Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **October/November 2021**

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 October/November 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **8** printed pages.

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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.

Maths-Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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.

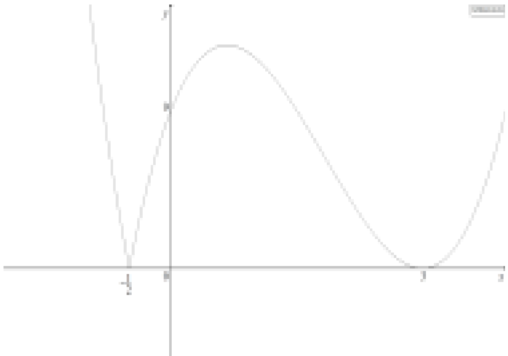
Abbreviations

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)	$1080°$	**B1**	
1(b)	$a = 4$	**B1**	
	$b = 3$	**B1**	
	$c = -2$	**B1**	
2(a)	$(0,\ 14)$	**2**	**B1** for x-coordinate **B1** for y-coordinate
2(b)	$y - 14 = -\frac{1}{2}x$	**2**	**M1** for finding the gradient of a perpendicular line and attempt at the straight line equation using *their B* **A1** Allow unsimplified
2(c)	Area = $\frac{1}{2} \times 14 \times 28$	**M1**	Must be a complete method making use of *their* answer to **(b)**
	196	**A1**	
3(a)	13 soi	**B1**	For finding the magnitude of $\begin{pmatrix} 12 \\ -5 \end{pmatrix}$
	$\begin{pmatrix} 36 \\ -15 \end{pmatrix}$	**B1**	
3(b)	$10 + 4\lambda = -4\mu$ or $-5 + 6\lambda = 5\mu$	**2**	**M1** for equating like vectors **Dep M1** for attempt to solve *their* simultaneous equations to obtain 2 solutions
	$\mu = -\frac{20}{11}$	**A1**	
	$\lambda = -\frac{15}{22}$	**A1**	
4(a)	$a = \frac{7}{2}$	**B1**	
	$b = 1$	**B1**	
	$c = \frac{1}{6}$	**B1**	

Question	Answer	Marks	Guidance
4(b)	$\left(3x^{\frac{2}{5}}-5\right)\left(x^{\frac{2}{5}}-1\right)=0$	2	**M1** for recognition of a quadratic in $x^{\frac{2}{5}}$ **Dep M1** for solution and a correct attempt to get at least one solution for *x*
	3.59	**A1**	
	1	**A1**	
5(a)	$0=8a+4b+12+4$	**B1**	For $\mathrm{p}(2)$
	$\mathrm{p}'(x)=3ax^2+2bx+6$	**M1**	For an attempt to obtain $\mathrm{p}'(x)$
	$3a-2b+6=-7$	**M1**	**Dep** for $\mathrm{p}'(-1)$
	$0=2a+b+4$ $-13=3a-2b$	**M1**	**Dep** on both previous **M** marks for solution of equations to obtain both *a* and *b*
	$a=-3 \quad b=2$	**A1**	
5(b)	$\mathrm{p}''(x)=-18x+4$	**M1**	For differentiation of *their* $\mathrm{p}'(x)$ to obtain $\mathrm{p}''(x)$
	4	**A1**	**FT** on twice *their b*.
6	$\frac{\mathrm{d}y}{\mathrm{d}x}=me^{3x}+2x^2\,(+c)$	**M1**	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=2e^{3x}+2x^2\,(+c)$	**A1**	
	$5=2+c$ $c=3$	**M1**	**Dep** on previous **M** mark
	$\mathrm{f}(x)=pe^{3x}+qx^3...$	**M1**	
	$y=\frac{2}{3}e^{3x}+\frac{2}{3}x^3...$	**A1**	
	$\frac{5}{3}=\frac{2}{3}+d$ $d=1$	**M1**	**Dep** on previous **M** mark
	$(\mathrm{f}(x)=)\ \frac{2}{3}e^{3x}+\frac{2}{3}x^3+3x+1$	**A1**	
7(a)	6	**B1**	

Question	Answer	Marks	Guidance
7(b)	$b = 192a$	**B1**	May be implied by the term in x
	$c = 240a^2$	**B1**	May be implied by the term in x^2
	$\frac{c}{240} = \frac{b^2}{192^2}$	**M1**	For elimination of a
	$5b^2 = 768c$	**A1**	For correct manipulation to verify the given answer
7(c)	$a = \frac{1}{16}$	**B1**	
	$c = \frac{15}{16}$	**B1**	
8(a)	$\sin\frac{AOC}{2} = \frac{3}{5}$ or $6^2 = 5^2 + 5^2 - (2\times5\times5)\cos AOC$	**M1**	For a complete method to find AOC
	$AOC = 1.2870$ $AOC = 1.287$	**A1**	**AG** Must see $AOC = 1.2870$ or better before rounding for **A1**
8(b)	Arc length = 1.287×5	**B1**	
	Perimeter = 32.4	**B1**	
8(c)	Sector area = $\frac{1}{2}\times5^2\times1.287$	**B1**	
	Area of triangle = $\frac{1}{2}\times5^2\times\sin1.287$	**B1**	
	Total area = 28.1	**B1**	
9(a)	$\frac{dy}{dx} = 2(2x+1)(x-3)+2(x-3)^2$ or $\frac{dy}{dx} = 6x^2 - 22x + 12$	**M1**	For differentiation of a quotient, or expansion and subsequent differentiation
	$0 = 2(x-3)(3x-2)$	**M1**	**Dep** for simplification, equating to zero and attempt to solve
	$(3, 0)$	**A1**	
	$\left(\frac{2}{3}, \frac{343}{27}\right)$	**A1**	

Question	Answer	Marks	Guidance
9(b)		4	**B1** for correct shape with maximum in the first quadrant **B1** for $\left(-\frac{1}{2},\ 0\right)$ and $(3,\ 0)$ with a $\lvert\text{cubic curve}\rvert$ with one max only **B1** for $(0,\ 9)$ with a $\lvert\text{cubic curve}\rvert$ with one max only **B1** All correct with a cusp at $x=-\frac{1}{2}$ and a minimum at $x=3$
9(c)	$\frac{343}{27}$	B1	**FT** on *their* answer from **(a)**
10(a)(i)	$2+(n-1)0.5=16$ oe	M1	For use of $a+(n-1)d$
	$n=29$	A1	
10(a)(ii)	$\frac{8}{2}(2(2)+7(0.5))$	M1	For use of sum formula, may be implied if distances have been multiplied by 5 first.
	$\frac{8}{2}(2(2)+7(0.5))\times 5$	M1	For multiplication by 5
	150 (km)	A1	
10(b)(i)	$r=1.25$ oe	B1	
10(b)(ii)	$2(1.25)^{n-1}>16$ or $2(1.25)^{n-1}=16$	M1	For use of ar^{n-1}
	$n-1>\frac{\ln 8}{\ln 1.25}$ or $n-1=\frac{\ln 8}{\ln 1.25}$	M1	**Dep** for correct method of solution to obtain $n-1$
	11	A1	
10(b)(iii)	$\frac{2(1.25^8-1)}{1.25-1}$	M1	For use of sum formula may be implied by multiplication by 5
	$\frac{2(1.25^8-1)}{1.25-1}\times 5$	M1	For multiplication by 5
	198 (km)	A1	Allow greater accuracy

Question	Answer	Marks	Guidance
11(a)	$3\cot^2\theta - 5\cot\theta - 2 = 0$	M1	For use of correct identity and simplification to a 3 term quadratic equated to zero.
	$\tan\theta = -3,\ \tan\theta = \frac{1}{2}$	M1	**Dep** for solution of quadratic and dealing with cot
	108.4°	A1	
	26.6°	A1	
11(b)	$\phi + \frac{\pi}{3} = -\frac{\pi}{6}$	M1	For a correct order of operations
	$\phi = -\frac{\pi}{2}$	A1	
	$\phi + \frac{\pi}{3} = \frac{7\pi}{6}$	M1	For a correct order of operations
	$\phi = \frac{5\pi}{6}$	A1	

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Question	Answer	Marks	Guidance
1(a)	$-3 < x < 1 \quad x > 5$	**B1**	
1(b)	$-\frac{1}{3}(x+3)(x-1)(x-5)$	3	**B1** for a negative cubic function **B1** for a cubic function multiplied by $\frac{1}{3}$ **B1** for $(x+3)(x-1)(x-5)$
2(a)	$a = \frac{10}{3}$ or $3\frac{1}{3}$	**B1**	
	$b = \frac{7}{3}$ or $2\frac{1}{3}$	**B1**	
	$c = \frac{9}{2}$ or $4\frac{1}{2}$ or 4.5	**B1**	
2(b)	$10(2^p)^2 - 17(2^p) + 3 = 0$ $(5(2^p) - 1)(2(2^p) - 3) = 0$ $2^p = \frac{1}{5},\ 2^p = \frac{3}{2}$	**M1**	For recognition of a quadratic in 2^p, attempt to factorise and solve for 2^p
	$p = \frac{\ln\frac{1}{5}}{\ln 2}$ or $p = \frac{\ln 1.5}{\ln 2}$ oe	**M1**	For correct attempt to deal with $2^p = k$
	−2.32	**A1**	
	0.585	**A1**	
3(a)	$\lg\frac{1000a^2}{b^4}$	4	**B1** for $3 = \lg 1000$
			B1 for use of power rule once
			B1 for use of addition or subtraction rule once
			B1 All correct

Question	Answer	Marks	Guidance
3(b)	**Either** $3\log_a 4 = \frac{3}{\log_4 a}$	B1	
	$2(\log_4 a)^2 - 7\log_4 a + 3 = 0$ $(2\log_4 a - 1)(\log_4 a - 3) = 0$ $\log_4 a = \frac{1}{2}$ or $\log_4 a = 3$	M1	For obtaining a quadratic equation and solution
	$a = 4^{\frac{1}{2}}$ or $a = 4^3$	M1	**Dep** For dealing with the logarithm correctly once, may be implied by a correct solution
	64	A1	
	2	A1	
	Or $2\log_4 a = \frac{2}{\log_a 4}$	(B1)	
	$3(\log_a 4)^2 - 7\log_a 4 + 2 = 0$ $(3\log_a 4 - 1)(\log_a 4 - 2) = 0$ $\log_a 4 = \frac{1}{3}$ or $\log_a 4 = 2$	(M1)	For obtaining a quadratic equation and solution
	$a^{\frac{1}{3}} = 4$ or $a^2 = 4$	(M1)	**Dep** For dealing with the logarithm correctly once, may be implied by a correct solution
	64	(A1)	
	2	(A1)	
4	$\tan\left(2x + \frac{\pi}{3}\right) = \frac{1}{\sqrt{3}}$	B1	
	$x = -\frac{7\pi}{12}, -\frac{\pi}{12}, \frac{5\pi}{12}, \frac{11\pi}{12}$	3	**M1** for using correct order of operations **A1** for two correct solutions **A1** for two further correct solutions and no other solutions in range

Question	Answer	Marks	Guidance
5	**Either** Maximum when $\sin\frac{x}{3}=1$ or minimum when $\sin\frac{x}{3}=-1$	**M1**	For recognition that value of maximum or minimum is necessary
	$c=9$	**A1**	
	$c=-1$	**A1**	
	or $\frac{dy}{dx}=\frac{5}{3}\cos\frac{x}{3}$ When $\frac{dy}{dx}=0$, $\sin\frac{x}{3}=+1$ or -1	**(M1)**	For differentiation, equating to zero to obtain values for $\sin\frac{x}{3}$
	$c=9$	**(A1)**	
	$c=-1$	**(A1)**	
6(a)	$0=-\frac{5}{4}+\frac{a}{4}+5+b$	**M1**	For use of the factor theorem
	$-24=-10+a+10+b$	**M1**	For use of the remainder theorem
	$a+4b=-15$ $a+b=-24$ leading to	**M1**	**Dep** on both previous **M** marks for solution of *their* equations without using a calculator
	$a=-27$, $b=3$	**A1**	
6(b)	$(2x+1)(5x^2 .... + \textit{their}\ b)$	**M1**	Allow for observation or algebraic long division. *Their a* and *b* must be integers.
	$(2x+1)(5x^2-16x+3)$	**A1**	
	$(2x+1)(5x-1)(x-3)$	**2**	**M1** for attempt to factorise *their* 3-term quadratic **A1** all correct from fully correct working
6(c)	3	**B1**	**FT** on *their* (integer) *b*
7(a)(i)	**b** – **a**	**B1**	
7(a)(ii)	**c** – **b**	**B1**	

Question	Answer	Marks	Guidance
7(a)(iii)	$n\overrightarrow{AB} = m\overrightarrow{BC}$	**M1**	For substitution of *their* **(i)** and **(ii)** into $n\overrightarrow{AB} = m\overrightarrow{BC}$
	$n\mathbf{a} + m\mathbf{c} = (m+n)\mathbf{b}$	**A1**	For correct manipulation to obtain the **given answer**
7(b)	$2\lambda - 4\mu + 4 = 4\lambda + 4$ or $\lambda + 7\mu - 7 = -2\lambda - 2$	**M1**	For equating like components at least once, allow unsimplified
		M1	**Dep** for solving *their* equations to obtain both λ and μ
	$\mu = 5$	**A1**	
	$\lambda = -10$	**A1**	
8(a)	**Either** Starting with a 6: 120 ways	**B1**	May be implied by final answer
	Starting with 5, 7 or 9: 540 ways	**B1**	May be implied by final answer
	Total 660	**B1**	
	Or Alternative 1 Ending with a 6: 180 ways	**(B1)**	May be implied by final answer
	Ending with 0 or 4: 480ways	**(B1)**	May be implied by final answer
	Total 660	**(B1)**	
	Or Alternative 2 11 ways of obtaining even 5-digit numbers which start with 5, 6, 7, 9	**(B1)**	For $11 \times k$ May be implied by final answer
	$^5P_3$ ways of arranging remaining 3 digits: 60	**(B1)**	For $m \times 60$ where m is from an attempt to list all cases for first and last digits May be implied by final answer
	$11 \times 60 = 660$	**(B1)**	
	Or Alternative 3 Total arrangements $^7P_5$ minus (all odds + evens starting with 1 + evens starting with 0 or 4) = 2520 – (1440 + 180 + 240)	**(B2)**	For 2520 – (1440 + 180 + 240)
	660	**(B1)**	

Question	Answer	Marks	Guidance
8(b)	$\dfrac{n!}{(n-4)!4!}=\dfrac{6n!}{(n-2)!2!}$	**B1**	
	$(n-2)(n-3)=72$	**2**	**B1** for $(n-2)(n-3)$
			B1 for 72
	$n=11$ only	**2**	**M1** for correct attempt to form and solve a quadratic equation **A1** for $n=11$ only
9(a)	$AOD=2\times\tan^{-1}\left(\dfrac{2}{3}\right)$	**M1**	For correct method to find *AOD*
	$AOD=1.1760...$ $AOD=1.176$ [to 3dp]	**A1**	Need to see 4 dp or more to justify 3 dp answer
9(b)	Major arc $MN=(2\pi-1.176)12$	**B1**	
	ND or *MA* $=12-\sqrt{13}$	**B1**	
	Perimeter = major arc *MN* + *MA* + *ND* + 16 oe	**B1**	For *their* values in a correct plan, may be implied by a correct answer
	Perimeter = 94.1	**B1**	
9(c)	Minor sector area = $\dfrac{1}{2}\times1.176\times12^2$ **or** Major sector area = $\dfrac{1}{2}\times(2\pi-1.176)\times12^2$	**B1**	
	Area = major sector area – remainder of rectangle or Area = area of circle – minor sector area – remainder of rectangle or Area = circle – rectangle – minor sector + triangle *AOD*	**B1**	For *their* values in a correct plan, may be implied by a correct answer
	Area = 350	**B1**	Allow greater accuracy
10(a)	At *A* $y=4$	**B1**	
	At *B* $y=\dfrac{13}{16}$ or 0.8125	**B1**	

Question	Answer	Marks	Guidance
10(b)	**Either** Area of trapezium = $\frac{231}{32}$	**B1**	Allow unsimplified
	$\int_{-1}^{2} \frac{1}{(x+2)^2} + \frac{3}{x+2}\,dx$ $= \left[-\frac{1}{x+2} + 3\ln(x+2)\right]_{-1}^{2}$	**2**	**B1** for $-\frac{1}{x+2}$ **B1** for $3\ln(x+2)$
	$\left[\left(-\frac{1}{4} + 3\ln 4\right) - (-1)\right]$	**M1**	For correct use of limits in *their* integral, but must have at least one of the two preceding **B** marks
	Area = $\frac{207}{32} - \ln 64$	**2**	**A1** for $\frac{207}{32}$ **A1** for $-\ln 64$
	Or $\int_{-1}^{2} -\frac{17}{16}x + \frac{47}{16} - \frac{1}{(x+2)^2} - \frac{3}{x+2}\,dx$ $\left[\left(-\frac{17}{32}x^2 + \frac{47}{16}x + \frac{1}{x+2} - 3\ln(x+2)\right)\right]_{-1}^{2}$	**(3)**	**B1** for $-\frac{17}{32}x^2 + \frac{47}{16}x$ **B1** for $\int \frac{1}{(x+2)^2}dx = -\frac{1}{(x+2)}$ **B1** for $\int \frac{3}{x+2}dx = 3\ln(x+2)$
	$\left(-\frac{17}{8} + \frac{47}{8} + \frac{1}{4} - 3\ln 4\right) - \left(-\frac{17}{32} - \frac{47}{16} + 1\right)$	**(M1)**	For correct use of limits in *their* integral, but must have at least one of the two preceding **B** marks
	Area = $\frac{207}{32} - \ln 64$	**(2)**	**A1** for $\frac{207}{32}$ **A1** for $-\ln 64$
11(a)(i)	0	**B1**	
11(a)(ii)	–3	**B1**	
11(a)(iii)	$\left(\frac{1}{2}(25+15)\times 30\right) + \left(\frac{1}{2}(30+60)\times 10\right) + \left(\frac{1}{2}\times 20\times 60\right)$	**M1**	For an unsimplified expression for the required area allowing at most one incorrect length
	Total distance = 1650	**A1**	
11(b)(i)	$v = 4\cos\frac{5\pi}{3} - 4$ $= -2$	**M1**	
	Speed = 2	**A1**	

Question	Answer	Marks	Guidance
11(b)(ii)	$a = -12\sin 3t$	**B1**	
	$\sin 3t = 0$ $3t = \pi$ Leading to	**M1**	For equating to zero and attempt to solve to obtain *t*, allow if in degrees
	$t = \frac{\pi}{3}$	**A1**	
11(b)(iii)	$s = k\sin 3t - 4t\left(+c\right)$	**M1**	
	$s = \frac{4}{3}\sin 3t - 4t$	**A1**	

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2021**

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.

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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:

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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).

GENERIC MARKING PRINCIPLE 3:

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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
- 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:

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Maths-Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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.

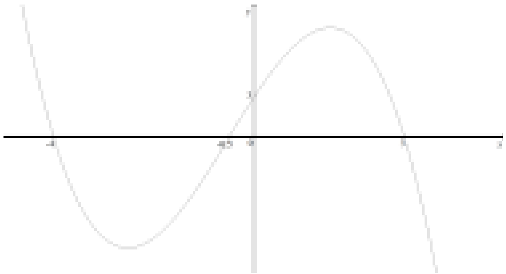
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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		3	**B1** for a cubic shape with a maximum in the first quadrant, a minimum in the third quadrant, extending into the second and 4th quadrants. The extensions must not curve incorrectly and not lead to a complete stationary point. **B1** for x-intercepts $-4, -\frac{1}{2}, 3$ either on diagram or stated but must be with a cubic graph. **B1** for y-intercept 3 either on diagram or stated but must be with a cubic graph.
2	$v = -4.91$ soi	B1	
	Speed = 4.91	B1	
3	$\tan\left(2x - \frac{\pi}{3}\right) = \pm\sqrt{3}$ soi or $\sin\left(2x - \frac{\pi}{3}\right) = \pm\frac{\sqrt{3}}{2}$ soi	B1	**B0** if negative root is rejected Allow truncated decimals May be implied by subsequent work From use of $\text{cosec}^2\left(2x - \frac{\pi}{3}\right) - 1 = \cot^2\left(2x - \frac{\pi}{3}\right)$
	$2x - \frac{\pi}{3} = -\frac{\pi}{3}, \frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}$ $2x = 0, \frac{2\pi}{3}, \pi, \frac{5\pi}{3}$ $x = 0, \frac{\pi}{3}, \frac{\pi}{2}, \frac{5\pi}{6}$ or 0, 1.05, 1.57, 2.62 or greater accuracy	4	**M1** for correct order of operations to obtain one solution in the range using $\tan\left(2x - \frac{\pi}{3}\right) = k$ or $\sin\left(2x - \frac{\pi}{3}\right) = m$, $\lvert m \rvert < 1$ **Dep M1** for correct order of operations to obtain a second solution in the range using $\left(2x - \frac{\pi}{3}\right) = \tan^{-1}(k) \pm \pi$ or $\left(2x - \frac{\pi}{3}\right) = \pi - \sin^{-1}(m)$, $\lvert m \rvert < 1$ oe $\left(2x - \frac{\pi}{3}\right) = -\sin^{-1}(m)$, $\lvert m \rvert < 1$ oe **A1** for any pair of correct solutions **A1** for remaining pair of solutions, with no extra solutions within the range
4(a)	$\frac{1}{256} - \frac{x^2}{24} + \frac{7x^4}{36}$	3	**B1** for $\frac{1}{256}$ **B1** for $-\frac{x^2}{24}$ **B1** for $\frac{7x^4}{36}$

Question	Answer	Marks	Guidance
4(b)	$4x^2+4+\frac{1}{x^2}$ soi	**B1**	
	Coefficient of x^2 $\left(their\,4\times their\,\frac{1}{256}\right)$ $+\left(their\,4\times their\,-\frac{1}{24}\right)$ $+\left(their\,\frac{7}{36}\right)$	**M1**	Allow one sign error, but must have 3 terms in x^2 only, with an attempt at addition.
	$\frac{25}{576}$	**A1**	
5(a)	$\frac{a(r^4-1)}{r-1}=17\frac{a(r^2-1)}{r-1}$	**M1**	Allow equivalents Allow if '*a*' terms missing (assume to have been cancelled)
	$(r^2-1)(r^2+1)=17(r^2-1)$ or better $r^4-17r^2+16=0$ oe $r^3+r^2-16r-16=0$ oe	**M1**	**Dep M1** for a correct simplified equation in *r* only
	$r=4$ only, from correct working	**A1**	
5(b)	$ar^5=64$	**M1**	For use of ar^5 with *their* positive *r*
	$a=0.0625$ or $\frac{1}{16}$	**A1**	Must be exact A0 if $r=4$ not from correct working in **(a)**
5(c)	Because $r>1$ oe	**B1**	**FT** on *their* $r>1$ Must have a value for *r*

Question	Answer	Marks	Guidance
6(a)	**Either** Starts with 8: 1680	**B1**	1680 must not be part of a product. May be implied by final answer
	Starts with 7 or 9: 2688	**B1**	May be implied by final answer
	Total: 4368	**B1**	
	Or Alternative 1 Starts with 7, 8 or 9 and ends in 1, 3 or 5: 3024	**(B1)**	Allow for 1008 three times May be implied by final answer
	Starts with 8 or 9 and ends in 7: 672 Starts with 7 or 8 and ends in 9: 672	**(B1)**	For both May be implied by final answer
	Total: 4368	**(B1)**	
	Or Alternative 2 13 ways of obtaining odd 5-digit numbers which start with 7, 8 or 9	**(B1)**	Needs to be part of a product. May be implied by final answer
	${}^8P_3$ ways of arranging the remaining 3 digits: 336	**(B1)**	Needs to be part of a product. May be implied by final answer
	Total = $13\times336=4368$	**(B1)**	
	Or Alternative 3 Last digit is 7 or 9: 1344	**B1**	May be implied by final answer
	Last digit is 1, 3 or 5: 3024	**B1**	May be implied by final answer
	Total: 4368	**B1**	
	Or Alternative 4 ${}^{10}P_5-({}^9P_4\times7)-({}^8P_3\times5)-({}^8P_3\times4)$ $-({}^8P_3\times5)$	**B2**	Must be complete
	Total: 4368	**B1**	
6(b)	$\frac{n!}{(n-3)!3!}=\frac{2n!}{(n-2)!2!}$ soi	**B1**	
	$(n-2)=6$ soi	**B2**	**Dep B1** on first **B** for $(n-2)$ soi **Dep B1** on first **B** for 6 soi
	$n=8$	**B1**	**Dep** on previous **B** marks

Question	Answer	Marks	Guidance
7(a)	$\sin AOQ = \frac{7}{10}$ $POA = \pi - AOQ$ or $14^2 = 10^2 + 10^2 - 200\cos AOB$ oe $POA = \frac{2\pi - AOB}{2}$	**M1**	Allow alternatives, but must be a complete method to find *POA*
	$POA = 2.366195157 = 2.366$ to 3 dp	**A1**	Must see an angle correct to more than 3dp used in order to justify 3 dp
7(b)	Area of sector = $\frac{1}{2}10^2(2.366)$ (118.3)	**B1**	Allow unsimplified. Also allow use of 2.37
	Area of triangle = $\frac{1}{2}10^2 \sin 2.366$ (35)	**B1**	Allow unsimplified. Also allow use of 2.37
	Total area = awrt 153	**B1**	Allow greater accuracy
7(c)	Major arc *PB* = 10×2.366	**B1**	Allow unsimplified. Also allow use of 2.37
	$\sin\frac{POA}{2} = \frac{AP/2}{10}$ or $AP^2 = 10^2 + 10^2 - 200\cos POA$	**M1**	For a valid attempt to find *AP* – may be seen in **(a)** or **(b)** but *AP* must be stated in this part.
	$AP = 18.5$	**A1**	Allow awrt 18.5
	Perimeter: major arc *PB* + 20 + *their AP*	**B1**	For plan, may be implied, but must have an attempt to calculate *AP*
	Total perimeter = 62.2	**A1**	Allow awrt 62.2
8(a)	$2x^2 + 2x - 2 = x^2 + 6x - 2$ $x^2 - 4x = 0$ $x(x-4) = 0$ $x = 0,\ x = 4$	**M1**	For obtaining an equation in one variable
		M1	**Dep** for a correct attempt to obtain at least one solution
	$(0, -1)$	**A1**	nfww
	$(4, 19)$	**A1**	nfww
	Mid-point $(2, 9)$ with sufficient detail	**B1**	**AG**

Question	Answer	Marks	Guidance
8(b)	**Either** Gradient of perpendicular $= -\frac{1}{5}$	**M1**	
	$y-9=-\frac{1}{5}(x-2)$	**M1**	**Dep** on previous **M** mark for perpendicular bisector using *their* mid-point and *their* perpendicular gradient
	$7-9=-\frac{1}{5}(12-2)$ oe	**A1**	For checking by substitution, must see evidence.
	Or Alternative 1 Gradient of perpendicular $= -\frac{1}{5}$	**(M1)**	
	$y-7=-\frac{1}{5}(x-12)$	**(M1)**	**Dep** on previous **M** mark for perpendicular bisector using $(12, 7)$ and *their* perpendicular gradient
	$9-7=-\frac{1}{5}(2-12)$ oe	**(A1)**	For checking by substitution, must see evidence
	Or Alternative 2 Gradient of perpendicular $= -\frac{1}{5}$	**(M1)**	
	Gradient of line joining *their* $(2, 9)$ to $(12, 7)$ $= = -\frac{1}{5}$	**(M1)**	
	$(2, 9)$ is a common point and gradients of perpendicular bisector and *l* are the same so *C* lies on *l*.	**(A1)**	
8(c)	$(22, 5)$	**2**	**B1** for 22 **B1** for 5
	$(-18, 13)$	**2**	**B1** for -18 **B1** for 13

Question	Answer	Marks	Guidance
9(a)	$e^{2y} = mx^2 + c$	B1	May be implied by later work
	Either $7.96 = 4m + c$ $3.76 = 2m + c$	M1	
	$m = 2.1$ oe	A1	
	$c = -0.44$ oe	A1	
	$y = \frac{1}{2}\ln\left(2.1x^2 - 0.44\right)$ oe	A1	Do not isw
	Or gradient = 2.1 oe	(B1)	
	Use of either $7.96 = 4m + c$ or $3.76 = 2m + c$	(M1)	For use with *their m*
	$c = -0.44$ oe	(A1)	
	$y = \frac{1}{2}\ln\left(2.1x^2 - 0.44\right)$ oe	(A1)	Must be bracketed correctly
9(b)	$y = \frac{1}{2}\ln\left(their\,2.1x^2 - their\,0.44\right)$ oe	M1	Must use the form $y = k\ln\left(px^2 \pm q\right)$ $p \neq 1$ and $q \neq 0$ or $e^{2y} = mx^2 + c$
	0.253	A1	
9(c)	$their\,2.1x^2 - their\,0.44 > 0$ or $= 0$ or ≥ 0 soi	B1	
	Correct attempt to obtain the critical value using $their\,2.1x^2 - 0.44 = 0$	M1	Must be from the form $y = k\ln\left(px^2 - q\right)$, $p \neq 1$ and $q > 0$
	$x > 0.458$ or $x > \sqrt{\frac{22}{105}}$ oe	A1	

Question	Answer	Marks	Guidance
10(a)	$\frac{\mathrm{d}y}{\mathrm{d}x} = (2x+3)^{\frac{1}{2}} + 5x(+c)$	**B1**	For $(2x+3)^{\frac{1}{2}}$, allow unsimplified
		M1	For $k(2x+3)^{\frac{1}{2}} + 5x$
	$10 = 3 + 15 + c$	**M1**	**Dep** for use of 10 and $x=3$ in *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ to obtain c
	$\frac{\mathrm{d}y}{\mathrm{d}x} = (2x+3)^{\frac{1}{2}} + 5x - 8$ soi	**A1**	
	When $x = 11$, $\frac{\mathrm{d}y}{\mathrm{d}x} = 5 + 55 - 8$ oe = 52	**A1**	**AG** – need to see sufficient detail
10(b)	$\mathrm{f}(x) = \frac{1}{3}(2x+3)^{\frac{3}{2}} + \frac{5x^2}{2}(-8x+d)$	**B1**	For $\frac{1}{3}(2x+3)^{\frac{3}{2}}$, must be $\int (2x+3)^{\frac{1}{2}}\,\mathrm{d}x$
		M1	For $k(2x+3)^{\frac{3}{2}} + \frac{5x^2}{2}$
	$\frac{19}{2} = \frac{27}{3} + \frac{45}{2} - 24 + d$ $d = 2$	**M1**	For use of $y = \frac{19}{2}$ and $x = 3$ in *their* y
	$(\mathrm{f}(x) =)\ \frac{1}{3}(2x+3)^{\frac{3}{2}} + \frac{5x^2}{2} - 8x + 2$	**A1**	Allow -8 if obtained from using $\frac{\mathrm{d}y}{\mathrm{d}x} = 52$ in **(a)** rather than $\frac{\mathrm{d}y}{\mathrm{d}x} = 10$
11(a)	$\frac{\mathrm{d}y}{\mathrm{d}x} =$ $\frac{(x+1)\left(\frac{1}{3}\times 2x \times (x^2-5)^{-\frac{2}{3}}\right) - (x^2-5)^{\frac{1}{3}}}{(x+1)^2}$ or $(x+1)^{-1}\left(\frac{1}{3}\times 2x\times(x^2-5)^{-\frac{2}{3}}\right)$ $+(x^2-5)^{\frac{1}{3}}\left(-(x+1)^{-2}\right)$	**3**	**B1** for $\frac{1}{3}\times 2x\times(x^2-5)^{-\frac{2}{3}}$ **M1** for an attempt at a quotient or a correct product **A1** for all other terms correct
	$\frac{-x^2+2x+15}{3(x+1)^2(x^2-5)^{\frac{2}{3}}}$	**3**	**Dep on first 3 marks** **A1** for $-x^2$ in a quadratic numerator **A1** for $2x$ in a quadratic numerator **A1** for 15 in a quadratic numerator

Question	Answer	Marks	Guidance
11(b)	$-x^2+2x+15=0$	**M1**	For attempt to solve *their* $-x^2+2x+15=0$ to obtain $x=$ .. Must be a quadratic equation.
	$x=5$ only	**A1**	
11(c)	**Either** Find the gradient either side of the stationary point	**B1**	
	If gradient changes from +ve to -ve: max If gradient changes from -ve to +ve: min	**B1**	**Dep** on previous **B1**
	Or Alternative 1 Take the second derivative and substitute in the value of x obtained in **(b)**	**(B1)**	Allow alternative valid methods Allow a general method as this is not dependent on **(a)** or **(b)**
	If second derivative is + ve, then a min If second derivative is – ve, then a max	**(B1)**	**Dep** on previous **B1**
	Or Alternative 2 Consider a y-value to one side of the stationary point	**(B1)**	Allow alternative valid methods Allow a general method as this is not dependent on **(a)** or **(b)**
	If y value of stationary point is greater, then a max. If y value of stationary point is less, then a min.	**(B1)**	**Dep** on previous **B1**

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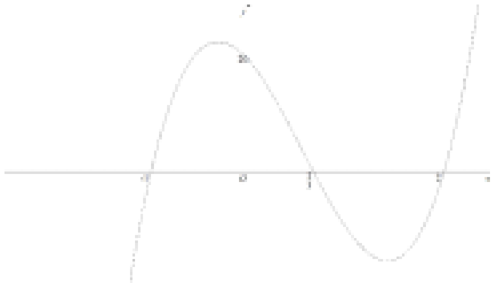
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1(a)		3	**B1** for a well-drawn cubic graph in the correct orientation with both arms extending beyond x-axis **B1** for $x=-1,\ x=2$ and $x=\frac{2}{3}$ either on the graph or stated with a cubic graph **B1** for $y=20$ either on the graph or stated with a cubic graph
1(b)	$-1<x<\frac{2}{3}$	**B1**	Must be found from a cubic graph
	$x>2$	**B1**	
2	$\left[\ln(x-1)+\frac{1}{x-1}\right]_3^5$	2	**B1** for $\ln(x-1)$ **B1** for $+\frac{1}{x-1}$
	$\left(\ln 4+\frac{1}{4}\right)-\left(\ln 2+\frac{1}{2}\right)$	**M1**	**Dep** on at least one B mark, for correct use of limits
	$\ln 2-\frac{1}{4}$	2	**A1** for $\ln 2$ **A1** for $-\frac{1}{4}$ oe
3(a)	$\text{p}(2):\ 8a-36+2b-6=0$	**B1**	
	$\text{p}(3):\ 27a-81+3b-6=66$	**B1**	
		M1	**Dep** on at least one of the previous B marks, for attempt to solve *their* equations and obtain a solution for both a and b
	$a=6,\ \ b=-3$	**A1**	For both
3(b)	$(x-2)(6x^2+3x+3)$	2	**M1** for attempt at quadratic factor either by observation to obtain $6x^2+px+3$ or by algebraic long division to obtain at least $6x^2+3x...$ **A1** all correct

Question	Answer	Marks	Guidance
3(c)	Discriminant of $\text{q}(x) = 3^2 - 4\times6\times3$ $= -63$ which is < 0	**M1**	For calculation of discriminant and confirmation that it is < 0
	$\text{q}(x)=0$ has no real solutions hence $\text{p}(x)=0$ has only one real solution	**A1**	For a correct conclusion from correct work.
4	$(a+x)^3 = a^3 + 3a^2x + 3ax^2\left[+x^3\right]$	**B1**	
	$\left(1-\frac{x}{3}\right)^5 = 1 - \frac{5}{3}x + \frac{10}{9}x^2...$	**2**	**M1** allow one sign error or one arithmetic slip
	$a^3 = 27, \quad a = 3$	**B1**	
	Term in x: $3a^2 - \frac{5}{3}a^3 = b$	**M1**	For multiplying *their* terms, must have sum of 2 relevant products = b
	$b = -18$	**A1**	
	Term in x^2 : $3a - \frac{5}{3}(3a^2) + \frac{10}{9}a^3 = c$	**M1**	For multiplying *their* terms, must have sum of 3 relevant products = c
	$c = -6$	**A1**	
5(a)	$\text{f} \geqslant -4$	**2**	**M1**for a valid method to find the least value of $x^2 + 4x$ **A1** for $\text{f} \geqslant -4$, $y \geqslant -4$ or $\text{f}(x) \geqslant -4$
5(b)	$\text{g} > 1$	**B1**	Allow $y > 1$ or $\text{g}(x) > 1$
5(c)	$\left(1+\text{e}^{2x}\right)^2 + 4\left(1+\text{e}^{2x}\right)[=21]$	**M1**	
	$\text{e}^{4x} + 6\text{e}^{2x} - 16 = 0$ $\left(\text{e}^{2x}+8\right)\left(\text{e}^{2x}-2\right)=0$	**M1**	**Dep** for quadratic in terms of e^{2x} and attempt to solve to obtain $\text{e}^{2x} = k$
	$\text{e}^{2x} = 2$ $x = \frac{1}{2}\ln k$	**M1**	**Dep** on both previous M marks, for attempt to solve $\text{e}^{2x} = k$
	$x = \ln\sqrt{2}$ or $\ln 2^{\frac{1}{2}}$	**A1**	
6(a)(i)	720	**B1**	
6(a)(ii)	480	**B1**	

Question	Answer	Marks	Guidance
6(a)(iii)	[Starts with 6 or 8]: 192	**B1**	
	[Starts with 9]: 72	**B1**	
	Total = 264	**B1**	
	Alternative [Ends with 9]:48	**(B1)**	
	[Ends with 1,3 or 5]:216	**(B1)**	
	Total = 264	**(B1)**	
6(b)	$\frac{45n!}{(n-4)!4!} = \frac{(n+1)(n+1)!}{((n+1)-5)!5!}$	**B1**	
	$45 = \frac{(n+1)^2}{5}$ leading to $15 = n+1$ or $n^2 + 2n - 224 = 0$	**M2**	**M1** for 15 **M1** for $n + 1$ OR **M1** for $n^2 + 2n - 224 = 0$ oe **M1** for $(n-14)(n+16) = 0$
	$n = 14$ only	**A1**	
7(a)(i)	110 (m)	**B1**	
7(a)(ii)		**B2**	**B1** for a line joining $(0,5)$ and $(10,5)$ **B1** for a line joining $(10,-2)$ and $(40,-2)$
7(b)(i)	$v = (2t+4)^{\frac{1}{2}} (+c)$	**M1**	For $k(2t+4)^{\frac{1}{2}}$
	$9 = 4 + c$	**M1**	**Dep** for attempt to find c using $v = 9$ and $t = 6$ in *their* v
	$(2t+4)^{\frac{1}{2}} + 5$	**A1**	

Question	Answer	Marks	Guidance
7(b)(ii)	$s=\frac{1}{3}(2t+4)^{\frac{3}{2}} \quad (+5t+d)$	M1	For $k(2t+4)^{\frac{3}{2}}$
	$\frac{1}{3}=\frac{64}{3}+30+d$	M1	**Dep** for attempt to find d using $s=\frac{1}{3}$ and $t=6$ in *their s*
	$\frac{1}{3}(2t+4)^{\frac{3}{2}}+5t-51$	A1	
8(a)	$x=\frac{\sqrt{3}+1}{2-\sqrt{3}}\times\frac{2+\sqrt{3}}{2+\sqrt{3}}$ leading to $x=\frac{5+3\sqrt{3}}{1}$	M1	For attempt to rationalise and simplify showing all working
	$x=5+3\sqrt{3}$	A1	
	Either: Using $x=5+3\sqrt{3}$ $y=(2-\sqrt{3})(52+30\sqrt{3})+5+3\sqrt{3}-1$ $=14+8\sqrt{3}+4+3\sqrt{3}$ Or: Using $x=\frac{\sqrt{3}+1}{2-\sqrt{3}}$ $y=(2-\sqrt{3})\frac{(\sqrt{3}+1)^2}{(2-\sqrt{3})^2}+\frac{\sqrt{3}+1}{2-\sqrt{3}}-1$ $=\frac{4+2\sqrt{3}+\sqrt{3}+1-2+\sqrt{3}}{2-\sqrt{3}}$ $=\frac{(4\sqrt{3}+3)}{2-\sqrt{3}}\times\frac{(2+\sqrt{3})}{(2+\sqrt{3})}$ $=\frac{8\sqrt{3}+6+12+3\sqrt{3}}{1}$	M1	For complete method, showing all steps. Allow one slip in arithmetic
	$11\sqrt{3}+18$	2	**A1** for 18 **A1** for $11\sqrt{3}$

Question	Answer	Marks	Guidance
8(b)	$\frac{dy}{dx}=2x\left(2-\sqrt{3}\right)+1$	M1	For attempt at differentiation to obtain form of $\frac{dy}{dx}=kx+1$
	$0=2x\left(2-\sqrt{3}\right)+1$ $x=-\frac{1}{2\left(2-\sqrt{3}\right)}\times\frac{\left(2+\sqrt{3}\right)}{\left(2+\sqrt{3}\right)}$ leading to $x=-\frac{1}{2}\frac{\left(2+\sqrt{3}\right)}{1}$	M1	**Dep** on previous M for equating to zero, rationalisation and attempt to simplify
	$x=-1-\frac{\sqrt{3}}{2}$	A1	
9(a)(i)	$(3y+2)(2x+1)$	B1	
9(a)(ii)	$(3\cos\theta+2)(2\sin\theta+1)=0$ $\cos\theta=-\frac{2}{3}$, $\sin\theta=-\frac{1}{2}$	M1	For relating to part (i) and a correct attempt to obtain $\cos\theta=...$ or $\sin\theta=...$
	$\theta=131.8^\circ,\ 228.2^\circ$ $\theta=210^\circ,\ 330^\circ$	3	**M1** for solving one of the equations to obtain one correct solution **A1** for any two correct solutions **A1** for a further two correct solutions with no extra solutions within the range
9(b)	$\cos\left(2\phi+\frac{\pi}{4}\right)=\frac{\sqrt{3}}{2}$ oe	B1	
	$\phi=-\frac{5\pi}{24},-\frac{\pi}{24},\frac{19\pi}{24},\frac{23\pi}{24}$	4	**M1** for solving to obtain one correct positive solution **M1** for solving to obtain one correct negative solution **A1** for any two correct solutions **A1** for a further two correct solutions with no extra solutions within the range
10(a)	$\sin\frac{AOB}{2}=\frac{7.5}{10}$	M1	For a valid method
	$AOB=1.696$ = 1.70 to 2 dp	A1	Must see greater accuracy to justify given answer

Question	Answer	Marks	Guidance
10(b)	$AC^2 = 10^2 + 25^2 - \left(2 \times 10 \times 25 \cos\left(\frac{AOB}{2}\right)\right)$	**M1**	For a complete and valid method to find AC
	$AC =$ awrt 19.9	**A1**	
	Major arc AB = awrt 45.9 or awrt 45.8	**B1**	
	Perimeter = awrt 85.5 or awrt 85.6	**A1**	
10(c)	Area of major sector AOB = $\frac{1}{2} \times 10^2 (2\pi - AOB)$	**M1**	
	awrt 229	**A1**	
	Area of kite $OACB$ = $\frac{1}{2} \times 15 \times 25$	**B1**	Allow working with 2 separate triangles
	Area of *their* major sector plus area of *their* kite	**M1**	
	Total area = awrt 417	**A1**	

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2021**

MARK SCHEME

Maximum Mark: 80

Published

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2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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.

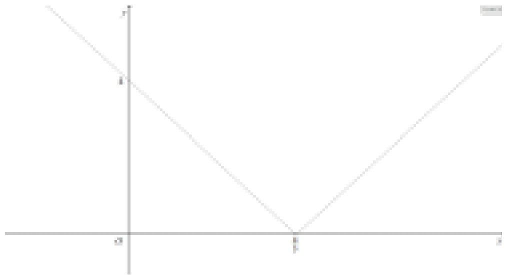
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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	$p^0q^{-5}r^{-\frac{2}{3}}$	**3**	**B1** for $a=0$ **B1** for $b=-5$ **B1** for $c=-\frac{2}{3}$
2(a)		**2**	**B1** for symmetrical V shape in the correct quadrant, touching the *x*-axis. Must have straight lines. **B1** for $x=\frac{4}{3}$ and $y=4$ only, either seen or stated on a modulus graph.
2(b)	$x\leqslant -1,\ x\geqslant\frac{11}{3}$ or 3.67 or better	**3**	**B1** for –1 from a correct method. **B1** for $\frac{11}{3}$ or 3.67 or better, from a correct method.
3(a)	$\overrightarrow{AC}=\mathbf{c}-\mathbf{a}$	**B1**	May be implied
	$\overrightarrow{OP}=\mathbf{a}+\frac{3}{5}\overrightarrow{AC}$ or $\mathbf{c}-\frac{2}{5}\overrightarrow{AC}$	**M1**	Maybe implied, for correct use of ratio $\overrightarrow{OP}=\mathbf{a}+\frac{3}{5}\left(their\,\overrightarrow{AC}\right)$ or $\mathbf{c}-\frac{2}{5}\left(their\,\overrightarrow{AC}\right)$
	$\overrightarrow{OP}=\frac{2}{5}\mathbf{a}+\frac{3}{5}\mathbf{c}$	**A1**	Allow unsimplified
3(b)	$\overrightarrow{OP}=\frac{2}{5}\mathbf{b}$ oe	**B1**	
	$\frac{2}{5}\mathbf{b}=\frac{2}{5}\mathbf{a}+\frac{3}{5}\mathbf{c}$ $2\mathbf{b}=2\mathbf{a}+3\mathbf{c}$	**B1**	**Dep** on previous B mark for equating vectors and rearrangement to obtain **AG**
	Alternative $\mathbf{b}=\frac{2}{5}\mathbf{a}+\frac{3}{5}\mathbf{c}+\frac{3}{5}\mathbf{b}$	**(B1)**	Need a clear indication of the method used, in the form of a correct unsimplified statement.
	$2\mathbf{b}=2\mathbf{a}+3\mathbf{c}$	**(B1)**	**Dep** for simplification to obtain AG

Question	Answer	Marks	Guidance
4	$\left(\frac{dy}{dx}=\right)\ \frac{1}{2}(3x+2)^{\frac{2}{3}}\quad(+c)$	**M1**	For $k_1(3x+2)^{\frac{2}{3}}$ where k_1 a constant.
	$4=2+c$	**M1**	**Dep** for use of 4 and $x=2$ in *their* $\frac{dy}{dx}$ to obtain c
	$\left(\frac{dy}{dx}=\right)\ \frac{1}{2}(3x+2)^{\frac{2}{3}}+2$	**A1**	May be implied by subsequent integration or by $c=2$
	$y=\frac{1}{10}(3x+2)^{\frac{5}{3}}\quad(+2x+d)$	**M1**	For $k_2(3x+2)^{\frac{5}{3}}$ where k_2 is a constant.
	$6.2=\frac{1}{10}(32)+4+d$	**M1**	**Dep** on previous M1 for use of $x=2$ and $y=6.2$ in *their y*
	$y=\frac{1}{10}(3x+2)^{\frac{5}{3}}+2x-1$	**A1**	Must be an equation
5(a)	$p=16$	**2**	**B1** for $\log_a\frac{5p}{4}=\log_a 20$ oe **B1** for 16, nfww
5(b)	$(3(3^x)-1)(3^x+3)=0$	**M1**	For recognition of a correct quadratic in 3^x and attempt to factorise or use quadratic formula
	$3^x=\frac{1}{3}$ $x=-1$	**2**	**M1 dep** for a correct attempt to solve $3^x=k,\ k>0$ **A1** for one solution only, must be from a correct solution.

