases from $\ln(1.2)$ to $\ln(1.2) + 0.125$. [3]

3 A 7-character password is to be selected from the 12 characters shown in the table. Each character may be used only once.

	Characters			
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Lower-case letters	e	f	g	h
Digits	1	2	3	4

Find the number of different passwords

(i) if there are no restrictions, [1]

(ii) that start with a digit, [1]

(iii) that contain 4 upper-case letters and 3 lower-case letters such that all the upper-case letters are together and all the lower-case letters are together. [3]

4 Do not use a calculator in this question.

It is given that $x+4$ is a factor of $p(x) = 2x^3 + 3x^2 + ax - 12$. When $p(x)$ is divided by $x-1$ the remainder is b.

(i) Show that $a = -23$ and find the value of the constant b. [2]

(ii) Factorise $p(x)$ completely and hence state all the solutions of $p(x) = 0$. [4]

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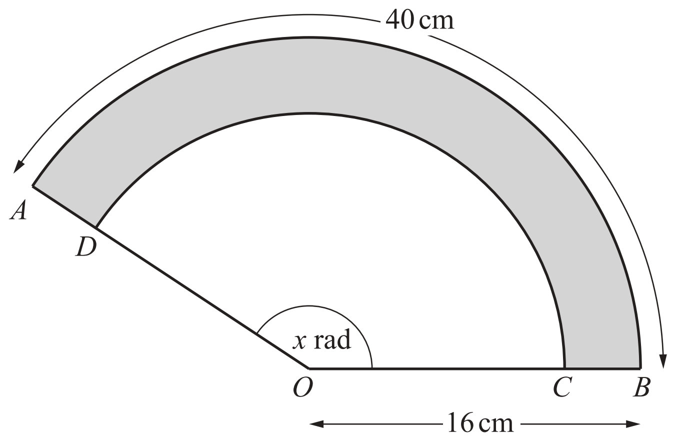
6



In the diagram *AOB* and *DOC* are sectors of a circle centre *O*. The angle *AOB* is x radians. The length of the arc *AB* is 40 cm and the radius *OB* is 16 cm.

(i) Find the value of x. [2]

(ii) Find the area of sector *AOB*. [2]

(iii) Given that the area of the shaded region *ABCD* is 140 cm^2, find the length of *OC*. [3]

7 Differentiate with respect to x

(i) $4x\tan x$, [2]

(ii) $\dfrac{e^{3x+1}}{x^2-1}$. [3]

8 An experiment was carried out recording values of y for certain values of x. The variables x and y are thought to be connected by the relationship $y = ax^n$, where a and n are constants.

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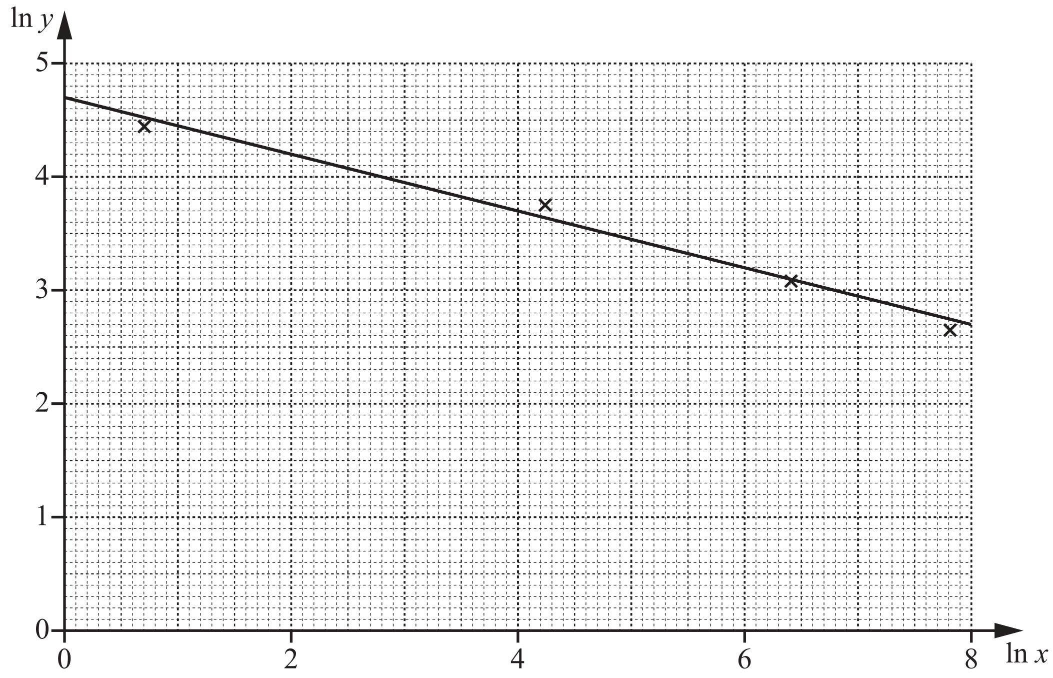
The values of $\ln y$ and $\ln x$ were plotted and a line of best fit drawn. This is shown in the diagram below.