Question	Answer	Marks	Guidance
5(c)	$\log_y 2 = \frac{1}{\log_2 y}$ or $\log_2 y = \frac{1}{\log_y 2}$ or $\log_y 2 = \frac{\log_a 2}{\log_a y}$ **and** $\log_2 y = \frac{\log_a y}{\log_a 2}$	B1	May be implied
	$4(\log_y 2)^2 - 4(\log_y 2) + 1 = 0$ $(2\log_y 2 - 1)^2 = 0$, $\log_y 2 = \frac{1}{2}$ or $(\log_2 y)^2 - 4(\log_2 y) + 4 = 0$ $(\log_2 y - 2)^2 = 0$, $\log_2 y = 2$ or $(\log_a y)^2 - 4(\log_a 2)(\log_a 4)\log_a y$ $+4(\log_a 2)^2 = 0$ $(\log_a y - 2\log_a 2)^2 = 0$ $\log_a y = 2\log_a 2$	M1	For obtaining a 3 term quadratic equation in either $\log_y 2$ or $\log_2 y$ and solving to obtain $\log_y 2 = k$ or $\log_2 y = k$, may be implied or equivalent using an alternative base.
	$y = 4$	A1	nfww
6(a)	$\frac{dy}{dx} = 2(3+\sqrt{5})x - 8\sqrt{5}$ or $x = \frac{8\sqrt{5}}{2(3+\sqrt{5})}$	M1	Either For differentiation must have one correct term. or for use of '$b^2 - 4ac = 0$', so $x = -\frac{b}{2a}$ at the stationary point.
	$x = \frac{4\sqrt{5}}{3+\sqrt{5}} \times \frac{(3-\sqrt{5})}{(3-\sqrt{5})}$ oe leading to $\frac{12\sqrt{5} - 20}{4}$ oe, this is the minimum acceptable working for this method.	M1	**Dep** for equating *their* $\frac{dy}{dx}$ to zero with attempt to solve and rationalisation using a two term factor, or rationalisation of $x = -\frac{b}{2a}$, using a two term factor with sufficient detail to imply no use of a calculator. Allow multiple equivalents. Allow one numerical slip or sign error.
	$x = -5 + 3\sqrt{5}$	2	**A1** for -5 **A1** for $3\sqrt{5}$

Question	Answer	Marks	Guidance
6(b)	$y=(3+\sqrt{5})(3\sqrt{5}-5)^2$ $-8\sqrt{5}(3\sqrt{5}-5)+60$ $=(3+\sqrt{5})(45+25-30\sqrt{5})$ $-120+40\sqrt{5}+60$ $=210+70\sqrt{5}-90\sqrt{5}-150$ $-120+40\sqrt{5}+60$	M1	For substitution of *their x* and simplification with sufficient detail to imply no use of a calculator. Allow one numerical slip or sign error in the expansion of $(3+\sqrt{5})(3\sqrt{5}-5)^2$ or one sign error in the other terms.
	$=20\sqrt{5}$	2	**A1** for all non surd terms = 0 **A1** for $20\sqrt{5}$
7(a)(i)	20160	B1	
7(a)(ii)	7200	2	**B1** for ${}^6P_4$ or $6\times5\times4\times3(=360)$ for 'inner' characters or ${}^5P_2$ or $4\times5(=20)$ for 'outer' characters Must be part of a product
7(a)(iii)	360	2	**B1** for ${}^3P_3$ or 3! or 6 for arrangements of symbols or ${}^5P_3$ or $5\times4\times3$ (= 60) for the digits Must be part of a product
7(b)	$\dfrac{n!}{(n-5)!5!}=\dfrac{6(n-1)!}{((n-1)-4)!4!}$	B1	May be implied by simplification e.g. $\dfrac{n!}{5!}=6\dfrac{(n-1)!}{4!}$ or $\dfrac{n(n-1)(n-2)(n-3)(n-4)}{5!}$ $=\dfrac{6(n-1)(n-2)(n-3)(n-4)}{4!}$
	Simplification of either the numerical factorials or the algebraic factorials	M1	
	$n=30$	A1	

Question	Answer	Marks	Guidance
8(a)	$\lg y = b\lg x + \lg A$	B1	May be implied by subsequent work
	$4.37 = 5.36b + \lg A$ $0.57 = 0.61b + \lg A$	M1	For at least one correct equation
	$b = 0.8$	A1	
	$\lg A = k \quad (0.082)$ $A = 10^k$	M1	**Dep** for substitution to obtain $\lg A = k$ and hence A
	$A = 1.21$	A1	
	Alternative 1 $\lg y = b\lg x + \lg A$	(B1)	May be implied by subsequent work
	Gradient = $\frac{4.37 - 0.57}{5.36 - 0.61}$	(M1)	
	$b = 0.8$	(A1)	
	$\lg A = k \quad (0.082)$ $A = 10^k$	(M1)	**Dep** for substitution into a correct equation to obtain $\lg A = k$ and hence A
	$A = 1.21$	(A1)	
	Alternative 2 $10^{4.37} = A \times 10^{5.36b}$ or $10^{0.57} = A \times 10^{0.61b}$	(B1)	
	$3.8 = 4.75b$	(M1)	For eliminating A correctly Must have B1.
	$b = 0.8$	(A1)	
	$A = 10^{4.37 - (5.36 \times (their b))}$ oe	(M1)	For a correct attempt to find A. Must have B1
	$A = 1.21$	(A1)	
8(b)	$y = 1.21(3)^{0.8}$ or $\lg y = 0.8\lg 3 + 0.082$	B1	**FT** for substitution into *their* equation
	$y =$ awrt 2.9	B1	
8(c)	$3 = 1.21x^{0.8}$ or $\lg 3 = 0.8\lg x + 0.082$	B1	**FT** for substitution into *their* equation
	$x =$ awrt 3.1	B1	

Question	Answer	Marks	Guidance
9(a)	$d = 12$	**B1**	
	$\frac{n}{2}\left(-8+(n-1)12\right) > 2000$ $3n^2 - 5n - 1000 > 0$	**M1**	For use of sum formula to obtain a three term quadratic inequality or equation
	$n = \frac{5 \pm \sqrt{25+12000}}{6}$ $n = 19.1$	**M1**	**Dep** for attempt at critical value(s) using *their* quadratic, may be using a calculator, so may be implied by a correct answer of 20.
	$n = 20$	**A1**	
9(b)(i)	$r = 3$	**2**	**M1** For $ar^6 = 27$ and $ar^8 = 243$ with an attempt to eliminate a to obtain r^2. Allow other valid methods.
9(b)(ii)	3^{26}	**2**	**B1** for $a = \frac{1}{27}$ or 3^{-3} nfww
9(c)	Common ratio or $r = \sin\theta$	**B1**	May be implied by e.g. $\frac{1}{1-\sin\theta}$ or $\frac{1-\sin^n\theta}{1-\sin\theta}$
	$-1 < \sin\theta < 1$ or $\lvert\sin\theta\rvert < 1$ or $-1 < r < 1$ or $\lvert r\rvert < 1$ with no incorrect statements seen.	**B1**	**Dep** on previous B1
10(a)	$\frac{1}{\sin\alpha} + \frac{1}{\cos\alpha} \quad (=0)$	**B1**	For dealing correctly with $\operatorname{cosec}^2\alpha$ and $\sec^2\alpha$ to obtain an expression in $\sin\alpha$ and $\cos\alpha$ only
	$\tan\alpha = -1$ or $\sin\alpha = -\cos\alpha$	**B1**	For an equation in $\tan\alpha$, may be implied by a correct solution.
	$\alpha = -\frac{\pi}{4}$ or -0.785 $\alpha = \frac{3\pi}{4}$ or 2.36	**2**	**B1** for one correct solution **B1** for a second correct solution and no extra solutions in the range.

Question	Answer	Marks	Guidance
10(b)(i)	$\dfrac{\cos^2\theta+1-2\sin\theta+\sin^2\theta}{\cos\theta(1-\sin\theta)}$	**M1**	For dealing with the fractions correctly and expansion of $(1-\sin\theta)^2$
	$\dfrac{1+1-2\sin\theta}{\cos\theta(1-\sin\theta)}$ or better	**M1**	**Dep** for use of identity, may be implied by $\dfrac{2(1-\sin\theta)}{\cos\theta(1-\sin\theta)}$
	$\dfrac{2(1-\sin\theta)}{\cos\theta(1-\sin\theta)}$	**M1**	**Dep** on previous M mark for simplification
	$\dfrac{2}{\cos\theta}=2\sec\theta$	**A1**	Need to see this detail for A1 Need to have had θ in every trigonometric ratio.
	Alternative 1 $\left(\dfrac{\cos\theta}{1-\sin\theta}\times\dfrac{1+\sin\theta}{1+\sin\theta}\right)+\dfrac{1-\sin\theta}{\cos\theta}$	**(M1)**	
	$\dfrac{\cos\theta(1+\sin\theta)}{\cos^2\theta}+\dfrac{1-\sin\theta}{\cos\theta}$	**(M1)**	**Dep** for use of identity
	$\dfrac{1+\sin\theta}{\cos\theta}+\dfrac{1-\sin\theta}{\cos\theta}$	**(M1)**	**Dep** on previous M mark for simplification
	$\dfrac{2}{\cos\theta}=2\sec\theta$	**(A1)**	Need to see this detail for A1 Need to have had θ in every trigonometric ratio.
	Alternative 2 $\dfrac{(1-\sin^2\theta)+(1-\sin\theta)^2}{\cos\theta(1-\sin\theta)}$	**(M1)**	For dealing with the fractions and using $\cos^2\theta=1-\sin^2\theta$.
	$\dfrac{(1-\sin\theta)(1+\sin\theta)+(1-\sin\theta)^2}{\cos\theta(1-\sin\theta)}$	**(M1)**	**Dep** for factorising $1-\sin^2\theta$
	$\dfrac{1+\sin\theta+1-\sin\theta}{\cos\theta}$	**(M1)**	**Dep** for simplification
	$\dfrac{2}{\cos\theta}=2\sec\theta$	**(A1)**	Need to see this detail for A1 Need to have had θ in every trigonometric ratio.

Question	Answer	Marks	Guidance
10(b)(ii)	$\cos 3\phi = \frac{1}{2}$	**B1**	
	$\phi = 20^{\circ}, 100^{\circ}, 140^{\circ}$	3	**M1** for one correct solution of *their* $\cos 3\phi = k$ using a correct order of operations **A1** for 2 correct solutions **A1** for a third correct solution with no extra solutions in the range
11	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{(2x-3)\frac{2x}{x^2+2} - 2\ln(x^2+2)}{(2x-3)^2}$	3	**B1** for $\frac{2x}{x^2+2}$ **M1** for differentiation of a quotient
	When $x = 2$, $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{4}{6} - 2\ln 6$, –2.92 Gradient of normal = 0.3428	**M1**	For $-\frac{1}{\textit{their } \frac{\mathrm{d}y}{\mathrm{d}x}}$
	When $x = 2$, $y = \ln 6$ or $1.79(176)$	**B1**	
	Equation of normal: $y - \ln 6 = -\frac{1}{\textit{their } \frac{\mathrm{d}y}{\mathrm{d}x}}(x-2)$ or $\ln 6 = -\frac{1}{\textit{their } \frac{\mathrm{d}y}{\mathrm{d}x}} \times (2) + c$	**M1**	**Dep** for equation of normal using $-\frac{1}{\textit{their } \frac{\mathrm{d}y}{\mathrm{d}x}}$ and *their y* with $x = 2$.
	When $x = 0$, $y =$ awrt 1.11	**A1**	Must be evaluated.

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2021**

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.

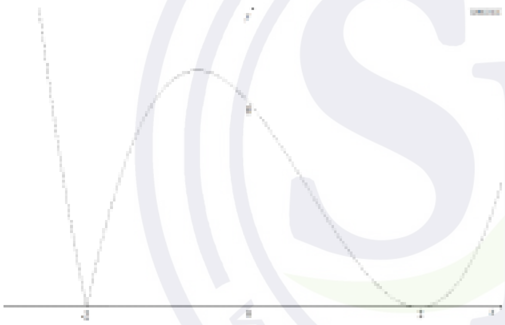
Abbreviations

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	$(4k)^2 - 4k(3k+1)$	M1	For use of the discriminant to obtain a two term quadratic expression.
	$4k^2 - 4k = 0$	M1	Dep to find critical values, allow if only one is found
	$k = 0,\ k = 1$	A1	For both critical values
	$k < 0 \quad k > 1$	A1	
2(a)	$x^2\left(3e^{3x}\right) + 2xe^{3x}$	3	**M1** for differentiation of a product **A1** for $x^2\left(3e^{3x}\right)$ **A1** for $+2xe^{3x}$
2(b)(i)	$2x\left(3x^2+4\right)^{-\frac{2}{3}}$	2	**M1** for $kx\left(3x^2+4\right)^{-\frac{2}{3}}$
2(b)(ii)	$\left[\frac{1}{2}\left(3x^2+4\right)^{\frac{1}{3}}\right]_0^2$	M1	For $k\left(3x^2+4\right)^{\frac{1}{3}}$
	$\left[\frac{1}{2}\left(16^{\frac{1}{3}}\right) - \frac{1}{2}\left(4^{\frac{1}{3}}\right)\right]$	M1	**Dep** for correct substitution of limits into *their* integral
	0.466	A1	
3	$\left(\cot^2\theta + 1\right) + 2\cot^2\theta = 2\cot\theta + 9$	B1	For use of correct identity
	$(3\cot\theta + 4)(\cot\theta - 2) = 0$ $\cot\theta = -\frac{4}{3},\quad \cot\theta = 2$	M1	For attempt to solve *their* quadratic in $\cot\theta$ to obtain $\cot\theta = k$
	$\tan\theta = -\frac{3}{4},\quad \tan\theta = \frac{1}{2}$	M1	For dealing with $\cot\theta = k$ correctly to get $\tan\theta = \frac{1}{k}$
	$\theta = -0.644$	A1	
	$\theta = 0.464$	A1	
4(a)	$64 - 48x^2 + 15x^4$	3	**B1** for 64 **B1** for $-48x^2$ **B1** for $15x^4$

Question	Answer	Marks	Guidance
4(b)	$9-\frac{6}{x^2}+\frac{1}{x^4}$	**B1**	
	$(their\,64\times 9)+(their\,-48\times -6)+(their\,15)$	**M1**	For considering terms independent of x, must have 3 terms
	879	**A1**	
5	$e^y = mx^2 + c$	**B1**	May be implied by later work
	$10 = 4.74m + c$ $5 = 2.24m + c$	**M1**	For at least one correct equation
	$5 = 2.5m$	**M1**	Dep for attempt to solve for m
	$m = 2,\ \ c = 0.52$	**A1**	For both
	$y = \ln\left(2x^2 + 0.52\right)$	**A1**	
	Alternative $e^y = mx^2 + c$	**(B1)**	May be implied by later work
	Gradient = $m = \frac{10-5}{4.74-2.24}$	**(M1)**	
	$10 = 4.74(their\ m) + c$ or $5 = 2.24(their\ m) + c$	**(M1)**	
	$m = 2,\ \ c = 0.52$	**(A1)**	For both
	$y = \ln\left(2x^2 + 0.52\right)$	**(A1)**	
6(a)	$\frac{\pi}{3}$	**B1**	
6(b)	$\frac{\pi a}{3} + 4a$	**2**	**B2 FT** for $\left(their\frac{\pi}{3}\times a\right)+4a$ or **B1 FT** for $their\frac{\pi}{3}\times a$

Question	Answer	Marks	Guidance
6(c)	$\frac{1}{2}(2a)^2 \sin\frac{\pi}{3}$	B1	**FT** *their* $\frac{\pi}{3}$
	$\frac{1}{2}a^2\frac{\pi}{3}$	B1	**FT** *their* $\frac{\pi}{3}$
	$\sqrt{3}a^2 - \frac{\pi a^2}{6}$	B1	**FT** *their* $\frac{\pi}{3}$
7(a)(i)	${}^8C_4$	M1	For realisation that there are 4 places left and 8 people available to fill them
	70	A1	
7(a)(ii)	1 teacher on committee: 5 ways	B1	
	${}^{12}C_8 - 5$	M1	
	490	A1	
	Alternative 2 teachers: 70 3 teachers: 210 4 teachers: 175 5 teachers: 35	(2)	**B1** for 2 correct cases
	490	(B1)	
7(b)	$\frac{n!}{(n-5)!} = 6\frac{(n-1)!}{(n-1-4)!}$	B1	
	$\frac{n}{(n-5)!} = \frac{6}{(n-5)!}$	M1	For simplification of either $n!$ and $(n-1)!$ or 'cancelling out' of the terms of $(n-5)!$
	$n = 6$	A1	nfww
8(a)	$b = 2$	B1	
	At $(0, 3)$: $3 = a + c$	B1	
	At $\left(\frac{5\pi}{6}, 0\right)$: $0 = a\cos\frac{5\pi}{3} + c$ $0 = \frac{a}{2} + c$	M1	For use of *their* b and $\left(\frac{5\pi}{6}, 0\right)$
	$a = 6$ $c = -3$	A1	For both

Question	Answer	Marks	Guidance
8(b)	$\left(\frac{\pi}{6}, 0\right)$	**B1**	Allow for $x = \frac{\pi}{6}$
8(c)	$\left(\frac{\pi}{2}, -9\right)$	**2**	**B1** for $\frac{\pi}{2}$ **B1** for -9
9(a)	$y = x^3 - 2x^2 - 4x + 8$	**B1**	
	$\frac{dy}{dx} = 3x^2 - 4x - 4$ $(3x+2)(x-2) = 0$	**M1**	For attempt to differentiate, allow one slip and for equating *their* $\frac{dy}{dx}$ to zero and attempt to solve to obtain $x = k$
	$\left(-\frac{2}{3}, \frac{256}{27}\right)$	**A1**	
	$(2, 0)$	**A1**	
9(b)		**4**	**B1** for curve with maximum in the second quadrant **B1** for $y = 8$ either on the curve or stated **B1** for $x = \pm 2$ either on the curve or stated **B1** for a cusp at $x = -2$ and a min at $x = 2$
9(c)	$0 < k < \frac{256}{27}$	**2**	**FT** on *their* $\frac{256}{27}$ **B1** for either $0 < k$ or $k < \frac{256}{27}$
10(a)	$\overrightarrow{CD} = \frac{3}{4}\mathbf{a}$	**B1**	
	$\overrightarrow{OD} = \mathbf{c} + \frac{3}{4}\mathbf{a}$	**B1**	
	$\overrightarrow{OE} = h\left(\mathbf{c} + \frac{3}{4}\mathbf{a}\right)$	**B1**	
	$\overrightarrow{DE} = h\left(\mathbf{c} + \frac{3}{4}\mathbf{a}\right) - \left(\mathbf{c} + \frac{3}{4}\mathbf{a}\right)$ oe cao	**B1**	
10(b)	$\overrightarrow{DE} = \frac{1}{4}\mathbf{a} + k\mathbf{c}$	**B1**	

Question	Answer	Marks	Guidance
10(c)	$\mathbf{c}(h-1)+\mathbf{a}\left(\frac{3h}{4}+\frac{3}{4}\right)=\frac{1}{4}\mathbf{a}+k\mathbf{c}$	M1	For equating *their* answer to (a) to *their* answer to (b)
	$\mathbf{c}(h-1)+\mathbf{a}\left(\frac{3h}{4}+\frac{3}{4}\right)=\frac{1}{4}\mathbf{a}+k\mathbf{c}$ $h-1=k$	M1	For attempt to equate like vectors once.
	$h=\frac{4}{3}$	A1	
	$k=\frac{1}{3}$	A1	
11(a)	$x+2y=10$ $x+y=2$	M1	For attempt to solve simultaneously
	$(-6, 8)$	A1	
	$x+2y=10$ $x+y=-2$	M1	For attempt to solve simultaneously
	$(-14, 12)$	A1	
	Alternative $x^2+x(10-x)+\frac{(10-x)^2}{4}=4$ or $(10-2y)^2+2y(10-2y)+y^2=4$	(M1)	For attempt to eliminate one of the variables using $(x+y)^2=4$
	$x^2+20x+84=0$ or $y^2-20y+96=0$	(M1)	**Dep** for attempt to obtain a 3 term quadratic equation = 0 and solve to obtain at least one solution, allow 1 arithmetic error
	$(-14, 12)$	(A1)	
	$(-6, 8)$	(A1)	
	Mid-point of *AB*: $(-10, 10)$	M1	For attempt to obtain the mid-point using *their* coordinates for *A* and *B*.
	Gradient of line perpendicular to *AB* = 2	M1	For attempt to obtain the perpendicular gradient using *their* coordinates for *A* and *B*.
	$y-\textit{their}\ 10=\textit{their}\ 2(x-\textit{their}(-10))$	M1	
	$20-10=2(-5+10)$ oe	A1	For verification

Question	Answer	Marks	Guidance
11(b)	$(10, 50)$	2	**FT** on t*heir* midpoint **B1** for each coordinate
	$(-20, -10)$	2	**FT** on t*heir* midpoint **B1** for each coordinate

Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **March 2021**

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 March 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **10** printed pages.

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.

Maths-Specific Marking Principles	
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nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1	$(3\ln 5x - 1)(\ln 5x + 1) = 0$ $\ln 5x = \frac{1}{3}$, $\ln 5x = -1$	**M1**	For recognition of a quadratic in $\ln 5x$ and attempt to solve to obtain $\ln 5x = k$
	$x = \frac{1}{5}e^{\frac{1}{3}}$, $\frac{\sqrt[3]{e}}{5}$, $e^{\frac{1}{3} - \ln 5}$ oe $x = \frac{1}{5e}$, $\frac{e^{-1}}{5}$, $e^{-1-\ln 5}$ oe	3	**Dep M1** for dealing with *their* $\ln 5x = k$ correctly once **A1** for $x = \frac{1}{5}e^{\frac{1}{3}}$ oe isw **A1** for $x = \frac{1}{5e}$ oe isw
2	$a = 3$	**B1**	
	$b = \frac{1}{2}$	**B1**	
	$c = 4$	**B1**	
3(a)	Gradient of line perp to $AB = -\frac{3}{4}$	**B1**	
	Mid-point of AB $(-1, 10)$ soi	**B1**	
	$y - 10 = -\frac{3}{4}(x + 1)$ soi	**M1**	For attempt at straight line using *their* perp gradient and *their* mid-point
	$a - 10 = -\frac{3}{4}(7 + 1)$ $a = 4$	**A1**	Allow $y = 4$
3(b)	$(-9, 16)$	2	**B1** for $x = -9$ **B1 FT** on *their a*, **dep** on **M1** from **(a)** for $y = 16$ or $20 - \textit{their } a$ **B1** for $-9, 16$
4(a)	$2\left(x + \frac{5}{4}\right)^2 - \frac{49}{8}$	3	**B1** for $b = \left(x + \frac{5}{4}\right)^2$ or $(x + 1.25)^2$ **B1** for $c = -\frac{49}{8}$ or -6.125

Question	Answer	Marks	Guidance
4(b)	$\left(-\frac{5}{4}, -\frac{49}{8}\right)$ oe	2	**B1** for $-\frac{5}{4}$ as part of a set of coordinates or $x=-\frac{5}{4}$, **FT** on $-$ *their b* **B1** for $-\frac{49}{8}$ as part of a set of coordinates or $y=-\frac{49}{8}$ **FT** on *their c* Need to be using *their* answer to **(a)** and not using differentiation as 'Hence'. **B1** for $-\frac{5}{4},-\frac{49}{8}$
4(c)		3	**B1** for correct shape, with maximum in the second quadrant and cusps on the *x*-axes and reasonable curvature for $x<-3$ and $x>0.5$. **B1** for $(-3,\ 0)$ and $(0.5,\ 0)$ either seen on the graph or stated, must have attempted a correct shape **B1** for $(0,\ 3)$ either seen on the graph or stated, must have attempted a correct shape
4(d)	$\frac{49}{8}$ oe	B1	**FT** on *their* $\lvert c\rvert$ from **(a)** Allow $\frac{49}{8}$ from other methods
5(a)	$\begin{pmatrix}-4\\3\end{pmatrix}t$ or $\begin{pmatrix}0\\0\end{pmatrix}+\begin{pmatrix}-4\\3\end{pmatrix}t$ oe	B1	
5(b)	$\begin{pmatrix}12\\6\end{pmatrix}+\begin{pmatrix}-5\\8\end{pmatrix}t$ or $\begin{pmatrix}12-5t\\6+8t\end{pmatrix}$	B1	

Question	Answer	Marks	Guidance
5(c)	$\overrightarrow{PQ}=\begin{pmatrix}12\\6\end{pmatrix}+\begin{pmatrix}-5\\8\end{pmatrix}t-\begin{pmatrix}-4\\3\end{pmatrix}t$	M1	For $their(b)-their(a)$, or $their(a)-their(b)$ Allow unsimplified. Both vectors must be in terms of t
	$\begin{pmatrix}12-t\\6+5t\end{pmatrix}$ soi	B1	
	$\left\|\left(\overrightarrow{PQ}\right)^2\right\|=(12-t)^2+(6+5t)^2$ $\left\|\left(\overrightarrow{PQ}\right)^2\right\|=26t^2+36t+180$	A1	Allow **FT** for use of modulus with $\begin{pmatrix}t-12\\-6-5t\end{pmatrix}$ and simplification to obtain the given result.
5(d)	Attempt to solve or consider the discriminant of $26t^2+36t+180=0$	M1	Must be using the equation from part (c) as 'Hence'.
	Conclusion from either $36^2-4(26)(180)<0$ or $t>0$	A1	Must have stated somewhere that $\left\|\left(\overrightarrow{PQ}\right)^2\right\|=0$ oe has been considered not just $\left\|\left(\overrightarrow{PQ}\right)^2\right\|$.
6(a)(i)	$a=10,\ 6=\dfrac{a}{1-r}$ $10=6-6r$	M1	For use of first term and sum to infinity to obtain an equation in r only
	$r=-\dfrac{2}{3}$	A1	
6(a)(ii)	$S_7=10\dfrac{\left(1-(their\ r)^7\right)}{1-\ their\ r}$	M1	For sum formula with $\|their\ r\|<1$.
	$S_7=6.35$	A1	
6(b)(i)	$\log_x 3$	B1	
6(b)(ii)	$S_n=\dfrac{n}{2}\left(2\log_x 3+(n-1)\log_x 3\right)$	M1	For use of sum formula with *their* (i)
	$\dfrac{n}{2}(n+1)\log_x 3,\ \dfrac{n}{2}\log_x 3^{n+1},\ \dfrac{n+1}{2}\log_x 3^n$	A1	Allow other similar equivalents
6(b)(iii)	$\dfrac{n}{2}(n+1)=3081$	M1	For a correct attempt to solve *their* (ii) $=3081\log_x 3$ to obtain an answer for n. Must be a 3 term quadratic in n only.
	$n=78$	A1	

Question	Answer	Marks	Guidance
6(b)(iv)	$1027 = \frac{78}{2}(79)\log_x 3$ or $3081 \log_x 3$	M1	For using *their* 78 in a sum equation or using 3081 to obtain x
	$x = 27$	A1	
7(a)	$AE^2 = \left(\sqrt{17}-1\right)^2 + \left(\sqrt{17}+1\right)^2$ $= 18 + 2\sqrt{17} + 18 - 2\sqrt{17}$	M1	For attempt to find *AE*. Must see at least 3 terms in an expansion that is not the difference of two squares to be convinced a calculator is not being used.
	$AE = 6$	A1	
	Perimeter = $4\sqrt{17} + 8 + \textit{their } AE$ $= 4\sqrt{17} + 14$	B1	**FT** on *their AE*
7(b)	Area = $\frac{1}{2}\left(3\sqrt{17}+7\right)\left(\sqrt{17}+1\right)$ oe $= \frac{1}{2}\left(51 + 3\sqrt{17} + 7\sqrt{17} + 7\right)$ oe	M1	For attempt at a trapezium or triangle and rectangle. Must see at least 3 terms in an expansion that is not the difference of two squares to be convinced a calculator is not being used. Allow one arithmetic slip.
	Area $= 29 + 5\sqrt{17}$	A1	
7(c)	$\tan AED = \frac{\sqrt{17}+1}{\sqrt{17}-1} \times \frac{\sqrt{17}+1}{\sqrt{17}+1}$	M1	For attempt at rationalisation.
	$\frac{9+\sqrt{17}}{8}$	A1	Must come from $\frac{18+2\sqrt{17}}{16}$ to be convinced a calculator is not being used.
7(d)	$\sec^2 AED = \tan^2 AED + 1$ $= \frac{\left(9+\sqrt{17}\right)^2}{64} + 1$ $\frac{81 + 17 + 18\sqrt{17} + 64}{64}$ oe if $\frac{\left(9+\sqrt{17}\right)^2}{64}$ and 1 are considered separately.	M1	For use of *their* **(c)** in the correct identity and attempt to simplify to obtain a single fraction. Must see at least 3 terms in an expansion that is not the difference of two squares to be convinced a calculator is not being used. Allow one arithmetic slip
	$\frac{81+9\sqrt{17}}{32}$ oe	A1	cao

Question	Answer	Marks	Guidance
8(a)(i)	$\sin x \frac{\sin x}{\cos x} + \cos x$	**B1**	
	$\frac{\sin^2 x + \cos^2 x}{\cos x}$ oe	**B1**	
	$\frac{1}{\cos x} = \sec x$	**B1**	Poor notation is B0
8(a)(ii)	$\sec\frac{\theta}{2} = 4$ $\cos\frac{\theta}{2} = \frac{1}{4}$	**M1**	For use of (i) and dealing with sec to obtain $\cos\frac{\theta}{2} = \frac{1}{4}$
	$\frac{\theta}{2} = 1.3181,\ 4.9651$ $\theta = 2.64$ or 0.839π $\theta = 9.93$ or 3.16π	**3**	**Dep M1** for a correct attempt to solve to obtain at least one solution for θ **A1** for one correct solution **A1** for a second correct solution and no extra solutions
8(b)	$\tan\left(y + 38^\circ\right) = \frac{1}{\sqrt{3}}$ $y = 172^\circ$ $y = 352^\circ$	**3**	**M1** for dealing with cot and a correct attempt to obtain at least one correct solution, allow for -8° **A1** for one correct solution **A1** for a second correct solution and no extra solutions
9(a)	$(2x-1)\left(x^2 - x - 1\right)$	**M1**	For attempt at factorisation by observation or by algebraic long division
	$(2x-1)\left(x^2 - x - 1\right)$	**A1**	cao
9(b)	At A $x = \frac{1}{2}$	**B1**	
	$x^2 - x - 1 = 0$	**M1**	For a valid attempt to solve *their* quadratic equation, allow for decimal solutions
	$x = \frac{1 \pm \sqrt{5}}{2}$ soi	**A1**	
	At B $x = \frac{1+\sqrt{5}}{2}$	**A1**	

Question	Answer	Marks	Guidance
9(c)	$\int \frac{1}{x}\,\mathrm{d}x = \ln x$	**B1**	
	$[\ln x]_{\frac{1}{2}}^{\frac{1+\sqrt{5}}{2}} = \ln\left(1+\sqrt{5}\right)$	**B1**	Allow $\ln\left(\frac{1+\sqrt{5}}{2}\right) - \ln\frac{1}{2}$
	$\left(\int -2x^2+3x+1\right)\mathrm{d}x = -\frac{2}{3}x^3+\frac{3x^2}{2}+x$	**M1**	**M1** for attempt at $-\frac{2}{3}x^3+\frac{3x^2}{2}+x$, must have 2 correct terms.
	$\left[-\frac{2}{3}x^3+\frac{3x^2}{2}+x\right]_0^{\frac{1}{2}}$ $=\left(-\frac{2}{3}\times\frac{1}{8}\right)+\left(\frac{3}{2}\times\frac{1}{4}\right)+\frac{1}{2}$ oe	**M1**	**Dep** for correct application of the limits 0 and $\frac{1}{2}$ and attempt to evaluate – may be implied by 0.792 or $\frac{19}{24}$.
	$\frac{19}{24}$	**A1**	
	$\ln\left(1+\sqrt{5}\right)+\frac{19}{24}$	**A1**	isw
10(a)	$\frac{(x-1)(6x)\left(2x^2+10\right)^{\frac{1}{2}}-\left(2x^2+10\right)^{\frac{3}{2}}}{(x-1)^2}$	**3**	**B1** for $\frac{3}{2}\times 4x\times\left(2x^2+10\right)^{\frac{1}{2}}$ oe **M1** for correct attempt at differentiation of a quotient **A1** for all the other terms correct
	$\left(\frac{\left(2x^2+10\right)^{\frac{1}{2}}}{(x-1)^2}\right)\left(4x^2-6x-10\right)$	**2**	**A2** for all 3 terms correct in the quadratic **A1** for 2 terms correct and 1 incorrect term in the quadratic **A0** for 1 term correct or no terms correct in the quadratic

Question	Answer	Marks	Guidance
10(b)	$4x^2 - 6x - 10 = 0$ $(2x-5)(x+1) = 0$	M1	For attempt to solve *their* quadratic = 0 and obtain at least one solution or state that *their* quadratic equation has no real roots.
	$x = \frac{5}{2}$	A1	
	Rejecting $x = -1$ correctly	A1	May be implied by the statement $x > 1$.
	Discounting $(2x^2 + 10)^{\frac{1}{2}} = 0$	B1	

Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **October/November 2020**

MARK SCHEME

Maximum Mark: 80

Published

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This document consists of **9** printed pages.

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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 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).

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Maths-Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
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4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
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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.

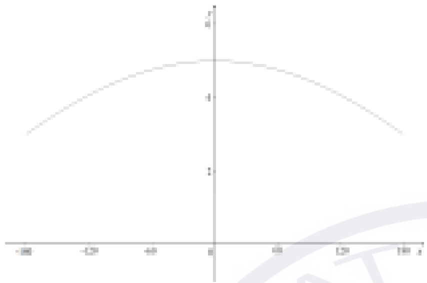
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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

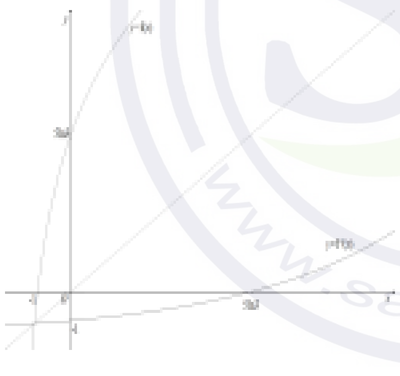
When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier 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	$y = \pm 3(x+2)(x+1)(x-4)$	**3**	**B1** for 3 **B1** for $(x+2)(x+1)(x-4)$ **B1** for $\pm$
2(a)	4	**B1**	
2(b)	1080° or 6π	**B1**	
2(c)		**3**	**B1** for shape, it must be symmetrical about the y-axis. **B1** for y-intercept of 5 **B1** for $(\pm 180^\circ, 3)$
3(a)	$a = \frac{3}{2}$ or $p^{\frac{3}{2}}$	**B1**	
	$b = \frac{10}{3}$ or $q^{\frac{10}{3}}$	**B1**	
	$c = -\frac{7}{3}$ or $r^{-\frac{7}{3}}$	**B1**	
3(b)	$\left(3x^{\frac{1}{3}} - 1\right)\left(2x^{\frac{1}{3}} - 1\right) = 0$	**M1**	For recognising as a quadratic in $x^{\frac{1}{3}}$ and attempt to solve to obtain $x^{\frac{1}{3}} = k$
	$x^{\frac{1}{3}} = \frac{1}{3}$, $x^{\frac{1}{3}} = \frac{1}{2}$ leading to $x = \frac{1}{27}$ or 0.0370 $x = \frac{1}{8}$ or 0.125	**2**	**Dep M1** for a valid method of solving $x^{\frac{1}{3}} = k$ where $k > 0$ **A1** for both
4(a)	$\frac{dy}{dx} = \frac{\sin x \times 3\sec^2 3x - \tan 3x \cos x}{\sin^2 x}$	**3**	**B1** for $3\sec^2 3x$ **M1** for differentiation of a quotient or equivalent product **A1** for all other terms apart from $3\sec^2 3x$ correct
	When $x = \frac{\pi}{3}$ $\frac{dy}{dx} = 2\sqrt{3}$	**A1**	
4(b)	$2\sqrt{3}h$	**B1**	**FT** on *their* answer to **(a)**

Question	Answer	Marks	Guidance
4(c)	$\frac{dy}{dx} \times \frac{dx}{dt} = \frac{dy}{dt}$ $2\sqrt{3} \times 3 = \frac{dy}{dt}$	**M1**	For correct use of rates of change using *their* answer to **(a)**
	$\frac{dy}{dt} = 6\sqrt{3}$	**A1**	
5(a)(i)	360	**B1**	
5(a)(ii)	Starts with 6: $1 \times 4 \times 3 \times 1 \quad = 12$	**B1**	
	Starts with 7 or 9 : $= 2 \times 4 \times 3 \times 2$ $= 48$	**B1**	
	Total = 60	**B1**	
	Alternative		
	Ending in 4: $\frac{1}{6} \times 360 \times \frac{3}{5} = 36$	**(B1)**	Allow unsimplified
	Ending in 6: $\frac{1}{6} \times 360 \times \frac{2}{5} = 24$	**(B1)**	Allow unsimplified
	Total = 60	**(B1)**	
5(b)(i)	1287	**B1**	
5(b)(ii)	$1287 - {}^7C_5$ or 1 doctor: 210 2 doctors: 525 3 doctors: 420 4 doctors: 105 5 doctors: 1	**M1**	For *their* **(b)(i)** $-{}^7C_5$ or listing all the other separate cases which must be evaluated, allow 1 error
	1266	**A1**	
5(b)(iii)	45	**B1**	
6(a)	Velocity vector = $\begin{pmatrix} -8 \\ 6 \end{pmatrix}$	**2**	**M1** for obtaining 5
	$\begin{pmatrix} 30 \\ 10 \end{pmatrix} + \begin{pmatrix} -8 \\ 6 \end{pmatrix} t$	**B1**	**FT** for $\begin{pmatrix} 30 \\ 10 \end{pmatrix} + (\textit{their} \text{ velocity vector})t$
6(b)	13	**B1**	

Question	Answer	Marks	Guidance
6(c)	$P:\begin{pmatrix}-50\\70\end{pmatrix}$ $Q:\begin{pmatrix}-30\\210\end{pmatrix}$	**M1**	Using $t=10$ to find position vector of each particle
	$\sqrt{20^2+140^2}$	**M1**	**Dep** on previous M mark, for use of Pythagoras on difference of the 2 position vectors
	$100\sqrt{2}$	**A1**	
7(a)	$\mathrm{f}\in\mathbb{R}$	**B1**	Allow *y* but not *x*
7(b)	$x=5\ln(2y+3)$ $\mathrm{e}^{\frac{x}{5}}=2y+3$	**M1**	For a complete attempt to obtain inverse
	$\mathrm{f}^{-1}(x)=\dfrac{\mathrm{e}^{\frac{x}{5}}-3}{2}$	**A1**	Must be using correct notation
	Domain $x\in\mathbb{R}$	**B1**	**FT** on *their* **(a)**. Must be using correct notation
7(c)		**5**	**B1** for shape of $y=\mathrm{f}(x)$ **B1** for shape of $y=\mathrm{f}^{-1}(x)$ **B1** for $5\ln 3$ or 5.5 and -1 on both axes for $y=\mathrm{f}(x)$ **B1** for $5\ln 3$ or 5.5 and -1 on both axes for $y=\mathrm{f}^{-1}(x)$ **B1** All correct, with apparent symmetry which may be implied be previous 2 B marks or by inclusion of $y=x$, and implied asymptotes, may have one or two points of intersection
8(a)(i)	$\dfrac{1}{\left(1+\dfrac{1}{\sin\theta}\right)\left(\sin\theta-\sin^2\theta\right)}$	**B1**	For use of $\operatorname{cosec}\theta=\dfrac{1}{\sin\theta}$, may be implied
	$\dfrac{1}{\sin\theta+1-\sin\theta-\sin^2\theta}$	**M1**	For expansion of brackets
	$\dfrac{1}{\cos^2\theta}$	**M1**	For simplification and use of identity
	$\sec^2\theta$	**A1**	For final result, must see $\dfrac{1}{\cos^2\theta}$

Question	Answer	Marks	Guidance
8(a)(ii)	$\cos^2\theta = \frac{3}{4}$	B1	For relating to and making use of **(a)**
	$\cos\theta = \pm\frac{\sqrt{3}}{2}$	M1	For attempt to solve, may be implied by one correct solution
	$\theta = -150^\circ,\ -30^\circ,\ 30^\circ,\ 150^\circ$	2	**A1** for any correct pair **A1** for a second correct pair and no extra solutions within the range
8(b)	$\tan\left(3\phi + \frac{2\pi}{3}\right) = 1$	B1	
	$3\phi + \frac{2\pi}{3} = \frac{\pi}{4},\ \frac{5\pi}{4},\ \frac{9\pi}{4}$ $3\phi = \frac{7\pi}{12},\ \frac{19\pi}{12}$	M1	For correct order of operations
	$\phi = \frac{7\pi}{36}$	A1	
	$\phi = \frac{19\pi}{36}$	A1	
9(a)	$\left[\ln x - \frac{1}{2}\ln(2x+3)\right]_1^a$	2	**B1** for $\ln x$ **B1** for $\frac{1}{2}\ln(2x+3)$
	$\ln a - \frac{1}{2}\ln(2a+3) + \frac{1}{2}\ln 5$	M1	For correct application of limits, must have at least one **B1**
	$\ln a\sqrt{\frac{5}{2a+3}}$	M1	**Dep** on previous M mark, for application of log laws
	$5a^2 - 18a - 27 = 0$	M1	**Dep** on previous M mark for equating to $\ln 3$ and simplification to a 3 term quadratic = 0
	$a = \frac{9+6\sqrt{6}}{5}$	A1	Must have one solution only

Question	Answer	Marks	Guidance
9(b)	$-\frac{1}{2}\cos\left(2x+\frac{\pi}{3}\right)+\frac{1}{2}\sin 2x-x$	3	**B1** for $-\frac{1}{2}\cos\left(2x+\frac{\pi}{3}\right)$ **B1** for $+\frac{1}{2}\sin 2x$ **B1** for $-x$
	$\left(-\frac{1}{2}\cos\pi+\frac{1}{2}\sin\frac{2\pi}{3}-\frac{\pi}{3}\right)-\left(-\frac{1}{2}\cos\frac{\pi}{3}\right)$	M1	For correct use of limits in *their* integral, must have at least one **B1** term
	$\frac{3}{4}+\frac{\sqrt{3}}{4}-\frac{\pi}{3}$	A1	
10(a)	$a+d=8$ $a+3d=18$	2	**B1** for both equations **M1** for attempt to solve *their* equations
	$a=3,\ \ d=5$	A1	For both
	$\frac{n}{2}\left(6+(n-1)5\right)>1560$	M1	For correct use of sum formula with *their a* and *d*, allow equality
	$5n^2+n-3120>0$	M1	For attempt to solve, allow equality, to obtain at least one critical value
	Positive critical value 24.9 25terms	A1	
10(b)(i)	$\frac{a}{1-r}=72$ and either $a+ar+ar^2=\frac{333}{8}$ or $\frac{a(1-r^3)}{1-r}=\frac{333}{8}$	B1	For both
	$a=72(1-r)$ and $a(1+r+r^2)=\frac{333}{8}$ oe $72(1-r)(1+r+r^2)=\frac{333}{8}$ or $72(1-r^3)=\frac{333}{8}$	M1	For attempt to obtain an equation in terms of *r* only
	$1-r^3=\frac{333}{576}$	A1	
	$r=0.75$	2	**M1** for attempt to solve *their* equation in *r*

Question	Answer	Marks	Guidance
10(b)(ii)	$a = 18$	**B1**	**FT** on their r provided $\lvert r \rvert < 1$

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Paper 1 **October/November 2020**

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rot rounded or truncated
SC Special Case
soi seen or implied

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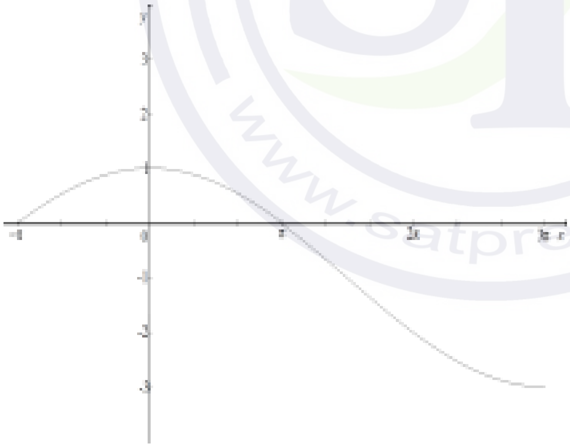
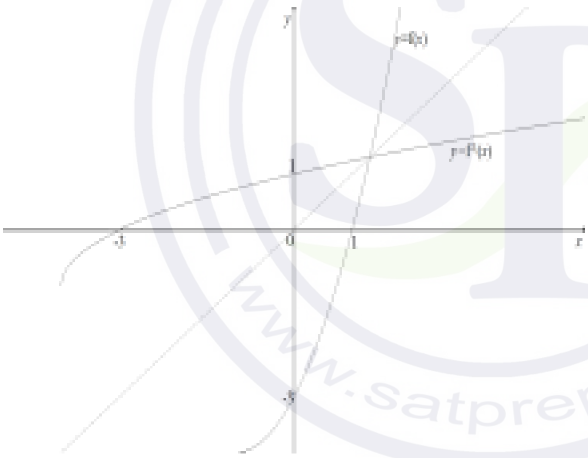
1	$2x^2 - (k+4)x + (k+4) \quad (=0)$ $2x^2 + (-k-4)x + (k+4) \quad (=0)$	**B1**	
	Discriminant: $(k+4)^2 - (4 \times 2 \times (k+4))$	**M1**	Use of discriminant to obtain 2 critical values using *their* 3 term quadratic
	± 4	**A1**	For critical values
	$k < -4 \quad k > 4$	**A1**	
2(a)	$y = -\frac{1}{2}(x+5)(x+1)(x-2)$	**3**	**B1** for negative soi **B1** for $\frac{1}{2}$ soi **B1** for $(x+5)(x+1)(x-2)$ or $x^3 + 4x^2 - 7x - 10$
2(b)	$-5 < x < -1$	**B1**	
	$x > 2$	**B1**	
3(a)	2	**B1**	
3(b)	6π or $1080°$	**B1**	
3(c)		**3**	**B1** for passing through $(-\pi,\ 0)$ and $(3\pi,\ -3)$ – must be a curve **B1** for correct shape with max on *y*-axis and a min at $x = 3\pi$ **B1** for passing through $(0,\ 1)$ and $(\pi,\ 0)$ only on the positive *x*-axis
4(a)	$a + 6d = 158$ $a + 9d = 149$	**B1**	For both equations, may be implied by a correct *a* and *d*
	$d = -3,$	**B1**	
	$a = 176$	**B1**	

Question	Answer	Marks	Guidance
4(b)	$\frac{n}{2}\left(352+(n-1)(-3)\right) \quad (<0)$	**M1**	For correct attempt at sum formula with *their a* and *their d*,
	$\frac{355}{3}$ or 118.3 oe	**A1**	
	119	**A1**	
5	$x^5+10x^3+40x+...$	**3**	**M1** for attempt to expand $\left(x+\frac{2}{x}\right)^5$, with at least 2 correct terms **A1** for $10x^3$ **A1** for $40x$
	Term in x^2 : $(1\times40)-(3\times10)$	**M1**	For $(1\times \textit{their } 40)\pm(3\times \textit{their } 10)$
	10	**A1**	
6(a)	It is a one-one function because of the given restricted domain or because $x \geqslant -1$	**B1**	
6(b)		**4**	**B1** for $y=\mathrm{f}(x)$ for $x>-1$ only **B1** for 1 on x-axis and –3 on y-axis for $y=\mathrm{f}(x)$ **B1** for $y=\mathrm{f}^{-1}(x)$ as a reflection of $y=\mathrm{f}(x)$ in the line $y=x$, maybe implied by intercepts with axes **B1** for 1 on y-axis and –3 on x-axis for $y=\mathrm{f}^{-1}(x)$

Question	Answer	Marks	Guidance
7(a)	$\frac{dy}{dx} = \frac{(2x+1)\frac{6x}{3x^2-5} - 2\ln(3x^2-5)}{(2x+1)^2}$ or $\frac{dy}{dx} = (2x+1)^{-1}\frac{6x}{3x^2-5} - 2(2x+1)^{-2}\ln(3x^2-5)$	3	**B1** for $\frac{6x}{3x^2-5}$ **M1** for attempt at a quotient or equivalent product **A1** for all terms other than $\frac{6x}{3x^2-5}$ correct
	When $x=\sqrt{2}$, $y=0$	**B1**	May be implied
	When $x=\sqrt{2}$, $\frac{dy}{dx} = \frac{6\sqrt{2}}{2\sqrt{2}+1}$ or $\frac{24-6\sqrt{2}}{7}$ or 2.22 oe Normal: $y = -\frac{(2\sqrt{2}+1)}{6\sqrt{2}}(x-\sqrt{2})$ oe or $y = -\frac{7}{24-6\sqrt{2}}(x-\sqrt{2})$ oe or $y = -\frac{1}{2.22}(x-\sqrt{2})$ oe or $y = -\frac{4+\sqrt{2}}{12}(x-\sqrt{2})$ oe or $y = -\frac{9+4\sqrt{2}}{24+6\sqrt{2}}(x-\sqrt{2})$ oe $y = -0.451x + 0.638$	2	**M1** for attempt at normal using *their* *y* and *their* perp gradient **A1** Allow equivalent surd forms
7(b)	$\left(\frac{6\sqrt{2}}{2\sqrt{2}+1}\right)h$ or $\frac{24-6\sqrt{2}}{7}h$ or other equivalent surd forms, or $2.22h$	**B1**	**FT** on *their* $\frac{dy}{dx}$ from **(a)**
8(a)	${}^{12}C_3 \times {}^{9}C_4 = 220 \times 126$ or ${}^{12}C_5 \times {}^{7}C_4 = 792 \times 35$ or ${}^{12}C_4 \times {}^{8}C_5 = 495 \times 56$ or other equivalents 27720	3	**B1** for one correct combination in a product of 2 or 3 combinations Must be numeric **B1** for a second appropriate combination in the same product Must be numeric
8(b)(i)	120	**B1**	
8(b)(ii)	48	**B1**	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td rowspan="6">8(b)(iii)</td><td>Starts with 7 or 9 24</td><td>B1</td><td>May be implied by 12 and 12</td></tr>
<tr><td>Starts with 8 18</td><td>B1</td><td></td></tr>
<tr><td>42</td><td>B1</td><td></td></tr>
<tr><td>Alternative
Ends with 3 18</td><td>(B1)</td><td></td></tr>
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<tr><td>42</td><td>(B1)</td><td></td></tr>
<tr><td rowspan="3">9(a)</td><td>$\frac{dy}{dx} = (2x-1)\times\frac{1}{2}\times4(4x+3)^{-\frac{1}{2}} + 2(4x+3)^{\frac{1}{2}}$</td><td>3</td><td>B1 for $\frac{1}{2}\times4(4x+3)^{-\frac{1}{2}}$ oe
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<tr><td rowspan="2">9(c)</td><td>For a complete method using 2nd derivative, or gradient or y values either side or one side of their stationary point e.g.
<table>
<tr><td>x</td><td>$<-\frac{1}{3}$</td><td>$-\frac{1}{3}$</td><td>$>-\frac{1}{3}$</td></tr>
<tr><td>$\frac{dy}{dx}$</td><td>$-$</td><td>0</td><td>+</td></tr>
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</table></td><td>M1</td><td>Must be using values of $x > -\frac{3}{4}$</td></tr>
<tr><td>Minimum</td><td>A1</td><td>Must be from correct work</td></tr>
</table>

Question	Answer	Marks	Guidance
10(a)	$\mathrm{p}(2)$: $48+4a+2b+2=0$ $2a+b+25=0$	**B1**	For $2a+b+25=0$ or multiple
	$\mathrm{p}(1)=-2\mathrm{p}(0)$ $a+b+12=0$	**B1**	For $a+b+12=0$
	$a=-13$, $b=1$	**2**	**M1** for attempt to solve *their* equations in a and b leading to 2 values **A1** for both
10(b)(i)	$\mathrm{p}\left(\frac{1}{2}\right)=\frac{6}{8}-\frac{13}{4}+\frac{1}{2}+2$	**M1**	For attempt to find $\mathrm{p}\left(\frac{1}{2}\right)$ using *their* a and b
	0	**A1**	
10(b)(ii)	$(x-2)(2x-1)(3x+1)$	**2**	**M1** for realising that 2 factors are known and 3rd factor can be got by observation or algebraic long division, or for making use of $x-2$ or $2x-1$ in order to obtain a quadratic factor **A1** Must see all factors together
11(a)	$\angle BOC=1.5$ rad	**B1**	
	$\sin 0.75=\frac{BC/2}{r}$	**M1**	For a complete attempt to find BC – must be using a right-angled triangle to get required result – **Given answer**
	$BC=2r\sin 0.75$	**A1**	
	Perimeter = $2r+2r\sin 0.75+4r+1.5r$	**M1**	**Dep** on first M mark for attempt at perimeter
	$r(7.5+2\sin 0.75)$	**A1**	**Given answer**
11(b)	Area = $(2r+2r\sin 0.75)r-\frac{1}{2}r^2(1.5-\sin 1.5)$ Area = $3.36r^2-0.75r^2+0.4987r^2$	**3**	**M1** for a correct plan **M1** for $(2r+2r\sin 0.75)r$, using *their* $2r\sin 0.75$ **B1** for segment $\frac{1}{2}r^2(1.5-\sin 1.5)$ $=0.251r^2$
	Area = $3.11r^2$	**A1**	

Question	Answer	Marks	Guidance
12(a)(i)	Area under graph: $\frac{1}{2}(60+40)\times 30+\frac{1}{2}(30+V)\times 30 \quad (=2775)$ or $\frac{1}{2}(20\times 30)+(40+30)+\frac{1}{2}(30+V)\times 30$	2	**M1** for attempt to find the area under the graph **Dep M1** on previous M mark for attempt to equate to 2775 and simplify in order to find V or $V-30$
	55	**A1**	
12(a)(ii)	0	**B1**	
12(b)(i)	$v=3\sin 2t \quad (+c)$	**M1**	Must have $\pm 3\sin 2t$
	$10=c$	**M1**	**Dep** for attempt to find $+c$,
	$v=3\sin 2t+10$	**A1**	
12(b)(ii)	$s=-\frac{3}{2}\cos 2t+10t+d$	**M1**	For attempt to integrate *their v*, must have $\pm\frac{3}{2}\cos 2t$
	$d=\frac{3}{2}$	**M1**	**Dep** on previous M mark for attempt to find *d*.
	$s=-\frac{3}{2}\cos 2t+10t+\frac{3}{2}$	**A1**	

Cambridge Assessment International Education

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ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2020**

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.

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Cambridge International is publishing the mark schemes for the October/November 2020 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **10** printed pages.

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.

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- 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
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GENERIC MARKING PRINCIPLE 5:

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3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
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5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
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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.

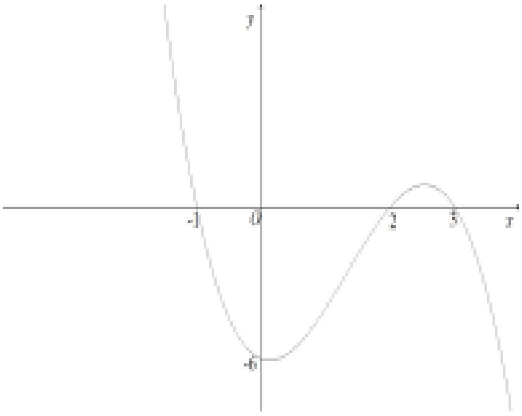
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

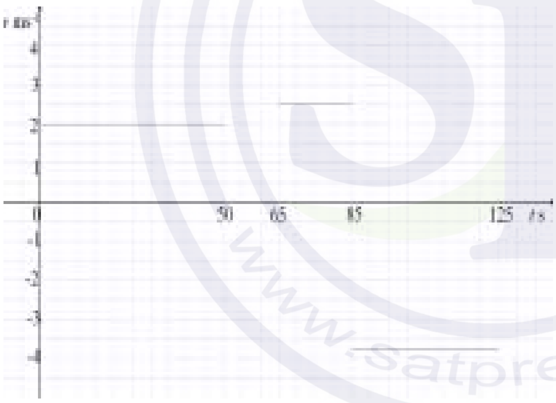
B Mark for a correct result or statement independent of Method marks.

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)		3	**B1** for a well-drawn cubic graph in correct orientation Both arms extending beyond x-axis Maximum above x-axis **B1** for x-intercepts **B1** for y-intercept
1(b)	$x < -1$	**B1**	Dep on a cubic curve in the correct orientation and –1 correct on x-axis
	$2 < x < 3$ or $3 > x > 2$	**B1**	Dep on a cubic curve in the correct orientation and 2 and 3 correct on x-axis
2(a)	$\frac{dy}{dx} = \frac{(x^2+1)2e^{2x-3} - 2xe^{2x-3}}{(x^2+1)^2}$ oe or $\frac{dy}{dx} = \frac{2e^{2x-3}}{(x^2+1)} - \frac{2xe^{2x-3}}{(x^2+1)^2}$ oe	3	**B1** for $\frac{d}{dx}\left(e^{2x-3}\right) = 2e^{2x-3}$ seen in a quotient rule or product rule expression **M1** for correct method for differentiating a quotient or equivalent product **A1 FT** from *their* $2e^{2x-3}$
2(b)	When $x = 2$, $\frac{dy}{dx} = \frac{6e}{25}$	**M1**	For evaluation of *their* $\frac{dy}{dx}$ when $x = 2$
	$\frac{6e}{25} \times \frac{dx}{dt} = 2$ oe	**M1**	For correct substitution of *their* evaluated $\frac{dy}{dx}$ and $\frac{dy}{dt} = 2$ in a correct rates of change equation
	$\frac{dx}{dt} = \frac{25}{3e}$, $\frac{50}{6e}$	**A1**	
3(a)(i)	$x > \frac{1}{2}$	**B1**	Must be using x

Question	Answer	Marks	Guidance
3(a)(ii)	$x = 4\ln(2y-1)$ $e^{\frac{x}{4}} = 2y-1$ $y = \frac{1}{2}\left(1+e^{\frac{x}{4}}\right)$	**M1**	For full method for inverse using correct order of operations
	$f^{-1}(x) = \frac{1}{2}\left(1+e^{\frac{x}{4}}\right)$ or $f^{-1}(x) = \frac{1}{2}\left(1+\sqrt[4]{e^x}\right)$	**A1**	Must be using correct notation
	$x \in \mathbb{R}$	**B1**	
3(b)	$\sqrt{2x-3}+5=7$	**M1**	For correct order
	$x = \frac{2^2+3}{2}$	**M1**	Dep on previous M mark, for obtaining x by simplifying and solving using correct order of operations, including squaring
	$x = \frac{7}{2}$ or 3.5	**A1**	
4(a)(i)		**3**	**B1** For $v = 2$ for $0 \leqslant t \leqslant 50$ **B1** For $v = 2.5$ for $65 \leqslant t \leqslant 85$ **B1** For $v = 3.75$ for $85 \leqslant t \leqslant 125$ and $v = 0$ for $50 \leqslant t \leqslant 65$
4(a)(ii)	300	**B1**	
4(b)	$\frac{dx}{dt} = -18\sin\left(3t+\frac{\pi}{3}\right)$	**M1**	$\pm 18\sin\left(3t+\frac{\pi}{3}\right)$
	$\frac{d^2x}{dt^2} = -54\cos\left(3t+\frac{\pi}{3}\right)$	**M1**	$\pm 54\cos\left(3t+\frac{\pi}{3}\right)$
	−27 nfww	**A1**	

Question	Answer	Marks	Guidance
5	$(1+x)\left(1+n\left(-\frac{x}{2}\right)+\frac{n(n-1)}{2}\left(\frac{x^2}{4}\right)...\right)$	2	**B1** For $\binom{n}{1}\left(-\frac{x}{2}\right)$ **B1** For $\binom{n}{2}\left(\frac{x^2}{4}\right)$
	$\frac{1}{4}\binom{n}{2}x^2-\frac{1}{2}\binom{n}{1}x^2=\frac{25}{4}x^2$	M1	Correctly using two terms in n to obtain an x^2 term and equating to $\frac{25}{4}x^2$ Dep on one B1
	$\frac{n(n-1)}{8}-\frac{n}{2}=\frac{25}{4}$ oe	A1	
	$n=10$ only	A1	
6(a)	$\lg y=\lg A+bx^2$	B1	Stated or may be implied by later work
	If using $\lg y=\lg A+bx^2$ as a starting point $5.25=\lg A+3.63b$ and $6.88=\lg A+4.83b$ or $5.25=\lg A+1.358(3.63)$ or $6.88=\lg A+1.358(4.83)$ OR If finding the equation of the straight line and then finding $\lg A$ and b by inspection $\lg y-6.88=1.358(x^2-4.83)$ or $\lg y-5.25=1.358(x^2-3.63)$ or $\lg y=1.358x^2+0.31..$(or 0.32..)	M1	For correctly finding required equation(s)
	$b=1.36$, $\frac{163}{120}$ or $1\frac{43}{120}$	B1	Must be b = and from correct working
	A in range 2.05 to 2.09	A1	
6(b)	$\lg y=0.3132+(4\times1.36)$ $y=2.09\times10^{4\times1.36}$	M1	For $\lg y=(\textit{their}\ \lg A)+4(\textit{their}\ b)$ or $y=(\textit{their}\ A)\left(10^{4(\textit{their}\ b)}\right)$
	Allow 553 000 to 576 000	A1	
6 (c)	$4=2.09\left(10^{1.36x^2}\right)$ or $\lg 4=0.3132+1.36x^2$	M1	$4=(\textit{their}\ A)\left(10^{\textit{their}\ bx^2}\right)$ or $\lg 4=(\textit{their}\ \lg A)+(\textit{their}\ b)x^2$
	awrt 0.46	A1	

Question	Answer	Marks	Guidance
7(a)	$-4a+b+5=0$ oe	**B1**	Allow multiples of equation
	$a+b-25=0$ oe	**B1**	Allow multiples of equation
	$a=6,\ b=19$	**2**	**M1** for solving *their* 2 equations and obtaining two solutions **A1** for both $a=6,\ b=19$
	$(x+4)(6x^2-5x+1)$ $A=6,\ B=-5,\ C=1$	**2**	**M1** for attempt to obtain quadratic factor by inspection or by algebraic long division **A1** $(6x^2-5x+1)$ or $A=6,\ B=-5,\ C=1$
	Alternative $a+b-25=0$ oe	**(B1)**	Allow multiples of equation
	Comparing coefficients $C=1$ and $A=a$	**(B1)**	
	$4A+B=b$	**(B1)**	
	Leading to $5A+B=25$	**(M1)**	For use of *their* $a+b-25=0$ to obtain an equation in A and B
	$4B+1=-19$	**(B1)**	
	$(x+4)(6x^2-5x+1)$ $A=6,\ B=-5,\ C=1$	**(A1)**	
7(b)	$(x+4)(3x-1)(2x-1)$	**B1**	Must follow from a correct solution to **(a)**
7(c)	–19	**B1**	
8(a)	$\angle AOB=1.45$ (radians)	**B1**	
8(b)	Sector area $=\frac{1}{2}(r^2)(1.45)$	**B1**	For correct sector area. Allow unsimplified
	Area of triangle $=\frac{1}{2}\times 0.5r\times r\times\sin(\pi-\ \textit{their}\ 1.45)$	**B1**	For correct area of triangle Allow unsimplified
	Total area = $0.973r^2$	**B1**	

Question	Answer	Marks	Guidance
8(c)	$(AC^2) = r^2 + 0.25r^2 - (2 \times r \times 0.5r\cos(\pi - 1.45))$	M1	For correct substitution in cosine rule using $(\pi - \textit{their } 1.45)$
	$AC = 1.17r$	A1	
	Perimeter = $2.95r + 1.17r$	B1	**FT** on *their AC*
	$r = 2.91$	A1	
9(a)	$\overrightarrow{AB} = \mathbf{b} - \mathbf{a}$ or $\overrightarrow{BA} = \mathbf{a} - \mathbf{b}$	B1	
	$\overrightarrow{OX} = \mathbf{a} + \frac{3}{4}\overrightarrow{AB}$ or $\overrightarrow{OX} = \mathbf{b} + \frac{1}{4}\overrightarrow{BA}$ $\overrightarrow{OX} = \mathbf{a} + \frac{3}{4}(\mathbf{b} - \mathbf{a})$ or $\overrightarrow{OX} = \mathbf{b} + \frac{1}{4}(\mathbf{a} - \mathbf{b})$	M1	For correct use of ratio, using *their* $\overrightarrow{AB}$ or $\overrightarrow{BA}$
	$\overrightarrow{OX} = \frac{\mathbf{a}}{4} + \frac{3}{4}\mathbf{b}$	A1	
9(b)	$\overrightarrow{AC} = 2\mathbf{b} - \mathbf{a}$	B1	
9(c)	$\overrightarrow{AY} = -\mathbf{a} + h\left(\frac{\mathbf{a}}{4} + \frac{3}{4}\mathbf{b}\right)$	B1	**FT** on *their* $\overrightarrow{OX}$
9(d)	$-\mathbf{a} + h\left(\frac{\mathbf{a}}{4} + \frac{3}{4}\mathbf{b}\right) = m(2\mathbf{b} - \mathbf{a})$	M1	For equating appropriate vectors and attempt to equate like vectors
	$-1 + \frac{h}{4} = -m$	A1	**FT** from *their* $\overrightarrow{AY}$ and $\overrightarrow{AC}$
	$\frac{3h}{4} = 2m$	A1	**FT** from *their* $\overrightarrow{AY}$ and $\overrightarrow{AC}$
	$h = \frac{8}{5},\ m = \frac{3}{5}$	A1	For both
10(a)	$\frac{3x + 10 + 2(x+1)}{(x+1)(3x+10)} = \frac{3x + 10 + 2x + 2}{(x+1)(3x+10)}$ $= \frac{5x + 12}{3x^2 + 13x + 10}$	B1	For expansion and simplification to obtain given answer

Question	Answer	Marks	Guidance
10(b)	$P\left(0,\ \frac{6}{5}\right)$ and $Q\left(-\frac{6}{5},\ 0\right)$ oe	**B1**	
	Area of triangle = $\frac{18}{25}$ or 0.72	**B1**	
	Area under curve = $\int_0^2 \frac{1}{x+1}+\frac{2}{3x+10}\ \mathrm{d}x$	**M1**	For use of part **(a)** and attempt to integrate to obtain at least one ln term.
	$=\left[\ln(x+1)+\frac{2}{3}\ln(3x+10)\right]_0^2$	**2**	**B1** For $\ln(x+1)$ **B1** For $\frac{2}{3}\ln(3x+10)$
	$=\ln 3+\frac{2}{3}\ln 16-\frac{2}{3}\ln 10$	**M1**	For correct use of limits. Dep on previous M mark.
	$=\frac{2}{3}\ln 3\sqrt{3}+\frac{2}{3}\ln 16-\frac{2}{3}\ln 10$	**M1**	For use of $\ln 3=\frac{2}{3}\ln 3\sqrt{3}$
	$=\frac{2}{3}\ln 3\sqrt{3}+\frac{2}{3}\ln\left(\frac{16}{10}\right)=\frac{2}{3}\ln\left(\frac{48\sqrt{3}}{10}\right)$	**M1**	For use of multiplication and division rule
	Total area = $\frac{18}{25}+\frac{2}{3}\ln\left(\frac{24\sqrt{3}}{5}\right)$ oe	**A1**	For correct answer in the required form dep on the three preceding M marks Must not be obtained using a calculator
11(a)	$2\cos x=3\frac{\sin x}{\cos x}\ \Rightarrow 2\cos^2 x=3\sin x$	**M1**	For use of $\tan x=\frac{\sin x}{\cos x}$ and multiplying by $\cos x$
	$2\left(1-\sin^2 x\right)=3\sin x$	**M1**	For use of correct identity
	$2\sin^2 x+3\sin x-2=0$	**A1**	For correct rearrangement to obtain the given answer
	Alternative $2\sin^2 x+3\sin x-2$ $=2\left(1-\cos^2 x\right)+3\sin x-2$	**(M1)**	For use of correct identity
	$=-2\cos x\cos x+3\sin x$ $=-3\tan x\cos x+3\sin x$	**(M1)**	For use of $2\cos x=3\tan x$
	$-3\sin x+3\sin x=0$	**(A1)**	For use of $\tan x\cos x=\sin x$ and answer 0

Question	Answer	Marks	Guidance
11(b)	$\sin\left(2\alpha+\frac{\pi}{4}\right)=\frac{1}{2}$ only	**B1**	For solution of quadratic from **(a)** to obtain $\sin\left(2\alpha+\frac{\pi}{4}\right)=\frac{1}{2}$ only
	$2\alpha+\frac{\pi}{4}=\frac{\pi}{6}, \frac{5\pi}{6}, \frac{13\pi}{6}$ $2\alpha=\frac{7\pi}{12}, \frac{23\pi}{12}$	**M1**	For correct order of operations in attempt to solve $\sin\left(2\alpha+\frac{\pi}{4}\right)=\frac{1}{2}$, may be implied by one correct solution
	$\alpha=\frac{7\pi}{24}$	**A1**	
	$\alpha=\frac{23\pi}{24}$	**A1**	

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ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **May/June 2020**

MARK SCHEME

Maximum Mark: 80

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

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Abbreviations

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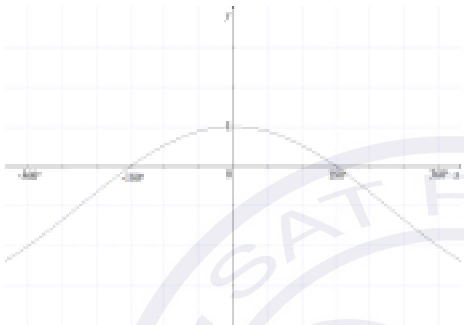
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1(a)	$y = -\frac{1}{2}(x+2)(x+1)(x-5)$	**B1**	For $-\frac{1}{2}$
		B1	For $(x+2)(x+1)(x-5)$
1(b)	$-2 \leqslant x \leqslant -1$	**B1**	
	$x \geqslant 5$	**B1**	
2(a)	1080°	**B1**	
2(b)		**B1**	For correct shape and symmetry about the *y*-axis
		B1	For correct *x*-intercepts
		B1	For correct *y*-intercept
3	$\frac{dr}{dt} = 5$	**B1**	
	$\frac{dA}{dr} = 2\pi r$	**B1**	
	$\frac{dA}{dt} = \frac{dA}{dr} \times \frac{dr}{dt}$ leading to $\frac{dA}{dt} = 10\pi r$	**M1**	Use of the chain rule, may be implied by $5 \times 6\pi$
	$\frac{dA}{dt} = 30\pi$	**A1**	

Question	Answer	Marks	Partial Marks
4	$x=\dfrac{-\left(4-2\sqrt{7}\right)+\sqrt{\left(4-2\sqrt{7}\right)^2-4\left(5+4\sqrt{7}\right)(-1)}}{2\left(5+4\sqrt{7}\right)}$	**M1**	For correct use of quadratic formula, allow inclusion of $\pm$ until final answer
	$x=\dfrac{-\left(4-2\sqrt{7}\right)+\sqrt{16+28-16\sqrt{7}+20+16\sqrt{7}}}{2\left(5+4\sqrt{7}\right)}$ $x=\dfrac{-\left(4-2\sqrt{7}\right)+8}{2\left(5+4\sqrt{7}\right)}$	**M1**	For attempt to simplify discriminant, must see attempt at expansion and subsequent simplification
	$x=\dfrac{4+2\sqrt{7}}{2\left(5+4\sqrt{7}\right)}$ or $x=\dfrac{2+\sqrt{7}}{\left(5+4\sqrt{7}\right)}$	**A1**	For either
	$x=\dfrac{2+\sqrt{7}}{\left(5+4\sqrt{7}\right)}\times\dfrac{5-4\sqrt{7}}{5-4\sqrt{7}}$ $x=\dfrac{10+5\sqrt{7}-8\sqrt{7}-28}{25-112}$	**M1**	For attempt to rationalise, must see attempt at expansion and subsequent simplification
	$x=\dfrac{6}{29}+\dfrac{\sqrt{7}}{29}$	**A1**	
5	$\dfrac{dy}{dx}=\dfrac{(x+2)\dfrac{6x}{3x^2-1}-\ln\left(3x^2-1\right)}{(x+2)^2}$	**B1**	B1 for $\dfrac{6x}{3x^2-1}$
		M1	For attempt to differentiate a quotient or an equivalent product, must have correct order of terms and correct sign
		A1	
	When $x=1$, $y=\dfrac{\ln 2}{3}$ or $0.231(0)$	**B1**	
	When $x=1$, $\dfrac{dy}{dx}=0.92298$, allow 0.923	**B1**	
	$y=0.923x-0.692$	**B1**	
6(a)	$x(5x+6)=8$ $5x^2+6x-8=0$	**M1**	For attempt to equate and obtain a 3-term quadratic in either x or y
	$\left(\dfrac{4}{5},\ 10\right)$	**A1**	Allow A1 if only x-coordinates or only y-coordinates are given
	(–2, –4)	**A1**	

Question	Answer	Marks	Partial Marks
6(b)	Midpoint $\left(-\frac{3}{5},\ 3\right)$	**B1**	
	Gradient 5	**B1**	
	$y-3=-\frac{1}{5}\left(x+\frac{3}{5}\right)$	**M1**	Attempt at perp bisector using *their* midpoint and perp gradient
	$x-3=-\frac{1}{5}\left(x+\frac{3}{5}\right)$	**M1**	For use of $y=x$ and attempt to solve
	$\left(\frac{12}{5},\ \frac{12}{5}\right)$	**A1**	
7(a)	0.8	**B1**	
7(b)	Sector area = $\frac{1}{2}12^2(0.8)$ 57.6	**B1**	Allow unsimplified
	$\tan 0.4=\frac{AM}{12}$ $AM=12\tan 0.4$ 5.074	**M1**	Attempt at AM using *their* $\frac{\theta}{2}$ Allow unsimplified
	Area of triangle $=\frac{1}{2}(5.074\times 2)\times 2\times 12$ 60.88	**M1**	Area of triangle using *their AM*, allow unsimplified
	Shaded area 3.28	**A1**	
7(c)	$\sin 0.4=\frac{AM}{OA}$ $OA=\frac{5.074}{\sin 0.4}$ 13.03	**M1**	Attempt to find OA using *their* $\frac{\theta}{2}$ and *their AM*
	Perimeter $=2(1.03)+9.6+2(5.074)$	**M1**	Allow if using *their* $\frac{\theta}{2}$ and *their CM*
	Perimeter = 21.8	**A1**	
8(a)	$\frac{3(2x+3)+3(2x-3)}{4x^2-9}$	**M1**	Must see for M1
	$\frac{12x}{4x^2-9}$	**A1**	

Question	Answer	Marks	Partial Marks
8(b)	$\int \frac{3}{2x-3}+\frac{3}{2x+3}\ \mathrm{d}x$ $=\frac{3}{2}\ln(2x-3)+\frac{3}{2}\ln(2x+3)$	**B2**	B1 for each correct term, having made use of (a)
	$\frac{3}{2}\ln\left(4x^2-9\right)+c$ or $\frac{3}{2}\ln\left((2x-3)(2x+3)\right)+c$ or $\ln\left(4x^2-9\right)^{\frac{3}{2}}+c$	**B1**	
8(c)	$\ln\left(4a^2-9\right)^{\frac{3}{2}}-\ln 7^{\frac{3}{2}}=\ln 5^{\frac{3}{2}}$	**M1**	For correct application of limits, allow equivalent forms
	$4a^2-9=35$	**A1**	For a correct method of dealing with logarithms and eliminating them
	$a=\sqrt{11}$	**M1**	For solving a quadratic equation, dep on first M mark
		A1	
9(a)	Second term: $a+d=-14$	**B1**	
	Sum: $4=a+10d$	**B1**	
	$d=2$	**B1**	
	$a=-16$	**B1**	
	Last term = 24	**B1**	Ft on *their d* and *their a*
9(b)(i)	$ar=27p^2$ $ar^4=p^5$	**B1**	For both equations
	$r=\frac{p}{3}$	**B1**	
9(b)(ii)	$a=81p$	**M1**	M1 for attempt to find a in terms of p
		A1	
	$S_\infty=\frac{81p}{1-\frac{p}{3}}$ or $\frac{243p}{3-p}$	**B1**	Follow through on *their a* and *their r*

Question	Answer	Marks	Partial Marks
9(b)(iii)	$81 = \dfrac{81p}{1-\dfrac{p}{3}}$ or $81 = \dfrac{243p}{3-p}$	**M1**	For attempt to solve using *their* answer to (ii) as far as $p = \ldots$
	$p = \dfrac{3}{4}$	**A1**	
10(a)(i)	$\dfrac{(\sec\theta+1)-(\sec\theta-1)}{\sec^2\theta-1}$	**M1**	For dealing with the fractions
	$\dfrac{2}{\tan^2\theta}$	**M1**	For use of the correct identity
	$2\cot^2\theta$	**A1**	A1 for given answer, must see $\dfrac{8}{\tan^2\theta}$ first
10(a)(ii)	$2\cot^2 2x = 6$ $\tan 2x = \pm\dfrac{1}{\sqrt{3}}$	**M1**	M1 for use of (i) and attempt to simplify
		A1	
		M1	M1 for attempt to solve, may be implied by one correct solution
	$2x = -150^\circ,\ -30^\circ,\ 30^\circ,\ 150^\circ$ $x = -75^\circ,\ -15^\circ,\ 15^\circ,\ 75^\circ$	**A2**	A1 for each pair of correct solutions
10(b)	$\sin\left(y+\dfrac{\pi}{3}\right) = \dfrac{1}{2}$	**M1**	For dealing with cosec and an attempt to solve
	$y + \dfrac{\pi}{3} = \dfrac{5\pi}{6},\ \dfrac{13\pi}{6}$	**M1**	M1 for a complete method of solution, may be implied by a correct solution
	$y = \dfrac{\pi}{2}$	**A1**	
	$y = \dfrac{11\pi}{6}$	**A1**	

Question	Answer	Marks	Partial Marks
11	$\frac{dy}{dx} = \frac{5}{2}\sin 2x(+c)$	M1	M1 for $k\sin 2x$
		A1	Condone omission of c
	$\frac{3}{4} = \frac{5}{2}\sin\left(-\frac{\pi}{6}\right) + c$	M1	Dep on first M1 for attempt to find c
	$c = 2$	A1	
	$y = -\frac{5}{4}\cos 2x + 2x(+d)$	M1	M1 for attempt to integrate *their* $\frac{dy}{dx}$
		A1	Condone omission of d
	$\frac{5\pi}{4} = -\frac{5}{4}\cos\left(-\frac{\pi}{6}\right) - \frac{\pi}{6} + d$	M1	Dep on previous M1 for attempt to find d
	$d = \frac{17\pi}{12} + \frac{5\sqrt{3}}{8}$ $y = -\frac{5}{4}\cos 2x + 2x + \frac{17\pi}{12} + \frac{5\sqrt{3}}{8}$ or $y = -\frac{5}{4}\cos 2x + 2x + 5.53$	A1	Must have the equation for A1

Cambridge Assessment International Education

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ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2020**

MARK SCHEME

Maximum Mark: 80

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

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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.

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- 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.

Maths-Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
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4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
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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.

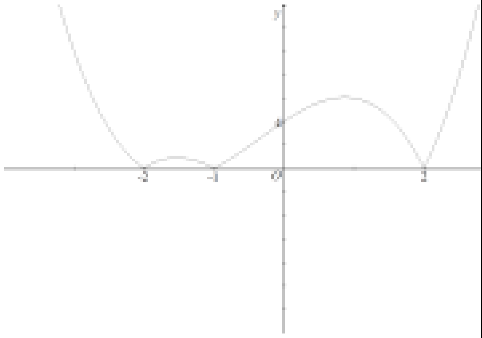
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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

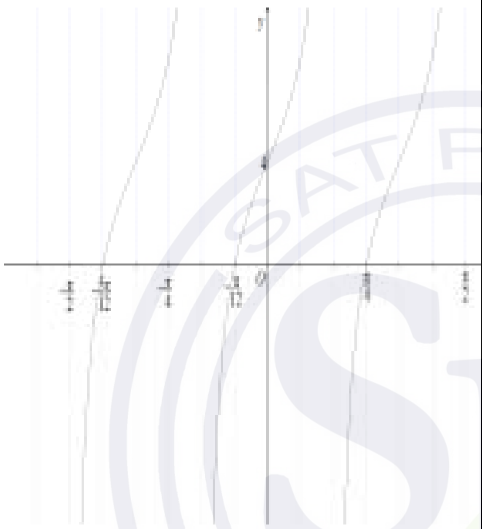
Question	Answer	Marks	Partial Marks
1		**B1**	Shape
		B1	Correct x-coordinates
		B1	Correct y-coordinate and max in first quadrant
2	$\frac{dr}{dt} = 0.5$	**B1**	
	$\frac{dV}{dr} = 4\pi r^2$	**B1**	
	$\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt}$ $\frac{dV}{dt} = \pi r^2$	**M1**	For attempt to use a correct form of the chain rule
	When $r = \frac{1}{4}$, $\frac{dV}{dt} = 0.125\pi$	**A1**	
3(a)	$4096 - 384x + 15x^2$	**B1**	For 4096
		B1	For $-384x$
		B1	For $15x^2$
3(b)	$(4096 - 384x + 15x^2)\left(x^2 - 2 + \frac{1}{x^2}\right)$	**B1**	For $\left(x^2 - 2 + \frac{1}{x^2}\right)$
	Term independent of x: $-2(4096) + 15$	**M1**	For use of 2 appropriate terms
	–8177	**A1**	
4(a)(i)	720	**B1**	
4(a)(ii)	600	**B1**	**FT** on *their* (i) $\times \frac{5}{6}$

Question	Answer	Marks	Partial Marks
4(a)(iii)	Starting with 8: $1\times4\times3\times2\times1=24$	B1	
	Starting with 3, 5 or 7: $3\times4\times3\times2\times2=144$	M1	May be considering each case separately, need all three cases for M1
		A1	
	Total = 168	A1	
4(a)(iii)	**Alternative** Plan for adding numbers ending in 2 and numbers ending in 8	M1	
	Ending in 2: $\left(\frac{1}{6}\times720\right)\times\frac{4}{5}=96$	B1	Allow unsimplified
	Ending in 8: $\left(\frac{1}{6}\times720\right)\times\frac{3}{5}=72$	B1	Allow unsimplified
	Total = 168	A1	
4(b)	${}^nC_3=6\,{}^nC_2$	B1	$\frac{n(n-1)(n-2)}{3!}$
	$\frac{n(n-1)(n-2)}{3!}=\frac{6n(n-1)}{2!}$	B1	$\frac{6n(n-1)}{2!}$
	$n(n-1)\left[(n-2)-18\right]=0$	M1	Valid attempt to solve, must have at least one previous B mark
	$n=20$	A1	
4(b)	**Alternative** ${}^nC_3=6\,{}^nC_2$ $(n-2)!2!=(n-3)!3!$	B1	For dealing with $(n-2)!$ and $(n-3)!$ to obtain $(n-2)$
	$(n-2)=6\times3$	B1	For dealing with 2! and 3! To obtain 6
	$n=20$	M1	Valid attempt to solve, must have at least one previous B mark
		A1	
5(a)	$f>9$	B1	Allow y but not x
5(b)	It is a one-one function because of the restricted domain	B1	

Question	Answer	Marks	Partial Marks
5(c)	$x=(2y+3)^2$ or equivalent	M1	For a correct attempt to find the inverse
	$y=\frac{\sqrt{x}-3}{2}$	M1	For correct rearrangement
	$f^{-1}=\frac{\sqrt{x}-3}{2}$	A1	Must have correct notation
5(d)	$x>9$	B1	**FT** on *their* (a)
5(e)	$f(\ln(x+4))=49$	M1	For correct order
	$(2\ln(x+4)+3)^2=49$ $\ln(x+4)=2$	M1	For correct attempt to solve, dep on previous M mark, as far as $x=$
	$x=e^2-4$	A1	
6(a)	$A\left(-\frac{5}{2},\ 0\right)$	B1	
	$x(-5-2x)+3=0$ $2x^2+5x-3=0$ $(2x-1)(x+3)=0$	M1	For attempt to eliminate one variable, obtain a 3-term quadratic equation = 0 and attempt to solve
	$B\left(\frac{1}{2},\ -6\right)$	A1	Allow A1 if just the x-coordinates or just the y-coordinates are given
6(b)	Area of triangle $=\frac{1}{2}\left(\frac{5}{2}+\frac{1}{2}\right)\times 6$, $=9$	M1	For attempt at triangle using *their* values
	$\int_{\frac{1}{2}}^{1}-\frac{3}{x}dx=\left[-3\ln x\right]_{\frac{1}{2}}^{1}$	M1	For attempt to integrate, must have ln
	$=3\ln\frac{1}{2}$	M1	correct application of limits, dep on previous M mark
	$=-3\ln 2$	M1	realisation that value of integral is negative and making the adjustment
		M1	application of log law, dep on previous M mark
	Area = 9 + ln8	A1	

Question	Answer	Marks	Partial Marks
7(a)	$\frac{dy}{dx} = (x^2-1)\frac{5}{2}(5x+2)^{-\frac{1}{2}} + 2x(5x+2)^{\frac{1}{2}}$	**B1**	For $\frac{5}{2}(5x+2)^{-\frac{1}{2}}$
		M1	For differentiation of a product
		A1	
	$\frac{dy}{dx} = \frac{(5x+2)^{-\frac{1}{2}}}{2}\left(5(x^2-1)+4x(5x+2)\right)$ or equivalent	**M1**	Dep on previous M mark for attempt to simplify
	$\frac{dy}{dx} = \frac{25x^2+8x-5}{2\sqrt{5x+2}}$	**A1**	
7(b)	$25x^2+8x-5=0$	**M1**	Equating their numerator in (a) to zero and attempt to solve
	$x = 0.315$	**A1**	
	$y = -1.70$	**A1**	
7(c)	Consideration of gradient or y values either side of stationary point, remembering that $x > 0$.	**M1**	Must be a complete method making use of *their* (a). Allow consideration of $25x^2+8x-5$ as a 'minimum curve'. Accept 2nd derivative method.
	Minimum	**A1**	
8(a)	$\mathbf{b}-\mathbf{a}$	**B1**	
8(b)	$\frac{1}{4}\mathbf{a}+\frac{1}{2}(\mathbf{b}-\mathbf{a})$ or $-\frac{3}{4}\mathbf{a}+\frac{1}{2}(\mathbf{a}+\mathbf{b})$	**B1**	For $\frac{1}{4}\mathbf{a}$ or $-\frac{3}{4}\mathbf{a}$
		B1	For $\frac{1}{2}(\mathbf{b}-\mathbf{a})$ or $\frac{1}{2}(\mathbf{a}+\mathbf{b})$
	$\frac{1}{2}\mathbf{b}-\frac{1}{4}\mathbf{a}$	**B1**	Correct and simplified
8(c)	$n\left(\frac{1}{2}\mathbf{b}-\frac{1}{4}\mathbf{a}\right)$	**B1**	**FT** on *their* answer to (b)
8(d)	$\frac{1}{2}(\mathbf{b}-\mathbf{a})+k\mathbf{b}$	**M1**	For use of *their* (a) and $k\mathbf{b}$
		A1	

Question	Answer	Marks	Partial Marks
8(e)	$\frac{1}{2}(\mathbf{b}-\mathbf{a})+k\mathbf{b}=n\left(\frac{1}{2}\mathbf{b}-\frac{1}{4}\mathbf{a}\right)$ $-\frac{1}{2}=-\frac{n}{4}$ $\frac{1}{2}+k=\frac{n}{2}$	**M1**	For equating *their* (c) and (d) and then equating like vectors to obtain 2 equations
	$n=2$	**A1**	
	$k=\frac{1}{2}$	**A1**	
9(a)(i)	$v=20\cos 2t$ when $t=\pi$, $v=20$	**B1**	
9(a)(ii)	$20\cos 2t=0$	**M1**	Equating *their* (i) to zero, must be a cosine and attempt to solve
	$t=\frac{\pi}{4}$	**A1**	
9(a)(iii)	$a=-40\sin 2t$	**M1**	Attempt to differentiate *their v*, dep on previous M mark, and use *their* value for (ii)
	–40	**A1**	
9(b)(i)	35	**B1**	
9(b)(ii)	$112.5=\frac{1}{2}(35+x)\times 5$	**M1**	Use of area under appropriate part of the graph
		A1	
	$x=10$	**A1**	
9(b)(iii)	$\frac{25}{5}=\frac{10}{t'}$	**M1**	Using a ratio method or otherwise, find extra time to stop = 2s or equivalent
	$t'=2$	**A1**	
	27	**A1**	

Question	Answer	Marks	Partial Marks
10(a)	$3x = -\frac{5\pi}{4} - \frac{\pi}{4}, \frac{3\pi}{4}$	**M1**	For a correct attempt to solve, may be implied by one correct solution
	$x = -\frac{\pi}{12}$	**A1**	
	$x = \frac{\pi}{4}$	**A1**	
	$x = -\frac{5\pi}{12}$	**A1**	
10(b)		**B1**	Shape – must have three 'parts' with asymptotes
		B1	For correct x-coordinates
		B1	For correct y-coordinate

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ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2020**

MARK SCHEME

Maximum Mark: 80

Published

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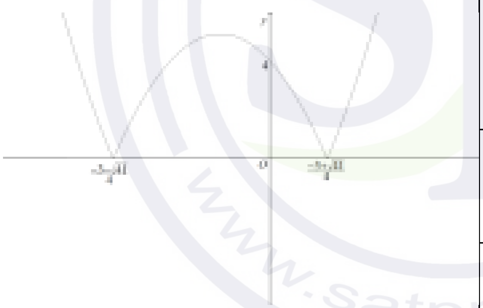
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1(a)	$\mathrm{f} > 3$	**B1**	Allow y but not x
	$\mathrm{g} \in \mathbb{R}$	**B1**	Allow y but not x
1(b)	$\ln(x-3)$	**B1**	
	$\ln(x-3)=9$ $x-3=\mathrm{e}^9$	**M1**	For attempt to equate to 9 and solve, must get rid of ln
	$x=\mathrm{e}^9+3$	**A1**	
1(c)	$9(9x-5)-5=112$	**M1**	For correct order of operation
	$x=2$	**A1**	
2(a)	Either $2\log_4 y=\log_2 y$ Or $\log_2 x=2\log_4 x$	**B1**	
	Either $\log_2 x+\log_2 y=8$ leading to $\log_2 xy=8$ Or $2\log_4 x+2\log_4 y=8$ leading to $\log_4 xy=4$	**M1**	For use of log law
	$xy=256$	**A1**	
2(b)	$2y^2-3y+1=0$	**B1**	
	$y=\frac{1}{2},\ 1$	**M1**	For attempt to solve for y
	$x=-1$	**A1**	
	$x=0$	**A1**	
3(a)	$v=(2t+1)^{\frac{1}{2}}(+c)$	**B1**	For $v=(2t+1)^{\frac{1}{2}}$ condone absence of c
	$8=1+c,\quad c=7$	**M1**	For attempt to find c must have $k(2t+1)^{\frac{1}{2}}$
	$v=(2t+1)^{\frac{1}{2}}+7$	**A1**	

Question	Answer	Marks	Partial Marks
3(b)	$s=\frac{1}{3}(2t+1)^{\frac{3}{2}}+7t(+d)$	**B1**	For $\frac{1}{3}(2t+1)^{\frac{3}{2}}$
		M1	For attempt to integrate *their* answer to (a), must have $k(2t+1)^{\frac{1}{2}}$ in (a)
	$4=\frac{1}{3}+d$, $d=\frac{11}{3}$	**M1**	Attempt to find d
	$s=\frac{1}{3}(2t+1)^{\frac{3}{2}}+7t+\frac{11}{3}$	**A1**	
4(a)	$2\left(x+\frac{3}{4}\right)^2-\frac{41}{8}$	**B3**	**B1** for 2 **B1** for $\frac{3}{4}$ **B1** for $-\frac{41}{8}$
4(b)	$\left(-\frac{3}{4},\ -\frac{41}{8}\right)$	**B2**	**B1** for $-\frac{3}{4}$ or **FT** on *their* $-b$ **B1** for $-\frac{41}{8}$ or **FT** on *their* c
4(c)		**B1**	For shape with max in 2nd quadrant
		B1	For x-intercepts $\frac{-3\pm\sqrt{41}}{4}$
		B1	For y-intercept of 4 and cusps
4(d)	$\frac{41}{8}$	**B1**	**FT** on *their c*

Question	Answer	Marks	Partial Marks
5(a)	p(3): $162+9a+36+b=11$ p(−1): $-6+a-12+b=-21$	M1	For attempt at $\mathrm{p}(3)$ and $\mathrm{p}(-1)$
	$9a+b+187=0$ $a+b+3=0$	A1	for both, may be implied by correct work later
	$a=-23,\quad b=20$	M1	attempt to solve simultaneous equations
		A1	For both
	$\mathrm{p}(x)=(x-2)(6x^2-11x-10)$	M1	For attempt to factorise or use algebraic long division
		A1	For $(6x^2-11x-10)$
5(b)	$\mathrm{p}(x)=(x-2)(3x+2)(2x-5)$	M1	For attempt to factorise or use quadratic formula – must be seen
	$2,\ -\frac{2}{3},\ \frac{5}{2}$	A1	For all three solutions
6(a)	$\frac{1}{13}\begin{pmatrix}5\\-12\end{pmatrix}$	B1	
6(b)	$4-2k=-10r$ $1+3k=5r$	M1	equating like vectors to obtain 2 equations
	$r=-\frac{7}{10},\ k=-\frac{3}{2}$	M1	Dep on previous M mark, for attempt to solve simultaneously
		A1	
6(c)(i)	$3\mathbf{q}-2\mathbf{p}$	B1	
6(c)(ii)	$9\mathbf{q}-6\mathbf{p}$	B1	
6(c)(iii)	A common point of *A* and the same direction vector	B1	
6(c)(iv)	1:2	B1	
7(a)	$\frac{1}{2}\times10^2\times\theta=35$ so $\theta=0.7$	B1	

Question	Answer	Marks	Partial Marks
7(b)	Arc length *CD*: 7	**B1**	
	$\sin(0.35) = \frac{AB/2}{12}$	**M1**	For a complete method to find *AB*, could be using cosine rule
	$AB = 8.23(0)$	**A1**	
	Perimeter = $7 + 4 + 8.23 = 19.2$	**A1**	
7(c)	Area of triangle $= \frac{1}{2}12^2 \sin 0.7$	**M1**	For complete attempt at triangle area, may use equivalent method
	Area of triangle $= 46.4$	**A1**	
	Shaded area $= 11.4$	**A1**	Follow through on *their* area of the triangle
8(a)	$\frac{n}{2}\left(14 + (n-1)0.4\right)$	**B1**	
	$\frac{n}{2}\left(14 + (n-1)0.4\right) > 300$ $0.4n^2 + 13.6n - 600 > 0$	**M1**	Attempt to form a 3 term inequality and find the positive critical value
	Positive critical value 25.29	**A1**	
	26 terms	**A1**	
8(b)	$a + ar = 9$	**B1**	
	$\frac{a}{1-r} = 36$	**B1**	
	$36(1+r)(1-r) = 9$	**M1**	attempt at solution of simultaneous equations
	$r = \frac{\sqrt{3}}{2}$	**A1**	

Question	Answer	Marks	Partial Marks
9	$x(5x-3)=2$ $5x^2-3x-2=0$	M1	attempt at a 3-term quadratic equation in one variable with solution
	$x=1$, $x=-\frac{2}{5}$	A1	Allow if $x=-\frac{2}{5}$ not seen
	$A\ (1,\ 2)$	A1	
	$B\ \left(\frac{3}{5},\ 0\right)$	B1	
	Area of triangle $=\frac{2}{5}$	M1	Using *their* A and B
	Area under curve: $\int_1^3 \frac{2}{x}\,dx=[2\ln x]_1^3$	B1	For $[2\ln x]_1^3$
	$=2\ln 3$	M1	For use of limits
	Total area $=\frac{2}{5}+\ln 9$	A1	
10(a)	$\frac{dy}{dx}=\frac{1}{2}x(x+2)^{-\frac{1}{2}}+(x+2)^{\frac{1}{2}}$	B1	For $\frac{1}{2}(x+2)^{-\frac{1}{2}}$
		M1	For differentiation of a product
		A1	
	$\frac{dy}{dx}=\frac{1}{2}(x+2)^{-\frac{1}{2}}[x+2(x+2)]$	M1	For attempt to simplify
	$\frac{dy}{dx}=\frac{3x+4}{2\sqrt{x+2}}$	A1	
10(b)	$3x+4=0$	M1	For setting *their* numerator in (a) to zero and attempt to solve
	$x=-\frac{4}{3}$	A1	
	$y=-\frac{4\sqrt{6}}{9}$ oe	A1	
10(c)	Using the gradient method or inspection of y-coordinates either side of stationary point. Allow use of second derivative	M1	complete method
	Minimum	A1	Must be from correct work

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/12**

Paper 12 **March 2020**

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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- 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.