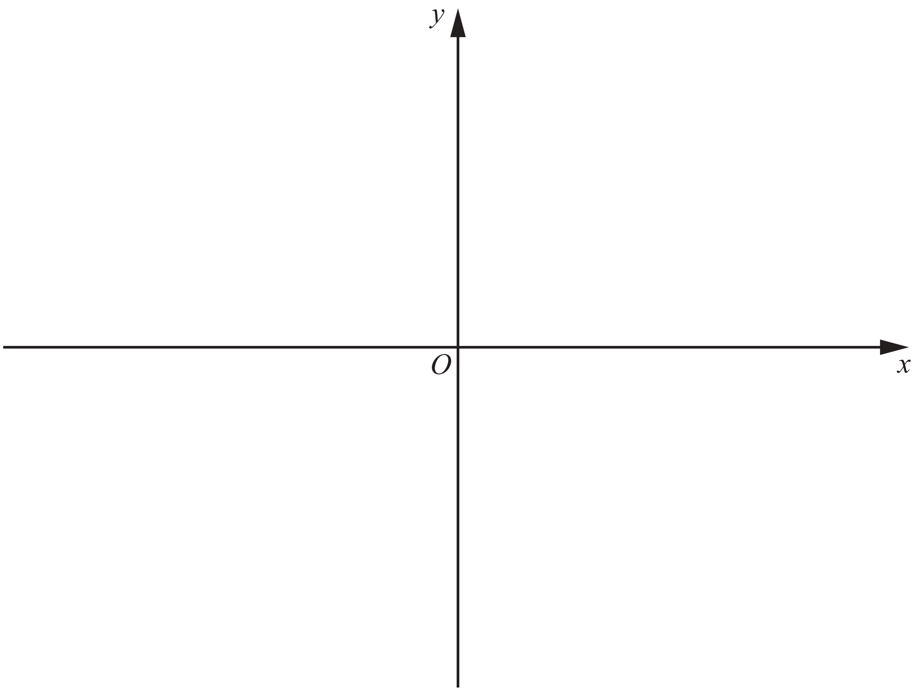


(ii) Use the graph to find the value of a and of n, stating the coordinates of the points that you use. [3]

(iii) Find the value of x when $y = 50$. [2]

9 **(i)** Express $5x^2 - 14x - 3$ in the form $p(x+q)^2 + r$, where p, q and r are constants. [3]

(ii) Sketch the graph of $y = \left|5x^2 - 14x - 3\right|$ on the axes below. Show clearly any points where your graph meets the coordinate axes. [4]



(iii) State the set of values of k for which $\left|5x^2 - 14x - 3\right| = k$ has exactly four solutions. [2]

10 A particle moves in a straight line such that its displacement, s metres, from a fixed point O at time t seconds, is given by $s = 4 + \cos 3t$, where $t \geqslant 0$. The particle is initially at rest.

(i) Find the exact value of t when the particle is next at rest. [2]

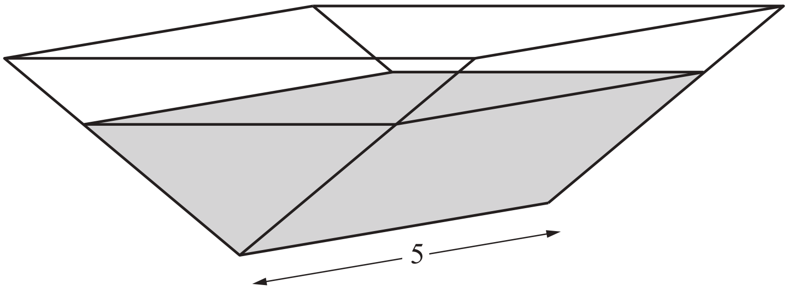
(ii) Find the distance travelled by the particle between $t = \frac{\pi}{4}$ and $t = \frac{\pi}{2}$ seconds. [3]

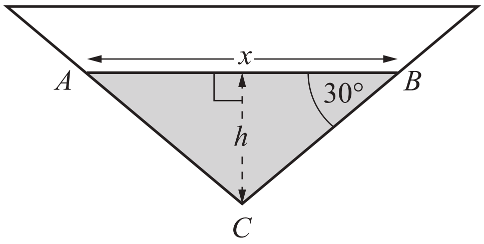
(iii) Find the greatest acceleration of the particle. [2]

11 **(a)** Solve $10\cos^2 x + 3\sin x = 9$ for $0° < x < 360°$. [5]

(b) Solve $3\tan 2y = 4\sin 2y$ for $0 < y < \pi$ radians. [5]

12 In this question all lengths are in metres.





A water container is in the shape of a triangular prism. The diagrams show the container and its cross-section. The cross-section of the water in the container is an isosceles triangle ABC, with angle ABC = angle BAC = 30°. The length of AB is x and the depth of water is h. The length of the container is 5.

(i) Show that $x = 2\sqrt{3}h$ and hence find the volume of water in the container in terms of h. [3]

(ii) The container is filled at a rate of $0.5\,\text{m}^3$ per minute. At the instant when h is $0.25\,\text{m}$, find

(a) the rate at which h is increasing, [4]

(b) the rate at which x is increasing. [2]

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Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4401850851

ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **May/June 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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International Examinations

[Turn over

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

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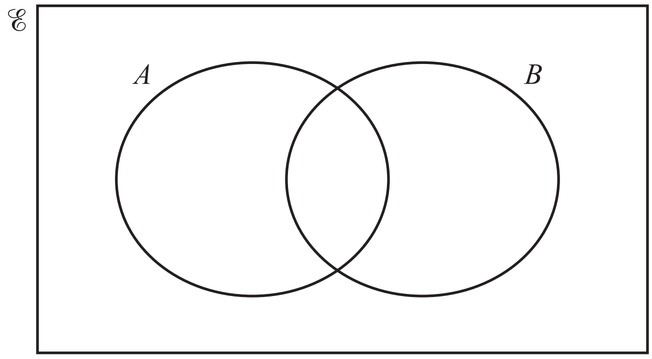
$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 **(i)** Show that $\cos\theta\cot\theta+\sin\theta=\operatorname{cosec}\theta$. [3]

(ii) Hence solve $\cos\theta\cot\theta+\sin\theta=4$ for $0°\leqslant\theta\leqslant 90°$. [2]

2 **(a)** On the Venn diagram below, shade the region that represents $A \cap B'$.



[1]

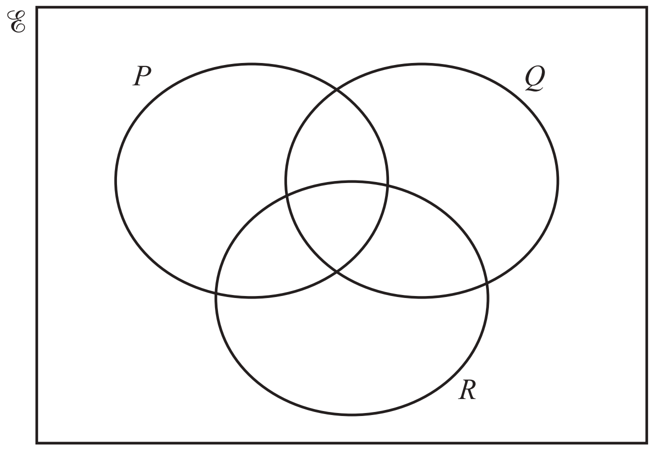
(b) The universal set ℰ and sets P, Q and R are such that

$(P \cup Q \cup R)' = \varnothing$, $P' \cap (Q \cap R) = \varnothing$,

$n(Q \cap R) = 8$, $n(P \cap R) = 8$, $n(P \cap Q) = 10$,

$n(P) = 21$, $n(Q) = 15$, $n(\mathscr{E}) = 30$.