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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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- marks are not deducted for omissions
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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.

Maths-Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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.

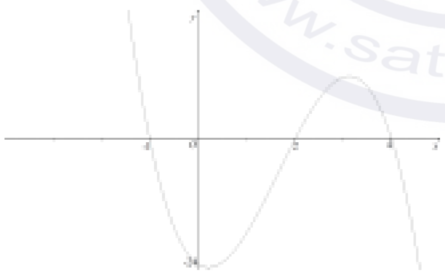
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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)		3	**B1** For correct shape with minimum point in the fourth quadrant and the maximum point in the first quadrant. Ends of the curve must be in the 2nd and 4th quadrants **B1** for correct x- intercepts $(-1,0)$, $(2,0)$, $(4,0)$ **B1** for correct y-intercept $(0,-24)$
1(b)	$x < -1$	**B1**	
	$2 < x < 4$	**B1**	

Question	Answer	Marks	Guidance
2	$2x^2+4x+k-1=kx+3$ $2x^2+(4-k)x+(k-4)=0$	2	**M1** for attempt to equate the line and curve and simplify to a 3 term quadratic equation = 0 **A1** for a correct equation, allow equivalent form
	$(4-k)^2=4\times2\times(k-4)$	M1	Use of discriminant in any form
	$k^2-16k+48=0$ $k=12,\ k=4$ Do not isw	2	Dep **M1** on previous M mark, for attempt to solve a quadratic equation in *k* **A1** for both
	Alternative 1		
	$2x^2+4x+k-1=kx+3$ $2x^2+(4-k)x+(k-4)=0$	**(2**	**M1** for attempt to equate the line and curve and simplify **A1** for a correct equation, allow equivalent form
	$k=4x+4$ $2\left(\frac{k-4}{4}\right)^2+(4-k)\left(\frac{k-4}{4}\right)+(k-4)=0$	**M1**	Equating gradients and substitution to obtain a quadratic equation in terms of *k*
	$k^2-16k+48=0$ $k=12$ and $k=4$ Do not isw	**2)**	Dep **M1** on previous M mark, for attempt to solve a quadratic equation in *k* **A1** for both
	Alternative 2		
	$2x^2+4x+k-1=kx+3$ $2x^2+(4-k)x+(k-4)=0$	**(2**	**M1** for attempt to equate the line and curve and simplify **A1** for a correct equation, allow equivalent form
	$k=4x+4$ $2x^2-4x=0$ $x=0,\ 2$	**M1**	Equating gradients and substitution to obtain a quadratic equation in terms of *x* and solution of this equation to obtain 2 *x* values
	$k=4x+4$ $k=12$ and $k=4$ Do not isw	**2)**	Dep **M1** on previous M mark, for substitution of their *x* values to obtain *k* values **A1** for both

Question	Answer	Marks	Guidance
3	$b = 243$	**B1**	Must be evaluated
	${}^5C_1 \times 3^4 \times (-a) = -81$	**M1**	Allow equivalent with no negative signs, allow sign error
	$a = \frac{1}{5}$ oe	**A1**	
	${}^5C_2 \times 3^3 \times (-a)^2$	**M1**	Allow with *their* a^2
	$c = \frac{54}{5}$ or 10.8 oe	**A1**	Must be from correct working
4	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{6x}{3x^2 - 4} - \frac{x^2}{2}$	**2**	**M1** for attempt to differentiate, must have at least one term correct **A1** All correct
	When $x = 2$, $\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{1}{2}$	**B1**	
	When $x = 2$, $y = \ln 8 - \frac{4}{3}$, or exact equivalent	**B1**	Allow $\ln 8 - \frac{8}{6}$
	Equation of tangent $y - \left(\ln 8 - \frac{4}{3}\right) = -\frac{1}{2}(x - 2)$ oe	**M1**	Dep on first M mark, allow unsimplified, allow use of decimals
	$\left(0,\ \ln 8 - \frac{1}{3}\right)$, or exact equivalent	**A1**	Allow $x = 0, y = \ln 8 - \frac{1}{3}$
5(a)	$\frac{1}{2}\left(5 - \sqrt{3}\right)\left(2 + 4\sqrt{3}\right)$ $\frac{1}{2}\left(10 - 2\sqrt{3} + 20\sqrt{3} - 12\right)$	**M1**	Need to see $\frac{1}{2}\left(10 - 18\sqrt{3} - 12\right)$ or $\left(5 - 9\sqrt{3} - 6\right)$ minimum for M1
	$9\sqrt{3} - 1$	**A1**	
5(b)	$\tan ABC = \frac{5 - \sqrt{3}}{1 + 2\sqrt{3}} \times \frac{1 - 2\sqrt{3}}{1 - 2\sqrt{3}}$ $= \frac{5 - \sqrt{3} - 10\sqrt{3} + 6}{1 - 12}$	**M1**	Attempt at trig ratio and attempt to rationalise. Need to see $5 - 11\sqrt{3} + 6$ in the numerator as a minimum for M1 Allow one error only
	$= \sqrt{3} - 1$	**2**	**A1** for $\sqrt{3}$, **A1** for -1

Question	Answer	Marks	Guidance
5(c)	$\sec^2 ABC = \tan^2 ABC + 1$ $= \left(\sqrt{3}-1\right)^2 + 1$ oe	M1	Allow use of correct identity with *their* (b)
	$= 5 - 2\sqrt{3}$	A1	
	Alternative		
	$\sec^2 ABC = \left(\dfrac{\sqrt{\left(5-\sqrt{3}\right)^2 + \left(1+2\sqrt{3}\right)^2}}{1+2\sqrt{3}}\right)^2$ leads to $\dfrac{41-6\sqrt{3}}{13+4\sqrt{3}}$ leads to $\dfrac{533+72-242\sqrt{3}}{121}$	(M1	For a complete method using triangle *ABD*, with sufficient detail in the expansions and rationalisation
	$= 5 - 2\sqrt{3}$	A1)	
6(a)	Midpoint = $(2, 7)$	B1	
	Gradient of $AB = \dfrac{6}{8}$ oe	B1	
	Perp bisector: $y - 7 = -\dfrac{4}{3}(x-2)$	M1	Must be using a perp gradient and a mid-point
	$4x + 3y - 29 = 0$	A1	Allow in any order but must be equated to zero.
6(b)	3	B1	FT on *their* **(a)**
6(c)	Displacement vector $\overrightarrow{CM} = \begin{pmatrix} -3 \\ 4 \end{pmatrix}$	M1	Allow equivalent vectors or other methods. May be implied by one correct coordinate.
	$(-1, 11)$	A1	Allow $x = -1,\ y = 11$

Question	Answer	Marks	Guidance
7(a)	$\text{p}\left(-\frac{1}{2}\right): -\frac{a}{8}+\frac{3}{4}-\frac{b}{2}-12=0$ $\text{p}(3): 27a+27+3b-12=105$	M1	For attempt at an equation using either $\text{p}\left(-\frac{1}{2}\right)$ or $\text{p}(3)$
	$a+4b=-90$	A1	Allow equivalent with constants collected
	$9a+b=30$	A1	Allow equivalent with constants collected
	$a=6, b=-24$	2	**M1** for attempt to solve *their* equations, dep on first M mark **A1** for both
7(b)	$(2x+1)(3x^2-12)$	2	**B1** for $3x^2$ **B1** for -12 and no extra term in x
7(c)	$x=-\frac{1}{2}$	B1	
	$x=\pm 2$	B1	Dep on both B marks in part (b)
8(a)	$\begin{pmatrix}-20\\48\end{pmatrix}$	B1	
8(b)	$\begin{pmatrix}-20\\48\end{pmatrix}t$	B1	Follow through on *their* (a)
8(c)	$\begin{pmatrix}12\\8\end{pmatrix}+\begin{pmatrix}-25\\45\end{pmatrix}t$ oe	B1	
8(d)	$\begin{pmatrix}12\\8\end{pmatrix}+\begin{pmatrix}-5\\-3\end{pmatrix}t$ oe	B1	
8(e)	$\left\|\overrightarrow{PQ}\right\|^2=(12-5t)^2+(8-3t)^2$	M1	Attempt to find modulus of *their* (d) which must contain terms in t
	$\left\|\overrightarrow{PQ}\right\|=\sqrt{144-120t+25t^2+64-48t+9t^2}$ $PQ=\sqrt{34t^2-168t+208}$	A1	Must see correct expansion leading to given answer.

Question	Answer	Marks	Guidance
8(f)	$34t^2 - 168t + 204 = 0$	**M1**	For dealing with square root correctly and attempt to solve a 3 term quadratic equation
	2.15 only	**A1**	
9(a)(i)	360	**B1**	
9(a)(ii)	60	**B1**	**FT** on *their* (b)(i) divided by 6
9(a)(iii)	A complete plan for dealing with odd numbers and numbers greater than 7000, see below	**M1**	Must be considering each case
	Starts with 8 and ends with odd = 48	**B1**	
	Starts with 7 or 9 and ends with odd = 72	**B1**	
	120	**A1**	
	Alternative		
	Their answer to **(a)(i)** –odd numbers starting with 2–odd number starting with 3 or 5–all even numbers	**(M1**	Must be considering each case
	All even numbers =120 Odd and starting with 2 = 48 Odd and starting with 3 or 5 = 72	**2**	**B1** for 1 correct
	120	**A1)**	
9(b)	$\frac{n!}{(n-3)!3!} = 92n$	**B1**	
	$n(n-1)(n-2) = 552n$	**M1**	Attempt to simplify factorials
	$n(n^2 - 3n - 550) = 0$ $n(n-25)(n+22) = 0$	**M1**	Dep on previous M mark for expansion and simplification to a cubic or quadratic in *n* and attempt to solve
	$n = 25$	**A1**	For $n = 25$ only
10(a)	$\alpha + 45^\circ = 144.7^\circ,\ 324.7^\circ$ $\alpha = 99.7^\circ,\ 279.7^\circ$	**3**	**M1** for attempt to solve using a correct order of operations, may be implied by one correct solution **A1** for 1 correct solution **A1** for a second correct solution and no extras

Question	Answer	Marks	Guidance
10(b)(i)	$\dfrac{(\sin\theta+1)-(\sin\theta-1)}{\sin^2\theta-1}$	M1	For dealing with fractions
	$\dfrac{2}{-\cos^2\theta}$	M1	For simplification of numerator and use of the correct identity
	$-2\sec^2\theta$ $a=-2$	A1	Must see previous line for A1
10(b)(ii)	$-2\sec^2 3\phi=-8$ oe $\sec 3\phi=\pm 2$	M1	For making use of (i) and attempt to simplify in terms of 3ϕ
	$\cos 3\phi=\pm\dfrac{1}{2}$	A1	
	$3\phi=-\dfrac{2\pi}{3},\ -\dfrac{\pi}{3},\ \dfrac{\pi}{3},\ \dfrac{2\pi}{3}$ $\phi=-\dfrac{2\pi}{9},\ -\dfrac{\pi}{9},\ \dfrac{\pi}{9},\ \dfrac{2\pi}{9}$ or ± 0.349, ± 0.698,	3	Dep **M1** for attempt to solve, may be implied by one correct solution **A1** for each pair of correct solutions
11	$\left[\ln(2x+3)+\ln(3x-1)-\ln x\right]_1^a$	2	**B1** for 1 term correct **B1** all correct
	$\left(\ln(2a+3)+\ln(3a-1)-\ln a\right)$ $-(\ln 5+\ln 2)$	M1	Correct substitution of limits, dep on first B1, ignore equality Must have 3 terms involving x
	$\ln\dfrac{(2a+3)(3a-1)}{10a}=\ln 2.4$	M1	For use of both addition and subtraction rules, ignore equality Or for use of addition rule on each side of an equation.
	$6a^2-17a-3=0$	A1	
	$a=3$	2	**M1** for solution of their quadratic **A1** for $a=3$ only

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS | **0606/11**
Paper 1 | **October/November 2019**
MARK SCHEME
Maximum Mark: 80

Published

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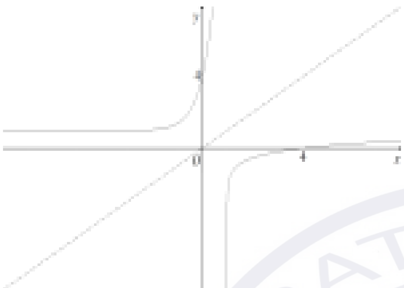
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1	$A' \cap B$ oe	**B1**	
	$(X \cap Y) \cup (X \cap Z)$ or $X \cap (Y \cup Z)$	**B1**	
2	$2x^2 + 3x + k = kx - 3$	**M1**	For an attempt to equate and simplify to a 3 term quadratic equation, allow an error in one term
	$2x^2 + (3-k)x + (k+3) = 0$	**A1**	
	$(3-k)^2 - 4 \times 2 \times (k+3)$	**M1**	For attempt to use the discriminant, allow previous error, leading to a quadratic equation in terms of k
	$k^2 - 14k - 15 = 0$ giving critical values of -1 and 15	**A1**	For critical values
	$-1 < k < 15$	**A1**	
3	Either $7^x \times 7^{2y}$ or $49^{\frac{x}{2}} \times 49^y$ or $5^{5x} \times 5^{2y}$ or $25^{\frac{5x}{2}} \times 25^y$	**M1**	For expressing the terms on the left hand side of either one of the 2 equations in terms of powers of 7, 49, 5 or 25
	$7^x \times 7^{2y} = 7^0$ or $49^{\frac{x}{2}} \times 49^y = 49^0$	**A1**	
	$5^{5x} \times 5^{2y} = 5^{-2}$ or $25^{\frac{5x}{2}} \times 25^y = 25^{-1}$	**A1**	
	leading to $x + 2y = 0$ and $5x + 2y = -2$	**M1**	For attempt to solve two linear equations, with integer coefficients and constants, in terms of x and y
	$x = -\frac{1}{2},\ y = \frac{1}{4}$	**A1**	
4(i)	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\ln\left(4x^2+1\right)\right) = \frac{8x}{4x^2+1}$	**B1**	
	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{(2x-3)\frac{8x}{(4x^2+1)} - 2\ln\left(4x^2+1\right)}{(2x-3)^2}$	**M1**	For attempt to differentiate a quotient
		A1	For all other terms, not including $\frac{8x}{4x^2+1}$, correct
4(ii)	When $x = 2$, $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{16}{17} - 2\ln 17$ $= -4.73$	**M1**	For attempt to find value of $\frac{\mathrm{d}y}{\mathrm{d}x}$ when $x = 2$ and multiply by h
	Change in $y = -4.73h$	**A1**	

Question	Answer	Marks	Guidance
5(i)	$f > 1$	**B1**	Must be using correct notation
	$g \in \mathbb{R}$	**B1**	Must be using correct notation
5(ii)	$g(0) = 1,\ g(1) = 2$ and attempt at $f(2)$	**M1**	For attempt at g^2 and correct order
	$f(2) = 164.8$ awrt 165	**A1**	
5(iii)		**B3**	**B1** for correct f and $(0,4)$, must be in first and second quadrant **B1** for correct f^{-1} and $(4,0)$, must be in first and fourth quadrant **B1** for $y = x$ and/or symmetry implied, by 'matching intercepts'. No intersection.
6	$\frac{dy}{dx} = k(8x+5)^{-\frac{1}{2}}$	**M1**	For attempt to differentiate, must be in the form $k(8x+5)^{-\frac{1}{2}}$
	$\frac{dy}{dx} = 4(8x+5)^{-\frac{1}{2}}$	**A1**	
	When $x = \frac{1}{2}$, $y = 3$	**B1**	
	Normal: $y - 3 = -\frac{3}{4}\left(x - \frac{1}{2}\right)$	**M1**	For attempt at the normal when $x = \frac{1}{2}$, using correct process for *their* $\frac{dy}{dx}$ and *their* y.
	$6x + 8y - 27 = 0$	**A1**	

Question	Answer	Marks	Guidance
7(i)	$\lg y = \lg A + x \lg b$	B1	For statement, may be implied by subsequent work
	Either $6 = \lg A + 3.4 \lg b$ or $3.6 = \lg A + 2.2 \lg b$	M1	For one correct equation
		M1	For another correct equation and attempt to solve simultaneously
	$\lg b = 2$, $b = 100$	A1	
	$\lg A = -0.8$, $A = 10^{-0.8}$ or 0.158	A1	
	Or Gradient = $\lg b = 2$	M1	equating gradient to $\lg b$ and attempt to evaluate
	$b = 100$	A1	Must be identified as b
	$6 = \lg A + 3.4 \lg b$ or $3.6 = \lg A + 2.2 \lg b$	M1	For a correct equation and attempt to find $\lg A$
	$\lg A = -0.8$, $A = 10^{-0.8}$ or 0.158	A1	Must be identified as A
7(ii)	$\lg 900 = -0.8 + 2x$ oe	M1	For correct use of $y = 900$
	$x = 1.88$	A1	
8(i)	$BC^2 = \left(7+\sqrt{5}\right)^2 + \left(7-\sqrt{5}\right)^2$ $= 49 + 14\sqrt{5} + 5 + 49 - 14\sqrt{5} + 5$ $= 108$	M1	For use of Pythagoras' theorem and attempt to expand and simplify
	$BC = 6\sqrt{3}$	A1	
	Perimeter $= 22 + 6\sqrt{5} + 6\sqrt{3}$	A1	

Question	Answer	Marks	Guidance
8(ii)	**Either** $\frac{1}{2}\left(4+3\sqrt{5}+11+2\sqrt{5}\right)\left(7+\sqrt{5}\right)$ $=\frac{1}{2}\left(15+5\sqrt{5}\right)\left(7+\sqrt{5}\right)$ $=\frac{1}{2}\left(105+35\sqrt{5}+15\sqrt{5}+25\right)$	**M1**	**Either** For a valid method and attempt to expand out and simplify
	Or $\left(4+3\sqrt{5}\right)\left(7+\sqrt{5}\right)+\frac{1}{2}\left(7+\sqrt{5}\right)\left(7-\sqrt{5}\right)$ $= 28 + 21\sqrt{5} + 4\sqrt{5} + 15 + \frac{1}{2}(49-5)$	**M1**	**Or** For a valid method and attempt to expand out and simplify
	Area = $65+25\sqrt{5}$	**A2**	**A1** for each term
9(i)	**Either** $15^2=10^2+10^2-200\cos AOB$ $\cos AOB=-0.125$	**M1**	For use of cosine rule
	$AOB=1.696$ so 1.70 to 2 dp	**A1**	Must have justification to 2 dp
	Or $\sin\left(\frac{AOB}{2}\right)=\frac{7.5}{10}$ $\frac{AOB}{2}=0.8481$	**M1**	For use of basic trig
	$AOB=1.696$ so 1.70 to 2 dp	**A1**	

Question	Answer	Marks	Guidance
9(ii)	Angle $DOC = \frac{\pi}{3}$	B1	
	Either $AOD = BOC = 0.5\left(2\pi - \frac{\pi}{3} - 1.696\right)$ $AOD = BOC = 1.77$	M1	For attempt to get *AOD* or *BOC*
	Arc lengths = 17.7	M1	For attempt at arc length using their previous answer
	Perimeter = $15 + 10 + (2 \times 17.7) = 60.4$	A1	
	Or Arc *AB* = 17 or Arc *CD* = $\frac{10\pi}{3}$	M1	For either arc length
	(20π – arc *AB* – arc *CD*)	M1	
	Perimeter = 60.4	A1	
9(iii)	**Either** Area of each sector = $\frac{1}{2}10^2(1.770)$	M1	For area of sector using their *BOC*
	Area of triangles = $\left(\frac{1}{2} \times 100 \times \sin\frac{\pi}{3}\right) + \left(\frac{1}{2} \times 100 \sin 1.70\right)$	M1	For area of one triangle using the sine rule oe
	Total area = $177 + 43.3 + 49.6$	M1	For plan
	Area = awrt 270	A1	
	Or Area of upper segment = $\frac{1}{2}10^2(1.696 - \sin 1.696)$	M1	For area of a sector or area of a triangle using the sine rule oe
	Area of lower segment = $\frac{1}{2}10^2\left(\frac{\pi}{3} - \sin\frac{\pi}{3}\right)$	M1	For whichever has not been obtained in previous part
	Shaded area = 100π – are of the 2 segments Area = $314.2 - 35.2 - 9.06$	M1	For plan
	Area = awrt 270	A1	

Question	Answer	Marks	Guidance
10	$1.5 = 2 + \cos 3x$ $\cos 3x = -0.5$	M1	For correct attempt to find points of intersection
	$3x = \frac{2\pi}{3},\ \frac{4\pi}{3}$	M1	For dealing with $3x$ correctly
	$x = \frac{2\pi}{9}$ or 40°	A1	
	$x = \frac{4\pi}{9}$ or 80°	A1	
	Either $\int_{\frac{2\pi}{9}}^{\frac{4\pi}{9}} 1.5 - (2 + \cos 3x)\ \mathrm{d}x$	M1	For subtraction method – condone omission of or incorrect limits
	$\left[-0.5x - k\sin 3x\right]_{\frac{2\pi}{9}}^{\frac{4\pi}{9}}$	M1	For attempt to integrate – condone omission of or incorrect limits
	$\left[-0.5x - \frac{1}{3}\sin 3x\right]_{\frac{2\pi}{9}}^{\frac{4\pi}{9}}$	A1	All correct – condone omission of or incorrect limits
	$\left(-\frac{2\pi}{9} + \frac{\sqrt{3}}{6}\right) - \left(-\frac{\pi}{9} - \frac{\sqrt{3}}{6}\right)$	M1	Dep for application of limits, must be in radians
	Area $= \frac{\sqrt{3}}{3} - \frac{\pi}{9}$	A1	
	Or $\left(1.5 \times \frac{2\pi}{9}\right)$	M1	For attempt at rectangle (must include subtraction subsequently)
	$\left[2x + k\sin 3x\right]_{\frac{2\pi}{9}}^{\frac{4\pi}{9}}$	M1	For attempt to integrate – condone omission of or incorrect limits
	$\left[2x + \frac{1}{3}\sin 3x\right]_{\frac{2\pi}{9}}^{\frac{4\pi}{9}}$	A1	All correct – condone omission of or incorrect limits
	$\left(\left(\frac{8\pi}{9} - \frac{\sqrt{3}}{6}\right) - \left(\frac{4\pi}{9} + \frac{\sqrt{3}}{6}\right)\right)$	M1	Dep for application of limits, must be in radians
	Area $= \frac{\sqrt{3}}{3} - \frac{\pi}{9}$	A1	

Question	Answer	Marks	Guidance
11(a)(i)	362 880	**B1**	
11(a)(ii)	$7! \times 2$	**B1**	For 7!
	10 080	**B1**	For $7! \times 2$ leading to 10080
11(a)(iii)	Total = $4! \times 4! \times 3! = 3456$	**B3**	**B1** for treating as 4 separate units 4! **B1** for either number of ways of arranging the maths books amongst themselves 4! or the number of ways of arranging the physics books amongst themselves 3!
11(b)(i)	18 564	**B1**	
11(b)(ii)	Total 3738	**B4**	**B1** 4 boys 3150 **B1** 5 boys 560 **B1** 6 boys 28
12	$\frac{dy}{dx} = k\cos\left(x + \frac{\pi}{3}\right) \quad + c$	**M1**	For attempt to integrate
	$\frac{dy}{dx} = -2\cos\left(x + \frac{\pi}{3}\right) \quad + c$	**A1**	All correct, condone omission of $+c$
	$5 = -2\cos\frac{2\pi}{3} + c$	**M1**	Dep for attempt to find c
	$\frac{dy}{dx} = -2\cos\left(x + \frac{\pi}{3}\right) + 4$	**A1**	
	$y = p\sin\left(x + \frac{\pi}{3}\right) \quad (+qx + d)$	**M1**	attempt to integrate a second time to obtain $y = p\sin\left(x + \frac{\pi}{3}\right)$
	$y = -2\sin\left(x + \frac{\pi}{3}\right) + 4x + d$	**A1**	All correct, condone omission of $+d$
	$\frac{5\pi}{3} = -2\sin\frac{2\pi}{3} + \frac{4\pi}{3} + d$	**M1**	Dep for attempt to find a second arbitrary constant
	$y = -2\sin\left(x + \frac{\pi}{3}\right) + 4x + \frac{\pi}{3} + \sqrt{3}$ or $y = -2\sin\left(x + \frac{\pi}{3}\right) + 4x + 2.78$	**A1**	

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/12**
Paper 1	**October/November 2019**
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 October/November 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **10** printed pages.

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.

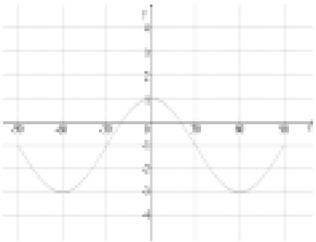
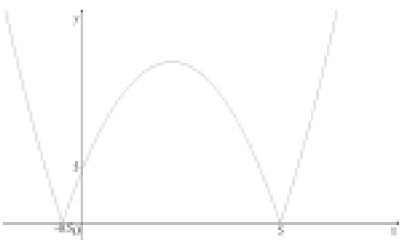
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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	Guidance
1(i)		**B3**	**B1** for y intercept $(0,1)$, must have a graph **B1** for starting and finishing at $(\pm 90, -1)$ **B1** for all correct, must be attempt at a curve passing through $(\pm 30, -1)$ and $(\pm 60, -3)$
1(ii)	2	**B1**	
1(iii)	120° or $\frac{2\pi}{3}$	**B1**	
2	$\lg y^2 = mx + c$	**B1**	May be implied by subsequent work
	Gradient $= -4 \quad (= m)$	**B1**	
	$c = 32$	**B1**	
	$y = 10^{their\ \frac{c}{2} + their\ \frac{mx}{2}}$	**M1**	Dep on first B1 Use of $\lg y^2 = 2\lg y$ and $10^{their\ \frac{c}{2} + their\ \frac{mx}{2}}$ Or use of $y^2 = 10^{(their\ c + their\ mx)}$ and $10^{their\ \frac{c}{2} + their\ \frac{mx}{2}}$
	$y = 10^{16-2x}$	**A1**	
3	$\left(1 - \frac{x}{7}\right)^{14} = 1 - 2x + \frac{13}{7}x^2$	**B2**	All terms correct or **B1** for 2 correct terms
	$(1-2x)^4 = 1 - 8x + 24x^2 \ldots$	**B2**	First three terms correct or **B1** for one incorrect term
	Product $= 1 - 10x + \frac{293}{7}x^2$	**M1**	For attempt to multiply out to obtain $(1) - 10x + mx^2$, $m \neq 16$
	$a = -10,\ b = \frac{293}{7}$	**A1**	For both, need to identify a and b
4(i)		**B4**	**B1** for shape, with max in first quadrant **B1** for $(-0.5, 0)$ and $(5, 0)$ **B1** for $(0, 5)$ **B1** all correct, with cusps and correct curvature for $x < 0.5$ and $x > 5$

Question	Answer	Marks	Guidance
4(ii)	$k = 0$	B1	Not from incorrect work
	Stationary point when $y = \pm\frac{121}{8}$ or ± 15.125	M1	For attempt to find y-coordinate of stationary point, must be a complete method i.e. Use of calculus Use of discriminant, Use of completing the square Use of symmetry Allow if seen in part (i), but must be used in (ii)
	$k > \frac{121}{8}$	A1	cao
5a(i)	fg	B1	
5a(ii)	g^{-1}	B1	
5a(iii)	f^{-1}	B1	
5a(iv)	g^2	B1	
5(b)(i)	Undefined at $x = 0$ oe	B1	
5(b)(ii)	$4 = a + b$ $h'(x) = \frac{p}{x^3}$ and attempt at $h'(1)$	M1	For attempt at $h(1)$ and differentiation to obtain $h'(1)$, must have the form $h'(x) = \frac{p}{x^3}$ oe
	$b = -8$ $a = 12$	A1	For both
6(a)	$p^{\frac{7}{2}}q^{\frac{5}{3}}r^{-\frac{7}{3}}$	B3	**B1** for each term or for each of $a = \frac{7}{2}$, $b = \frac{5}{3}$, $c = -\frac{7}{3}$

Question	Answer	Marks	Guidance
6(b)	**Either** $\log_7 x + \frac{2}{\log_7 x} = 3$	M1	For change of base.
	$(\log_7 x)^2 - 3\log_7 x + 2 = 0$ $\log_7 x = 1, \quad \log_7 x = 2$	M1	Dep for forming a 3 term quadratic equation in $\log_7 x$ and a correct attempt to solve
	$x = 7, \quad x = 49$	M1	Dep on both previous M marks for dealing with a base 7 logarithm correctly
		A1	For both
	Or $\frac{1}{\log_x 7} + 2\log_x 7 = 3$	M1	For change of base
	$2(\log_x 7)^2 - 3\log_x 7 + 1 = 0$ $\log_x 7 = 1, \quad \log_x 7 = 0.5$	M1	Dep for forming a 3 term quadratic equation in $\log_x 7$ and a correct attempt to solve
	$x = 7, \quad x = 49$	M1	Dep on both previous M marks for dealing with a base x logarithm correctly
		A1	For both
	Or $\frac{\lg x}{\lg 7} + 2\frac{\lg 7}{\lg x} = 3$ or $\lg 1000$	M1	For change of base
	$(\lg x)^2 - 3\lg 7(\lg x) + 2(\lg 7)^2 = 0$ $\lg x = 2\lg 7 \qquad \lg x = \lg 7$	M1	Dep for forming a 3 term quadratic equation in $\lg x$ and a correct attempt to solve
	$x = 7, \quad x = 49$	M1	Dep on both previous M marks for dealing with a base 10 logarithm correctly
		A1	For both, must be exact
7(i)	$\frac{dy}{dx} = \left(e^{x^2} + 1\right) + 2xe^{x^2}(x+5)$	B1	For $2xe^{x^2}$
		M1	For attempt at differentiating a product or expanding brackets and differentiating a product
		A1	For all other terms, apart from $2xe^{x^2}$, correct

Question	Answer	Marks	Guidance
7(ii)	When $x = 0.5,\ \frac{dy}{dx} = 9.35$	M1	For attempt to find *their* $\frac{dy}{dx}$ when $x = 0.5$ and multiplication by p
	Approximate change = $9.35p$	A1	
7(iii)	$\frac{dy}{dx} \times \frac{dx}{dt} = \frac{dy}{dt}$ $9.346 \times \frac{dx}{dt} = 2$	M1	For use of correct rates of change equation using *their* $\frac{dy}{dx}$ when $x = 0.5$ and $\frac{dy}{dt} = 2$
	$\frac{dx}{dt} = 0.214$	A1	FT on $\frac{2}{their\ 9.346}$ Must be correct to at least 3 sf
8(a)(i)	**Either** $\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 0 \\ 1 & 1 & 2 \\ 0 & 1 & 3 \\ 3 & 0 & 1 \end{pmatrix}\begin{pmatrix} 4 \\ 2 \\ 0 \end{pmatrix}$ or $\begin{pmatrix} 2 & 1 \\ 1 & 3 \\ 1 & 1 \\ 0 & 1 \\ 3 & 0 \end{pmatrix}\begin{pmatrix} 4 \\ 2 \end{pmatrix}$	B2	For correct matrices in correct order or **B1** if one correct matrix and a slip in one element of the other matrix
	Or $\begin{pmatrix} 4 & 2 & 0 \end{pmatrix}\begin{pmatrix} 2 & 1 & 1 & 0 & 3 \\ 1 & 3 & 1 & 1 & 0 \\ 1 & 0 & 2 & 3 & 1 \end{pmatrix}$ or $\begin{pmatrix} 4 & 2 \end{pmatrix}\begin{pmatrix} 2 & 1 & 1 & 0 & 3 \\ 1 & 3 & 1 & 1 & 0 \end{pmatrix}$	B2	For correct matrices in correct order or **B1** if one correct matrix and a slip in one element of the other matrix
8(a)(ii)	$\begin{pmatrix} 10 \\ 10 \\ 6 \\ 2 \\ 12 \end{pmatrix}$ or $\begin{pmatrix} 10 & 10 & 6 & 2 & 12 \end{pmatrix}$ Team E	M1	For matrix multiplication of *their* (i), with at least 2 elements correct, **must be in correct form**, may be unsimplified
		A1	All correct and identifying team E
8(b)(i)	$\frac{1}{6}\begin{pmatrix} 4 & 1 \\ -2 & 1 \end{pmatrix}$	B2	**B1** for $\frac{1}{6}$ and **B1** for $\begin{pmatrix} 4 & 1 \\ -2 & 1 \end{pmatrix}$

Question	Answer	Marks	Guidance
8(b)(ii)	$\mathbf{C} = \mathbf{A}^{-1}\mathbf{B}$	**M1**	For pre-multiplication by *their* inverse from **(i)**
	$\mathbf{C} = \frac{1}{6}\begin{pmatrix} 4 & 1 \\ -2 & 1 \end{pmatrix}\begin{pmatrix} 5 & 0 \\ 1 & -2 \end{pmatrix}$	**M1**	Dep for matrix multiplication, using *their* inverse from (i), at least 2 elements correct
	$= \frac{1}{6}\begin{pmatrix} 21 & -2 \\ -9 & -2 \end{pmatrix}$ oe	**A1**	
9(i)	$\pi r^2 h = 1200\pi$	**B1**	
	$h = \frac{1200}{r^2}$ or $\pi rh = \frac{1200\pi}{r}$ and substitution into *their S*	**B1**	Must have attempt to use in an equation for S
	$S = 2\pi r^2 + \left(2\pi r \times \frac{1200}{r^2}\right)$ leading to given answer	**B1**	
9(ii)	$\frac{dS}{dr} = 4\pi r - \frac{2400\pi}{r^2}$	**M1**	Must obtain the form $Ar + \frac{B}{r^2}$
	When $\frac{dS}{dr} = 0$, $r = \sqrt[3]{600}$, 8.43	**M1**	Dep for equating to zero and attempt to solve to obtain $r = \ldots$
		A1	For correct r
	$S_{\text{min}} = 1340$ or 1341	**A1**	
	Either $\frac{d^2S}{dr^2} = 4\pi + \frac{4800\pi}{r^3}$ $\frac{d^2S}{dr^2} > 0$ so minimum	**B1**	For a correct method to reach a correct conclusion If r is not calculated, then must state that $r > 0$
	Or Consideration of gradient e.g. **r**: < 8.43, 8.43, >8.43 $\frac{dS}{dr}$: –, 0, + Minimum point	**B1**	Must be making a correct and convincing argument with sufficient detail

Question	Answer	Marks	Guidance
10(i)	**Either** $18^2 = 10^2 + 10^2 - 200\cos AOB$	M1	Attempt to use cosine rule
	$\cos AOB = -0.62$	A1	Allow unsimplified
	$AOB = 2.2395$ or greater accuracy, so 2.24 (to 2 dp) or $AOB = 2.239...$ so 2.24 (to 2 dp) $AOB = 2.240$ so 2.24 (to 2 dp)	A1	Must justify 2 dp
10(i)	**Or** $\sin\frac{AOB}{2} = \frac{9}{10}$ or $\tan\frac{AOB}{2} = \frac{9}{\sqrt{19}}$ or $\cos\frac{AOB}{2} = \frac{\sqrt{19}}{10}$	M1	Attempt at trig using a right angled triangle
	$\frac{AOB}{2} =$ awrt 1.12	A1	
	$AOB = 2.2395$ or greater accuracy, so 2.24 (to 2 dp) or $AOB = 2.239...$ so 2.24 (to 2 dp) $AOB = 2.240$ so 2.24 (to 2 dp)	A1	Must justify 2 dp
10(ii)	$AOC = 2\pi - 2(2.2395)$ or $\frac{AOC}{2}$ or $ABC = \pi - (2.2395)$ oe	M1	For attempt to find angle AOC or ABC $AOC = 2\pi - 2(\textit{their } AOB)$ $ABC = \pi - (\textit{their } AOB)$ oe
	$AOC = 1.804$ or 1.803	A1	Condone 1.8 or 1.80
	Arc length = 18.04 or 18.03	M1	For attempt at arc length using $10 \times \textit{their } AOC$
	$AC = 20\sin\frac{AOC}{2}$ or $36\sin\frac{ABC}{2}$ or $\sqrt{10^2 + 10^2 - 200\cos AOC}$ or $\sqrt{18^2 + 18^2 - 648\cos ABC}$ $= 15.69$ or 15.7	M1	For attempt at AC using *their AOC*, or ABC but $AOC \neq 2.24$ or $\frac{2\pi}{3}$
	Perimeter = 33.7	A1	Allow awrt 33.7

Question	Answer	Marks	Guidance
10(iii)	Area of sector = 50×1.804 $= 90.2$ or 90.15	M1	For attempt at sector area $\frac{1}{2}\times 10^2\times \textit{their } AOC$ AOC must be in radians
	Area of triangle = $50\sin 1.804 = 48.6$ or 48.66	M1	For attempt at area of triangle $\frac{1}{2}\times 10^2\times \sin \textit{their } AOC$ AOC must be in radians
	Shaded area = 41.6 or 41.5	A1	Lack of accuracy is penalised here
11	$\frac{dy}{dx} = 2(3x-1)^{\frac{1}{3}} + c$	M1	For $\left(\frac{dy}{dx}=\right)\ a(3x-1)^{\frac{1}{3}}$, condone omission of $+c$
		A1	All correct, condone omission of c
	$6 = 4 + c$	M1	Dep for attempt to find c
	$\left(\frac{dy}{dx}=\right)\ 2(3x-1)^{\frac{1}{3}} + 2$	A1	All correct, may be implied by $c = 2$
	$y = \frac{1}{2}(3x-1)^{\frac{4}{3}} + 2x + d$	M1	For attempt to integrate *their* $\frac{dy}{dx}$ to obtain the form $y = b(3x-1)^{\frac{4}{3}}\ (+mx+d)$
		A1	All correct, condone omission of d
	$11 = 14 + d$	M1	Dep for attempt to find d, a second arbitrary constant, having used an arbitrary constant for $\frac{dy}{dx}$
	$y = \frac{1}{2}(3x-1)^{\frac{4}{3}} + 2x - 3$	A1	

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2019**

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 October/November 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level 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.

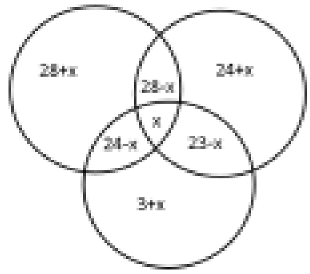
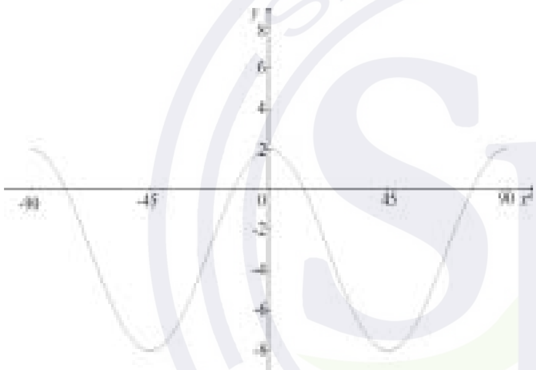
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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

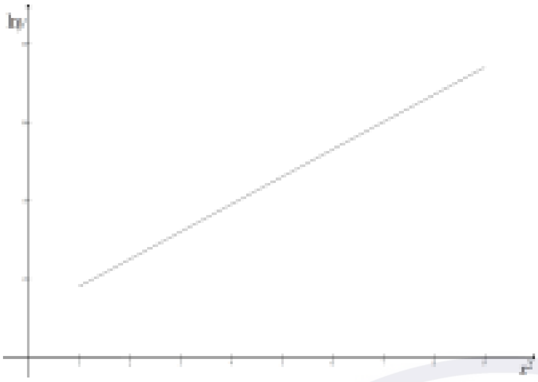
When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier 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	Guidance
1(i)		**M1**	for a Venn diagram showing at least 4 correct 'parts' in terms of x
		A1	for all 7 'parts' correct in terms of x on a Venn diagram or in working. May be implied by a correct equation.
	$80+24+x+23-x+3+x=145$ $50+28+x+28-x+24+x=145$ $75+28+x+24-x+3+x=145$ $50+80+75-(23+28+24)+x=145$ or equivalents	**M1**	for forming an equation in x using sum of 'parts' = 145 or $50+80+75-(23+28+24)+x=145$ Equations must be seen
	$x=15$	**A1**	from correct working only
1(ii)	43	**B1ft**	for *their* x plus 28
2(i)		**B4**	**B1** for a maximum at $(0, 2)$ **B1** for minimums at $y=-8$ and no other minimums **B1** for starting at $(-90^\circ, 2)$ and finishing at $(90^\circ, 2)$ **B1** for a fully correct curve with correct shape, particularly at end points, that has earned all three previous B marks.
2(ii)	5	**B1**	
2(iii)	90°	**B1**	
3(i)	$\frac{dy}{dx}=kx\left(3x^2-1\right)^{-\frac{4}{3}}$	**M1**	
	$\frac{dy}{dx}=-\frac{1}{3}\times 6x\left(3x^2-1\right)^{-\frac{4}{3}}$	**A1**	
3(ii)	When $x=\sqrt{3}$, $\frac{dy}{dx}=-\frac{\sqrt{3}}{8}$ $-\frac{\sqrt{3}}{8}p$ or $-0.217p$	**B1**	**FT** on *their* $\frac{dy}{dx}$ of the form $kx\left(3x^2-1\right)^{-\frac{4}{3}}$

Question	Answer	Marks	Guidance
3(iii)	When $x=\sqrt{3}$, $y=\frac{1}{2}$	B1	for $y=\frac{1}{2}$
	Normal: $y-\frac{1}{2}=\frac{8}{\sqrt{3}}\left(x-\sqrt{3}\right)$	M1	Dep on M1in part(i). An equation of the normal using *their* normal gradient, $\sqrt{3}$ and *their* y
		A1	allow unsimplified
4(i)	$-\frac{1}{13}\begin{pmatrix}-1 & -2\\ -4 & 5\end{pmatrix}$ oe	B2	**B1** for $-\frac{1}{13}$ **B1** for $\begin{pmatrix}-1 & -2\\ -4 & 5\end{pmatrix}$
4(ii)	$\frac{1}{13}\begin{pmatrix}1 & 2\\ 4 & -5\end{pmatrix}\begin{pmatrix}12\\ 7\end{pmatrix}$ $=\frac{1}{13}\begin{pmatrix}26\\ 13\end{pmatrix}$	M1	for pre-multiplication by *their* inverse from (i)
		M1	for correct method for matrix multiplication
	$=\begin{pmatrix}2\\ 1\end{pmatrix}$	A1	
	$x=1.11$	B1	
	$y=\frac{\pi}{4}$ or 0.785	B1	
5(i)	$\frac{d}{dx}\left(\ln\left(x^2+3\right)\right) = \frac{2x}{\left(x^2+3\right)}$	B1	
	$\frac{dy}{dx}=\left(x^2+3\right)\frac{2x}{\left(x^2+3\right)}+2x\ln\left(x^2+3\right)$	M1	for product rule
		A1	**FT** *their* $\frac{2x}{\left(x^2+3\right)}$
5(ii)	$\left(x^2+3\right)\ln\left(x^2+3\right)=\int 2x+2x\ln\left(x^2+3\right)\ dx$	M1	for using *their* result from (i) for $2x+kx\ln\left(x^2+3\right)$
	$\int x\ln\left(x^2+3\right)\ dx$ $=\frac{1}{2}\left(x^2+3\right)\ln\left(x^2+3\right)-\frac{x^2}{2}(+c)$	A1	

Question	Answer	Marks	Guidance
6(i)	$\ln y = \ln A + x^2 \ln b$ or $\lg y = \lg A + x^2 \lg b$	**B1**	May be implied by a table of values for x^2 and $\ln y$ or $\lg y$ or axes labelled $\ln y$ or $\lg y$ and x^2
		**M1**	for attempt to plot either $\ln y$ or $\lg y$ against x^2 using an evenly spaced scale on each axis.
		A2	**A2** All points on a correct line (for $1 \leqslant x^2 \leqslant 9$) with axes correctly labelled **A1** One point not on the correct line or a correct line with axes not correctly labelled. **A0** Two or more points not on the correct line or one point not on the line and axes incorrect
6(ii)	Gradient $= \ln b$ or $\lg b$ $\ln b \approx 0.7$ or $\lg b \approx 0.3$ leading to	**M1**	for a complete method using the gradient of *their* straight-line graph of lg*y* or ln*y* against x^2 to obtain *b*
	$b = 2$ (allow 1.6 – 2.4)	**A1**	from correct working
	Intercept $= \ln A$ or $\lg A$ $\ln A \approx 1.1$ $\lg A \approx 0.5$ leading to	**M1**	for a complete method using intercept of *their* straight-line graph of lg*y* or ln*y* against x^2 to find *A*
	$A = 3$ (allow 2.5 – 3.6)	**A1**	from correct working
6(iii)	$100 = 3\left(2^{x^2}\right)$ or $\ln 100 = \mathit{their}1.1 + \mathit{their}0.7x^2$ or $\lg 100 = \mathit{their}0.5 + \mathit{their}0.3x^2$ or reading from lg*y* = 2 to obtain x^2 or from ln*y* = 4.6 to obtain x^2	**M1**	for a valid method to find x^2 Substitution methods should be using values of *A* and *b* in range
	leading to $x = 2.25$ (allow 2.0 – 2.7)	**A1**	for an answer in range from correct working
7(a)(i)	15 120	**B1**	
7(a)(ii)	1680	**B1**	
7(a)(iii) Method 1	Total = 2310	**B3**	B1 1st digit is 7 or 9 1680 or 210×8 B1 1st digit is 8 630 or 210×3
7(a)(iii) Method 2	Total = 2310	**B3**	B1 for 5th digit is 2,4 or 6 1890 or 210×9 B1 for 5th digit is 8 420 or 210×2

Question	Answer	Marks	Guidance
7(b)(i)	3003	**B1**	
7(b)(ii)	28	**B1**	
7(b)(iii)	Total 1419	**B3**	B1 Including husband and wife 495 B1 Excluding husband and wife 924
8(a)(i)	$\log_a a + 2\log_a y + \log_a x$	**M1**	for $\log_a a + \log_a x + \log_a y^2$ **and** $\log_a y^2 = 2\log_a y$
	$1 + 2q + p$	**A1**	
8(a)(ii)	$3\log_a x - \log_a y - \log_a a$	**M1**	for $\log_a x^3 - (\log_a a + \log_a y)$ **and** $\log_a x^3 = 3\log_a x$
	$3p - q - 1$ or $3p - (q+1)$	**A1**	
8(a)(iii)	$\frac{1}{p} + \frac{1}{q}$	**B1**	
8(b)	$m - 3m^2 + 4 = 0$ $m = \frac{4}{3}, \quad (-1)$ $x = \frac{\lg \frac{4}{3}}{\lg 3}$, $x = \frac{\ln \frac{4}{3}}{\ln 3}$ or $\lg_3 \frac{4}{3}$	**M1**	for obtaining a quadratic in m or 3^x
		M1	Dep for attempt to solve quadratic and deal with 3^x correctly
	$x = 0.262$ only	**A1**	
9(i)	$100 = 2r + 2r\theta + 3r\theta$	**M1**	for addition of $2r$ and two arc lengths with at least one correct arc length
	$\theta = \frac{100 - 2r}{5r}$ or $\frac{20}{r} - \frac{2}{5}$ oe	**A1**	
9(ii)	$\frac{1}{2}9r^2\theta - \frac{1}{2}4r^2\theta$	**M1**	for subtraction of two sector areas with at least one sector area correct.
	$\frac{5r^2}{2}\left(\frac{100-2r}{5r}\right)$	**A1**	Must expand and simplify to obtain given answer $50r - r^2$
9(iii)	$\frac{dA}{dr} = 50 - 2r$ $0 = 50 - 2r$ leading to $r = 25$	**M1**	for differentiation and equating to zero and obtaining r or for using completing the square $-(25 - r)^2 + 25^2$
	Max when $A = 625$	**A1**	

Question	Answer	Marks	Guidance
9(iv)	When $r=10,\ \frac{\mathrm{d}A}{\mathrm{d}r}=30$	B1	
	$\frac{\mathrm{d}r}{\mathrm{d}t}=\frac{3}{30}$	M1	for $\frac{\mathrm{d}r}{\mathrm{d}t}=\frac{3}{their\,30}$ where *their* 30 has been obtained from an evaluation of $\frac{\mathrm{d}A}{\mathrm{d}r}$ at $r=10$
	$\frac{\mathrm{d}r}{\mathrm{d}t}=0.1$ or $\frac{1}{10}$	A1	
9(v)	$\frac{\mathrm{d}\theta}{\mathrm{d}r}=-\frac{20}{r^2}$ oe	B1	
	$\frac{\mathrm{d}\theta}{\mathrm{d}r}=-\frac{1}{5}$ oe $\frac{\mathrm{d}\theta}{\mathrm{d}t}=\frac{1}{10}\times-\frac{1}{5}$ oe	M1	for $their\frac{\mathrm{d}r}{\mathrm{d}t}\times their\frac{\mathrm{d}\theta}{\mathrm{d}r}$ with both evaluated at $r=10$
	$\frac{\mathrm{d}\theta}{\mathrm{d}t}=-\frac{1}{50}$ or -0.02	A1	
10(a)(i)	$\pm\frac{20--20}{5}$	M1	for finding the gradient of the relevant part
	8	A1	
10(a)(ii)	7.5	B1	
10(a)(iii)	$\frac{1}{2}(5+7.5)20+\left(\frac{1}{2}\times2.5\times20\right)$ or $20\times5+\left(\frac{1}{2}\times2.5\times20\right)+\left(\frac{1}{2}\times2.5\times20\right)$ oe	M1	for a correct expression for total area using *their* 7.5
	150	A1	
10(b)(i)	$x=3e^{2t}+t+c$	M1	for $ke^{2t}+t$ Condone omission of c
	$0=3e^0+0+c$ When $t=0,\ x=0$ so $c=-3$	M1	Dep for substitution to find c
	$x=3e^{2t}+t-3$	A1	

Question	Answer	Marks	Guidance
10(b)(ii)	$\frac{dv}{dt} = 12e^{2t}$ so $12e^{2t} = 24$	M1	for ke^{2t} equated to 24
	$2t = \ln 2$	M1	Dep for correct order of operations to obtain $2t$
	$t = \frac{1}{2}\ln 2$, $\ln\sqrt{2}$ or 0.347	A1	

Cambridge IGCSE

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Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **May/June 2019**

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.