Complete the Venn diagram to show this information and state the value of $n(R)$.



$n(R) =$ .... [4]

3 It is given that $x+3$ is a factor of the polynomial $\mathrm{p}(x) = 2x^3 + ax^2 - 24x + b$. The remainder when $\mathrm{p}(x)$ is divided by $x-2$ is -15. Find the remainder when $\mathrm{p}(x)$ is divided by $x+1$. [6]

4 Find the coordinates of the points where the line $2y - 3x = 6$ intersects the curve $\frac{x^2}{4} + \frac{y^2}{9} = 5$. [5]

5 **(a)** Four parts in a play are to be given to four of the girls chosen from the seven girls in a drama class. Find the number of different ways in which this can be done. [2]

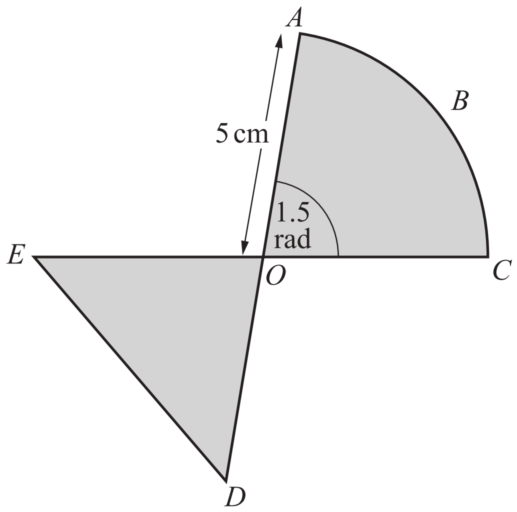
(b) Three singers are chosen at random from a group of 5 Chinese, 4 Indian and 2 British singers. Find the number of different ways in which this can be done if

(i) no Chinese singer is chosen, [1]

(ii) one singer of each nationality is chosen, [2]

(iii) the three singers chosen are all of the same nationality. [2]

6



In the diagram, *ABC* is an arc of the circle centre *O*, radius 5 cm, and angle *AOC* is 1.5 radians. *AD* and *CE* are diameters of the circle and *DE* is a straight line.

(i) Find the total perimeter of the shaded regions. [3]

(ii) Find the total area of the shaded regions. [3]

7 Vectors **i** and **j** are vectors parallel to the x-axis and y-axis respectively.

Given that $\mathbf{a} = 2\mathbf{i} + 3\mathbf{j}$, $\mathbf{b} = \mathbf{i} - 5\mathbf{j}$ and $\mathbf{c} = 3\mathbf{i} + 11\mathbf{j}$, find

(i) the exact value of $|\mathbf{a} + \mathbf{c}|$, [2]

(ii) the value of the constant m such that $\mathbf{a} + m\mathbf{b}$ is parallel to $\mathbf{j}$, [2]

(iii) the value of the constant n such that $n\mathbf{a} - \mathbf{b} = \mathbf{c}$. [2]

8 **(a)** $\mathbf{A} = \begin{pmatrix} 2 & -1 \\ 1 & -3 \end{pmatrix}$ and $\mathbf{B} = \begin{pmatrix} 0 & -2 \\ 3 & -5 \end{pmatrix}$. Find $(\mathbf{BA})^{-1}$. [4]

(b) The matrix **X** is such that **XC** = **D**, where $\mathbf{C} = \begin{pmatrix} -2 & 5 & 3 \\ 0 & 10 & 4 \end{pmatrix}$ and $\mathbf{D} = \begin{pmatrix} -4 & 5 & 4 \end{pmatrix}$.

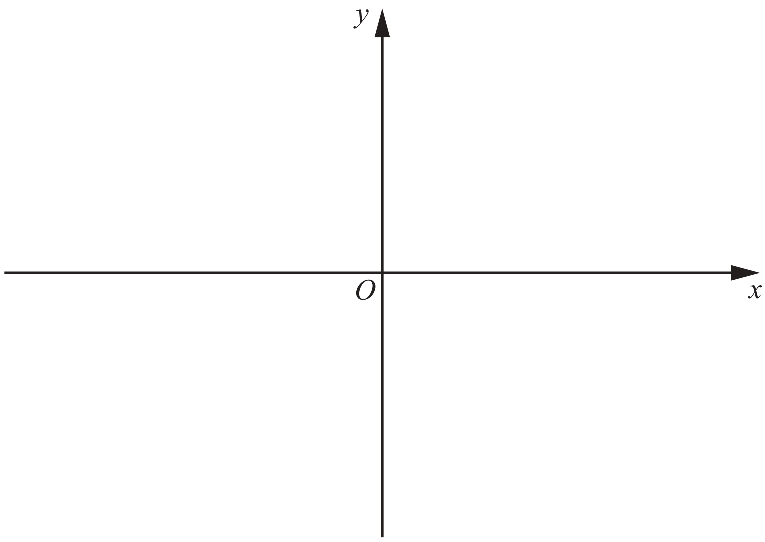
(i) State the order of the matrix **C**. [1]

(ii) Find the matrix **X**. [2]

9 **(i)** Differentiate $x^4(\sqrt{\sin x})$ with respect to x. [4]

(ii) Hence find $\int\left(x + \dfrac{x^4 \cos x}{\sqrt{\sin x}} + 8x^3(\sqrt{\sin x})\right)\mathrm{d}x$. [3]

10 **(a)** **(i)** On the axes below, sketch the graph of $y = |(x+3)(x-5)|$ showing the coordinates of the points where the curve meets the x-axis. [2]



(ii) Write down a suitable domain for the function $f(x) = |(x+3)(x-5)|$ such that f has an inverse. [1]

(b) The functions g and h are defined by

$$g(x) = 3x - 1 \qquad \text{for } x > 1,$$
$$h(x) = \frac{4}{x} \qquad \text{for } x \neq 0.$$

(i) Find $hg(x)$. [1]

(ii) Find $(hg)^{-1}(x)$. [2]

(c) Given that $p(a) = b$ and that the function p has an inverse, write down $p^{-1}(b)$. [1]

11 **(a)** Find $\int \sqrt[3]{2x-1}\,dx$. [2]

(b) **(i)** Find $\int \sin 4x\,dx$. [2]

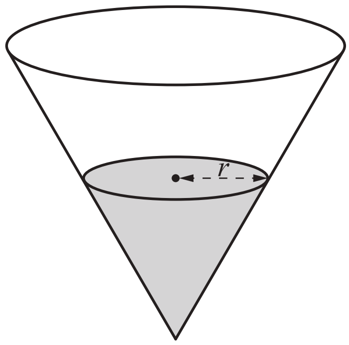
(ii) Hence evaluate $\int_{\frac{\pi}{8}}^{\frac{\pi}{4}} \sin 4x\,dx$. [2]

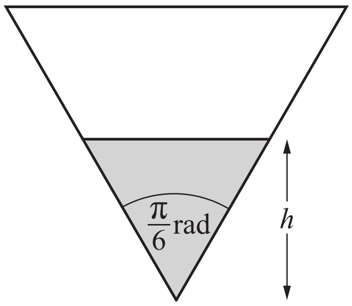
(c) Show that $\int_{0}^{\ln 8} e^{\frac{x}{3}}\,dx = 3$. [5]

12 In this question all lengths are in centimetres.

The volume of a cone of height h and base radius r is given by $V = \frac{1}{3}\pi r^2 h$.

It is known that $\sin\frac{\pi}{12} = \frac{\sqrt{6}-\sqrt{2}}{4}$, $\cos\frac{\pi}{12} = \frac{\sqrt{6}+\sqrt{2}}{4}$, $\tan\frac{\pi}{12} = 2-\sqrt{3}$.





A water cup is in the shape of a cone with its axis vertical. The diagrams show the cup and its cross-section. The vertical angle of the cone is $\frac{\pi}{6}$ radians. The depth of water in the cup is h. The surface of the water is a circle of radius r.