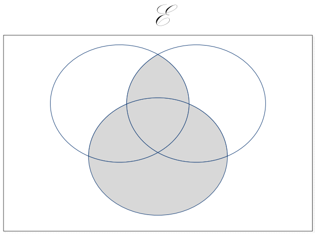
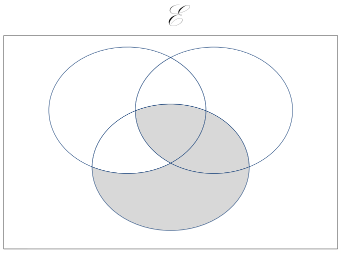
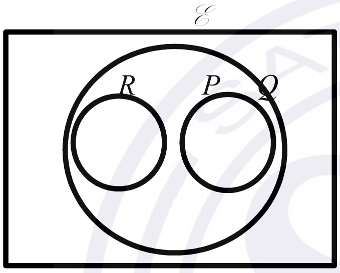
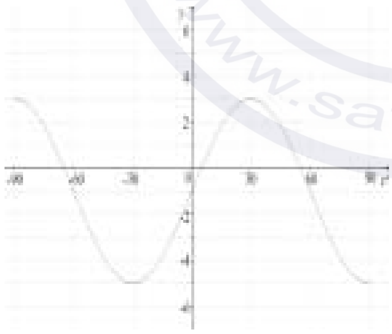
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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(a)		**B1**	
		**B1**	
1(b)		**B2**	**B1** for $P \subset R$ and $Q \subset R$ **B1** for $P \cap Q = \varnothing$
2(i)	4	**B1**	
2(ii)	120° or $\frac{2\pi}{3}$	**B1**	
2(iii)		**B3**	**B1** for a complete curve starting at $(-90^\circ, 3)$ and finishing at $(90^\circ, -5)$ **B1** for $-5 \leqslant y \leqslant 3$ for a complete curve Minimum point(s) at $y = -5$ Maximum point(s) at $y = 3$ **DepB1** for a fully correct sine curve satisfying both the above and passing through $(-60^\circ, -1), (0^\circ, -1)$ and $(60^\circ, -1)$
3(i)	–12	**B1**	
3(ii)	$(2\times -3-1)(k-3)-12=23$ oe or $2(-3)^2+(2k-1)(-3)-k-12=23$	**M1**	
	$k=-2$	**A1**	

Question	Answer	Marks	Guidance
3(iii)	$(2x-1)(x-2)-12=-25$ $2x^2-5x+15=0$	**M1**	expansion and simplification to a 3 term quadratic equation equated to zero, using *their k*.
	Discriminant: $25-(4\times2\times15)$ $=-95$	**M1**	using discriminant for their three term quadratic equation
	which is < 0 so no real solutions	**A1**	cao for correct discriminant and correct conclusion
4(i)	$a=256$	**B1**	
	$8\times2^7\times bx[=256x]$ oe or $\frac{8\times7\times2^6\times(bx)^2}{2}[=cx^2]$ oe	**M1**	
	$b=\frac{1}{4}$ oe, $c=112$	**A2**	**A1** for each
4(ii)	$(256+256x+112x^2)\left(4x^2-12+\frac{9}{x^2}\right)$	**B1**	for $\left(4x^2-12+\frac{9}{x^2}\right)$
	Terms independent of x are $(256\times(-12))+(112\times9)$ $=-3072+1008$	**M1**	adding and selecting $(\textit{their}\,256\times\textit{their}\,(-12))+(\textit{their}\,112\times\textit{their}\,9)$
	$=-2064$	**A1**	
5(i)	$v=20\times\frac{1}{\sqrt{3^2+4^2}}\begin{pmatrix}3\\4\end{pmatrix}$ oe	**M1**	finding and using the magnitude of $\begin{pmatrix}3\\4\end{pmatrix}$
	$v=\begin{pmatrix}12\\16\end{pmatrix}$	**A1**	
5(ii)	$\mathbf{r}_p=\begin{pmatrix}1\\2\end{pmatrix}+\begin{pmatrix}12\\16\end{pmatrix}t$	**M1**	correct use of position vector and *their* velocity vector
		A1	

Question	Answer	Marks	Guidance
5(iii)	$\begin{pmatrix}17\\18\end{pmatrix}+\begin{pmatrix}8\\12\end{pmatrix}t=\begin{pmatrix}1\\2\end{pmatrix}+\begin{pmatrix}12\\16\end{pmatrix}t$ Leading to $17+8t=1+12t$ or $18+12t=2+16t$	M1	equating position vectors of both particles at time *t* and solve either equation for *t*
	$t=4$	A1	
	Position vector of collision $\begin{pmatrix}49\\66\end{pmatrix}$	A1	
6	Method 1 $3x^2-2x+1=2x+5$ leading to	M1	equating the equations of the line and the curve and rearranging to obtain a three term quadratic equated to zero
	$3x^2-4x-4=0$	A1	
	$x=-\frac{2}{3}$ and $x=2$	A1	
	$\int_{-\frac{2}{3}}^{2}\left(2x+5-\left(3x^2-2x+1\right)\right)\,dx$	M1	subtraction (either way round)
	$\int_{-\frac{2}{3}}^{2}\left(4+4x-3x^2\right)\,dx$	M1	integration to $Ax+Bx^2+Cx^3$
	$\left[4x+2x^2-x^3\right]_{-\frac{2}{3}}^{2}$	A1	for $4x+2x^2-x^3$ oe
	$(8+8-8)-\left(-\frac{8}{3}+\frac{8}{9}+\frac{8}{27}\right)$ $=8--\frac{40}{27}$	M1	**Dep** on preceding M1 correct use of limits
	$=\frac{256}{27}$ or 9.48 or $9\frac{13}{27}$	A1	

Question	Answer	Marks	Guidance
6	Method 2 $3x^2 - 2x + 1 = 2x + 5$ leading to	M1	equating the line and the curve and rearranging to obtain a three term quadratic equated to zero
	$3x^2 - 4x - 4 = 0$	A1	
	$x = -\frac{2}{3}$ and $x = 2$	A1	
	Area of trapezium = $\frac{1}{2}\left(\frac{11}{3} + 9\right) \times \frac{8}{3}$	B1	area of the trapezium, allow unsimplified
	Area under curve = $\int_{-\frac{2}{3}}^{2} 3x^2 - 2x + 1 \, dx$	M1	integration to $Ax + Bx^2 + Cx^3$
	$= \left[x^3 - x^2 + x\right]_{-\frac{2}{3}}^{2}$	A1	for $x^3 - x^2 + x$
	$= \left((8 - 4 + 2) - \left(-\frac{8}{27} - \frac{4}{9} - \frac{2}{3}\right)\right)$ $6 - -\frac{38}{27}$	M1	**DepM1** for correct use of limits.
	Shaded Area = $\frac{152}{9} - \frac{200}{27}$ $= \frac{256}{27}$ or 9.48 or $9\frac{13}{27}$	A1	
7(a)	Method 1 $\log_3 x + \frac{\log_3 x}{\log_3 9} = 12$	B1	change to base 3 logarithm
	$\frac{3\log_3 x}{2} = 12$ $x = 3^8$ or $\sqrt[3]{3^{24}}$	M1	simplification and dealing with base 3 logarithms to obtain a power of 3
	$x = 6561$	A1	

Question	Answer	Marks	Guidance
7(a)	Method 2 $\frac{\log_9 x}{\log_9 3} + \log_9 x = 12$	**B1**	change to base 9
	$3\log_9 x = 12$ $x = 9^4$ or $\sqrt[3]{9^{12}}$	**M1**	simplification and dealing with base 9 logarithms to obtain a power of 9
	$x = 6561$	**A1**	
7(b)	Method 1 $\log_4(3y^2 - 10) = \log_4(y-1)^2 + \frac{1}{2}$	**B1**	use of power rule
	$\log_4 \frac{3y^2 - 10}{(y-1)^2} = \frac{1}{2}$	**B1**	**DepB1** for use of division rule
	$\frac{3y^2 - 10}{(y-1)^2} = 2$	**B1**	for $\frac{1}{2} = \log_4 2$
	$y^2 + 4y - 12 = 0$	**M1**	**Dep** on first two B marks simplification to a three term quadratic.
	$y = 2$ only	**A1**	
7(b)	Method 2 $\log_4(3y^2 - 10) = \log_4(y-1)^2 + \frac{1}{2}$	**B1**	use of power rule
	$\log_4(3y^2 - 10) = \log_4(y-1)^2 + \log_4 2$	**B1**	for $\log_4 2$
	$3y^2 - 10 = 2(y-1)^2$	**B1**	**Dep** on first B1 use of the multiplication rule
	$y^2 + 4y - 12 = 0$	**M1**	**Dep** on first and third B marks. simplification to a 3 term quadratic
	$y = 2$ only	**A1**	

Question	Answer	Marks	Guidance
8(i)	$f > -1$	B1	or $f(x) > -1$, $y > -1$, $(-1, \infty)$, $\{y : y > -1\}$
8(ii)	$e^y = \frac{x+1}{5}$ oe	M1	a complete valid method to obtain the inverse function
	$y = \ln\left(\frac{x+1}{5}\right)$ or $f^{-1}(x) = \ln\left(\frac{x+1}{5}\right)$ oe	A1	
	Domain $x > -1$ or $(-1, \infty)$	B1	**FT** *their* **(i)** or correct
8(iii)	$g(1) = 5$ so $fg(1) = f(5)$	M1	evaluation using correct order of operations
	$5e^5 - 1 = 741$	A1	awrt 741 or $5e^5 - 1$
8(iv)	$g^2(x) = (x^2+4)^2 + 4$	M1	correct use of g^2
	$x^4 + 8x^2 + 16 + 4 = 40$ $(x^2+4)^2 = 36$ or $x^4 + 8x^2 - 20 = 0$ $(x^2+10)(x^2-2) = 0$	M1	**DepM1** for forming and solving a quadratic in x^2
	$x = \pm\sqrt{2}$ only	A1	
9(i)	<u>Method 1</u> $600\pi = 2\pi r^2 + 2\pi rh$	B1	
	$h = \frac{600\pi - 2\pi r^2}{2\pi r}$	M1	making h subject from a two term expression for SA.
	$V = \pi r^2 h$ $V = \pi r^2\left(\frac{600\pi - 2\pi r^2}{2\pi r}\right)$ $V = \pi r^2\left(\frac{300}{r} - r\right)$ $V = 300\pi r - \pi r^3$	A1	correct substitution and manipulation to obtain given answer

Question	Answer	Marks	Guidance
9(i)	Method 2 $600\pi = 2\pi r^2 + 2\pi rh$	B1	
	$600\pi r = 2\pi r^3 + 2\pi r^2 h$	M1	multiplying both sides by r
	$\frac{600\pi r - 2\pi r^3}{2} = \pi r^2 h$ $V = \pi r^2 h$ $V = 300\pi r - \pi r^3$	A1	correct manipulation to obtain $\pi r^2 h$
9(ii)	$\frac{dV}{dr} = 300\pi - 3\pi r^2$	M1	differentiation of given formula to $A+Br^2$
	When $\frac{dV}{dr} = 300\pi - 3\pi r^2 = 0$	M1	equating to zero and attempt to solve
	$r = 10$	A1	
	$V = 2000\pi$ or 6280 or 6283	A1	
	$\frac{d^2V}{dr^2} = -6\pi r$, $\frac{d^2V}{dr^2} < 0$ so maximum	B1	cao for $\frac{d^2V}{dr^2} = -6\pi r$, $\frac{d^2V}{dr^2} = -60\pi$ or other correct method leading to maximum
10(i)	Method 1 $\lg y = A + Bx^2$	B1	statement soi
	$16 = A + 6B$ $4 = A + 2B$	M1	one correct equation
	leading to $A = -2$ and $B = 3$	A2	**A1** for each
10(i)	Method 2 $\lg y = A + Bx^2$	B1	statement soi
	Gradient = B $B = 3$	B1	
	$16 = A + 6B$ or $4 = A + 2B$	M1	a correct equation
	$A = -2$	A1	

Question	Answer	Marks	Guidance
10(i)	Method 3 $\lg y - 4 = 3(x^2 - 2)$ or $\lg y - 16 = 3(x^2 - 6)$ OR $4 = 3(2) + c$ or $16 = 3(6) + c$	**M1**	correct equation or for correct method for finding constant.
	$\lg y = A + Bx^2$	**B1**	statement soi by *their A* and *B*
	Hence $y = 10^{3x^2-2}$ $B = 3$	**B1**	
	$A = -2$	**A1**	
10(ii)	$y = 10^{-2+3\left(\frac{1}{\sqrt{3}}\right)^2}$	**M1**	correct use of *their A* and *B*
	$y = 0.1$ oe	**A1**	
10(iii)	$2 = 10^{3x^2-2}$	**M1**	correct use of *their A* and *B*
	$\lg 2 = 3x^2 - 2$ $x = \sqrt{\frac{\lg 2 + 2}{3}}$	**M1**	complete correct method to solve for *x*
	$x = 0.876$	**A1**	

Question	Answer	Marks	Guidance
11(i)	$\frac{dy}{dx} = (x^2+1)(2x-3)^{-\frac{1}{2}} + 2x(2x-3)^{\frac{1}{2}}$	M1	differentiation of a product
		B1	for $\frac{d}{dx}(2x-3)^{\frac{1}{2}} = \frac{1}{2} \times 2(2x-3)^{-\frac{1}{2}}$ oe
		A1	all else correct i.e. $\frac{dy}{dx} = (x^2+1)f(x) + 2x(2x-3)^{\frac{1}{2}}$
	$= (2x-3)^{-\frac{1}{2}}(x^2+1+2x(2x-3))$	M1	correctly taking out a factor of $(2x-3)^{-\frac{1}{2}}$ or correctly using $(2x-3)^{\frac{1}{2}}$ as denominator
	$= \frac{5x^2-6x+1}{(2x-3)^{\frac{1}{2}}}$	A1	
11(ii)	When $x=2$, $y=5$	B1	
	$\frac{dy}{dx} = 9$, so gradient of normal $= -\frac{1}{9}$	M1	substitution to obtain gradient and correct method for gradient of normal
	Equation of normal $y-5 = -\frac{1}{9}(x-2)$	M1	**DepM1** for equation of normal
	$x+9y-47=0$ or $-x-9y+47=0$	A1	Must be in this form

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/12**
Paper 1	**May/June 2019**
MARK SCHEME	
Maximum Mark: 80	

Published

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Generic Marking Principles

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- 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.

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

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- marks are not deducted for omissions
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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.

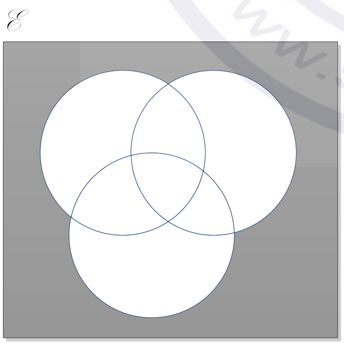
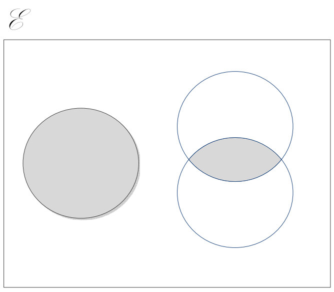
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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

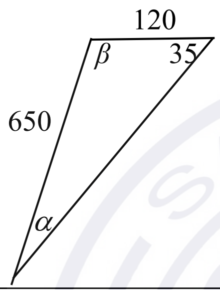
awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1(a)		B1	
		B1	

Question	Answer	Marks	Guidance
1(b)	$P=\{30^\circ, 150^\circ, 210^\circ, 330^\circ\}$	B1	May be seen or implied in a Venn diagram Allow without set notation
	$Q=\{30^\circ, 150^\circ\}$	B1	May be seen or implied in a Venn diagram Allow without set notation
	$P\cap Q=\{30^\circ, 150^\circ\}$	B1	**Dep** on both previous B marks Must be in set notation
2	**Either:** $(2x+3)^2(x-1)=3(2x+3)$ $(2x+3)(2x^2+x-6)(=0)$	M1	For attempt to equate line and curve and attempt to simplify to $2x+3$ × a quadratic factor or cancelling $2x+3$ and obtaining a quadratic factor
	$(2x+3)(2x^2+x-6)=0$ $(2x+3)(2x-3)(x+2)=0$	M1	**Dep** for attempt at 3 linear factors from a linear term and a quadratic term
	$\left(-\frac{3}{2}, 0\right)$	B1	
	$\left(\frac{3}{2}, 18\right)$	A1	**Dep** on first M mark only
	$(-2, -3)$	A1	**Dep** on first M mark only
	Or: $(2x+3)^2(x-1)=3(2x+3)$ $4x^3+8x^2-9x-18(=0)$	M1	For attempt to equate line and curve and attempt to simplify to a cubic equation, by collecting like terms
	$(x+2)(4x^2-9)$ $(2x-3)(2x^2+7x+6)$ $(2x+3)(2x^2+x-6)$ $(2x+3)(2x-3)(x+2)(=0)$	M1	**Dep** For attempt to find a factor from a 4 term cubic equation (usually $x+2$), do long division oe to obtain a quadratic factor and factorise this quadratic factor
	$\left(-\frac{3}{2}, 0\right)$	A1	
	$\left(\frac{3}{2}, 18\right)$	A1	
	$(-2, -3)$	A1	
3(i)	1000	B1	

Question	Answer	Marks	Guidance
3(ii)	$\frac{dB}{dt} = 400e^{2t} - 1600e^{-2t}$	B1	
	$3 = e^{2t} - 4e^{-2t}$ oe	M1	For equating an equation of the form $ae^{2t} + be^{-2t}$ to 1200 and dividing by 400
	$e^{4t} - 3e^{2t} - 4 = 0$	A1	
3(iii)	$(e^{2t} + 1)(e^{2t} - 4) = 0$	M1	For attempt to factorise and solve, dealing with exponential correctly, to obtain $e^{2t} = \ldots$
	$t = \ln 2,\ \frac{1}{2}\ln 4$ or awrt 0.693 only isw if appropriate	A1	
4(a)	$a = \frac{5}{2}$	B1	
	$b = -\frac{3}{2}$	B1	
	$c = \frac{11}{2}$	B1	
4(b)	$9x^{\frac{1}{2}} - 3y^{-\frac{1}{2}} = 12$ $4x^{\frac{1}{2}} + 3y^{-\frac{1}{2}} = 14$	M1	For attempt to solve simultaneous equations. Must reach $kx^{\frac{1}{2}} = \ldots$ or $ky^{-\frac{1}{2}} = \ldots$ oe
	$x = 4$	A1	
	$y = \frac{1}{4}$	A1	
5(i)	$9.6 = 12\theta$	M1	For use of arc length
	$\theta = 0.8$	A1	

Question	Answer	Marks	Guidance
5(ii)	Either $\tan\theta = \frac{AB}{12}$, $(AB = 12.36)$ Or $OB = \frac{12}{\cos\theta}$ $(OB = 17.22)$	**M1**	For attempt to find AB or OB using *their* θ May be implied by a correct triangle area Allow if using degrees consistently
	Either Area $\Delta OAB = \frac{1}{2} \times 12 \times$ *their* 12.36 Or Area $\Delta OAB = \frac{1}{2} \times 12 \times$ *their* $17.22 \times \sin\theta$ $(= 74.1 \text{ or } 74.2)$	**M1**	Allow if using degrees consistently For attempt to find area of triangle using *their* θ
	Area of sector $OAC = \frac{1}{2} \times 12^2 \times 0.8$ $= 57.6$	**B1**	Allow unsimplified
	Area of shaded region = 16.5 or 16.6	**A1**	
6(a)(i)	40320	**B1**	
6(a)(ii)	No. of ways with maths books as 1 unit = $5!$ or $5 \times 4!$ or ${}^5P_5$ or 120	**B1**	
	No. of ways maths books can be arranged amongst themselves = $4!$ or ${}^4P_4$ or 24	**B1**	
	Total = $(5! \times 4! \text{ oe}) = 2880$	**B1**	
6(a)(iii)	No. of ways with maths books as 1 unit and geography books as 1 unit = $3!$ or ${}^3P_3$ or $3 \times 2!$ or 6	**B1**	
	No. of ways maths books can be arranged amongst themselves and geography books can be arranged amongst themselves $= 4! \times 3!$ or ${}^4P_4 \times {}^3P_3$ or 144	**B1**	
	Total = $(3! \times 4! \times 3! \text{ oe})$ = 864	**B1**	
6(b)(i)	${}^{12}C_6 = 924$	**B1**	

Question	Answer	Marks	Guidance
6(b)(ii)	**Either:** $924 - {}^8C_6$	M1	For *their* **(i)** – the number of teams of just men
	Total = 896	A1	
	Or: 5M 1W : ${}^8C_5 \times {}^4C_1$ $(=224)$ 4M 2W : ${}^8C_4 \times {}^4C_2$ $(=420)$ 3M 3W : ${}^8C_3 \times {}^4C_3$ $(=224)$ 2M 4W : ${}^8C_2 \times {}^4C_4$ $(=28)$	M1	For a complete method
	Total = 896	A1	
7(i)		B1	For correct triangle, may be implied by a correct sine rule or cosine rule.
	$\frac{120}{\sin\alpha}$ or $\frac{120}{\sin(55-\theta)} = \frac{650}{\sin 35}$ or $\frac{650}{\sin 145}$	M1	For use of a correct sine rule to obtain $\alpha = ...$ or $\theta = ...$ Or for a correct cosine rule leading to a value for *v*, followed by a correct sine rule leading to one of the other angles
	$\alpha = 6.08^\circ$ or $\beta = 138.9$	A1	May be implied by a correct $\theta =$ awrt 49°
	Bearing is 048.9° or 049°	A1	
7(ii)	Either $\frac{v_r}{\sin(145 - their\alpha)} = \frac{650}{\sin 35}$ or $\frac{120}{\sin(their\alpha)}$ Or $v_r^2 = 650^2 + 120^2 -$ $(2 \times 650 \times 120)\cos(145 - their\alpha)$	M1	For use of sine rule or cosine rule to find resultant velocity Do not allow for a right-angled triangle May be seen in **(i)**
	$v_r = 745$	A1	For correct resultant velocity, allow awrt 745
	Time taken = $\frac{1250}{their\ 744.7}$	M1	For correct attempt at finding time using *their v* , $\neq$ 650, 120, 770 or 530
	$= 1.68$ hours or I hour 41 mins or 101 mins	A1	

Question	Answer	Marks	Guidance
8(i)	$e^y = \frac{m}{x} + c$	B1	May be implied by subsequent work
	Either $20 = 2m + c$ $8 = 4m + c$	M1	For at least 1 correct equation
		M1	**Dep** For attempt to solve *their* 2 equations simultaneously to obtain at least one unknown
	leading to $m = -6,\ c = 32$	A1	For both
	$y = \ln\left(32 - \frac{6}{x}\right)$	A1	Must have correct brackets Mark the final answer given
	Or: Gradient = $m = (-6)$	M1	For attempt to find gradient and equate it to *m*
	$20 = 2m + c$ or $8 = 4m + c$ or $e^y - 8 = m\left(\frac{1}{x} - 4\right)$ or $e^y - 20 = m\left(\frac{1}{x} - 2\right)$	M1	For at least 1 correct equation, may be using *their m*
	leading to $c = 32$ and $m = -6$	A1	For both $m = -6,\ c = 32$
	$y = \ln\left(32 - \frac{6}{x}\right)$	A1	
8(ii)	$x > \frac{3}{16}$ oe	B1	
8(iii)	$y = \ln 30$ isw	B1	
8(iv)	$2 = \ln\left(32 - \frac{6}{x}\right)$	M1	For a correct substitution and attempt to re-arrange using 2, *their* 32 and *their* – 6, keeping exactness to obtain $x =$
	$x = \frac{6}{32 - e^2}$ oe	A1	Must be exact

Question	Answer	Marks	Guidance
9(i)	$5 = 4 + 2\cos 3x$	**M1**	For attempt to solve trig equation to obtain one correct solution
	$\frac{\pi}{9}$	**A1**	
	$-\frac{\pi}{9}$	**A1**	
9(ii)	**Either:** $\int_{-\frac{\pi}{9}}^{\frac{\pi}{9}} 4 + 2\cos 3x - 5 \text{ d}x$	**M1**	For use of subtraction method
	$\left[\frac{2}{3}\sin 3x - x\right]_{-\frac{\pi}{9}}^{\frac{\pi}{9}}$	**M1**	For attempt to integrate to obtain the form $a\sin 3x + bx$
		B1	For $\frac{2}{3}\sin 3x$
		B1	For $-x$, may be implied by $4x - 5x$
	$\left(\frac{\sqrt{3}}{3} - \frac{\pi}{9}\right) - \left(-\frac{\sqrt{3}}{3} + \frac{\pi}{9}\right)$	**M1**	**Dep** on previous M mark for correct application of *their* limits in radians from **(i)** retaining exactness
	Shaded area = $\frac{2\sqrt{3}}{3} - \frac{2\pi}{9}$ oe isw	**A1**	

Question	Answer	Marks	Guidance
9(ii)	**Or:** Area of rectangle = $5\times\frac{2\pi}{9}$	M1	$5\times$ the difference of *their* limits in exact radians
	Area under curve = $\left[4x+\frac{2}{3}\sin 3x\right]_{-\frac{\pi}{9}}^{\frac{\pi}{9}}$	M1	For attempt to integrate to obtain the form $a\sin 3x+bx$
		B1	For $\frac{2}{3}\sin 3x$
		B1	For $4x$
	$\left(\frac{\sqrt{3}}{3}+\frac{4\pi}{9}\right)-\left(-\frac{\sqrt{3}}{3}-\frac{4\pi}{9}\right)$ $\left(=\frac{2\sqrt{3}}{3}+\frac{8\pi}{9}\right)$	M1	**Dep** on previous M mark for correct application of *their* limits in exact radians from **(i)** retaining exactness
	Shaded area = $\frac{2\sqrt{3}}{3}-\frac{2\pi}{9}$ oe isw	A1	
10(i)	$800=4x^2h$	B1	
	$h=\frac{800}{4x^2}$ oe or $xh=\frac{800}{4x}$ oe	B1	
	$(S=)2hx+8xh+4x^2$ oe	M1	Allow if *h* is substituted at this point
	$S=4x^2+\left(\frac{2000}{x}\right)$	A1	Leading to AG, must have *S* = or surface area = at some point and no errors

Question	Answer	Marks	Guidance
10(ii)	$\left(\frac{dS}{dx}=\right)8x-\frac{2000}{x^2}$	B1	For correct differentiation
	When $\frac{dS}{dx}=0$, $x=\sqrt[3]{250}$ oe (6.30)	M1	For equating to zero and attempt to solve, must get as far as $x = \ldots$, must be using the form $ax+\frac{b}{x^2}$
		A1	For correct positive x
	$S=476$ only	A1	
	$\frac{d^2S}{dx^2}=8+\frac{4000}{x^3}$ $\frac{d^2S}{dx^2}>0$ or 24 so minimum	B1	For a correct convincing method, with enough detail to reach a correct conclusion of a minimum. Must be using $x=\sqrt[3]{250}$ oe
11		M1	For attempt at differentiating a product
		B1	For $\frac{2}{3}\times 3(3x+1)^{-\frac{1}{3}}$
	$\left(\frac{dy}{dx}=\right)(x-2)\times\frac{2}{3}\times 3(3x+1)^{-\frac{1}{3}}+(3x+1)^{\frac{2}{3}}$	A1	For all other terms correct
	$y=\frac{4}{3}$	B1	
	When $x=\frac{7}{3}$, $\frac{dy}{dx}=\frac{13}{3}$	M1	For attempt at normal equation using $-\frac{1}{their\ m}$ and *their y* when $x=\frac{7}{3}$
	Equation of normal: $y-\frac{4}{3}=-\frac{3}{13}\left(x-\frac{7}{3}\right)$	A1	For correct normal equation, may be implied by a correct final answer
	At y-axis, $y=\frac{73}{39}$ $\left(0,\frac{73}{39}\right)$ isw	A1	

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Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2019**

MARK SCHEME

Maximum Mark: 80

Published

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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.

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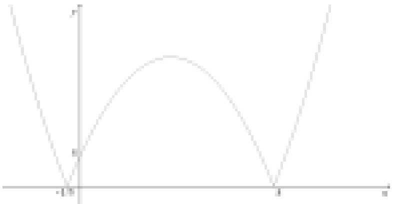
B Mark for a correct result or statement independent of Method marks.

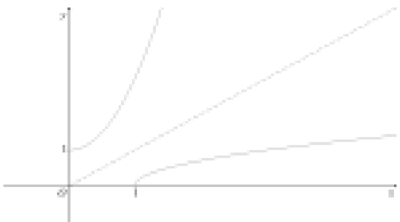
When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier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

Abbreviations

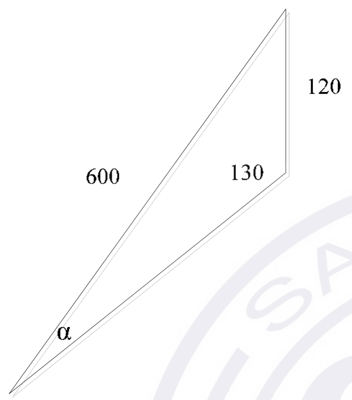
awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Guidance
1	$A \cap B = \varnothing$	**B1**	
	$Z \subset (X \cap Y)$	**B2**	**B1** for identifying $X \cap Y$
2	$a = \frac{3}{2}$	**B1**	
	$b = \frac{7}{3}$	**B1**	
	$c = 3$	**B1**	
3	$x^2 + (3-m)x + m - 4 = 0$	**M1**	For equating line and curve and attempting to obtain a quadratic equation equated to zero
	Discriminant: $(3-m)^2 - 4(m-4)$	**M1**	**Dep** For use of $b^2 - 4ac$, could be implied by use of quadratic formula
	$(m-5)^2$	**A1**	
	Always positive or zero for any *m,* so line and curve will always touch or intersect	**A1**	For a suitable comment/conclusion
4(i)		**B1**	For $\frac{6x^3}{(2x^3+5)}$
		M1	For attempt to differentiate a quotient
	$\frac{dy}{dx} = \frac{(x-1)\frac{6x^2}{(2x^3+5)} - \ln(2x^3+5)}{(x-1)^2}$	**A1**	For all other terms correct
	When $x = 2$, $\frac{dy}{dx} = \frac{24}{21} - \ln 21$ or $\frac{8}{7} - \ln 21$, or -1.90	**A1**	
4(ii)	$-1.90p$ oe	**B1**	

Question	Answer	Marks	Guidance
5(i)		B1	For shape with maximum in 1st quadrant
		B1	For $\left(-\frac{1}{3}, 0\right)$ and $(5, 0)$
		B1	For $(0, 5)$
		B1	All correct with cusps and correct shape for $x < -\frac{1}{3}$ and $x > 5$
5(ii)		M1	For attempt to find maximum point
	Maximum point when $x = \frac{7}{3}$	A1	For $x = \frac{7}{3}$
	$y = \frac{64}{3}$ so $k = \frac{64}{3}$	A1	
6(i)	$\frac{1}{\cos\theta} - \frac{\sin\theta}{\cos\theta} \times \sin\theta$ oe	M1	For dealing with sec, tan and cosec in terms of sin and cos
	$\frac{1 - \sin^2\theta}{\cos\theta}$	M1	For simplification and use of identity
	$\frac{\cos^2\theta}{\cos\theta}$	A1	For simplification to AG
6(ii)	$\cos 2\theta = \frac{\sqrt{3}}{2}$	M1	For use of part **(i)** and attempt to solve to get as far as $2\theta = ...$
	$2\theta = 30^{\circ}, 330^{\circ}$	M1	For dealing with double angle correctly, may be implied by one correct solution
	$\theta = 15^{\circ}, 165^{\circ}$	A1	For both
6(iii)	$\sin\left(\phi + \frac{\pi}{3}\right) = \pm\frac{1}{\sqrt{2}}$ $\phi + \frac{\pi}{3} = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}, \frac{9\pi}{4}$	M1	For correct attempt to solve, may be implied by $\phi + \frac{\pi}{3} = \frac{\pi}{4}$
		M1	**Dep** For dealing with compound angle correctly
	$\phi = \frac{5\pi}{12}, \frac{11\pi}{12}, \frac{17\pi}{12}, \frac{23\pi}{12}$	A2	**A1** for one correct pair, **A1** for a second correct pair with no extra solutions in the range.

Question	Answer	Marks	Guidance
7(i)	$AC^2 = \left(2\sqrt{5}-1\right)^2 + \left(2+\sqrt{5}\right)^2$	**M1**	For use of Pythagoras' theorem and attempt to expand brackets
	$= 20 - 4\sqrt{5} + 1 + 4 + 4\sqrt{5} + 5$	**A1**	For correct unsimplified, must be convinced of non-calculator use
	$AC = \sqrt{30}$	**A1**	
7(ii)	$\tan ACB = \dfrac{2\sqrt{5}-1}{2+\sqrt{5}} \times \dfrac{2-\sqrt{5}}{2-\sqrt{5}}$	**M1**	For attempt at tan *ACB* and rationalisation
	$= \dfrac{4\sqrt{5}-2-10+\sqrt{5}}{4-5}$ oe	**M1**	**Dep** For seeing at least 3 terms in the numerator
	$= 12 - 5\sqrt{5}$	**A1**	
7(iii)	$\sec^2 ACB = \tan^2 ACB + 1$ $= 144 - 120\sqrt{5} + 125 + 1$	**M1**	For use of identity using *their* **(ii)**
	$= 270 - 120\sqrt{5}$	**A1**	
8(i)	$g \geqslant 1$	**B1**	Must be using correct notation
8(ii)	$g\left(\sqrt{62}\right) = 125$	**B1**	
	$f^{-1}(x) = \frac{1}{3}\ln x$	**B1**	
	$\frac{1}{3}\ln 125 = \ln 5$	**B1**	For correct order and manipulation to obtain the given answer, need to see $\frac{1}{3}\ln 125$
8(iii)	$3e^{3x} = 24$	**M1**	For dealing with derivatives correctly
	$x = \frac{1}{3}\ln 8$	**A1**	
	$x = \ln 2$	**A1**	
8(iv)		**B3**	**B1** for correct g with intercept **B1** for $y = x$ and/or implication of symmetry **B1** for correct g^{-1} with intercept
9(a)(i)	$7! = 5040$	**B1**	

Question	Answer	Marks	Guidance
9(a)(ii)	Treating the 4 trophies as 1 unit so there are 4! ways	**B1**	Maybe implied by a correct answer
	There are also 4! ways of arranging the football trophies amongst themselves	**B1**	
	Total = $4! \times 4! = 576$	**B1**	
9(a)(iii)	Treating the 4 football trophies as 1 unit and the 2 cricket trophies as 1 unit so there are 3! ways	**B1**	Maybe implied by a correct answer
	There are also 4! ways of arranging the football trophies amongst themselves and 2 ways of arranging the cricket trophies	**B1**	Maybe implied by a correct answer
	Total = $3! \times 4! \times 2 = 288$	**B1**	
9(b)(i)	3003	**B1**	
9(b)(ii)	28	**B1**	
9(b)(iii)	3003 – 1	**M1**	For *their* **(i)** – 1
	3002	**A1**	**FT**
10(i)		**M1**	Attempt to integrate to obtain $k(2x+3)^{\frac{1}{2}}$
	$\frac{dy}{dx} = (2x+3)^{\frac{1}{2}} \quad (+c)$	**A1**	All correct, condone omission of $+c$
	$5 = 3 + c$	**M1**	**Dep** For attempt at c
	$\frac{dy}{dx} = (2x+3)^{\frac{1}{2}} + 2$	**M1**	For a further attempt to integrate
	$y = \frac{1}{3}(2x+3)^{\frac{3}{2}} + 2x(+d)$	**A1**	All correct, condone omission of $+d$
	$-\frac{1}{3} = \frac{8}{3} + 1 + d$	**M1**	For attempt at d
	$y = \frac{1}{3}(2x+3)^{\frac{3}{2}} + 2x - 4$	**A1**	Must have $y =$

Question	Answer	Marks	Guidance
10(ii)	When $x = 3,\ y = 11$	M1	For attempt to find y using *their* **(i)**
		M1	**Dep** For attempt at normal
	Normal: $y - 11 = -\frac{1}{5}(x - 3)$	A1	All correct unsimplified
	$x + 5y - 58 = 0$	A1	For correct form
11(i)		B1	For correct triangle, may be implied by subsequent work
	$\frac{120}{\sin\alpha} = \frac{600}{\sin 130}$	M1	For use of the correct sine rule
	$\alpha = 8.81^{\circ}$	A1	Allow greater accuracy
	Bearing 041.2° or 041°	A1	Allow greater accuracy
11(ii)	$\frac{v_r}{\sin 41.19} = \frac{600}{\sin 130} = \frac{120}{\sin\alpha}$	M1	For use of sine rule using *their* α or cosine rule
	$v_r = 515.8$ awrt 516	A1	
	Time taken $= \frac{2500}{515.8}$	M1	For attempt to find time using *their* v_r, not 600, 720 or 480
	$= 4.85$ or 4.84	A1	

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/12**

Paper 12 **March 2019**

MARK SCHEME

Maximum Mark: 80

Published

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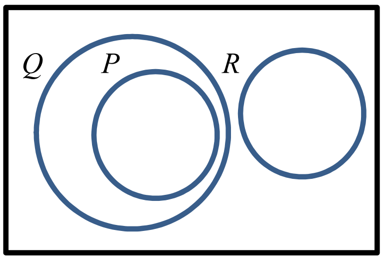
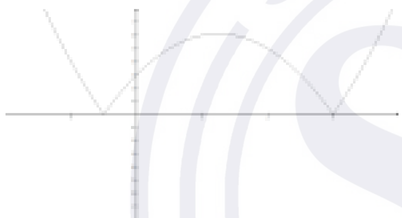
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1(a)(i)	6	**B1**	
1(a)(ii)	1	**B1**	
1(b)		2	**B1** for P contained within Q **B1** for Q and R separate
1(c)	$S' \cap T'$ or $(S \cup T)'$ oe	**B1**	
	$(X \cap Y) \cup (X \cap Z)$ or $X \cap (Y \cup Z)$ oe	**B1**	
2		4	**B1** for general shape with maximum point in 1st quadrant **B1** for $\left(-\frac{1}{2}, 0\right)$ and $(3,0)$ soi **B1** for $(0,3)$ soi **B1 dep** on first B1, with cusps and correct shape for $x < -\frac{1}{2}$ and $x > 3$
3(i)	$729 - 162x + 15x^2$	3	**B1** for 729 **B1** for $-162x$ **B1** for $15x^2$ Mark final answer
3(ii)	$(729 - 162x + 15x^2)\left(x^2 - 4 + \frac{4}{x^2}\right)$	**B1**	for expansion of $\left(x - \frac{2}{x}\right)^2$
	Term independent of $x = -2916 + 60$	**M1**	for attempt to find independent term, must be considering 2 products using *their* answer to part **(i)**
	$= -2856$	**A1**	
4(i)	$p'(x) = 6x^2 + 2ax + b$	**B1**	for $p'(x) = 6x^2 + 2ax + b$
	$p'(-3) = 54 - 6a + b$, $= -24$ leading to $6a - b = 78$	**B1**	must be convinced of correct substitution and simplification AG

Question	Answer	Marks	Partial Marks
4(ii)	$p\left(\frac{1}{2}\right): \frac{2}{8}+\frac{a}{4}+\frac{b}{2}-49=0$	**M1**	for attempt at $p\left(\frac{1}{2}\right)$ equated to 0
	$6a-b=78$ $a+2b=195$ oe	**M1**	**M Dep** on previous M for attempt to solve both equations
	leading to $a=27$	**A1**	
	$b=84$	**A1**	
4(iii)	$(2x-1)(x^2+14x+49)$	**2**	**M1** for factorisation by observation or by long division
4(iv)	$(2x-1)(x+7)^2$	**B1**	
5(i)	$\log_4 16+\log_4 p$	**M1**	for dealing with product correctly
	$2+p$	**A1**	
5(ii)	$7\log_4 x-\log_4 256$	**M1**	for dealing with power and division correctly
	$7p-4$	**A1**	
5(iii)	$2+p-(7p-4)=5$ leading to $p=\frac{1}{6}$	**M1**	for use of parts **(i)** and **(ii)** to obtain a value for *p*
	so $x=4^{\frac{1}{6}}$	**M1**	for correct attempt to deal with $\log_4$ in order to obtain *x*
	$x=1.26$	**A1**	
6(a)	**BA** and **CB**	**2**	**B1** for one correct product of 2 matrices **B1** for a second correct product of 2 matrices, with no other incorrect products
6(b)(i)	$\frac{1}{16}\begin{pmatrix} 3 & 2 \\ -5 & 2 \end{pmatrix}$ oe	**2**	**B1** for $\frac{1}{16}$ soi **B1** for $\begin{pmatrix} 3 & 2 \\ -5 & 2 \end{pmatrix}$

Question	Answer	Marks	Partial Marks
6(b)(ii)	$\mathbf{X}^{-1}\mathbf{XZ} = \mathbf{X}^{-1}\mathbf{Y}$ $\mathbf{Z} = \frac{1}{16}\begin{pmatrix} 3 & 2 \\ -5 & 2 \end{pmatrix}\begin{pmatrix} 4 & 1 \\ 2 & 0 \end{pmatrix}$	M1	for pre-multiplication by *their* inverse matrix
	attempt at matrix multiplication	M1	**M1 Dep** on previous M mark, must have at least 2 correct elements
	$\mathbf{Z} = \frac{1}{16}\begin{pmatrix} 16 & 3 \\ -16 & -5 \end{pmatrix}$ oe	A1	
7(i)	Area = $\frac{1}{2}\left(8+6\sqrt{5}\right)\left(10-2\sqrt{5}\right)$	M1	for a correct method of finding the area of the trapezium
	$=10+22\sqrt{5}$	A2	**A1** for 10 with sufficient working seen **A1** for $22\sqrt{5}$ with sufficient working seen
7(ii)	$\cot\theta = \frac{4}{10-2\sqrt{5}}$	B1	
	$=\frac{4\left(10+2\sqrt{5}\right)}{\left(10-2\sqrt{5}\right)\left(10+2\sqrt{5}\right)}$	M1	for attempt to rationalise an expression for $\cot\theta$, some evidence of expansion must be seen
	$=\frac{1}{2}+\frac{\sqrt{5}}{10}$	A1	
8(a)(i)	0	B1	
8(a)(ii)	Area under curve = $\frac{1}{2}(2\times10)+(4\times10)+\frac{1}{2}(10+20)\times4$	M1	for attempt to find the total area under the graph
	= 110	A1	
8(b)(i)	When $t=\frac{7\pi}{12}$, $v=-2.5$	M1	for substitution of $t=\frac{7\pi}{12}$ and correct attempt to evaluate
	Speed = 2.5	A1	must be positive
8(b)(ii)	$a=6\cos 2t$	M1	for differentiation to get acceleration, must be of the form $m\cos 2t$
	When acceleration = 0, $\cos 2t = 0$	M1	**M Dep** on previous M mark for equating to zero and correct attempt to solve to get a solution in radians.
	$t=\frac{\pi}{4}$ or 0.785	A1	