(i) Find an expression for r in terms of h and show that the volume of water in the cup is given by $V = \frac{\pi(7-4\sqrt{3})h^3}{3}$. [4]

(ii) Water is poured into the cup at a rate of $30\,\text{cm}^3\,\text{s}^{-1}$. Find, correct to 2 decimal places, the rate at which the depth of water is increasing when $h = 5$. [4]

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Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

5291701669

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **May/June 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

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Mathematical Formulae

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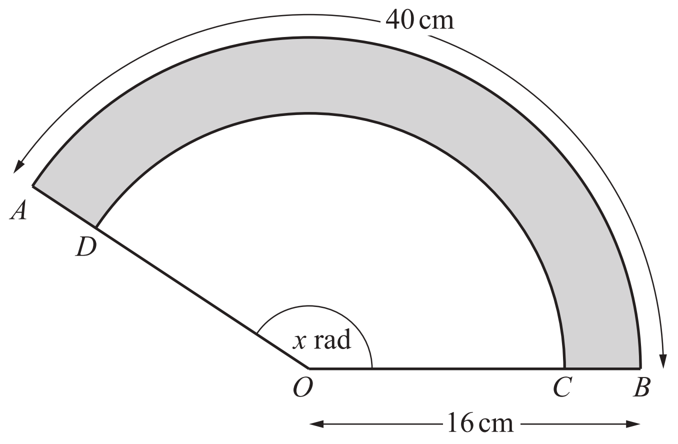

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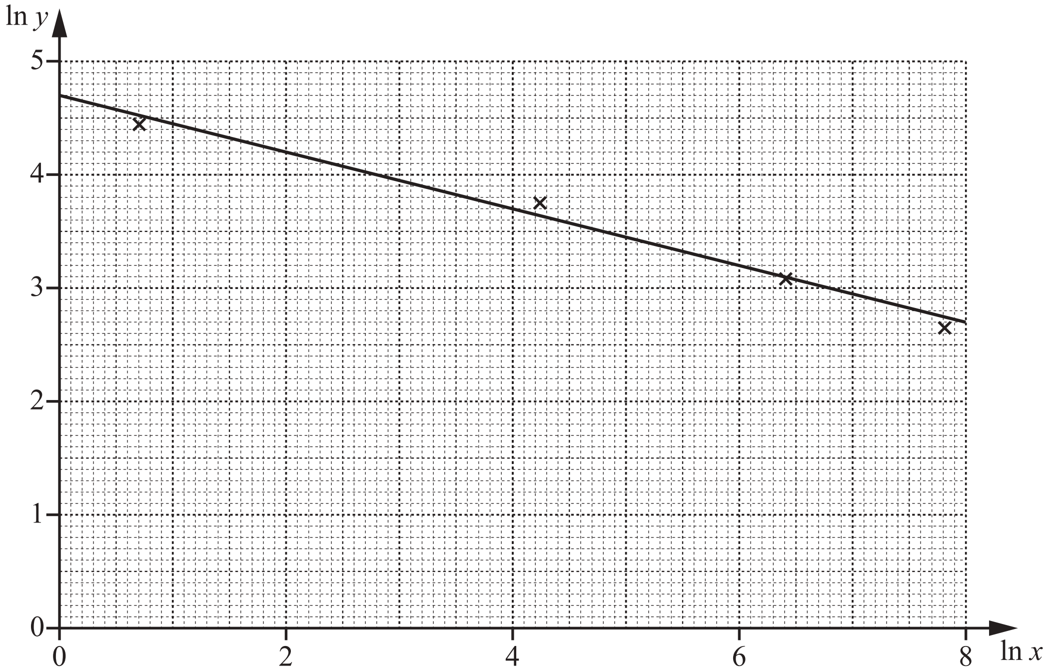