Question	Answer	Marks	Partial Marks
9(i)	$\frac{1}{2}r^2\theta = 36$ $\theta = \frac{72}{r^2}$	**M1**	for use of the area of the sector
	$P = 2r + r\theta$	**M1**	for attempt to find P making use of the area
	$P = 2r + \frac{72}{r}$	**A1**	for attempt to simplify to obtain AG
9(ii)	$\frac{dP}{dr} = 2 - \frac{72}{r^2}$	**M1**	for attempt to differentiate to obtain the form $a + \frac{b}{r^2}$ and equate to zero
	When $\frac{dP}{dr} = 0,\ r = 6$	**A1**	
	$P = 24$	**A1**	
	$\frac{d^2P}{dr^2} = \frac{144}{r^3}$ positive so minimum	**B1**	**FT** on *their* positive r, for a correct method to determine the nature of the stationary point leading to a correct conclusion. If the second derivative is evaluated, it must be correct for *their* r.
10(i)	$\frac{dy}{dx} = 2e^{2x} + 3x \quad (+c)$	**2**	**M1** for attempt to integrate to obtain the form $me^{2x} + nx$ **A1** all correct
	$c = 8$	**M1**	**M1 Dep** on previous M mark for attempt to get c
	$y = e^{2x} + \frac{3x^2}{2} + 8x \ (+d)$	**2**	**M1** for attempt to integrate again to obtain the form $pe^{2x} + qx^2 (+rx)$ **A1** all correct, **FT** on *their* ke^{2x} and *their* c
	$d = -6$	**M1**	**M1 Dep** on previous M mark for attempt to get d
	$y = e^{2x} + \frac{3x^2}{2} + 8x - 6$	**A1**	

Question	Answer	Marks	Partial Marks
10(ii)	When $x = \frac{1}{4}$, $y = -2.26$ $\frac{dy}{dx} = 12.0$	M1	for attempt to obtain both y and $\frac{dy}{dx}$ using *their* work from **(i)**
	$y + 2.26 = -\frac{1}{12}\left(x - \frac{1}{4}\right)$	2	**M1 Dep** on previous M mark for attempt to obtain the equation of the normal **A1** allow unsimplified, must be using correct accuracy or exact equivalents.
11(a)	$2\sin x\left(\cos^2 x - 1\right) = 0$	M1	for obtaining in terms of sin and cos to obtain one solution correctly
	$\sin x = 0$, $x = 0^\circ$, 180°	B1	for $x = 0^\circ$, 180° and no other in the given range for the solution of this equation
	$\cos x = \pm\frac{1}{\sqrt{2}}$, $x = 45^\circ$, 135°	A1	for $x = 45^\circ$, 135° and no other in the given range for the solution of this equation
11(b)(i)	$\frac{1}{\cos\theta} - \frac{\sin^2\theta}{\cos\theta}$	M1	for dealing with cot and sec
	$\frac{\cos^2\theta}{\cos\theta}$	M1	for correct use of identity
	$\cos\theta$	A1	for all correct working to gain AG
11(b)(ii)	$\cos 3\theta = \frac{1}{2}$ $\theta = \frac{5\pi}{9}$ or $\frac{\pi}{9}$	M1	for use of part **(i)** and attempt to solve correctly to obtain a positive angle, may be implied by one correct solution
	$\theta = -\frac{5\pi}{9}$ or $-\frac{\pi}{9}$	M1	for use of part **(i)** and attempt to solve correctly to obtain a negative angle, may be implied by one correct solution
	$\theta = \pm\frac{\pi}{9}$, $\pm\frac{5\pi}{9}$	A2	**A1** for one correct pair of solutions **A1** for a second pair of solutions with no extra solutions within the range

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ADDITIONAL MATHEMATICS	**0606/11**
Paper 1	**October/November 2018**
MARK SCHEME	
Maximum Mark: 80	

Published

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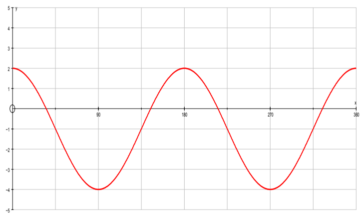
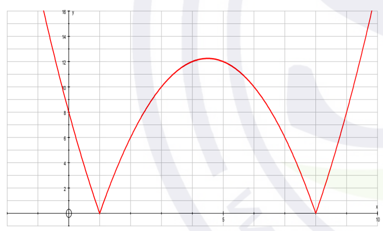
soi seen or implied

Question	Answer	Marks	Guidance
1(a)		**B3**	**B1** for 2 cycles, one max and 2 min points in the correct places and up to a max at each end **B1** for going between 2 and –4 **B1** for starting at $(0,2)$ and finishing at $(360,2)$
1(b)(i)	4	**B1**	
1(b)(ii)	60° or $\frac{\pi}{3}$	**B1**	
2(i)	$\left(p\left(-\frac{1}{2}\right)=\right)\ -\frac{1}{4}+\frac{5}{4}-2+a=2$ $(q(-2)=)\ 16-6a+b=0$	**M1**	For either $p\left(-\frac{1}{2}\right)=2$ or $q(-2)=0$
	$a=3$	**A1**	
	$b=2$	**A1**	
2(ii)	$r(x)=2x^3+x^2-5x+1$	**M1**	For $r(x)$ using *their* $p(x)$ and $q(x)$
	$r\left(\frac{2}{3}\right)=\frac{16}{27}+\frac{4}{9}-\frac{10}{3}+1$	**M1**	For $r\left(\frac{2}{3}\right)$
	$=-\frac{35}{27}$	**A1**	Must be exact

Question	Answer	Marks	Guidance
3	$(3+kx)^6 =$ $729+1458kx+1215k^2x^2$	**B2**	**B1** for $1458kx$ or $1215k^2x^2$
	Terms in x^2 for $(2-x)(3+kx)^6$ $= -1458k + 2430k^2$ $2430k^2 - 1458k = 972$	**M1**	For attempt at further expansion to obtain 2 terms in x^2 and equating to 972
	$5k^2 - 3k - 2 = 0$ $(5k+2)(k-1) = 0$	**M1**	**Dep** for solution of resulting 3 term quadratic
	$k = -\frac{2}{5}$	**A1**	
	$k = 1$	**A1**	
4(i)	$\left(x-\frac{9}{2}\right)^2 - \frac{49}{4}$	**B2**	**B1** for $\frac{9}{2}$ or $\frac{49}{4}$
4(ii)	$\left(\frac{9}{2}, -\frac{49}{4}\right)$	**B1**	**FT** *their p* and *q*
4(iii)		**B3**	**B1** for shape **B1** for cusps at $(1, 0)$ and $(8, 0)$ **B1** for all correct, passing through $(0, 8)$ with maximum in correct position
4(iv)	$\frac{49}{4}$	**B1**	**FT** *their q*
5(i)	$\frac{1}{2}r^2\theta = 48$	**B1**	
	$\theta = \frac{96}{r^2}$	**B1**	**Dep** Must have previous B1
5(ii)	$r\theta = 12$	**B1**	For statement of arc length
	$r \times \frac{96}{r^2} = 12$	**M1**	For attempt to use part **(i)** to find either r or θ
	$r = 8$ and $\theta = 1.5$	**A1**	For both

Question	Answer	Marks	Guidance
5(iii)	Area = $48-\left(\frac{1}{2}r^2\sin\theta\right)$	M1	For a complete method including a correct attempt for the area of the triangle using their r and θ
	$=16.1$	A1	
6(i)	For $\frac{4x}{2x^2+3}$	B1	
		M1	For attempt to differentiate a quotient or appropriate product
	$\frac{dy}{dx}=\frac{(5x+2)\frac{4x}{2x^2+3}-5\ln(2x^2+3)}{(5x+2)^2}$	A1	All other terms correct
	When $x=0$ $\frac{dy}{dx}=\frac{-5\ln 3}{4}$	A1	For **given answer**
6(ii)	$y=\frac{1}{2}\ln 3$ or 0.549	B1	May be implied by tangent equation, allow 0.55
	Equation of tangent $y=\left(-\frac{5}{4}\ln 3\right)x+\frac{1}{2}\ln 3$ or $y=-1.37x+0.549$	B1	
7(a)	$\lg 100=2$	B1	
	$3\lg x=\lg x^3$	B1	
	$\lg\frac{100x^3}{y}$	B1	
7(b)(i)	$6x^2+7x-3=0$ $(2x+3)(3x-1)=0$	M1	For obtaining in suitable quadratic form and attempt to solve
	$x=-\frac{3}{2}$ $x=\frac{1}{3}$	A1	For both

Question	Answer	Marks	Guidance
7(b)(ii)	$x = \log_a 3$ $\frac{1}{3} = \log_a 3$	**M1**	For realising connection with part **(i)** and attempt to solve $\frac{1}{3} = \log_a 3$ or $-\frac{3}{2} = \log_a 3$
	$a = 27$	**A1**	
	$-\frac{3}{2} = \log_a 3$	**M1**	For realising connection with part **(i)** and attempt to solve $-\frac{3}{2} = \log_a 3$ or $\frac{1}{3} = \log_a 3$
	$a = \left(\frac{1}{3}\right)^{\frac{2}{3}}$ or 0.481 or $\left(\frac{1}{9}\right)^{\frac{1}{3}}$ oe	**A1**	
8(i)		**M1**	For attempt to use chain rule to obtain $kx\left(5x^2+4\right)^{\frac{1}{2}}$ where k is a constant
	$\frac{3}{2}(10x)\left(5x^2+4\right)^{\frac{1}{2}}$	**A1**	Allow unsimplified
8(ii)		**M1**	For attempt to use part **(i)** if in correct form of $m\left(5x^2+4\right)^{\frac{3}{2}}$
	$\frac{1}{15}\left(5x^2+4\right)^{\frac{3}{2}} \quad (+c)$	**A1**	**FT** on *their* $\frac{1}{k}\left(5x^2+4\right)^{\frac{3}{2}}$
8(iii)		**M1**	For use of limits if *their* **(ii)** Must be in the form $m\left(5x^2+4\right)^{\frac{3}{2}}$
	$\frac{1}{15}\left(\left(5a^2+4\right)^{\frac{3}{2}} - 4^{\frac{3}{2}}\right) \quad \left[=\frac{19}{15}\right]$	**A1**	
	$\left(5a^2+4\right)^{\frac{3}{2}} = 27$	**M1**	**Dep** For complete and correct method to deal with the power of $\frac{3}{2}$
	leading to $a = 1$	**A1**	
9(i)	3	**B1**	

Question	Answer	Marks	Guidance
9(ii)		M1	For attempt to differentiate to obtain $a + be^{-t}$
	$\frac{ds}{dt} = 4 - 3e^{-t}$	A1	All correct
	$2 = 4 - 3e^{-t}$	M1	**Dep** for correct attempt to solve equation involving exponential where $e^{-t} > 0$
	leading to $t = \ln\frac{3}{2}$ or $-\ln\frac{2}{3}$	A1	Must be an exact form
9(iii)	When $t = \ln 5$, $\frac{ds}{dt} = \frac{17}{5}$	M1	For attempt to find value of $\frac{ds}{dt}$ when $t = \ln 2$
		M1	**Dep** for attempt to use method of small changes
	$\partial s = \frac{17h}{5}$	A1	
10(i)	Velocity of A $\begin{pmatrix} 6 \\ 8 \end{pmatrix}$	B1	For velocity, may be implied by later work
	When $t = 6$, $\mathbf{r}_A = \begin{pmatrix} 2 \\ -5 \end{pmatrix} + 6\begin{pmatrix} 6 \\ 8 \end{pmatrix}$	M1	For a complete and correct method
	$= \begin{pmatrix} 38 \\ 43 \end{pmatrix}$	A1	For 43
10(ii)	$\mathbf{r}_B = \begin{pmatrix} 16 \\ 37 \end{pmatrix} + \begin{pmatrix} 4 \\ 2 \end{pmatrix} t$	B1	
10(iii)	$\begin{pmatrix} 16 \\ 37 \end{pmatrix} + \begin{pmatrix} 4 \\ 2 \end{pmatrix} t = \begin{pmatrix} 2 \\ -5 \end{pmatrix} + \begin{pmatrix} 6 \\ 8 \end{pmatrix} t$	M1	For equating position vectors at a time t
	$16 + 4t = 2 + 6t$ or $37 + 2t = -5 + 8t$	M1	**Dep** for equating like vectors at least once
	$t = 7$	A1	Allow from one correct equation
	Both equations lead to $t = 7$	B1	For showing that $t = 7$ satisfies both equations thus verifying collision, or equivalent
10(iv)	$\begin{pmatrix} 44 \\ 51 \end{pmatrix}$	B1	

Question	Answer	Marks	Guidance
11(a)(i)		**B1**	For critical values
	$2 \leqslant f \leqslant 4$	**B1**	**Dep** For correct inequality and notation
11(a)(ii)	$x = 3\cos y$ $\cos 2y = 0.5$	**M1**	For attempt to find f^{-1} and equate to 0.5
	$2y = \frac{\pi}{3}$	**M1**	**Dep** For correct attempt to solve, dealing with the double angle
	$y = \frac{\pi}{6}$	**A1**	
11(b)	$g^2(x) = g(3 - x^2)$ $= 3 - (3 - x^2)^2$	**M1**	For correct attempt at g^2, allow unsimplified
	$-6 + 6x^2 - x^4 = -6$ $6x^2 - x^4 = 0$	**M1**	**Dep** for equating to –6 and attempt to solve to obtain a non-zero root
	$x = 0$	**B1**	
	$x = \pm\sqrt{6}$	**A1**	

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Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/12**
Paper 1	**October/November 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.

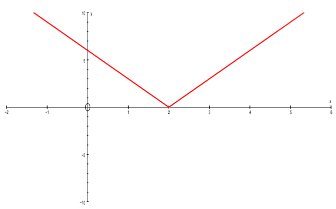
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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

Question	Answer	Marks	Guidance
1	$\sin(x+50^\circ)=-\frac{1}{\sqrt{2}}$ $(x+50^\circ=-45^\circ,\ 225^\circ)$	M1	For order of operations – subtraction of 1, division by $\pm\sqrt{2}$ and attempt at $\sin^{-1}$
		M1	**Dep** For obtaining a solution by subtracting 50°
	$x=-95^\circ,\ 175^\circ$	A2	**A1** for one correct solution **A1** for a second correct solution and no others within the range
2	$\frac{dy}{dx}=5x+\frac{1}{2}e^{2x}\quad(+c)$	M1	For attempt to integrate to get $\frac{dy}{dx}$ in the form $5x+pe^{2x}$. Condone omission of $+c$
	When $x=0$, $\frac{dy}{dx}=4$ so $c=\frac{7}{2}$	M1	**Dep** For attempt to get value of c
	$y=\frac{5x^2}{2}+\frac{1}{4}e^{2x}+\frac{7}{2}x\quad(+d)$	M1	**Dep** on first M1 only For attempt to get y in the form including $\frac{5x^2}{2}+pe^{2x}$. Condone omission of $+d$.
	When $x=0$, $y=-3$ so $d=-\frac{13}{4}$	M1	**Dep** on previous **DepM1** For attempt to obtain d, allow if c not found
	$y=\frac{5x^2}{2}+\frac{1}{4}e^{2x}+\frac{7}{2}x-\frac{13}{4}$	A1	Must have an equation
3(i)		B2	**B1** for correct shape with vertex at $(2,0)$ **Dep B1** for passing through or starting at $(0,6)$

Question	Answer	Marks	Guidance
3(ii)	**Either** $6-3x=2$ $x=\frac{4}{3}$	**B1**	For $x=\frac{4}{3}$
	$6-3x=-2$	**M1**	For considering – 2
	$x=\frac{8}{3}$	**A1**	
	Or $9x^2-36x+32=0$	**M1**	For squaring each side and attempt to solve a 3 term quadratic = 0
	$x=\frac{4}{3}$	**A1**	
	$x=\frac{8}{3}$	**A1**	
3(iii)	$x<\frac{4}{3},\ \ x>\frac{8}{3}$	**B1**	**FT** on *their* solutions in part **(ii)**, must both be positive and written as 2 separate statements
4(i)		**B1**	For $\frac{2}{2x+1}$
		M1	For attempt to differentiate a product
	$\frac{dy}{dx}=x^3\frac{2}{2x+1}+3x^2\ln(2x+1)$	**A1**	For all other terms correct
	When $x=0.3$, $\frac{dy}{dx}=0.161$	**A1**	For awrt 0.161
4(ii)	$0.161h$	**B1**	**FT** on *their* numerical answer to part **(i)**
5(i)	7th term: $924a^6b^6x^6=924x^6$ $924a^6b^6=924$ $924a^6(bx)^6=924x^6$	**B1**	For any correct statement
	$(ab)^6=1$ or $ab=1$ so $b=\frac{1}{a}$	**B1**	**Dep** on first **B1** Must be convinced, nfww

Question	Answer	Marks	Guidance
5(ii)	6th term: $792a^7b^5x^5 = 198x^5$ $792a^7b^5 = 198$ $792a^7(bx)^5 = 198x^5$	**B1**	For any correct statement
	use of $ab = 1$ to obtain $a^2 = \ldots$ or $b^2 = \ldots$	**M1**	For attempt to solve *their* equations simultaneously to obtain an equation in a^2 or b^5
	$a = \frac{1}{2}$	**A1**	
	$b = 2$	**A1**	
6(i)		**M1**	For $kx(5x - 125)^{-\frac{1}{3}}$
	$\frac{2}{3} \times 10x(5x^2 - 125)^{-\frac{1}{3}}$ $\left(\frac{20}{3}x(5x^2 - 125)^{-\frac{1}{3}}\right)$	**A1**	Allow unsimplified
6(ii)		**M1**	For $m(5x^2 - 125)^{\frac{2}{3}} \quad (+c)$
	$\frac{3}{20}(5x^2 - 125)^{\frac{2}{3}} \quad (+c)$	**A1**	**FT** on *their* k from part **(i)**
6(iii)	$\frac{3}{20}\left((375)^{\frac{2}{3}} - (55)^{\frac{2}{3}}\right)$	**M1**	**Dep** on previous **M1** For use of limits in *their* answer to part **(ii)**, must be in the form $m(5x^2 - 125)^{\frac{2}{3}} \quad (+c)$,
	$= 5.63$	**A1**	Allow greater accuracy

Question	Answer	Marks	Guidance
7(a)	$\left\|\begin{pmatrix}-12\\5\end{pmatrix}\right\| = 13$	B1	For magnitude, may be implied by a correct **v**
	$\mathbf{v} = \begin{pmatrix}-36\\15\end{pmatrix}$ or $3\begin{pmatrix}-12\\5\end{pmatrix}$	B1	Must be a vector
7(a) Alternative	If $t\left\|\begin{pmatrix}-12\\5\end{pmatrix}\right\| = 39$, $t = 3$	B1	For value of t, may be implied by a correct **v**
	$\mathbf{v} = \begin{pmatrix}-36\\15\end{pmatrix}$ or $3\begin{pmatrix}-12\\5\end{pmatrix}$	B1	
7(b)		M1	For equating like vectors at least once
	$17r + 2s + 3 = 0$ $2r + 6s + 9 = 0$	M1	**Dep** For solution of resulting equations to obtain 2 solutions
	$r = 0$	A1	
	$s = -\frac{3}{2}$ oe	A1	
8(i)	$a(a+4) - 12 = 0$	M1	For correct use of det = 0
	$a^2 + 4a - 12 = 0$	M1	**Dep** For solution of resulting quadratic equation
	leading to $a = -6$, $a = 2$	A1	For both
8(ii)	$\mathbf{A}^{-1} = \frac{1}{20}\begin{pmatrix}8 & -3\\-4 & 4\end{pmatrix}$ oe	B2	**B1** for $\frac{1}{20}$ **B1** for $\begin{pmatrix}8 & -3\\-4 & 4\end{pmatrix}$
8(iii)	$\mathbf{B} = \mathbf{A}^{-1}\begin{pmatrix}2 & 3\\4 & -5\end{pmatrix}$	M1	For pre-multiplication by their $\mathbf{A}^{-1}$
		M1	**Dep** For multiplication of 2 matrices – need to see at least 2 correct elements – may be unsimplified
	$= \frac{1}{20}\begin{pmatrix}4 & 39\\8 & -32\end{pmatrix}$	A1	For final matrix oe

Question	Answer	Marks	Guidance
9(i)	$p(-3)=0$ leading to $-27a+9b-3c-9=0$	**M1**	For substitution of $x=-3$ and equating to zero
	$p'(x)=3ax^2+2bx+c$ $p'(0)=36$	**M1**	For differentiation in the form rx^2+sx+t and substitution of $x=0$
	$c=36$	**A1**	nfww
	$p''(x)=6ax+2b$ $p''(0)=2b$	**M1**	For further differentiation in the form $vx+w$ of *their* $p'(x)$ and substitution of $x=0$
	$b=43$	**A1**	nfww
	$a=10$	**A1**	nfww
9(ii)	$p\left(\frac{1}{2}\right)$	**M1**	For use of $x=\frac{1}{2}$ in *their* $p(x)$ from part **(i)**
	21	**A1**	
10(i)	$a=2$	**B1**	
	$\cos bx=-\frac{1}{2}$	**M1**	For a correct attempt to solve $\cos b\frac{\pi}{6}=\pm\frac{a}{4}$ provided $0<a\leqslant 4$ to get $b=...$
	leading to $b=4$	**A1**	
10(ii)	$\cos 4x=-\frac{1}{2}$	**M1**	**Dep** For attempt to solve *their* $\cos bx=\pm\frac{a}{4}$ provided $0<a\leqslant 4$ or use of symmetry to get $x=...$
	$x=\frac{\pi}{3}$ so $\left(\frac{\pi}{3},0\right)$	**A1**	
10(iii)	At M, $y=-2$	**B1**	
	$x=\frac{\pi}{4}$	**B1**	

Question	Answer	Marks	Guidance
11(i)	$2r + r\theta = 10$	M1	For use of arc length and attempt to get perimeter, must have 2 terms involving r
		M1	**Dep** For attempt to get r in terms of θ
	$r = \frac{10}{2+\theta}$	A1	
	$A = \frac{1}{2}\left(\frac{10}{2+\theta}\right)^2 \theta$	M1	For attempt to obtain the area of the sector in terms of θ only, using *their r*
	$A = \frac{50\theta}{(2+\theta)^2}$	A1	For manipulation to get the required answer nfww **AG**
11(ii)		M1	For attempt to differentiate a quotient or an equivalent product
	$\frac{\mathrm{d}A}{\mathrm{d}\theta} = \frac{50(2+\theta)^2 - 100\theta(2+\theta)}{(2+\theta)^4}$ or $\frac{\mathrm{d}A}{\mathrm{d}\theta} = 50(2+\theta)^{-2} - 100\theta(2+\theta)^{-3}$	A1	All correct, allow unsimplified
	When $\frac{\mathrm{d}A}{\mathrm{d}\theta} = 0$	M1	For equating *their* $\frac{\mathrm{d}A}{\mathrm{d}\theta}$ to 0 and attempt to solve – need to see at least one line of working
	$\theta = 2$	A1	Condone inclusion of -2
	$A = \frac{25}{4}$	A1	

Question	Answer	Marks	Guidance
11(ii) Alternative	Starting again using $\theta = \frac{10-2r}{2}$ so $A = 5r - r^2$	**M1**	A complete method to obtain $\frac{dA}{dr}$
	$\frac{dA}{dr} = 5 - 2r$	**A1**	
	When $\frac{dA}{dr} = 0$	**M1**	For equating to zero and attempt to solve
	$r = 2.5$	**A1**	
	$A = \frac{25}{4}$	**A1**	
12	$2x^2 + 7x = 0$ or $y^2 - 3y - 10 = 0$	**M1**	For attempt to obtain a simplified quadratic equation in one variable equated to 0
		M1	**Dep** For solution of quadratic
	$(0, 5)$	**A1**	
	$\left(-\frac{7}{2}, -2\right)$	**A1**	
	Midpoint $\left(-\frac{7}{4}, \frac{3}{2}\right)$	**B1**	
	Gradient of *AB* = 2 $\therefore \perp$ gradient = $-\frac{1}{2}$	**M1**	For attempt to obtain gradient of line perpendicular to *AB* using *their* coordinates
	$\perp$ bisector: $y - \frac{3}{2} = -\frac{1}{2}\left(x + \frac{7}{4}\right)$	**M1**	For a correct attempt to obtain equation of perpendicular bisector using their midpoint and *their* perpendicular gradient
	Consideration of when $y = x$	**M1**	**Dep** on previous **M1** For attempt to find intersection with the line $y = x$
	$x = y = \frac{5}{12}$	**A1**	For both

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ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2018**

MARK SCHEME

Maximum Mark: 80

Published

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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)	${}^5C_3 \times 2^2 \times (px)^3$	**B1**	
	$40p^3 = -\frac{8}{25}$ $p^3 = -\frac{8}{1000}$	**M1**	equating *their* coefficient of x^3 to $-\frac{8}{25}$ and finding p^3
	$p = -\frac{1}{5}$ or $p = -0.2$	**A1**	
1(b)	${}^8C_4 \times (2x^2)^4 \times \left(\frac{1}{4x^2}\right)^4$	**B1**	
	$70 \times 16 \times \frac{1}{256}$	**M1**	at least two of $70, 16, \frac{1}{256}$ correct in an evaluation of a three-term product
	$\frac{35}{8}$, 4.375, $4\frac{3}{8}$	**A1**	cao
2(i)	$\theta = \frac{20-2r}{r}$	**B1**	
	Area = $\frac{1}{2}r^2\left(\frac{20-2r}{r}\right)$	**M1**	use of *their* θ in terms of r in formula for sector area
	$A = 10r - r^2$	**A1**	simplification to get given answer
	Alternative		
	$s = 20 - 2r$	**B1**	
	$= \frac{1}{2}r(20-2r)$	**M1**	use of formula for sector area using *their* expression for s in terms of r
	$A = 10r - r^2$	**A1**	simplification to get given answer
2(ii)	$\frac{dA}{dr} = 10 - 2r$ When $\frac{dA}{dr} = 0$, $r = 5$	**M1**	for $\frac{dA}{dr} = 10 - kr$, equating to zero and solving for r
	$\theta = \frac{(20 - 2\times 5)}{5}$	**M1**	**Dep** substitution of *their* value of r to get θ
	$\theta = 2$	**A1**	

Question	Answer	Marks	Guidance
3(i)	$AC^2 = \left(5\sqrt{3}+5\right)^2 + \left(5\sqrt{3}-5\right)^2$	**M1**	correct use of Pythagoras or correct use of cosine rule with cos90
	$= 75 + 25 + 50\sqrt{3} + 75 + 25 - 50\sqrt{3}$ $= 200$	**M1**	correct expansion to 6 or 8 terms
	$AC = 10\sqrt{2}$	**A1**	from $AC^2 = 200$
3(ii)	$\tan BCA = \dfrac{5\sqrt{3}+5}{5\sqrt{3}-5}$ oe	**B1**	
	$= \dfrac{\left(5\sqrt{3}+5\right)\left(5\sqrt{3}+5\right)}{\left(5\sqrt{3}-5\right)\left(5\sqrt{3}+5\right)}$ oe $= \dfrac{100+50\sqrt{3}}{50}$ oe	**M1**	for rationalisation
	$= 2 + \sqrt{3}$	**A1**	
4(i)		**M1**	for $10\left(1+\cos 3x\right)^9$ f(x)
		M1	for $k\sin 3x\left(1+\cos 3x\right)^9$
	$\dfrac{dy}{dx} = -30\sin 3x\left(1+\cos 3x\right)^9$	**A1**	
	When $x = \dfrac{\pi}{2}$, $\dfrac{dy}{dx} = 30$	**A1**	
4(ii)	Use of $\dfrac{dy}{dx} \times \dfrac{dx}{dt} = \dfrac{dy}{dt}$ with $\dfrac{dy}{dt} = 6$	**M1**	*their* $\dfrac{dy}{dx} \times \dfrac{dx}{dt} = 6$
	$\dfrac{dx}{dt} = \dfrac{1}{5}$ or 0.2	**A1**	**FT** from *their* answer from part **(i)**

Question	Answer	Marks	Guidance
5(i)	$\log_9 4 = \dfrac{\log_3 4}{\log_3 9}$	**B1**	change of base
	$= \dfrac{1}{2}\log_3 4$ $= \dfrac{1}{2}\log_3 2^2$ or $\log_3 \sqrt{4}$ $= \log_3 2$	**B1**	**Dep** must have B1 for change of base and full working
	Alternative A		
	$\log_9 4 = 2\log_9 2$	**B1**	use of power rule
	$= \dfrac{2\log_3 2}{\log_3 9}$ $= \dfrac{2\log_3 2}{2\log_3 3}$ $= \log_3 2$	**B1**	**Dep** change of base and full working
	Alternative B		
	$x = \log_9 4 \Rightarrow 9^x = 4$ $9^x = 4 \Rightarrow 3^{2x} = 4$	**B1**	correct use of indices to reach $3^{2x} = 4$
	$\Rightarrow 3^x = 2 \Rightarrow x = \log_3 2$ $\therefore \log_9 4 = \log_3 2$	**B1**	**Dep** full working
	Alternative C		
	$\log_9 4 = \dfrac{\log_{10} 4}{\log_{10} 9}$ $= \dfrac{2\log_{10} 2}{2\log_{10} 3}$	**B1**	change of base and use of power rule
	$= \log_3 2$	**B1**	**Dep** change of base and full working

Question	Answer	Marks	Guidance
5(ii)	$\log_3 2 + \log_3 x = 3$ $\log_3 2x = 3$	**B1**	for $\log_3 2x = 3$
	$3^3 = 2x$	**B1**	
	$x = 13.5,\ \ x = \frac{27}{2}$	**B1**	
	Alternative		
	$\log_3 x = \log_3 27 - \log_3 2$	**B1**	
	$= \log_3 \frac{27}{2}$	**B1**	
	$x = 13.5,\ \ x = \frac{27}{2}$	**B1**	
6(i)	$\frac{\mathrm{d}s}{\mathrm{d}t} = -6\mathrm{e}^{-0.5t} + 4$	**M1**	for $k\mathrm{e}^{-0.5t} + 4$
	When $\frac{\mathrm{d}s}{\mathrm{d}t} = 0,\ \mathrm{e}^{-0.5t} = \frac{2}{3}$ $-0.5t = \ln\frac{2}{3}$ $t = -2\ln\frac{2}{3}$	**M1**	**Dep** equating to zero and correct order of operations to solve for t
	$t = 0.811$	**A1**	
6(ii)		**M1**	for $k\mathrm{e}^{-0.5t}$
	$\frac{\mathrm{d}^2 s}{\mathrm{d}t^2} = 3\mathrm{e}^{-0.5t}$	**A1**	
6(iii)	$3\mathrm{e}^{-0.5t} = 0.3$ $\mathrm{e}^{-0.5t} = 0.1$ $t = \frac{\ln 0.1}{-0.5}$	**M1**	correct order of operations and correct use of ln to solve $k\mathrm{e}^{-0.5t} = 0.3$ for t
	$s = 12\mathrm{e}^{-0.5\times 4.605} + 4\times 4.605 - 12$	**M1**	**Dep** use of t to obtain s
	$s = 7.62$	**A1**	
6(iv)	$\mathrm{e}^{-0.5t}$ is always positive or $\mathrm{e}^{-0.5t}$ can never be zero or negative	**B1**	correct comment about $\mathrm{e}^{-0.5t}$

Question	Answer	Marks	Guidance
7(i)	$\overrightarrow{AD} = m(\mathbf{c} - \mathbf{a})$	**B1**	
7(ii)	$\overrightarrow{AD} = \overrightarrow{OD} - \mathbf{a}$	**B1**	for $\overrightarrow{OD} = \frac{2}{3}\mathbf{b}$
	$= \frac{2}{3}\mathbf{b} - \mathbf{a}$	**B1**	**FT** *their* $\overrightarrow{OD}$ if $\overrightarrow{OD} = k\mathbf{b}$
7(iii)	$m(\mathbf{c} - \mathbf{a}) = \frac{2}{3}\mathbf{b} - \mathbf{a}$	**M1**	equating parts **(i)** and **(ii)**
	$24\mathbf{a}(1-m) + 24m\mathbf{c} = 16\mathbf{b}$ Comparing with $15\mathbf{a} + 9\mathbf{c} = 16\mathbf{b}$	**M1**	attempt to eliminate or compare like vectors using given condition
	$m = \frac{3}{8}$	**A1**	
8(i)	$5 \leqslant \mathrm{f}(x) \leqslant 6$ or $[5, 6]$ oe	**B2**	**B1** for $5 \leqslant \mathrm{f}(x) \leqslant p$ ($p > 5$) or for $q \leqslant \mathrm{f}(x) \leqslant 6$ ($q < 6$)
8(ii)	$x = \sin\frac{y}{4} + 5$	**M1**	complete valid attempt to obtain the inverse with operations in correct order.
	$y = 4\sin^{-1}(x - 5)$	**A1**	
	Range $0 \leqslant y \leqslant 2\pi$	**B1**	
8(iii)	$2\left(\sin\frac{\left(x - \frac{\pi}{3}\right)}{4} + 5\right)$ $(= 11)$	**B1**	for $\sin\frac{\left(x - \frac{\pi}{3}\right)}{4} + 5$
	$\sin\frac{\left(x - \frac{\pi}{3}\right)}{4} = \frac{1}{2}$	**M1**	for $\sin\frac{\left(x - \frac{\pi}{3}\right)}{4} = k$
	$x = 4\sin^{-1}\left(\frac{1}{2}\right) + \frac{\pi}{3}$ oe	**M1**	**Dep** for use of $\sin^{-1}$ and correct order of operations to obtain x. Allow one +/– or ×/ ÷ sign error
	$x = \pi$ or 3.14	**A1**	$x = \pi$ and no other solutions in range

Question	Answer	Marks	Guidance
9	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\ln\left(3x^2+1\right)\right)=\frac{6x}{3x^2+1}$	**B1**	for $\frac{6x}{3x^2+1}$
	$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{x^2\frac{6x}{3x^2+1}-2x\ln\left(3x^2+1\right)}{x^4}$ or $\frac{\mathrm{d}y}{\mathrm{d}x}=\left(\frac{-2}{x^3}\right)\ln\left(3x^2+1\right)+\left(\frac{1}{x^2}\right)\frac{6x}{\left(3x^2+1\right)}$	**M1**	differentiation of a quotient or product
	$\frac{x^2\,\mathrm{f}(x)-2x\ln\left(3x^2+1\right)}{x^4}$ or for $\left(-\frac{2}{x^3}\right)\ln\left(3x^2+1\right)+\left(\frac{1}{x^2}\right)\mathrm{f}(x)$	**A1**	
	When $x=2$, $\frac{\mathrm{d}y}{\mathrm{d}x}=-0.410$	**A1**	
	Gradient of perp = 2.436…	**M1**	use of $-\frac{1}{m}$ with a gradient obtained by differentiation
	When $x=2,\ y=0.641$ or $\frac{1}{4}\ln 13$	**B1**	
	Normal: $y-0.641=2.436\left(x-2\right)$	**M1**	**Dep**
	$y=2.44x-4.23$	**A1**	
10(i)	$x+8=12+x-x^2$ $x^2=4$, $x=\pm 2$ or $y^2-16y+60=0$ $y=6$ or $y=10$	**M1**	correct method of solution to obtain x or y
	$x=2,\ y=10$ $x=-2,\ y=6$	**A2**	**A1** for $x=-2$ and $x=2$ or for $y=6$ and $y=10$ or for either point from a correctly solved equation.
10(ii)		**M1**	for $12x+px^2+qx^3\quad(+c)$
	$12x+\frac{x^2}{2}-\frac{x^3}{3}\quad(+c)$	**A1**	

Question	Answer	Marks	Guidance
10(iii)	$\left[12x+\frac{x^2}{2}-\frac{x^3}{3}\right]_{-2}^{2}-\left(\frac{1}{2}(6+10)\times 4\right)$	B1	**FT** area of the trapezium unsimplified $\left(\frac{1}{2}(6+10)\times 4\right)$ or $\left[\frac{2^2}{2}+8\times 2\right]-\left[\frac{(-2)^2}{2}+8\times(-2)\right]$ (= 32)
	$\left[12\times 2+\frac{2^2}{2}-\frac{2^3}{3}\right]-\left[12\times -2+\frac{(-2)^2}{2}-\frac{(-2)^3}{3}\right]$	M1	correct use of correct limits for area under the curve using *their* integral of the form $12x+px^2+qx^3$
	$=\frac{128}{3}$ oe	A1	
	$=\frac{32}{3}$ oe	A1	
	Alternative		
	$\int_{-2}^{2} 12+x-x^2-x-8\ \mathrm{d}x$ $=\int_{-2}^{2} 4-x^2\ \mathrm{d}x$	M1	subtraction of the two equations with intent to integrate the result
	$=\left[4x-\frac{x^3}{3}\right]_{-2}^{2}$	A1	
	$\left[4\times 2-\frac{8}{3}\right]-\left[4\times -2+\frac{8}{3}\right]$	M1	**Dep** for correct application of limits
	$=\frac{32}{3}$ oe	A1	
11(i)	$\mathrm{p}\left(\frac{1}{2}\right)=a\left(\frac{1}{2}\right)^3+17\left(\frac{1}{2}\right)^2+b\left(\frac{1}{2}\right)-8$	M1	expression for $\mathrm{p}\left(\frac{1}{2}\right)$
	$\mathrm{p}(-3)=a(-3)^3+17(-3)^2+b(-3)-8$	M1	expression for $\mathrm{p}(-3)$
	$\frac{a}{8}+\frac{17}{4}+\frac{b}{2}-8=0$ $-27a+153-3b-8=-35$	A1	both equations correct (allow equivalents and terms not collected but powers should be evaluated)
	Leading to $a=b=6$	A1	from correct equations with evidence that both have been found correctly in order to verify that $a=b$

Question	Answer	Marks	Guidance
11(ii)	$(2x-1)(3x^2+10x+8)$	B2	**B1** for $3x^2$ and +8 from factorisation or for $3x^2+10x...$ from long division
11(iii)	$(2x-1)(x+2)(3x+4)$	B1	cao
11(iv)	$\sin\theta = \frac{1}{2}$	B1	
	$\theta = 30^{\circ},\ 150^{\circ}$	B2	**B1** for a first correct solution **B1** for a second correct solution with no extras in range $0 \leqslant \theta \leqslant 180$ and no solution arising from other factors.

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
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rot	rounded or truncated
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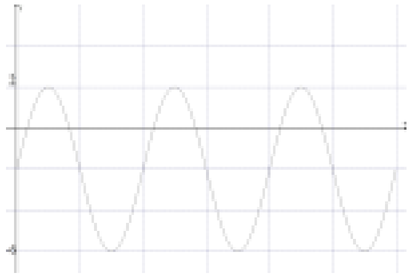
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Partial Marks</th></tr>
<tr><td>1</td><td>Substitution and simplification to obtain a 3 term quadratic in one variable</td><td>M1</td><td>substitution of $y = x + 4$ or $x = y - 4$ and simplification to 3 terms.</td></tr>
<tr><td></td><td>$x^2 - 2x - 8 = 0$ 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></td><td>Solution of quadratic equation</td><td>M1</td><td>M1 dep</td></tr>
<tr><td></td><td>$x = 4,\ y = 8$
$x = -2,\ y = 2$</td><td>A2</td><td>A1 for each pair</td></tr>
<tr><td>2</td><td>Midpoint $\left(\frac{5}{2}, -1\right)$</td><td>B1</td><td></td></tr>
<tr><td></td><td>Gradient of line $= -\frac{8}{3}$</td><td>B1</td><td></td></tr>
<tr><td></td><td>Gradient of perp $= \frac{3}{8}$</td><td>M1</td><td></td></tr>
<tr><td></td><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></td><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>4(i)</td><td>$b = 4$</td><td>B1</td><td></td></tr>
<tr><td></td><td>$c = 6$</td><td>B1</td><td></td></tr>
<tr><td></td><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></td><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 $\frac{20\,000}{800} = e^{2k}$ 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
	$x=\frac{-\sqrt{2}\pm\sqrt{18}}{2}$	**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**	
	$\left(x+\frac{\sqrt{2}}{2}\right)^2=4+\frac{1}{2}$ $x=\pm\frac{3}{\sqrt{2}}-\frac{\sqrt{2}}{2}$	**M1**	Correct use of completing the square method
	$x=-\frac{4}{\sqrt{2}},\ \frac{2}{\sqrt{2}}$	**M1**	**M1dep** for dealing with $\sqrt{2}$ in denominator
	$x=\sqrt{2},\quad -2\sqrt{2}$	**A1**	
11(i)	$\frac{dy}{dx}=16-\frac{54}{x^3}$	**M1**	for $\frac{dy}{dx}=16\pm\frac{p}{x^3}$
	Equating to zero and obtaining x^3	**M1**	**M1dep**
	$x=\frac{3}{2},\ y=36$	**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 $x=\frac{9}{2},\quad y=\frac{2}{3}$
	$y=\frac{1}{3}(2x-5)^{\frac{3}{2}}+4x-20$	A1	for correct equation

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2018**

MARK SCHEME

Maximum Mark: 80

Published

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This document consists of **10** printed pages.

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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 5:

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GENERIC MARKING PRINCIPLE 6:

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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.

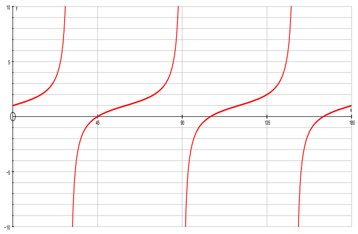
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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(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)	$\frac{d^2x}{dt^2} = \frac{k_2}{(5t+3)^2}$	M1	
	$\frac{d^2x}{dt^2} = -\frac{25}{(5t+3)^2}$ When $t = 0$, $\frac{d^2x}{dt^2} = -\frac{25}{9}$ 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	
	$\frac{d}{dx}(2x-1)^{\frac{1}{2}} = (2x-1)^{-\frac{1}{2}}$ for a quotient $\frac{d}{dx}(2x-1)^{-\frac{1}{2}} = -(2x-1)^{-\frac{3}{2}}$ for a product	B1	
	either $\frac{dy}{dx} = \frac{\sqrt{2x-1} - (x+2)\left[(2x-1)^{-\frac{1}{2}}\right]}{\left(\sqrt{2x-1}\right)^2}$ or $\frac{dy}{dx} = (2x-1)^{-\frac{1}{2}} - (x+2)\left[(2x-1)^{-\frac{3}{2}}\right]$	A1	All other terms correct
	When $\frac{dy}{dx} = 0$, $2x - 1 = x + 2$	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**	
	$t = 4\ln 2, \quad \ln 16$	**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
	$\left(3\sin\theta - 1\right)\left(\sin\theta - 1\right) = 0$ $\sin\theta = \frac{1}{3}, \quad \sin\theta = 1$	**M1**	For attempt to solve a 3 term quadratic equation in $\sin\theta$ to obtain $\sin\theta =$
	$\theta = 19.5^\circ, \quad 160.5^\circ$	**A1**	
	90°	**A1**	
8(b)	$\tan 2\phi = \sqrt{3}$ $2\phi = \frac{\pi}{3}, \quad -\frac{2\pi}{3}$	**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^{their3} or 4^{their2}
	$a = 64$	**A1**	
	$a = 16$	**A1**	
10(i)	$AC^2 = \left(4\sqrt{3}-5\right)^2 + \left(4\sqrt{3}+5\right)^2$	**M1**	For attempt to use the cosine rule
	$-2\left(4\sqrt{3}-5\right)\left(4\sqrt{3}+5\right)\cos 60^\circ$	**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

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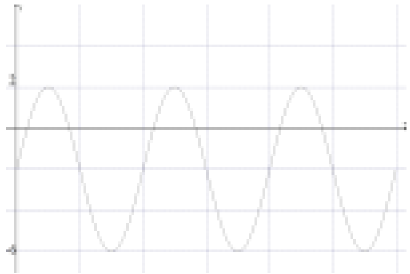
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Partial Marks</th></tr>
<tr><td rowspan="4">1</td><td>Substitution and simplification to obtain a 3 term quadratic in one variable</td><td>M1</td><td>substitution of $y = x + 4$ or $x = y - 4$ and simplification to 3 terms.</td></tr>
<tr><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 $\frac{20\,000}{800} = e^{2k}$ 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
	$x=\frac{-\sqrt{2}\pm\sqrt{18}}{2}$	**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**	
	$\left(x+\frac{\sqrt{2}}{2}\right)^2=4+\frac{1}{2}$ $x=\pm\frac{3}{\sqrt{2}}-\frac{\sqrt{2}}{2}$	**M1**	Correct use of completing the square method
	$x=-\frac{4}{\sqrt{2}},\ \frac{2}{\sqrt{2}}$	**M1**	**M1dep** for dealing with $\sqrt{2}$ in denominator
	$x=\sqrt{2},\quad -2\sqrt{2}$	**A1**	
11(i)	$\frac{dy}{dx}=16-\frac{54}{x^3}$	**M1**	for $\frac{dy}{dx}=16\pm\frac{p}{x^3}$
	Equating to zero and obtaining x^3	**M1**	**M1dep**
	$x=\frac{3}{2},\ y=36$	**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

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/12**

Paper 12 **March 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 March 2018 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **9** printed pages.

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	Guidance
1	attempt at $\mathrm{p}(2)$ or $\mathrm{p}(-3)$	M1	
	$2\mathrm{p}(2)=\mathrm{p}(-3)$	M1	attempt at correct relationship
	$22=a-b$	A1	may be implied, allow unsimplified
	$\mathrm{p}(-1)=0$ $a+b=-2$	B1	B1 for $a+b=-2$, allow unsimplified
	$a=10\ \ b=-12$	A1	A1 for both
2(i)	$k\cos 3x$	M1	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=15\cos 3x$	A1	A1 all correct
2(ii)	When $x=\frac{\pi}{3}$, $y=4$	B1	for $y=4$
	attempt to find the equation of the tangent	M1	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=-15$ $y-4=-15\left(x-\frac{\pi}{3}\right)$ Equation of tangent $\left(\begin{array}{l} y=-15x+5\pi+4 \text{ or} \\ y=-15x+19.7 \end{array}\right)$	A1	**A1FT** for correct equation, using *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$, allow unsimplified
3(a)	$\frac{18+12\sqrt{5}-6\sqrt{5}-20}{4-\sqrt{5}}$	M1	attempt to deal with the numerator
	$\frac{6\sqrt{5}-2}{4-\sqrt{5}}\times\frac{4+\sqrt{5}}{4+\sqrt{5}}$ $\frac{22\sqrt{5}+22}{11}$	M1	attempt to rationalise
	$2\sqrt{5}+2$	A1	must be convinced a calculator has not been used
3(b)	$AC^2=\left(6-2\sqrt{3}\right)^2+\left(6+2\sqrt{3}\right)^2$ $-2\left(6-2\sqrt{3}\right)\left(6+2\sqrt{3}\right)\left(-\frac{1}{2}\right)$	M1	application of the cosine rule
	simplification of surds	M1	**M1Dep**
	$AC=2\sqrt{30}$	A1	

Question	Answer	Marks	Guidance
4(i)	–2	**B1**	
	$-\frac{1}{2} \leqslant x \leqslant \frac{1}{2}$	**B1**	
4(ii)	attempt to differentiate a quotient	**M1**	
	for $\frac{8x}{4x^2-1}$	**B1**	
	$\frac{dy}{dx} = \frac{(x+2)\frac{8x}{(4x^2-1)} - \ln(4x^2-1)}{(x+2)^2}$	**A1**	everything else correct
4(iii)	When $x = 2$ $\frac{dy}{dx} = \frac{4}{15} - \frac{\ln 15}{16}$ or 0.0974	**M1**	attempt to evaluate $\frac{dy}{dx}$ when $x = 2$ and attempt to use method of small changes
	$\partial y = 0.0974h$	**A1**	cao
5(i)	$n = 10$	**B1**	
	$10 \times 2^9 \times a = -1280$	**M1**	attempt to equate second terms
	$a = -\frac{1}{4}$	**A1**	
	${}^{10}C_2 \times 2^8 \times \left(-\frac{1}{4}\right)^2 = 720$	**M1**	attempt to equate third terms
	$b = 720$	**A1**	
5(ii)	$\left[\left(1024 - 1280x + 720x^2\right)\right]\left(\frac{1}{x^2} - 2 + x^2\right)$	**B1**	expansion of $\left(x - \frac{1}{x}\right)^2$
	Independent term $= 720 - 2048$	**M1**	attempt to find independent term, must be considering 2 terms
	$= -1328$	**A1**	Must be identified

Question	Answer	Marks	Guidance
6(i)	$\mathbf{c}-\mathbf{a}$	B1	
6(ii)	attempt to use the ratio	M1	
	$\overrightarrow{OM}=\mathbf{a}+\frac{2}{3}(\mathbf{c}-\mathbf{a})$ or $\mathbf{c}-\frac{1}{3}(\mathbf{c}-\mathbf{a})$ $\left(=\frac{2}{3}\mathbf{c}+\frac{1}{3}\mathbf{a}\right)$	A1	allow unsimplified
6(iii)	$\overrightarrow{OM}=\frac{3}{5}\mathbf{b}$	B1	
6(iv)	$\frac{3}{5}\mathbf{b}=\frac{2}{3}\mathbf{c}+\frac{1}{3}\mathbf{a}$	M1	attempt to equate *their* (ii) and (iii)
	$5\mathbf{a}+10\mathbf{c}=9\mathbf{b}$	A1	Must be convinced from simplification
6(v)	$\overrightarrow{AB}=\mathbf{b}-\mathbf{a}$ $=\frac{5}{9}\mathbf{a}+\frac{10}{9}\mathbf{c}-\mathbf{a}$	M1	use of (iv) with $\mathbf{b}-\mathbf{a}$ or $\mathbf{a}-\mathbf{b}$
	$=-\frac{4}{9}\mathbf{a}+\frac{10}{9}\mathbf{c}$	A1	
7(a)	$2a^2-4a=6-3a$ $2a^2-a-6=0$	M1	attempt to use determinant correctly, obtain a 3 term quadratic equation and attempt to solve correctly
	$a=2$	A1	
	$a=-\frac{3}{2}$	A1	
7(b)(i)	$\frac{1}{5}\begin{pmatrix}4 & -1\\ -3 & 2\end{pmatrix}$	B2	B1 for $\frac{1}{5}$ B1 for $\begin{pmatrix}4 & -1\\ -3 & 2\end{pmatrix}$
7(b)(ii)	$\mathbf{A}^{-1}\mathbf{AC}=\mathbf{A}^{-1}\mathbf{B}$	M1	for pre-multiplying
	$\mathbf{C}=\frac{1}{5}\begin{pmatrix}4 & -1\\ -3 & 2\end{pmatrix}\begin{pmatrix}2 & 0\\ -3 & 5\end{pmatrix}$	M1	**M1Dep** for attempt at matrix multiplication, at least 2 terms correct, allow with *their* inverse
	$=\frac{1}{5}\begin{pmatrix}11 & -5\\ -12 & 10\end{pmatrix}$ oe	A1	

Question	Answer	Marks	Guidance
7(c)	$\begin{pmatrix} -\frac{3}{4} & 0 \\ 0 & -\frac{3}{4} \end{pmatrix}$	**B1**	
8(i)	for attempt to integrate to obtain $k_1e^{2t} + k_2t^2$	**M1**	
	$x = 6e^{2t} - 24t^2 \quad (+c)$	**A1**	all correct, condone omission of $+ c$
	When $t = 0$, $x = 0$ $\therefore c = -6$	**M1**	**M1Dep** for attempt to find c
	$x = 6e^{2t} - 24t^2 - 6$	**A1**	
8(ii)	$\frac{d^2x}{dt^2} = 24e^{2t} - 48$	**M1**	attempt to differentiate to obtain $k_1e^{2t} + k_2$
	When acceleration = 0, $e^{2t} = 2$ oe	**M1**	equating to zero and attempt to solve
	$t = \frac{1}{2}\ln 2$ or $t = \ln\sqrt{2}$ or 0.347	**A1**	
8(iii)	substitution of *their* (ii) into given equation for v	**M1**	
	$v = 24 - 24\ln 2$ or $24 - 48\ln\sqrt{2}$ or 7.36	**A1**	
9(i)	$\ln y = \ln A + bx$	**B1**	
9(ii)	$\ln y$  x	**M1**	attempt to plot $\ln y$ against x Allow $\lg y$ against x Allow $\lg y$ against $\lg e^x$
	straight line with all points joined	**A1**	

Question	Answer	Marks	Guidance
9(iii)	Gradient = b	M1	**M1Dep** on (ii) for attempt to find gradient and equate to b or $b\lg e$ if $\lg y$ plotted against x
	$b = -0.5$, allow -0.45 to -0.55	A1	value within the given range
	Intercept = $\ln A$ ($= 7.6$)	M1	**M1Dep** on (ii) for attempt to use intercept or coordinates of a point on the curve with *their* gradient to obtain A
	$A = 2000$ allow $1900 - 2100$	A1	
9(iv)	use of graph or appropriate substitution	M1	
	When $y = 500$, $x = 2.77$ allow $2.2 - 3.0$	A1	
9(v)	use of graph or appropriate substitution	M1	
	When $x = 5$, $\ln y = 5.1$ $y = 164$ allow $155 - 175$	A1	

Question	Answer	Marks	Guidance
10(i)	$y = -3x^3 - 11x^2 - 8x + 4$	**M1**	attempt to differentiate
	$\frac{dy}{dx} = -9x^2 - 22x - 8$	**A1**	all correct
	When $\frac{dy}{dx} = 0$, $9x^2 + 22x + 8 = 0$	**M1**	**M1Dep** for equating to zero and correct attempt to solve
	$x = -2$	**A1**	SC Allow B1 for $x = -2$ if A1 not obtained from differentiation
	$x = -\frac{4}{9}$	**A1**	
	10(i) Alternate scheme		
	$\frac{dy}{dx} = (x+2)^2(-3) + (1-3x)2(x+2)$	**M1**	attempt to differentiate
	all correct	**A1**	
	When $\frac{dy}{dx} = 0$, $(x+2)(-4-9x) = 0$ oe	**M1**	**M1Dep** for equating to zero and correct attempt to solve
	$x = -2$	**A1**	SC Allow B1 for $x = -2$ if A1 not obtained from differentiation
	$x = -\frac{4}{9}$	**A1**	
10(ii)	$D\left(\frac{1}{3}, 0\right)$	**B1**	Allow mismatch of letters
	$C\ (0, 4)$	**B1**	Allow mismatch of letters
10(iii)	Area $= \int_0^{\frac{1}{3}} -3x^3 - 11x^2 - 8x + 4\ dx$	**M1**	correct attempt to integrate a cubic equation
	$= \left[-\frac{3}{4}x^4 - \frac{11}{3}x^3 - 4x^2 + 4x\right]_0^{\frac{1}{3}}$	**A2**	A1 for 3 terms correct A1 for all correct
	$-\frac{3}{4}\left(\frac{1}{81}\right) - \frac{11}{3}\left(\frac{1}{27}\right) - \frac{4}{9} + \frac{4}{3}$	**M1**	**M1Dep** for application of limits
	$= \frac{241}{324}$ or 0.744	**A1**	

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ADDITIONAL MATHEMATICS | **0606/11**
Paper 1 | **October/November 2017**
MARK SCHEME
Maximum Mark: 80

Published

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MARK SCHEME NOTES

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

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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)	$p\left(\frac{1}{2}\right) = \frac{a}{8} + \frac{b}{4} - \frac{13}{2} + 4$	**M1**	attempt at $p\left(\frac{1}{2}\right)$
	$p'(x) = 3ax^2 + 2bx - 13$ $p'\left(\frac{1}{2}\right) = \frac{3a}{4} + b - 13$	**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'
	$x(y-2) = 4y + 1$ $x = \frac{4y+1}{y-2}$	M1	collecting together like terms
	$h^{-1}(x) = \frac{4x+1}{x-2}$	A1	correct answer with correct notation
	Range $h^{-1} \neq 4$	B1	must be using a correct notation
6(b)(ii)	$h^2(x) = h\left(\frac{2x+1}{x-4}\right)$ $= \frac{2\left(\frac{2x+1}{x-4}\right)+1}{\left(\frac{2x+1}{x-4}\right)-4}$	M1	dealing with h^2 correctly
	dealing with fractions within fractions	M1	
	$= \frac{5x-2}{17-2x}$ oe	A1	
7(i)	$\ln(2x+1) - \ln(2x-1)$	B1	
7(ii)	attempt to differentiate	M1	
	$\frac{dy}{dx} = \frac{2}{2x+1} - \frac{2}{2x-1} + 4$	A1	all correct
	attempt to obtain in required form	DM1	
	$= \frac{16x^2-8}{4x^2-1}$	A1	A1 all correct
7(iii)	When $\frac{dy}{dx} = 0$, $16x^2 - 8 = 0$	M1	setting $\frac{dy}{dx} = 0$ and attempt to solve
	$x = \frac{1}{\sqrt{2}}$ only	A1	

Question	Answer	Marks	Guidance
7(iv)	$\frac{d^2y}{dx^2} = \frac{32x\left(4x^2-1\right)-8x\left(16x^2-8\right)}{\left(4x^2-1\right)^2}$	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: $1001 - \left(2 \times {}^{12}C_9\right)$	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
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/12**
Paper 1	**October/November 2017**
MARK SCHEME	
Maximum Mark: 80	

Published

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MARK SCHEME NOTES

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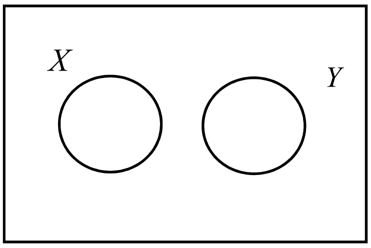
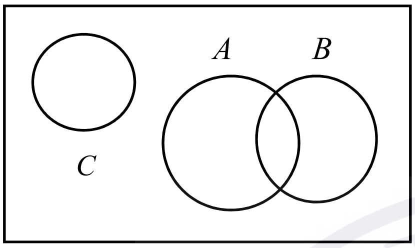
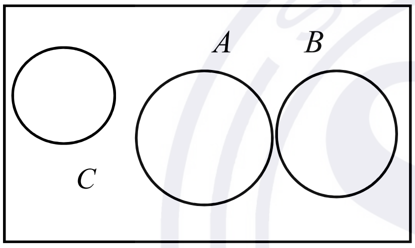
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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.

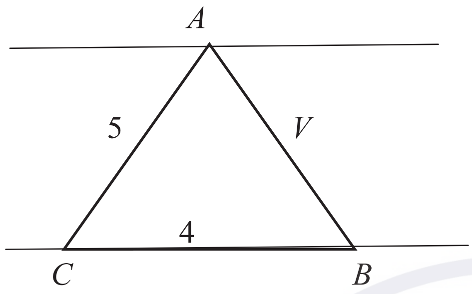
Abbreviations

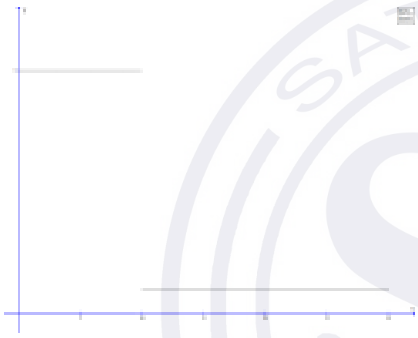
awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Guidance
1(i)	 	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	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\left(x^2+1\right)\left(\frac{6x}{3x^2+2}\right)-2x\ln\left(3x^2+2\right)}{\left(x^2+1\right)^2}$	A1	all other terms correct.
	When $x=2$, $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{5\left(\frac{12}{14}\right)-4\ln 14}{25}$	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)	$f^{-1}(x) = e^x$ or $g(4) = 35$	**B1**	First B1 may be implied by correct answer or by use of 35
	$f^{-1}g(4) = e^{35}$	**B1**	
6(iv)	$\frac{y-3}{2} = x^2$ or $\frac{x-3}{2} = y^2$	**M1**	valid attempt to obtain the inverse
	$g^{-1}(x) = \sqrt{\frac{x-3}{2}}$	**A1**	correct form, must be $g^{-1}(x) =$ or $y =$
	Domain $x > 3$	**B1**	Must have correct notation
7(i)	$p\left(\frac{1}{2}\right)$: $\frac{a}{8} + 2 + \frac{b}{2} + 5 = 0$	**M1**	substitution of $x = \frac{1}{2}$ and equating to zero (allow unsimplified)
	$p(-2)$: $-8a + 32 - 2b + 5 = -25$	**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)	$V^2=5^2+4^2-\left(2\times5\times4\times\cos65^{\circ}\right)$	**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

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ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2017**

MARK SCHEME

Maximum Mark: 80

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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	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**	
	$k < -\frac{1}{2}, \quad k > \frac{9}{2}$	**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)	$\frac{5}{14}\left[\left(7x-10\right)^{\frac{2}{5}}\right]_6^a = \frac{25}{14}$ $\frac{5}{14}\left(7a-10\right)^{\frac{2}{5}} - \frac{5}{14}\left(7\times6-10\right)^{\frac{2}{5}} = \frac{25}{14}$ $\left(7a-10\right)^{\frac{2}{5}} - 4 = 5$	**M1**	correct application of limits for $k\left(7x-10\right)^{\frac{2}{5}}$
	$a = \frac{9^{\frac{5}{2}}+10}{7}$	**M1**	**M1dep** for evaluation of $\left(7\times6-10\right)^{\frac{2}{5}}$ 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**	
	Alternative method $2.4 = p(0.2)+q$ $0.9 = p(0.8)+q$	**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)	$y = \mathrm{e}^{\left(-\frac{5}{2}x^2+2.9\right)}$	**M1**	dealing with ln
	$y = \mathrm{e}^{-\frac{5}{2}x^2} \times \mathrm{e}^{2.9}$	**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**	
	$\frac{dy}{dx}=\left((x-4)\times\frac{5}{3}\times3(3x-1)^{\frac{2}{3}}\right)+(3x-1)^{\frac{5}{3}}$	**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 $x=3$, $\frac{dy}{dx}=8^{\frac{2}{3}}\times3$	**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 = $\left(\frac{1}{2}\times10^2\times1.48\right)+21.8+2\left(\frac{1}{2}\times10^2\sin2.18(4)\right)$	B2	**B1** for $\left(\frac{1}{2}\times10^2\times1.48\right)+21.8$ **B1** for $2\left(\frac{1}{2}\times10^2\sin2.18(4)\right)$
	= 178	B1	awrt 178 from correct working
	<u>Alternative method 1</u> Segment area $=\frac{1}{2}\left(10^2\left(2.18-\sin2.18\right)\right)$	B1	**B1** for $2\times\frac{1}{2}\left(10^2\left(2.18(4)-\sin2.18(4)\right)\right)$
	Area required = $100\pi-2\times\frac{1}{2}\left(10^2\left(2.18(4)-\sin2.18(4)\right)\right)$	B1	
	= 178	B1	awrt 178 from correct working
	<u>Alternative method 2</u> Area of trapezium = $\frac{1}{2}\left((13.5+4.33)(17.1)\right)$	B1	correct area of trapezium *ABCD* (allow unsimplified)
	Area of segments = $\frac{1}{2}\left(10^2\left(1.48-\sin1.48\right)\right)$ + $\frac{1}{2}\left(10^2\left(0.436-\sin0.436\right)\right)$	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* $\frac{1}{2}\begin{vmatrix} 0 & 0 & \frac{-5}{4} & 0 \\ 1 & \frac{-17}{8} & \frac{-3}{2} & 1 \end{vmatrix}$
	$= \frac{1}{2}\left\|-\frac{5}{4}-\frac{85}{32}\right\|$ oe	**M1**	**M1dep** for correct method of evaluation
	$= \frac{125}{64}$ or 1.95 or $1\frac{61}{64}$	**A1**	

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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This document consists of **8** printed pages.

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.

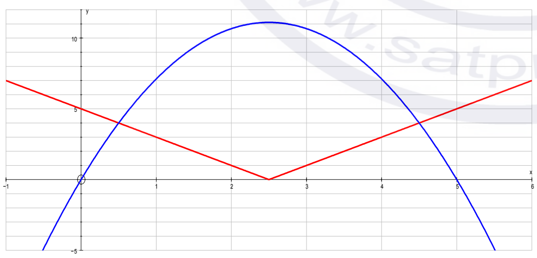
Abbreviations

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(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	$p(3)=27+9a+3b-48$	**M1**	attempt to find $p(3)$
	$3a+b=9$ oe	**A1**	
	$p'(x)=3x^2+2ax+b$ $p'(1)=3+2a+b$	**M1**	attempt to differentiate and find $p'(1)$ 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	
	$(t-2)^{\frac{1}{2}}\left(4+5(t-2)\right)$	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 $f^{-1}(x) = \frac{1}{4}\left(\ln 3 - \ln(x-5)\right)$ or $f^{-1}(x) = -\frac{1}{4}\left(\ln(x-5) - \ln 3\right)$	B1	
	Domain $x > 5$	B1	
4(b)	$\ln\left(x^2+5\right) = 2$	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 $\frac{150}{72}$
	$\sin 1.04 = \dfrac{\frac{AB}{2}}{12}$	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**	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{5}{3}\times6x\left(3x^2+8\right)^{\frac{2}{3}}$	**A1**	all correct
	When $\frac{\mathrm{d}y}{\mathrm{d}x}=0$ 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 $\frac{\mathrm{d}y}{\mathrm{d}x}$	**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 $-1\leqslant x\leqslant6$ **B1** for intercepts at x = 0 and x = 5 for a quadratic graph
8(ii)	$2x-5=\pm4$	**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)	$3\tan\left(\frac{x}{3}\right)$ $(+c)$	**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 International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2017**

MARK SCHEME

Maximum Mark: 80

Published

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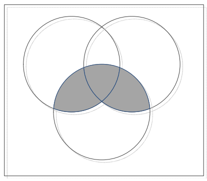
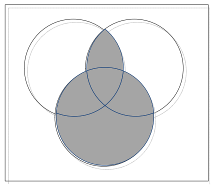
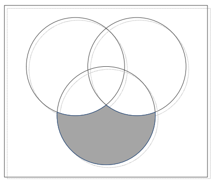
SC Special Case
soi seen or implied

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 $\cot\theta=\frac{\cos\theta}{\sin\theta}$, $\tan\theta=\frac{\sin\theta}{\cos\theta}$, $\mathrm{cosec}\,\theta=\frac{1}{\sin\theta}$
	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 $\frac{\mathrm{cosec}\,\theta}{\frac{1}{\tan\theta}(1+\tan^2\theta)}$	M1	dealing with fractions
	$=\frac{\tan\theta\,\mathrm{cosec}\,\theta}{\sec^2\theta}$	M1	use of appropriate identity
	$=\frac{\sin\theta}{\cos\theta}\times\frac{1}{\sin\theta}\times\cos^2\theta$	M1	for $\cot\theta=\frac{1}{\tan\theta}$, $\tan\theta=\frac{\sin\theta}{\cos\theta}$, $\sec\theta=\frac{1}{\cos\theta}$, $\mathrm{cosec}\,\theta=\frac{1}{\sin\theta}$
	$=\cos\theta$	A1	correct simplification, with all correct
	Alternative 2 $\frac{\mathrm{cosec}\,\theta}{\frac{1}{\cot\theta}(\cot^2\theta+1)}$	M1	dealing with fractions
	$=\frac{\cot\theta\,\mathrm{cosec}\,\theta}{\mathrm{cosec}^2\theta}$	M1	use of appropriate identity
	$=\frac{\cot\theta}{\mathrm{cosec}\,\theta}$ $=\frac{\cos\theta}{\sin\theta}\times\sin\theta$	M1	for $\cot\theta=\frac{\cos\theta}{\sin\theta}$, $\tan\theta=\frac{\sin\theta}{\cos\theta}$, $\mathrm{cosec}\,\theta=\frac{1}{\sin\theta}$
	$=\cos\theta$	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 $[k\sin 2\theta]_0^a = \frac{\sqrt{3}}{4}$ 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*.
	$DOC = AOB - 2(\textit{their } AOD)$	**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 $DC^2=8^2+8^2-(2\times 8\times 8\times\cos 1.43)$	**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)	$\frac{1}{2}\times 8^2(2.43-\sin 2.43)-\frac{1}{2}\times 8^2(1.431-\sin 1.431)$	**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 = $\frac{1}{2}\times 8^2(0.5-\sin 0.5)$	**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 = $\frac{1}{2}\times 8^2\times\frac{1}{2}$	**B1**	area of small sector, allow unsimplified, (could be doubled)
	Area of triangle *ODC* = $\frac{1}{2}\times 8^2\times\sin 1.43$	**B1**	area of triangle *ODC*, allow unsimplified
	Area of triangle *OAB* = $\frac{1}{2}\times 8^2\times\sin 2.43$	**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 = $\frac{1}{2}\times 8^2(0.5-\sin 0.5)$	**B1**	area of a small segment, allow unsimplified, could be doubled
	$\frac{1}{2}\times\frac{(15-10.49)}{2}(6.041-2.784)$	**B1**	area of a small triangle, allow unsimplified, could be doubled
	Area of rectangle = $10.49\times(6.041-2.784)$	**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)	me^{2x-1} where m is numeric constant	**M1**	
	$f(x)=\frac{1}{2}e^{2x-1}\quad(+c)$	**A1**	condone omission of +*c*
	$\frac{7}{2}=\frac{1}{2}+c$	**DM1**	correct attempt to find arbitrary constant
	$f(x)=\frac{1}{2}e^{2x-1}+3$	**A1**	must be an equation
11(ii)	ke^{2x-1} where *k* is a numeric constant	**M1**	
	$f''(x)=2e^{2x-1}$	**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.

This document consists of **8** printed pages.

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.

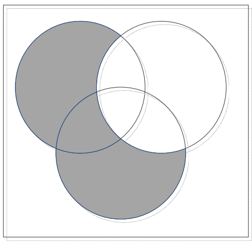
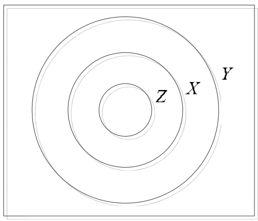
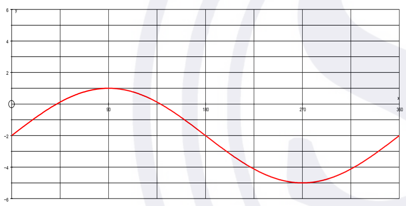
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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 = $\frac{1}{2}(3+2\sqrt{5})(4+6\sqrt{5})$ $= \frac{1}{2}(12+26\sqrt{5}+60)$	**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
	$\mathbf{A} + 3\mathbf{C} = \begin{pmatrix} -12 & 7 \\ 11 & 7 \end{pmatrix}$	**A1**	
6(a)(ii)	correct attempt to multiply	**M1**	implied by 2 correct elements
	$\mathbf{BA} = \begin{pmatrix} 17 & 9 \\ 14 & 18 \\ -3 & -1 \end{pmatrix}$	**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**	

Cambridge IGCSE

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Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/12**

Paper 12 **March 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.

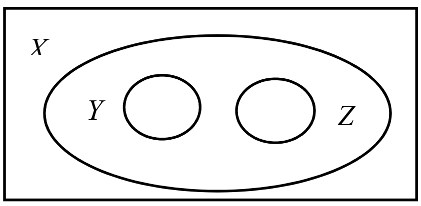
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

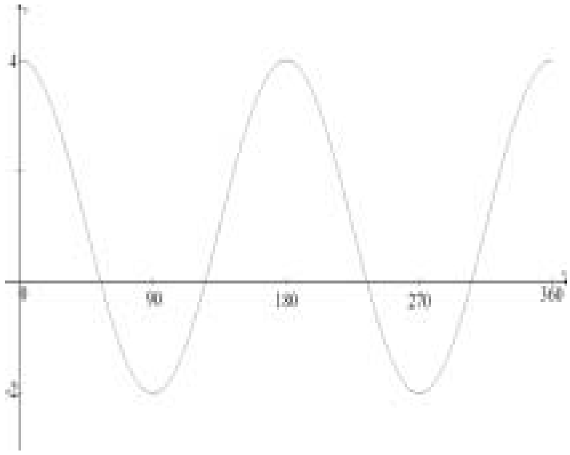
B Mark for a correct result or statement independent of Method marks.

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
www without wrong working

Question	Answer	Marks	Part Marks
1 (a) (i)	0	B1	
(ii)	10	B1	
(b)		B1	either $X \cap Y = Y$ or $X \cap Z = Z$
		B1	$Y \cap Z = \varnothing$
		B1	completely correct Venn diagram.

Question	Answer	Marks	Part Marks
2 (i)		B1 B1 B1	2 complete cycles having a maximum at $y=4$ and a minimum at $y=-2$ completely correct curve
(ii)	$\left(90^{\circ},-2\right)$	B1	
3	$a^5+5a^4\left(\frac{x}{4}\right)+10a^3\left(\frac{x}{4}\right)^2$ $a^5=32$, so $a=2$ $b=5\times\frac{1}{4}\times\left(their\,a\right)^4$, leading to $b=20$ $c=10\times\frac{1}{16}\times\left(their\,a\right)^3$ leading to $c=5$	 B1 M1 A1 M1 A1	 correct attempt to obtain b
4 (a) (i)	$\frac{1}{10}\begin{pmatrix}4 & 3\\ -2 & 1\end{pmatrix}$	B1 B1	for $\frac{1}{\text{determinant}}$ for matrix
(ii)	$\mathbf{M}=\frac{1}{10}\begin{pmatrix}4 & 3\\ -2 & 1\end{pmatrix}\begin{pmatrix}-1 & -5\\ 4 & 2\end{pmatrix}$ $\mathbf{M}=\frac{1}{5}\begin{pmatrix}4 & -7\\ 3 & 6\end{pmatrix}$ oe	M1 A2,1,0	pre-multiplication by the matrix from part (i) –1 each element error
(b)	$-3a+2=4\left(6a-4\right)$ $a=\frac{2}{3}$	M1 A1	correct use of a determinant

Question	Answer	Marks	Part Marks
5 (i)	LHS $= \dfrac{1}{\sin\theta} - \sin\theta$		
	$= \dfrac{1-\sin^2\theta}{\sin\theta}$	M1	dealing with $\operatorname{cosec}\theta$ and attempt at dealing with fractions
	$= \dfrac{\cos^2\theta}{\sin\theta}$	M1	correct use of identity
	$= \cot\theta\cos\theta$	A1	completely correct proof
(ii)	$\cot\theta\cos\theta = \frac{1}{3}\cos\theta$ $3\cot\theta\cos\theta - \cos\theta = 0$ $\cos\theta(3\cot\theta - 1) = 0$	M1	use of part (i), manipulation and factorisation
	$\cos\theta = 0 \quad \cot\theta = \frac{1}{3}$, so $\tan\theta = 3$	M1	dealing with $\cot\theta$ and attempt to solve
	$\theta = \frac{\pi}{2}, \frac{3\pi}{2}$, $\theta = 1.25, 4.39$	A1,A1	**A1** for each pair of solutions (allow 1.57 and 4.71)
6 (a) (i)	40 320	B1	
(ii)	720	B1	
(iii)	5040	B1	
(b) (i)	35	B1	
(ii)	1	B1	
(iii)	Twins in team of 4 ${}^5C_2 = 10$ Twins in team of 3 $= 5$ Total = 15 www	B1 B1 B1	

Question	Answer	Marks	Part Marks
7 (a)	$\frac{102}{17}\begin{pmatrix}8\\-15\end{pmatrix}$	M1	attempt to obtain magnitude of $\begin{pmatrix}8\\-15\end{pmatrix}$ and use it
	$\begin{pmatrix}48\\-90\end{pmatrix}$	A1	
(b)	$\begin{pmatrix}2p-2q+4\\10p+2q+3\end{pmatrix}=\begin{pmatrix}p^2\\27\end{pmatrix}$	M1	dealing with the scalar and with addition
	$2p-2q+4=p^2$ $10p+2q+3=27$	M1 A1	equating like vectors and simplifying both equations correct
	leading to $p^2-12p+20=0$	M1	elimination of q and subsequent solution of quadratic
	$p=2,\ q=2$ $p=10,\ q=-38$	A1 A1	
8 (i)	$\frac{\mathrm{d}y}{\mathrm{d}x}=-2\cos 2x\ (+c)$	M1 A1	integration to obtain the form $a\cos 2x$ correct, condone omission of c
	$5=-2\cos\pi+c$	M1	attempt to find c
	$\frac{\mathrm{d}y}{\mathrm{d}x}=3-2\cos 2x$	A1	May be implied by a correct c
(ii)	$y=3x-\sin 2x\ (+c)$	M1 A1	integration to obtain the form $a\sin 2x$ correct, condone omission of c
	$-\frac{1}{2}=\frac{\pi}{4}-\frac{1}{2}+c$	M1	attempt to find c
	$y=3x-\sin 2x-\frac{\pi}{4}$ oe	A1	
(iii)	When $x=\frac{\pi}{12}$, $\frac{\mathrm{d}y}{\mathrm{d}x}=3-\sqrt{3}$		
	Normal equation: $y+\frac{1}{2}=\frac{1}{\sqrt{3}-3}\left(x-\frac{\pi}{12}\right)$	M1	attempt to obtain perpendicular gradient and normal equation
		A1FT	**FT** on *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ from (i). Allow unsimplified
	$y=-0.789x-0.294$ cao	A1	

Question	Answer	Marks	Part Marks
9 (i)	$\frac{1}{2}\times 10^2\times\theta = 20\pi$	M1	use of sector area to obtain θ
	$\theta = \frac{2\pi}{5}$	A1	
(ii)	Arc length $AB = 4\pi$	B1FT	**FT** *their* θ
	$BC^2 = 10^2 + 10^2 - (2\times 10\times 10\times\cos 2\theta)$ or $\frac{BC}{\sin\frac{4\pi}{5}} = \frac{10}{\sin\frac{\pi}{10}}$	M1	valid attempt to obtain *BC*
	$BC = 19.02$	A1	
	Perimeter = 50.6	A1	
(iii)	Area = Either $\left(\frac{1}{2}\times 19.02^2\sin\frac{\pi}{5}\right)$	M1	area of triangle *ACB*
	$+\left(20\pi - \left(\frac{1}{2}\times 10^2\sin\frac{2\pi}{5}\right)\right)$	M1	area of relevant segment
	= 121.6 allow awrt 122	A1	
	Or $20\pi + 2\left(\frac{1}{2}\times 10\times 10\sin\frac{4\pi}{5}\right)$	M1,M1	**M1** for area of triangle *AOB* or *AOC* **M1** for a complete method
	= 121.6 allow awrt 122	A1	

Question	Answer	Marks	Part Marks
10	$(2x-5)^{\frac{3}{2}} = 3\sqrt{3}$	M1	attempt to find x-coordinate of B
	$x = 4$	A1	x-coordinate of B
	At A $x = 2.5$	B1	x-coordinate of A
	Either		
	Area $= \frac{1}{2}\times\frac{3}{2}\times 3\sqrt{3} - \int_{2.5}^{4}(2x-5)^{\frac{3}{2}}\,dx$	M1	plan and attempt to find the area of the triangle. Allow unsimplified
	$= \frac{9\sqrt{3}}{4} - \left[\frac{1}{5}(2x-5)^{2.5}\right]_{2.5}^{4}$	M1	attempt at integration, must be in the form $(2x-5)^{2.5}$
		A1	correct integration
	$= \frac{9\sqrt{3}}{4} - \left(\frac{1}{5}(3)^{2.5} - 0\right)$	DM1	attempt to use limits correctly
	$= \frac{9\sqrt{3}}{20}$	A1	
	Or		
	line AB: $y = 2\sqrt{3}x - 5\sqrt{3}$	M1	equation of AB and attempt to integrate
	Area $= \int_{2.5}^{4} 2\sqrt{3}x - 5\sqrt{3} - (2x-5)^{\frac{3}{2}}\,dx$	M1	attempt at integration, must contain the form $(2x-5)^{2.5}$
	$= \left[\sqrt{3}x^2 - 5\sqrt{3}x - \frac{(2x-5)^{\frac{5}{2}}}{5}\right]_{2.5}^{4}$	A1	correct integration
	$= \frac{9\sqrt{3}}{4} - \frac{9\sqrt{3}}{5}$	DM1	attempt to use correct limits correctly
	$= \frac{9\sqrt{3}}{20}$	A1	
11 (i)	$\ln y = \ln A + bx$	B1	may be implied by later work
		M1	use of either point correctly in above equation or equivalent
	$0.7 = \ln A + b$ $3.7 = \ln A + 2.5b$	A1	one correct equation
	leading to $b = 2$	A1	
	and $\ln A = -1.3$, so $A = 0.273$ or $e^{-1.3}$	M1,A1	M1 for dealing with ln correctly to obtain A.
(ii)	$\ln y = -1.3 + 2x$ $\ln y = 2.7$	M1	valid attempt to find y. Must include correct substitution and dealing with ln correctly.
	$y = 14.9$	A1	

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **October/November 2016**

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 October/November 2016 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

Question	Answer	Marks	Part Marks
1 (a) (i)	10	**B1**	
(ii)	22	**B1**	
(iii)	4	**B1**	
(b) (i)	$Q \subset R$	**B1**	
(ii)	$P \cap Q = \varnothing$, or { }	**B1**	
2	$a = 1,\ b = -3,\ c = -1$	**B3**	**B1** for each
3	$3y^2 + 5y - 2 = 0$	**B1**, **B1**	**B1** for $5y$ or $5\log_3 x$, **B1** for –2
	$y = \frac{1}{3},\ y = -2$	**M1**	for correct attempt at the solution of *their* quadratic equation
	$x = 3^{\frac{1}{3}},\ x = 3^{-2}$	**M1**	for dealing with one base 3 logarithm correctly
	$x = 1.44,\ x = \frac{1}{9}$	**A1**, **A1**	**A1** for each
4 (i)	$32x^{10} - \frac{80}{3}x^7 + \frac{80}{9}x^4$	**B3**	**B1** for each term, powers of x must be simplified
(ii)	Coefficients needed:		
	$\left(3 \times \mathit{their} - \frac{80}{3}\right) + \left(1 \times \mathit{their}\ 32\right)$	**M1**	for dealing with 2 terms
	$= -48$	**A1**	Allow **A1** for $-48x^7$

Question	Answer	Marks	Part Marks
5 (i)	$\frac{dy}{dx} = \frac{3}{2(3x+2)}$	B1	for correct derivative of log function
	When $x = -\frac{1}{3}$, $y = 0$, $\frac{dy}{dx} = \frac{3}{2}$	B1	for $y = 0$
	Equation of normal: $y = -\frac{2}{3}\left(x + \frac{1}{3}\right)$	M1 A1	**M1** for attempt at a gradient of a perpendicular from differentiation and the equation of the normal
(ii)	$Q\left(0, -\frac{2}{9}\right)$ or $(0, 0.22)$ or better	B1 ft	Follow through on *their c* from part (i)
	$R\left(0, \frac{1}{2}\ln 2\right)$ or $(0, 0.35)$ or better	B1	
	Area of PQR $= \frac{1}{2}\left(\frac{1}{2}\ln 2 + \frac{2}{9}\right) \times \frac{1}{3}$ $= 0.0948$	B1	Allow 0.095
6 (a)	**YX**, **XZ**	B2	**B2** for both with no extras **B1** for 1 correct with or without extras **B1** for both correct with extras **B0** for anything else
(b) (i)	$\frac{1}{18}\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}$	B1, B1	**B1** for $\frac{1}{18}$, **B1** for $\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}$
(ii)	$\mathbf{C} = \mathbf{A}^{-1}\mathbf{B}$ $= \frac{1}{18}\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}\begin{pmatrix} -4 & 2 \\ 10 & 4 \end{pmatrix}$	M1	for pre-multiplication
	$= \begin{pmatrix} -1 & 1 \\ 2 & 0 \end{pmatrix}$	A1, A1	**A1** for any correct pair of elements, but must be from correct matrices

Question	Answer	Marks	Part Marks
7 (i)	$\left(0, \sqrt{3}\right)$ or $\left(0, 1.73\right)$ or better	**B1**	
(ii)	$\left(\frac{\pi}{6}, 2\right)$ or $\left(0.524, 2\right)$ or better	**B1**, **B1**	**B1** for each
(iii)	$\cos\left(x-\frac{\pi}{6}\right)=0$	**M1**	for correct attempt to solve trigonometric equation
	$x=\frac{2\pi}{3}$ oe or 2.09 or better	**A1**	
(iv)	$2\sin\left(x-\frac{\pi}{6}\right)$ (+c)	**B1**	
(v)	Area $=\left[2\sin\left(x-\frac{\pi}{6}\right)\right]_0^{\frac{2\pi}{3}}$	**M1**	for correct use of **their** limits, in radians, into $k\sin\left(x-\frac{\pi}{6}\right)$.
	$= 2 + 1$ $= 3$	**A1**	
8 (i)	$47-24=12\theta$		
	$\theta=\frac{23}{12}$, so $\theta=1.917$ or better	**M1**	for complete correct method to get $\theta =$
	$\theta=1.92$ to 2dp	**A1**	must have evidence of working to more than 2 dp, allow if 1.916 seen (truncated)
(ii)	$\sin\frac{\theta}{2}=\frac{CD/2}{12}$	**M1**	for a complete method, may use cosine rule to get *CD*
	CD = awrt 19.6 or 19.7	**A1**	
(iii)	Area of sector = awrt 138	**B1**	for sector area, allow unsimplified
	Area of triangle *AOB* = awrt 67 or 68	**M1**	for a correct attempt at area
	Area of segment = awrt 70 or 71	**M1**	for segment area (*their* sector area – *their* triangle area)
	AD × *AB* + segment area = 425	**M1**	for complete method to find *AD*
	leading to *AD* = awrt 18.1 or 18.0	**A1**	Allow **A1** for 18
	Alternative method:		
	Area of sector = awrt 138	**B1**	for sector area
	Difference in length between *BC* (or *AD*) and *OM* where *M* is the midpoint of *CD* = 6.88, allow awrt 6.9	**M1**	for attempt to find difference between parallel sides
	Remaining area consists of two trapezia each of width 9.85 and each of area 143.4 $\frac{1}{2}(2BC-6.88)\times 9.85=143.4$ oe	**M1**	for area of one trapezium $\frac{1}{2}(2BC - \textit{their}\ 6.88)\times \textit{their}\ 9.85$ oe
		M1	for attempt to find either *BC* or *AD*
	leading to *AD* = awrt 18.1 or 18.0	**A1**	

Question	Answer	Marks	Part Marks
9 (i)	$\text{p}\left(\frac{3}{2}\right)$: $\frac{27a}{8}-\left(4\times\frac{9}{4}\right)+\frac{3b}{2}+18\quad(=0)$	**M1**	for attempt at $\text{p}\left(\frac{3}{2}\right)$
	$\text{p}'\left(\frac{3}{2}\right)=\left(3a\times\frac{9}{4}\right)-\left(8\times\frac{3}{2}\right)+b\quad(=0)$	**M1**	for differentiation and attempt at $\text{p}'\left(\frac{3}{2}\right)$
	leading to $9a+4b+24=0$ oe and $27a+4b-48=0$ oe	**M1**	for solution of simultaneous equations, to get either a or b
	leading to $a=4,\ b=-15$	**A1**	for both
(ii)	$(x+2)(2x-3)^2$ oe	**M1, A1**	**M1** for attempt at long division or factorisation
(iii)	$(x+2)(2x-3)^2=x+2$ $x+2=0,\ x=-2$	**B1**	Must be using $(x+2)$ correctly using part (ii) to get $x=-2$
	$(2x-3)^2=1$ leading to $x=1,\ x=2$	**M1** **A1**	for solution of the quadratic equation
10 (a) (i)	$20U+\frac{1}{2}\left(U+\frac{U}{2}\right)10=165$	**M1** **DM1**	for realising that area under the graph is needed and attempt to find an area for equating their area to 165 and attempt to solve
	leading to $U=6$	**A1**	
(ii)	Gradient of line: -0.3	**M1, A1**	**M1** for use of the gradient, must be negative
(b) (i)	27	**B1**	
(ii)	$t^2=8\ln 4$ $t=3.33$ or better	**M1** **A1**	for a correct attempt to solve $e^{\frac{t^2}{8}}=4$
(iii)	acceleration $=3\frac{2t}{8}e^{\frac{t^2}{8}}\left(e^{\frac{t^2}{8}}-4\right)^2$	**M1, A1**	**M1** for a correct attempt to differentiate using the chain rule
	When $t=1,\ a=6.98$	**M1, A1**	**M1** for use of $t=1$ in their acceleration

Question	Answer	Marks	Part Marks
11 (i)	$\ln y = \ln A + x\ln b$	B1	may be implied, if equation not seen specifically, by correct values for A and b
	Gradient: $\ln b = -\frac{0.12}{8}$, $= -0.015$	M1	for use of gradient to obtain ln b
	$b = 0.985$	A1	Allow **A1** for $e^{-0.015}$
	Intercept: $\ln A = 0.26$	DM1	for use of one of the given points correctly
	$A = 1.30$	A1	Allow **A1** for $e^{0.26}$ or 1.3
	Alternative 1		
	$\ln y = \ln A + x\ln b$	B1	
	$0.2 = 4\ln b + \ln A$	M1	for one correct equation
	$0.08 = 12\ln b + \ln A$	DM1	for attempt to obtain either ln$A$ or ln$b$ from simultaneous equations
	$A = 1.30$ and $b = 0.985$	A1, A1	Allow **A1** for $b = e^{-0.015}$ and $a = e^{0.26}$ or 1.3
	Alternative 2		
	$1.22 = Ab^4$	B1	
	$1.08 = Ab^{12}$	B1	
		M1	for correct attempt to obtain b or A, must already have **B2**
	$A = 1.30$ and $b = 0.985$	A1, A1	Allow **A1** for $b = e^{-0.015}$ and $a = e^{0.26}$ or 1.3
(ii)	When $x = 6$, $\ln y = 0.17$	M1	for $\ln y = \mathit{their} \ln A + 6\ \mathit{their} \ln b$ or $y = \mathit{their}\ A \times (\mathit{their}\ b)^6$
	$y = 1.19$	A1	allow awrt 1.18 to 1.20
(iii)	When $y = 1.1$, $\ln y = 0.095$	M1	for $\ln 1.1 = \mathit{their} \ln A + x\ \mathit{their} \ln b$ or $1.1 = \mathit{theirA} \times (\mathit{theirb})^x$
	$x = 11$	A1	allow 10.5 to 11.5

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **October/November 2016**

MARK SCHEME

Maximum Mark: 80

Published

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(iii)	4	**B1**	
(b) (i)	$Q \subset R$	**B1**	
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2	$a = 1,\ b = -3,\ c = -1$	**B3**	**B1** for each
3	$3y^2 + 5y - 2 = 0$	**B1**, **B1**	**B1** for $5y$ or $5\log_3 x$, **B1** for –2
	$y = \frac{1}{3},\ y = -2$	**M1**	for correct attempt at the solution of *their* quadratic equation
	$x = 3^{\frac{1}{3}},\ x = 3^{-2}$	**M1**	for dealing with one base 3 logarithm correctly
	$x = 1.44,\ x = \frac{1}{9}$	**A1**, **A1**	**A1** for each
4 (i)	$32x^{10} - \frac{80}{3}x^7 + \frac{80}{9}x^4$	**B3**	**B1** for each term, powers of x must be simplified
(ii)	Coefficients needed:		
	$\left(3 \times \textit{their} - \frac{80}{3}\right) + \left(1 \times \textit{their}\ 32\right)$	**M1**	for dealing with 2 terms
	$= -48$	**A1**	Allow **A1** for $-48x^7$

Question	Answer	Marks	Part Marks
5 (i)	$\dfrac{dy}{dx} = \dfrac{3}{2(3x+2)}$	B1	for correct derivative of log function
	When $x = -\dfrac{1}{3}$, $y = 0$, $\dfrac{dy}{dx} = \dfrac{3}{2}$	B1	for $y = 0$
	Equation of normal: $y = -\dfrac{2}{3}\left(x + \dfrac{1}{3}\right)$	M1 A1	**M1** for attempt at a gradient of a perpendicular from differentiation and the equation of the normal
(ii)	$Q\left(0, -\dfrac{2}{9}\right)$ or $(0, 0.22)$ or better	B1 ft	Follow through on *their c* from part (i)
	$R\left(0, \dfrac{1}{2}\ln 2\right)$ or $(0, 0.35)$ or better	B1	
	Area of PQR $= \dfrac{1}{2}\left(\dfrac{1}{2}\ln 2 + \dfrac{2}{9}\right) \times \dfrac{1}{3}$ $= 0.0948$	B1	Allow 0.095
6 (a)	**YX**, **XZ**	B2	**B2** for both with no extras **B1** for 1 correct with or without extras **B1** for both correct with extras **B0** for anything else
(b) (i)	$\dfrac{1}{18}\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}$	B1, B1	**B1** for $\dfrac{1}{18}$, **B1** for $\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}$
(ii)	$\mathbf{C} = \mathbf{A}^{-1}\mathbf{B}$ $= \dfrac{1}{18}\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}\begin{pmatrix} -4 & 2 \\ 10 & 4 \end{pmatrix}$	M1	for pre-multiplication
	$= \begin{pmatrix} -1 & 1 \\ 2 & 0 \end{pmatrix}$	A1, A1	**A1** for any correct pair of elements, but must be from correct matrices

Question	Answer	Marks	Part Marks
7 (i)	$\left(0, \sqrt{3}\right)$ or $\left(0, 1.73\right)$ or better	**B1**	
(ii)	$\left(\frac{\pi}{6}, 2\right)$ or $\left(0.524, 2\right)$ or better	**B1**, **B1**	**B1** for each
(iii)	$\cos\left(x-\frac{\pi}{6}\right)=0$	**M1**	for correct attempt to solve trigonometric equation
	$x=\frac{2\pi}{3}$ oe or 2.09 or better	**A1**	
(iv)	$2\sin\left(x-\frac{\pi}{6}\right)$ (+c)	**B1**	
(v)	Area $=\left[2\sin\left(x-\frac{\pi}{6}\right)\right]_0^{\frac{2\pi}{3}}$	**M1**	for correct use of **their** limits, in radians, into $k\sin\left(x-\frac{\pi}{6}\right)$.
	$= 2 + 1$ $= 3$	**A1**	
8 (i)	$47-24=12\theta$		
	$\theta=\frac{23}{12}$, so $\theta=1.917$ or better	**M1**	for complete correct method to get $\theta=$
	$\theta=1.92$ to 2dp	**A1**	must have evidence of working to more than 2 dp, allow if 1.916 seen (truncated)
(ii)	$\sin\frac{\theta}{2}=\frac{CD/2}{12}$	**M1**	for a complete method, may use cosine rule to get *CD*
	CD = awrt 19.6 or 19.7	**A1**	
(iii)	Area of sector = awrt 138	**B1**	for sector area, allow unsimplified
	Area of triangle *AOB* = awrt 67 or 68	**M1**	for a correct attempt at area
	Area of segment = awrt 70 or 71	**M1**	for segment area (*their* sector area – *their* triangle area)
	AD × *AB* + segment area = 425	**M1**	for complete method to find *AD*
	leading to *AD* = awrt 18.1 or 18.0	**A1**	Allow **A1** for 18
	Alternative method:		
	Area of sector = awrt 138	**B1**	for sector area
	Difference in length between *BC* (or *AD*) and *OM* where *M* is the midpoint of *CD* = 6.88, allow awrt 6.9	**M1**	for attempt to find difference between parallel sides
	Remaining area consists of two trapezia each of width 9.85 and each of area 143.4 $\frac{1}{2}\left(2BC-6.88\right)\times 9.85=143.4$ oe	**M1**	for area of one trapezium $\frac{1}{2}\left(2BC-\textit{their}\ 6.88\right)\times \textit{their}\ 9.85$ oe
		M1	for attempt to find either *BC* or *AD*
	leading to *AD* = awrt 18.1 or 18.0	**A1**	