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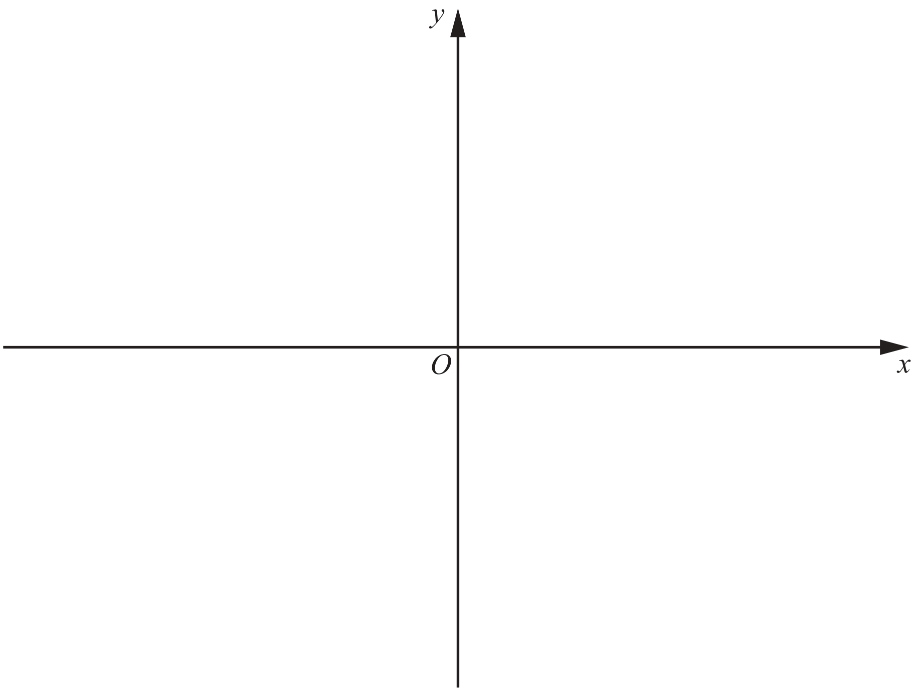
(iii) Find the value of x when $y = 50$. [2]

9 **(i)** Express $5x^2 - 14x - 3$ in the form $p(x+q)^2 + r$, where p, q and r are constants. [3]

(ii) Sketch the graph of $y = \left|5x^2 - 14x - 3\right|$ on the axes below. Show clearly any points where your graph meets the coordinate axes. [4]



(iii) State the set of values of k for which $\left|5x^2 - 14x - 3\right| = k$ has exactly four solutions. [2]

10 A particle moves in a straight line such that its displacement, s metres, from a fixed point O at time t seconds, is given by $s = 4 + \cos 3t$, where $t \geqslant 0$. The particle is initially at rest.

(i) Find the exact value of t when the particle is next at rest. [2]

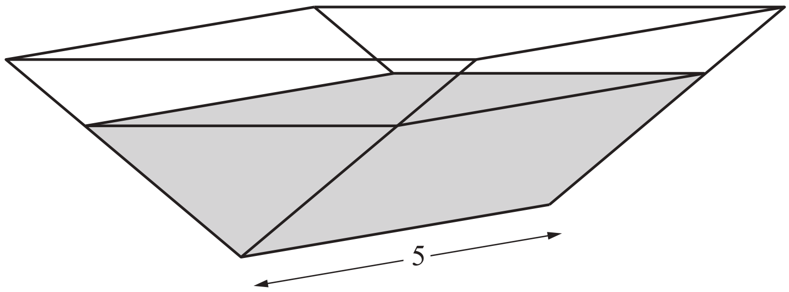
(ii) Find the distance travelled by the particle between $t = \frac{\pi}{4}$ and $t = \frac{\pi}{2}$ seconds. [3]

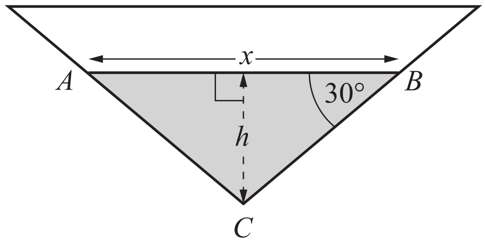
(iii) Find the greatest acceleration of the particle. [2]

11 **(a)** Solve $10\cos^2 x + 3\sin x = 9$ for $0° < x < 360°$. [5]

(b) Solve $3\tan 2y = 4\sin 2y$ for $0 < y < \pi$ radians. [5]

12 In this question all lengths are in metres.





A water container is in the shape of a triangular prism. The diagrams show the container and its cross-section. The cross-section of the water in the container is an isosceles triangle ABC, with angle ABC = angle $BAC = 30°$. The length of AB is x and the depth of water is h. The length of the container is 5.

(i) Show that $x = 2\sqrt{3}h$ and hence find the volume of water in the container in terms of h. [3]

(ii) The container is filled at a rate of $0.5\,\text{m}^3$ per minute. At the instant when h is $0.25\,\text{m}$, find

(a) the rate at which h is increasing, [4]

(b) the rate at which x is increasing. [2]

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