Question	Answer	Marks	Part Marks
9 (i)	$p\left(\frac{3}{2}\right)$: $\frac{27a}{8}-\left(4\times\frac{9}{4}\right)+\frac{3b}{2}+18\ \ (=0)$	M1	for attempt at $p\left(\frac{3}{2}\right)$
	$p'\left(\frac{3}{2}\right)=\left(3a\times\frac{9}{4}\right)-\left(8\times\frac{3}{2}\right)+b\ \ (=0)$	M1	for differentiation and attempt at $p'\left(\frac{3}{2}\right)$
	leading to $9a+4b+24=0$ oe and $27a+4b-48=0$ oe	M1	for solution of simultaneous equations, to get either *a* or *b*
	leading to $a=4,\ b=-15$	A1	for both
(ii)	$(x+2)(2x-3)^2$ oe	M1, A1	**M1** for attempt at long division or factorisation
(iii)	$(x+2)(2x-3)^2=x+2$ $x+2=0,\ x=-2$	B1	Must be using $(x+2)$ correctly using part (ii) to get $x=-2$
	$(2x-3)^2=1$	M1	for solution of the quadratic equation
	leading to $x=1,\ x=2$	A1	
10 (a) (i)	$20U+\frac{1}{2}\left(U+\frac{U}{2}\right)10=165$	M1	for realising that area under the graph is needed and attempt to find an area
		DM1	for equating their area to 165 and attempt to solve
	leading to $U=6$	A1	
(ii)	Gradient of line: -0.3	M1, A1	**M1** for use of the gradient, must be negative
(b) (i)	27	B1	
(ii)	$t^2=8\ln 4$ $t=3.33$ or better	M1 A1	for a correct attempt to solve $e^{\frac{t^2}{8}}=4$
(iii)	acceleration $=3\frac{2t}{8}e^{\frac{t^2}{8}}\left(e^{\frac{t^2}{8}}-4\right)^2$	M1, A1	**M1** for a correct attempt to differentiate using the chain rule
	When $t=1,\ a=6.98$	M1, A1	**M1** for use of $t=1$ in their acceleration

Question	Answer	Marks	Part Marks
11 (i)	$\ln y = \ln A + x \ln b$	**B1**	may be implied, if equation not seen specifically, by correct values for A and b
	Gradient: $\ln b = -\frac{0.12}{8}$, $= -0.015$	**M1**	for use of gradient to obtain ln b
	$b = 0.985$	**A1**	Allow **A1** for $e^{-0.015}$
	Intercept: $\ln A = 0.26$	**DM1**	for use of one of the given points correctly
	$A = 1.30$	**A1**	Allow **A1** for $e^{0.26}$ or 1.3
	Alternative 1		
	$\ln y = \ln A + x \ln b$	**B1**	
	$0.2 = 4\ln b + \ln A$	**M1**	for one correct equation
	$0.08 = 12\ln b + \ln A$	**DM1**	for attempt to obtain either ln$A$ or ln$b$ from simultaneous equations
	$A = 1.30$ and $b = 0.985$	**A1**, **A1**	Allow **A1** for $b =$ $e^{-0.015}$ and $a =$ $e^{0.26}$ or 1.3
	Alternative 2		
	$1.22 = Ab^4$	**B1**	
	$1.08 = Ab^{12}$	**B1**	
		M1	for correct attempt to obtain b or A, must already have **B2**
	$A = 1.30$ and $b = 0.985$	**A1**, **A1**	Allow **A1** for $b =$ $e^{-0.015}$ and $a =$ $e^{0.26}$ or 1.3
(ii)	When $x = 6$, $\ln y = 0.17$	**M1**	for $\ln y = \textit{their} \ln A + 6\ \textit{their} \ln b$ or $y = \textit{their}\ A \times (\textit{their}\ b)^6$
	$y = 1.19$	**A1**	allow awrt 1.18 to 1.20
(iii)	When $y = 1.1$, $\ln y = 0.095$	**M1**	for $\ln 1.1 = \textit{their} \ln A + x\ \textit{their} \ln b$ or $1.1 = \textit{theirA} \times (\textit{theirb})^x$
	$x = 11$	**A1**	allow 10.5 to 11.5

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **October/November 2016**

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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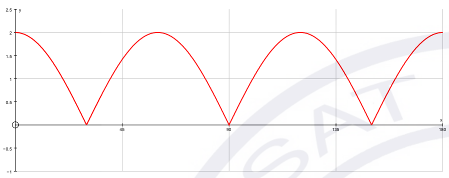
Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied
www without wrong working

Question	Answer	Marks	Part Marks
1		B1 B1 B1	for symmetrical shape as in the diagram with curved maxima of equal height and cusps on the x-axis for a complete 'curve' with all low points on the x-axis and all high points on $y=2$ for a complete 'curve' meeting the x-axis at $x=30^{\circ}$, 90°, 150° only.
2	$=\dfrac{4m^2-9}{2m+3}$	M1	for multiplying each term by $\sqrt{m}$, using a common denominator of $\sqrt{m}$ or for multiplying numerator and denominator by $2\sqrt{m}-\dfrac{3}{\sqrt{m}}$
	$=\dfrac{(2m-3)(2m+3)}{2m+3}$	A1	for a correct expression that will cancel $\dfrac{(2m-3)(2m+3)}{2m+3}$, $\dfrac{(4m^2-9)(2m-3)}{(4m^2-9)}$ $\dfrac{(2m-3)(2m+3)(2m-3)}{(2m+3)(2m-3)}$, or equivalents
	$=2m-3$	A1	for $2m-3$ or $A=2,\ B=-3$
	Alternative Method $(4m\sqrt{m}-\dfrac{9}{\sqrt{m}})$ $=(2\sqrt{m}+\dfrac{3}{\sqrt{m}})\,(Am+B)$	M1	for correct expansion
	Comparing coefficients $2A=4,\ 3A+2B=0,\ 3B=-9$	A1 A1	for correct comparisons to obtain A and B for $2m-3$ or $A=2,\ B=-3$

Question	Answer	Marks	Part Marks
3 (i)	$3x^2 - 2xp + (p+3) = 0$ $(-2p)^2 - 4\times 3\times (p+3) \geqslant 0$ oe	M1	for obtaining a 3-term quadratic in the form $ax^2 + bx + c(=0)$
		DM1	for correct substitution of *their* a, b and c into '$b^2 - 4ac$' and use of discriminant.
	$p^2 \geqslant 3(p+3)$ or $4p^2 - 12p - 36 \geqslant 0$ $p^2 - 3p - 9 \geqslant 0$	A1	for full correct working, $\geqslant$ the only sign used, $\geqslant$ used before division by 4 and $\geqslant$ used in answer line and penultimate line.
(ii)	Correct method of solution $p^2 - 3p - 9 = 0$ leading to critical values	M1	for correct substitution in the quadratic formula or for correct attempt to complete the square. (allow 1 sign error in either method)
	$p = \dfrac{3 \pm 3\sqrt{5}}{2}$	A1	for both correct critical values
	$p \leqslant \dfrac{3 - 3\sqrt{5}}{2}$, $p \geqslant \dfrac{3 + 3\sqrt{5}}{2}$	A1	for correct range
4 (i)	$64 - 48x + 15x^2$	B3	for each correct term
(ii)	$(4\times '64') + (2\times '-48') + (3\times '15')$	M1	for correctly obtaining three products using *their* coefficients in (i)
		A1	for two correct out of three products (unsimplified) cao
	= 205 cao	A1	for 205 selected as final answer
5 (i)	$\log_9 xy = \log_9 x + \log_9 y$	M1	for use of $\log AB = \log A + \log B$
	$= \dfrac{\log_3 x}{\log_3 9} + \dfrac{\log_3 y}{\log_3 9}$	M1	for correct method for change of base. Division by $\log_3 9$ should be seen and not implied.
	$= \dfrac{\log_3 x}{2} + \dfrac{\log_3 y}{2} = \dfrac{5}{2}$		
	$\log_3 x + \log_3 y = 5$	A1	for dealing with 2 correctly and 'finishing off'
	Alternative method		
	$\log_9 xy = \dfrac{5}{2}$	M1	for obtaining xy as a power of 3
	$xy = 9^{\frac{5}{2}} = 3^5$	M1	for correct use of $\log_3$
	$\log_3 xy = 5$ $\log_3 x + \log_3 y = 5$	A1	for using law for logs and arriving at correct answer

Question	Answer	Marks	Part Marks
(ii)	$\log_3 x(5-\log_3 x)=-6$		
	$-(\log_3 x)^2+5\log_3 x=-6$	M1	for substitution, correct expansion of brackets and manipulation to get a 3 term quadratic
	$(\log_3 x)^2-5\log_3 x-6=0$	A1	for a correct quadratic equation in the form $ax^2+bx+c=0$
	leading to $\log_3 x=6,\ \ \log_3 x=-1$	A1	for both solutions
		DM1	for method of solution of $\log_3 x=k$ or $\log_3 y=k$
	$x=729,\ \ x=\frac{1}{3}$		
	$y=\frac{1}{3},\ \ y=729$	A1	for all x and y correct
6 (i)	$\frac{6x}{3x^2-11}$	M1 A1	**M1** for $\frac{mx}{3x^2-11}$
(ii)	$p=\frac{1}{6}$	B1	**FT** for $p=\frac{1}{m}$
(iii)	$\frac{1}{6}\ln(3a^2-11)-\frac{1}{6}\ln 1=\ln 2$	M1	for correct use of limits in $p\ln(3x^2-11)$ May be implied by following equation
	$\ln(3a^2-11)=\ln 2^6$	DM1	for dealing with logs correctly
	$3a^2-11=64$	DM1	for solution of $3a^2-11=k$
	$a=5$ only	A1	for 5 obtained from an exact method

Question	Answer	Marks	Part Marks
7 (i)	$\ln y = \ln A + \frac{b}{x}$	B1	for equation, may be implied, must be using ln unless recovered
	Gradient: $b = -0.8$	B1	for $b = -0.8$ oe
	Intercept or use of equation: $\ln A = 4.7$	B1	for ln A = 4.7 oe, allow 4.65 to 4.75
	$A = 110$	B1	for A = 110, allow 105 to 116 Allow *A* in terms of e
	Alternative Method $3.5 = \ln A + 1.5b$ and $1.5 = \ln A + 4b$	B1	for one equation
	leading to $b = -0.8$	B1	for $b = -0.8$
	$\ln A = 4.7$	B1	for $\ln A = 4.7$
	and $A = 110$	B1	for $A = 110$ or $e^{4.7}$
	Alternative Method $e^{1.5} = Ae^{4b}$	B1	for $e^{1.5} = Ae^{4b}$ or $4.48 = Ae^{4b}$
	$e^{3.5} = Ae^{1.5b}$	B1	for $e^{3.5} = Ae^{1.5b}$ or $33.1 = Ae^{1.5b}$
	leading to $b = -0.8$	B1	for $b = -0.8$
	and $A = 110$	B1	for $A = 110$ or $e^{4.7}$
(ii)	When $x = 0.32, \frac{1}{x} = 3.125, \ln y = 2.2$	M1	for a complete method to obtain *y*, using either the graph, using *their* values in the equation for ln*y* or using *their* values in the equation for *y*.
	$y = 9$ (allow 8.5 to 9.5) or $e^{2.2}$	A1	
(iii)	When $y = 20$, $\ln y = 3$, $\frac{1}{x} = 2.125$	M1	for a complete method to obtain *x*, using either the graph, using *their* values in the equation for ln*y* or using *their* values in the equation for *y*.
	so $x = 0.47$ (allow 0.45 to 0.49)	A1	

Question	Answer	Marks	Part Marks
8 (a) (i)	$\dfrac{\operatorname{cosec}\theta}{\operatorname{cosec}\theta-\sin\theta}=\dfrac{\frac{1}{\sin\theta}}{\frac{1}{\sin\theta}-\sin\theta}$	M1	for using $\operatorname{cosec}\theta=\dfrac{1}{\sin\theta}$ and either attempt to multiply top and bottom by $\sin\theta$ or an attempt to combine terms in denominator.
	$=\dfrac{1}{1-\sin^2\theta}$ or $=\dfrac{\frac{1}{\sin\theta}}{\frac{(1-\sin^2\theta)}{\sin\theta}}$	DM1	for correct use of $1-\sin^2\theta=\cos^2\theta$
	$=\dfrac{1}{\cos^2\theta}$ $=\sec^2\theta$	A1	for completing the proof
	Alternative Method using cosec $\dfrac{\operatorname{cosec}\theta}{\operatorname{cosec}\theta-\sin\theta}=\dfrac{\operatorname{cosec}\theta}{\operatorname{cosec}\theta-\frac{1}{\operatorname{cosec}\theta}}$		
	$=\dfrac{\operatorname{cosec}^2\theta}{\operatorname{cosec}^2\theta-1}$	M1	for using $\sin\theta=\dfrac{1}{\operatorname{cosec}\theta}$ and an attempt to combine terms in denominator.
	$=\dfrac{1+\cot^2\theta}{\cot^2\theta}$	DM1	for use of $1+\cot^2\theta=\operatorname{cosec}^2\theta$
	$=\tan^2\theta+1=\sec^2\theta$	A1	for completing the proof
(ii)	$\cos^2\theta=\dfrac{1}{4},\ \cos\theta=\pm\dfrac{1}{2}$ or $\tan^2\theta=3,\ \tan\theta=\pm\sqrt{3}$ or $\sin^2\theta=\dfrac{3}{4},\ \sin\theta=\pm\dfrac{\sqrt{3}}{2}$	M1	for using (i) to obtain a value for $\cos^2\theta$, $\tan^2\theta$ or $\sin^2\theta$ and then taking the square root.
	$\theta=60^\circ, 120^\circ, 240^\circ, 300^\circ$	A1 A1	for two correct values for two further correct values and no extras in range.
(b)	$\tan\left(x+\dfrac{\pi}{4}\right)=\dfrac{1}{\sqrt{3}}$	M1	for correct order of operations, can be implied by $x=-\dfrac{\pi}{12}$
	$x=\dfrac{\pi}{6}-\dfrac{\pi}{4},\ \dfrac{7\pi}{6}-\dfrac{\pi}{4},\ \dfrac{13\pi}{6}-\dfrac{\pi}{4}$		
	$x=\left(-\dfrac{\pi}{12}\right),\ \dfrac{11\pi}{12},\ \dfrac{23\pi}{12}$	A1,A1	**A1** for $x=\dfrac{11\pi}{12}$ **A1** for $x=\dfrac{23\pi}{12}$ If there are extra solutions in range in addition to the two correct ones then **A1A0**

Question	Answer	Marks	Part Marks
9 (a) (i)	${}^{18}C_5 = 8568$ mmm	B1	
(ii)	**Either** ${}^{10}C_4 \times {}^{8}C_1 = 1680$ ${}^{10}C_3 \times {}^{8}C_2 = 3360$ ${}^{10}C_2 \times {}^{8}C_3 = 2520$ ${}^{10}C_1 \times {}^{8}C_4 = 700$ Total = 8260	B1 B2,1,0 B1	for a correct plan **B2** 4 correct numbers with no extras **B1** 3 correct numbers (out of 3 or 4) for correct total
	Or *their* ${}^{18}C_5 - \left({}^{10}C_5 + {}^{8}C_5\right)$ $8568 - (252 + 56)$ Total =8260	B1 B1 B1 B1	for correct plan for 252 subtracted for 56 subtracted for correct total
(b) (i)	${}^{10}P_6 = 151200$	B1	
(ii)	$4 \times {}^{8}P_4 \times 3$ $= 20160$	M1 A1	for correct unsimplified for correct numerical answer
(iii)	Answer to (i) - ${}^{7}P_6$ =146160	M1 A1 A1	for correct plan for correct unsimplified for correct numerical answer
	Alternative: 1 symbol: 45360 2 symbols: 75600 3 symbols: 25200 Total: 146160	B2,1,0 B1	**B2** for all 3 correct **B1** for 2 correct (out of 2 or 3) for correct sum

Question	Answer	Marks	Part Marks
10 (i)	$\mathrm{f}(x)=3x^2-4\mathrm{e}^{2x}\ (+c)$	M1 A1 A1	for one correct term for one correct term $3x^2$ or $-4\mathrm{e}^{2x}$ for a second correct term with no extras
	passing through $(0,-3)$ $-3=3\times 0-4\mathrm{e}^0+c$	DM1	for correct method to find *c*.
	$\mathrm{f}(x)=3x^2-4\mathrm{e}^{2x}+1$	A1	for correct equation
(ii)	$\mathrm{f}'(0)=-8$	B1	for $m=\frac{1}{8}$
	Normal: $y+3=\frac{1}{8}x$	M1	for equation of normal using $m=\frac{1}{8}$
	$8y+24=x$ $y=2-3x$	DM1	for solving normal equation simultaneously with $y=2-3x$ to get a value of x
	leads to $x=\frac{8}{5}$ oe	A1	for $x=\frac{8}{5}$, 1.6 oe
	Area = $=\frac{1}{2}\times 3\times\frac{8}{5}$ = 2.4 oe	B1	**FT** for a numerical answer equal to $\left\lvert\frac{1}{2}\times 3\times \text{their } x\right\rvert$
11 (i)	$a=8t-8$ When $t=3$, $a=16$	B1 B1	for $8t-8$ for 16
(ii)	0.5, 1.5	B1,B1	**B1** for each
(iii)	$s=\frac{4}{3}t^3-4t^2+3t$	M1 A1	for at least two terms correct all correct
	when $t=\frac{1}{2}$, $s=\frac{2}{3}$	DM1	for calculating displacement when either $t=\frac{1}{2}$ or $t=\frac{3}{2}$
	when $t=\frac{3}{2}$, $s=0$	DM1	for calculating displacement at $t=\frac{1}{2}$ and doubling.
	total distance travelled = $\frac{4}{3}$	A1	for $\frac{4}{3}$ oe allow 1.33
	Alternative method	M1A1 DM1	As before **DM1** for calculating displacement when $t=0.5$ or for calculating distance travelled between $t=0.5$ and $t=1.5$
		DM1	**DM1** for doubling distance travelled between $t=0.5$ and $t=1.5$ or for adding that distance to displacement at $t=0.5$
		A1	**A1** for $\frac{4}{3}$ oe allow 1.33

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Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **May/June 2016**

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
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

Question	Answer	Marks	Guidance
1 (i)	-27	**B1**	
(ii)	$9-8k=0$	**M1**	for use of discriminant with a complete method to get to $k=$
	$k=\frac{9}{8}$	**A1**	
	Or $\frac{dy}{dx}=4x-3$	**M1**	for a complete method to get to $k=$
	when $\frac{dy}{dx}=0$, $x=\frac{3}{4}$		
	so $k=\frac{9}{8}$	**A1**	
	Or completing the square		
	$y=2\left(x-\frac{3}{4}\right)^2+k-\frac{9}{8}$	**M1**	for a complete method to get to $k=$
	$k=\frac{9}{8}$	**A1**	
2 (a)	$2^{4(3x-1)}=2^{3(x+2)}$ or $4^{2(3x-1)}=4^{\frac{3}{2}(x+2)}$ or $8^{\frac{4}{3}(3x-1)}=8^{x+2}$ or $16^{3x-1}=16^{\frac{3}{4}(x+2)}$	**B1**	**B1** for a correct statement
		M1	for equating indices
	leading to $x=\frac{10}{9}$ cao	**A1**	
(b)	$p=\frac{5}{3}$	**B1**	
	$q=-2$	**B1**	

Question	Answer	Marks	Guidance
3	On x-axis, $2x^2 - 7 = 1$ $x = 2$	M1 A1	for equating to 1
	$\frac{dy}{dx} = \frac{4x}{2x^2 - 7}$	B1	
	When $x = 2$, $\frac{dy}{dx} = 8$		
	Gradient of normal $= -\frac{1}{8}$		
	Equation of normal $y = -\frac{1}{8}(x - 2)$	M1	for attempt at perpendicular through *their* $(2, 0)$, must be using $y = 0$
	Required form $x + 8y - 2 = 0$	A1	must be equated to zero with integer coefficients
4 (a)	$\mathbf{A}^2 = \begin{pmatrix} 7 & -2 \\ -3 & 6 \end{pmatrix}$	B1	
	$\mathbf{A}^2 - 2\mathbf{B} = \begin{pmatrix} 1 & -2 \\ -5 & 2 \end{pmatrix}$	M1 A1	for their $\mathbf{A}^2 - 2\mathbf{B}$
(b)	$\begin{pmatrix} 4 & 1 \\ 10 & 3 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$		
	so $\begin{pmatrix} x \\ y \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 3 & -1 \\ -10 & 4 \end{pmatrix}\begin{pmatrix} 1 \\ 1 \end{pmatrix}$	M1 DM1	for pre-multiplication by *their* inverse matrix **DM1** for attempt at matrix multiplication
	leading to $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ -3 \end{pmatrix}$		
	$x = 1$ $y = -3$	A1 A1	Allow in matrix form
5 (i)	$\frac{d}{dx}\left(\frac{e^{4x}}{4} - xe^{4x}\right) = e^{4x} - \left(\left(x \times 4e^{4x}\right) + e^{4x}\right)$	B1 M1 A1	for $\frac{d}{dx}\left(\frac{e^{4x}}{4}\right) = e^{4x}$ for attempt to differentiate a product for a correct product
	$= -4xe^{4x}$	A1	for correct final answer
(ii)	$\int_0^{\ln 2} xe^{4x}\, dx = -\frac{1}{4}\left[\frac{e^{4x}}{4} - xe^{4x}\right]_0^{\ln 2}$	B1FT	**FT** for use of *their* $\frac{1}{p} \times \left(\frac{e^{4x}}{4} - xe^{4x}\right)$, must be numerical p, but $\neq 0$
	$= -\frac{1}{4}\left(\left(\frac{16}{4} - 16\ln 2\right) - \frac{1}{4}\right)$	B1 M1	for $e^{4\ln 2} = 16$ for correct use of limits, must be an integral of the correct form
	$= 4\ln 2 - \frac{15}{16}$	A1	

Question	Answer	Marks	Guidance
6 (i)	$2-\sqrt{5} < \mathrm{f}(x) \leqslant 2$	B2	**B1** for $\leqslant 2$ **B1** for $2-\sqrt{5}<$ or awrt –0.24 Must be using f, f(x) or y, $2-\sqrt{5}<$, if not then **B1** max
(ii)		M1	for a correct method to find the inverse
	$\mathrm{f}^{-1}(x)=(2-x)^2-5$	A1	
	Domain $2-\sqrt{5}<x\leqslant 2$ Range y or $-5\leqslant \mathrm{f}^{-1}(x)<0$	B1 B1	Must be using the correct variables for the B marks
(iii)	$\mathrm{fg}(x)=\mathrm{f}\left(\dfrac{4}{x}\right)$	M1	for correct order of functions
	$=2-\sqrt{\dfrac{4}{x}+5}$	DM1	for solution of equation
	leading to $x=-4$	A1	
7 (i)	Finding an angle of 68.2° or 21.8°	B1	
	$\dfrac{4.5}{\sin 68.2}=\dfrac{2.4}{\sin\alpha}$	B1	for the sine rule
	leading to $\alpha = 29.7^\circ$ (allow ± 0.1)	B1	
	Direction is 82.1° to the bank, upstream(allow $\pm 0.1^\circ$)	B1	
(ii)	$\dfrac{4.5}{\sin 68.2}=\dfrac{2.4}{\sin 29.7}=\dfrac{v_r}{\sin 82.1}$	B1	for the sine rule
	leading to $v_r = 4.8$	B1	for resultant velocity
		M1	for attempt to find AB and hence the time taken
	time taken = $\dfrac{80.78}{4.8}=16.8$	A1	
	Alternative method:		
	Finding an angle of 68.2° or 21.8°	B1	
	$4.5^2=2.4^2+v_r^2-(2\times 2.4\times v_r\cos 68.2)$	B1	for correct use of the cosine rule
	leading to $v_r=4.8$	B1	for resultant velocity
	Use of sine rule to obtain angle and direction to obtain direction is 82.1° to the bank, upstream	B1 B1 B1	for use of the sine rule for $\alpha = 29.7^\circ$ for 82.1°
		M1	for attempt to find AB and hence the time taken
	Use of time taken = $\dfrac{80.78}{4.8}=16.8$	A1	

Question	Answer	Marks	Guidance
8 (i)	$y-6=-\frac{4}{12}(x+8)$ $(3y+x=10)$	M1 A1	for a correct method allow unsimplified
(ii)	$y-7=3(x+1)$ $(y=3x+10)$	DM1 A1	for attempt at a perpendicular line using $(-1, 7)$ allow unsimplified
(iii)	point of intersection $(-2, 4)$ which is the midpoint of AB	M1 M1 A1	for attempt to find the point of intersection using simultaneous equations for attempt to find midpoint for all correct
	Alternative method: Midpoint $(-2, 4)$ Verification that this point lies on CP.	M1 M1 A1	for attempt to find midpoint for full verification for all correct
(iv)	$CP=\sqrt{10}$ or 3.16	B1	
(v)	Area = $\frac{1}{2}\times\sqrt{10}\times4\sqrt{10}$ $=20$	M1 A1	for correct method **using *CP*** for 19.9 – 20.1

Question	Answer	Marks	Guidance
9 (i)	$2\cos x\cot x = \cot x + 2\cos x$ $2\cos x\dfrac{\cos x}{\sin x}+1=\dfrac{\cos x}{\sin x}+2\cos x$	M1	for use of $\cot x=\dfrac{\cos x}{\sin x}$ for both terms
	$2\cos^2 x+\sin x=\cos x+2\cos x\sin x$	DM1	for multiplication throughout by $\sin x$
	$2\cos^2 x-2\cos x\sin x=\cos x-\sin x$		
	$2\cos x(\cos x-\sin x)=\cos x-\sin x$	DM1	for attempt to factorise
	$(2\cos x-1)(\cos x-\sin x)=0$	A1	for completely correct solution www
	Alternative method: $a\cos^2 x-a\cos x\sin x-b\cos x$ $+b\sin x=0$	M1	for expansion of RHS
	$a\cos x\cot x-a\cos x-b\cot x+b=0$	DM1 DM1	for division by $\sin x$ for comparing like terms to obtain both *a* and *b*
	$a=2,\quad b=1$	A1	for both correct www
(ii)	$(2\cos x-1)(\cos x-\sin x)=0$		
	$\cos x=\dfrac{1}{2}$, $\tan x=1$	M1	for either
	$x=\dfrac{\pi}{3}$, $x=\dfrac{\pi}{4}$	A1,A1	**A1** for each, penalise extra solutions within the range by withholding the last A mark
	Alternative method: $(2\cos x-1)(\cot x-1)=0$ Leading to $\cos x=\dfrac{1}{2}$, $\tan x=1$	M1	for attempt to factorise the original equation and attempt to solve
	$x=\dfrac{\pi}{3}$, $x=\dfrac{\pi}{4}$	A1,A1	**A1** for each, penalise extra solutions within the range by withholding the last A mark
10 (i)	$f(-2)=-32-2k+p=0$	M1	for attempt at $f(-2)$
	$f'\left(\dfrac{1}{2}\right)=\dfrac{12}{4}+k=0$	M1	for attempt at $f'\left(\dfrac{1}{2}\right)$
	leading to $k=-3$ and $p=26$	A1,A1	**A1** for each
(ii)		B1FT	**FT** for *their* $\dfrac{p}{2}$
	$(x+2)(4x^2-8x+13)$	B1	all correct
(iii)	Showing that $4x^2-8x+13=0$ has no real roots	M1,	M1 for a valid attempt at solution of equation leading to no solution or consideration of the discriminant
	so $x=-2$ only www	A1	

Question	Answer	Marks	Guidance
11 (i)	$AB = 2r\sin\theta$ or $\sqrt{r^2 + r^2 - 2r^2\cos 2\theta}$ or $\dfrac{r\sin 2\theta}{\sin\left(\frac{\pi}{2} - \theta\right)}$ or $\dfrac{r\sin 2\theta}{\cos\theta}$	B1	
(ii)	$2r\sin\theta + 2r\theta = 20$	M1	for use of (i) + arc length = 20, oe
	$r = \dfrac{10}{\theta + \sin\theta}$	A1	must be convinced
(iii)	$\dfrac{dr}{d\theta} = -\dfrac{10(1+\cos\theta)}{(\theta + \sin\theta)^2}$	M1 A2,1,0	for a correct attempt to differentiate –1 each error
	When $\theta = \dfrac{\pi}{6}$, $\dfrac{dr}{d\theta} = -17.8$	A1	allow awrt -17.8
(iv)	$\dfrac{dr}{dt} = 15$	B1	may be implied
	$\dfrac{d\theta}{dt} = \dfrac{dr}{dt} \div \dfrac{dr}{d\theta}$	M1	for use of $\dfrac{15}{\textit{their}\text{ (iii)}}$
	$\dfrac{d\theta}{dt} = -0.842$	A1	allow -0.84 or -0.843

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **May/June 2016**

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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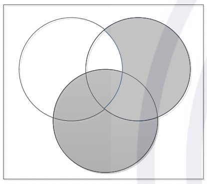
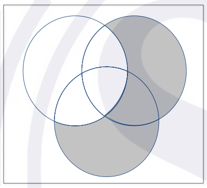
Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

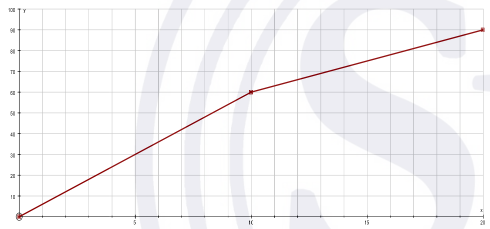
Question	Answer	Marks	Guidance
1 (a)	$Y \subset X$ or $Y \subseteq X$ only $Y \cap Z = \varnothing$ or $\{\ \}$ only	**B1** **B1**	
(b)	**(i)**  **(ii)** 	**B1** **B1**	
2 (i)	$32 - \frac{20}{x} + \frac{5}{x^2}$	**B3**	**B1** for each correct term – must be integers
(ii)	$(3 \times 32) + \left(-\frac{20}{x} \times 4x\right) = 16$ Accept $16x^0$	**M1** **A1**	for $(3 \times \mathit{their}\ 32) + \left(\frac{\mathit{their}(-20)}{x} \times 4x\right)$
3 (i)	$\mathbf{b} - \mathbf{c} = \begin{pmatrix} 6 \\ -2 \end{pmatrix}$ $4 + y^2 = 36 + 4$ $y = \pm 6$	**B1** **M1** **A1**	may be implied by further correct working for one correct attempt at using the modulus
(ii)	$\mu + 4 = 2\lambda$ or $-4\mu + 24 = 7\lambda$ $\mu - 4 = -\lambda$ or $8\mu - 8 = \lambda$ leading to $\mu = \frac{4}{3}$, $\lambda = \frac{8}{3}$ oe allow 1.33 and 2.67 or better	**B1** **B1** **DB1**	for one correct equation in μ and λ for a second correct equation in μ and λ for both, must have both previous **B** marks

Question	Answer	Marks	Guidance
4	$\left(4+\sqrt{5}\right)x^2+\left(2-\sqrt{5}\right)x-1=0$		**You must be convinced that a calculator is not being used.**
	$x=\dfrac{-\left(2-\sqrt{5}\right)\pm\sqrt{\left(2-\sqrt{5}\right)^2-4\left(4+\sqrt{5}\right)(-1)}}{2\left(4+\sqrt{5}\right)}$	M1 A1	for use of quadratic formula (allow one sign error), allow $b^2=9-4\sqrt{5}$ all correct
	$x=\dfrac{-\left(2-\sqrt{5}\right)\pm\sqrt{9-4\sqrt{5}+16+4\sqrt{5}}}{2\left(4+\sqrt{5}\right)}$	DM1	for attempt to simplify the discriminant (minimum of 4 terms must be seen in discriminant, 2 terms involving √5 and 2 constant terms)
	$=\dfrac{-\left(2-\sqrt{5}\right)+5}{2\left(4+\sqrt{5}\right)}$		
	$=\dfrac{3+\sqrt{5}}{2\left(4+\sqrt{5}\right)}$	A1	for $\dfrac{3+\sqrt{5}}{2\left(4+\sqrt{5}\right)}$ or $\dfrac{3+\sqrt{5}}{8+2\sqrt{5}}$, ignore negative solution if included
	$=\dfrac{\left(3+\sqrt{5}\right)\left(4-\sqrt{5}\right)}{2\left(4+\sqrt{5}\right)\left(4-\sqrt{5}\right)}$	M1	for attempt to rationalise an expression of the form $\dfrac{a\pm b\sqrt{5}}{c\pm d\sqrt{5}}$ as part of their solution of the quadratic Must obtain an integer denominator
	$=\dfrac{7+\sqrt{5}}{22}$	A1	**Final A1 can only be awarded if all previous marks have been obtained**
5 (i)	$\left(1-\cos\theta\right)\left(1+\sec\theta\right)$ $=1-\cos\theta+\dfrac{1}{\cos\theta}-\dfrac{\cos\theta}{\cos\theta}$ $=\sec\theta-\cos\theta$ $=\dfrac{1}{\cos\theta}-\cos\theta$	M1	M1 for expansion and use of $\sec\theta=\dfrac{1}{\cos\theta}$ consistently, allow one sign error
	$=\dfrac{1-\cos^2\theta}{\cos\theta}$	DM1	for attempt at a single fraction, dependent on first **M1**
	$=\dfrac{\sin^2\theta}{\cos\theta}$	A1	
	$=\sin\theta\tan\theta$ www	A1	

Question	Answer	Marks	Guidance
	Alternative method: $(1-\cos\theta)\left(\frac{\cos\theta+1}{\cos\theta}\right)$	M1	for attempt at a single fraction for second factor and use of $\sec\theta = \frac{1}{\cos\theta}$
	$= \frac{1-\cos^2\theta}{\cos\theta}$	DM1	for expansion
	$= \frac{\sin^2\theta}{\cos\theta}$	A1	
	$= \sin\theta\tan\theta$ www	A1	
(ii)	$\sin\theta\tan\theta = \sin\theta$ $\sin\theta(\tan\theta - 1) = 0$		
	$\tan\theta = 1,\ \theta = \frac{\pi}{4}$, allow 0.785 or better	B1	for $\theta = \frac{\pi}{4}$ from $\tan\theta = 1$
	$\sin\theta = 0,\ \theta = 0,\ \pi$ or 3.14 or better	B1 B1	for $\theta = 0$ from $\sin\theta = 0$ for $\theta = \pi$ from $\sin\theta = 0$
6	$\frac{d}{dx}\left(e^{3x}(4x+1)^{\frac{1}{2}}\right)$		
	$= e^{3x}\frac{1}{2}\times 4(4x+1)^{-\frac{1}{2}} + 3e^{3x}(4x+1)^{\frac{1}{2}}$	B1	for $re^{3x}(4x+1)^{-\frac{1}{2}}$ must be part of a sum, $r = \frac{1}{2}$ or 2 or $\frac{1}{2}\times 4$
		B1	for $se^{3x}(4x+1)^{\frac{1}{2}}$ must be part of a sum, s is 1 or 3
	$= \frac{2e^{3x}}{(4x+1)^{\frac{1}{2}}} + 3e^{3x}(4x+1)^{\frac{1}{2}}$	B1	for all correct, allow unsimplified
	$= \frac{e^{3x}}{(4x+1)^{\frac{1}{2}}}(2+12x+3)$	DM1	for $\frac{e^{3x}}{(4x+1)^{\frac{1}{2}}}(a+bx)$, dependent on first 2 **B** marks , must be using a correct method, collecting terms in the numerator correctly
	$= \frac{e^{3x}}{(4x+1)^{\frac{1}{2}}}(12x+5)$	A1	
7 (i)	$\cos 3x = \frac{1}{2},\ x = \frac{\pi}{9}$ or $0.349,\ 20^\circ$, allow 0.35	M1 A1	for correct attempt to solve the trigonometric equation
(ii)	$B\left(\frac{\pi}{3},\ 3\right)$ or $(1.05,\ 3)$, $(60^\circ,\ 3)$	B1B1	**B1** for each, must be in correct position or in terms of $x =$ and $y =$

Question	Answer	Marks	Guidance
(iii)	$\int_{\frac{\pi}{9}}^{\frac{\pi}{3}} 1-2\cos 3x \, dx = \left[x - \frac{2}{3}\sin 3x\right]_{\frac{\pi}{9}}^{\frac{\pi}{3}}$	M1 A1	for $x \pm a\sin 3x$ attempt to integrate at least one term for correct integration
	$= \frac{\pi}{3} - \left(\frac{\pi}{9} - \left(\frac{2}{3} \times \frac{\sqrt{3}}{2}\right)\right)$	DM1	for correct use of limits from **(i)** and **(ii)**, must be in radians
	$= \frac{2\pi}{9} + \frac{\sqrt{3}}{3}$ oe or 1.28	A1	
8 (i)	$\lg y = x^2 \lg b + \lg A$ $\lg b = \pm 0.21$ $b = 0.617$ allow 0.62, $10^{-0.21}$ $\lg A = 0.94$ allow 0.93 to 0.95 $A = 8.71$ allow awrt 8.5 to 8.9	 B1 B1 B1 B1	 for $\lg b = \pm 0.21$ may be implied
	Alternative method 5.37 or $10^{0.73} = Ab$ 1.259 or $10^{0.1} = Ab^4$ $b^3 = 10^{-0.63}$ $b = 0.617$ allow 0.62, $10^{-0.21}$ $A = 8.71$ allow awrt 8.5 to 8.9	 B1 B1 B1 B1	 for both equations, allow correct to 2 sf
(ii)	$x = 1.5$, $x^2 = 2.25$ $y = 2.93$, allow awrt 2.9 or 3.0	M1 A1	for correct use of graph $y = theirA \times theirb^{1.5^2}$ or $\lg y = \lg theirA + \left(1.5^2 \lg theirb\right)$
(iii)	$\lg y = 0.301$, or $2 =$ '$8.71(0.617)^{x^2}$' $x = 1.74$, allow $\sqrt{3}$ or awrt 1.7, 1.8	M1 A1	for correct use of graph to read off x^2 $2 = theirA(theirb)^{x^2}$ or $\lg 2 = (\lg theirb)x^2 + \lg(theirA)$
9 (i)	$y = \frac{2}{3}(3x+10)^{\frac{1}{2}}$ $(+c)$	B1 B1	for $p(3x+10)^{\frac{1}{2}}$ where p is a constant for $\frac{2}{3}(3x+10)^{\frac{1}{2}}$ oe unsimplified
	passes through $\left(2, -\frac{4}{3}\right)$, so $c = -4$	M1	for attempt to find c, must have attempt to integrate, must have the first **B1**
	$y = \frac{2}{3}(3x+10)^{\frac{1}{2}} - 4$ oe	A1	

Question	Answer	Marks	Guidance
(ii)	When $x=5$, $y=-\frac{2}{3}$	B1	
	perpendicular gradient $=-5$	B1	
		M1	for attempt at the normal using *their* perpendicular gradient and *their* y value (but not $y=-\frac{4}{3}$ or $-\frac{5}{3}$).
	Equation of normal: $y+\frac{2}{3}=-5(x-5)$	A1	
	When $y=-\frac{5}{3}$,	DM1	for use of $y=-\frac{5}{3}$ in their normal equation to get as far as $x=\ldots$
	$x=5.2$ oe	A1	
10 (i)	Area: $20=\pi x^2+xy$	B1	
	$y=\frac{20-\pi x^2}{x}$	B1	
	$P=2\pi x+2x+2y$		
	$=2\pi x+2x+2\left(\frac{20}{x}-\pi x\right)$	M1	for attempt to use perimeter and obtain in terms of x only
	$=2x+\frac{40}{x}$	A1	all steps seen, www AG
	Alternative method:		
	$20=\pi x^2+xy$	B1	
	$P=2\pi x+2y+2x$		
	$=\frac{2}{x}\left(\pi x^2+xy\right)+2x$	M1	for attempt to use perimeter and write in $\frac{\pi x^2+xy}{x}$
	$=\frac{2}{x}(20)+2x$	B1	for replacing πx^2+xy with 20
	$=2x+\frac{40}{x}$	A1	all steps seen, www AG

Question	Answer	Marks	Guidance
(ii)	$\frac{dP}{dx} = 2 - \frac{40}{x^2}$	M1	for attempt to differentiate
	When $\frac{dP}{dx} = 0$,	DM1	for equating to zero and attempt to solve at least as far as $x^2 =$
	$x = 2\sqrt{5}$ allow 4.47, $\sqrt{20}$	A1	
	leading to $P = 8\sqrt{5}$, allow 17.9	A1	
	$\frac{d^2P}{dx^2} = \frac{80}{x^3}$, always positive so a minimum	A1	for this statement or use of gradient inspection either side of correct x
11 (a) (i)	Distance = area under graph	M1	for attempt to find the area, one correct area seen (triangle, rectangle or trapezium) as part of a sum.
	= 1275	A1	
(ii)	deceleration is 1.5 oe	B1	
(b)		B1	for a straight line between $(0,0)$ and $(10,60)$
		B1FT	**FT** a straight line between $(10, 60)$ and $(20, 90)$, a displacement vector $\begin{pmatrix}10\\30\end{pmatrix}$ from *their* $(10, \textit{their}\,60)$
(c) (i)	e^{2t} is always positive or oe	B1	
(ii)	$a = 8e^{2t}$ $e^{2t} = \frac{3}{2}$	M1	for attempt to differentiate, must be of the form pe^{2t}, equate to 12 and solve.
	$t = \frac{1}{2}\ln\frac{3}{2}$, $\ln\sqrt{\frac{3}{2}}$ or $\frac{1}{2}\ln 1.5$	A1	Allow fractions equivalent to $\frac{3}{2}$
(iii)	$s = \left[2e^{2t} + 6t\right]_{0.4}^{0.5}$	M1 A1	for attempt to integrate to get $qe^{2t} + 6t$ all correct
	$= (2e + 3) - (2e^{0.8} + 2.4)$	DM1	for correct use of limits or considering distances separately, ignore attempts at c
	$(= 8.436 - 6.851)$ $= 1.59$, allow 1.58	A1	

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/13**

Paper 1 **May/June 2016**

MARK SCHEME

Maximum Mark: 80

Published

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This document consists of **7** printed pages.

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awrt answers which round to
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dep dependent
FT follow through after error
isw ignore subsequent working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied
www without wrong working

Question	Answer	Marks	Guidance
1 **(i)**	-27	**B1**	
(ii)	$9-8k=0$	**M1**	for use of discriminant with a complete method to get to $k=$
	$k=\frac{9}{8}$	**A1**	
	Or $\frac{\mathrm{d}y}{\mathrm{d}x}=4x-3$ when $\frac{\mathrm{d}y}{\mathrm{d}x}=0$, $x=\frac{3}{4}$	**M1**	for a complete method to get to $k=$
	so $k=\frac{9}{8}$	**A1**	
	Or completing the square $y=2\left(x-\frac{3}{4}\right)^2+k-\frac{9}{8}$	**M1**	for a complete method to get to $k=$
	$k=\frac{9}{8}$	**A1**	
2 **(a)**	$2^{4(3x-1)}=2^{3(x+2)}$ or $4^{2(3x-1)}=4^{\frac{3}{2}(x+2)}$ or $8^{\frac{4}{3}(3x-1)}=8^{x+2}$ or $16^{3x-1}=16^{\frac{3}{4}(x+2)}$	**B1**	**B1** for a correct statement
		M1	for equating indices
	leading to $x=\frac{10}{9}$ cao	**A1**	
(b)	$p=\frac{5}{3}$	**B1**	
	$q=-2$	**B1**	

Question	Answer	Marks	Guidance
3	On x-axis, $2x^2 - 7 = 1$ $x = 2$	M1 A1	for equating to 1
	$\frac{dy}{dx} = \frac{4x}{2x^2 - 7}$	B1	
	When $x = 2$, $\frac{dy}{dx} = 8$		
	Gradient of normal $= -\frac{1}{8}$		
	Equation of normal $y = -\frac{1}{8}(x - 2)$	M1	for attempt at perpendicular through *their* $(2, 0)$, must be using $y = 0$
	Required form $x + 8y - 2 = 0$	A1	must be equated to zero with integer coefficients
4 (a)	$\mathbf{A}^2 = \begin{pmatrix} 7 & -2 \\ -3 & 6 \end{pmatrix}$	B1	
	$\mathbf{A}^2 - 2\mathbf{B} = \begin{pmatrix} 1 & -2 \\ -5 & 2 \end{pmatrix}$	M1 A1	for their $\mathbf{A}^2 - 2\mathbf{B}$
(b)	$\begin{pmatrix} 4 & 1 \\ 10 & 3 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$		
	so $\begin{pmatrix} x \\ y \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 3 & -1 \\ -10 & 4 \end{pmatrix}\begin{pmatrix} 1 \\ 1 \end{pmatrix}$	M1 DM1	for pre-multiplication by *their* inverse matrix **DM1** for attempt at matrix multiplication
	leading to $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ -3 \end{pmatrix}$		
	$x = 1$ $y = -3$	A1 A1	Allow in matrix form
5 (i)	$\frac{d}{dx}\left(\frac{e^{4x}}{4} - xe^{4x}\right) = e^{4x} - \left(\left(x \times 4e^{4x}\right) + e^{4x}\right)$	B1 M1 A1	for $\frac{d}{dx}\left(\frac{e^{4x}}{4}\right) = e^{4x}$ for attempt to differentiate a product for a correct product
	$= -4xe^{4x}$	A1	for correct final answer
(ii)	$\int_0^{\ln 2} xe^{4x}\, dx = -\frac{1}{4}\left[\frac{e^{4x}}{4} - xe^{4x}\right]_0^{\ln 2}$	B1FT	**FT** for use of *their* $\frac{1}{p} \times \left(\frac{e^{4x}}{4} - xe^{4x}\right)$, must be numerical p, but $\neq 0$
	$= -\frac{1}{4}\left(\left(\frac{16}{4} - 16\ln 2\right) - \frac{1}{4}\right)$	B1 M1	for $e^{4\ln 2} = 16$ for correct use of limits, must be an integral of the correct form
	$= 4\ln 2 - \frac{15}{16}$	A1	

Question	Answer	Marks	Guidance
6 (i)	$2-\sqrt{5} < \mathrm{f}(x) \leqslant 2$	B2	**B1** for $\leqslant 2$ **B1** for $2-\sqrt{5}<$ or awrt –0.24 Must be using f, f(x) or y, $2-\sqrt{5}<$, if not then **B1** max
(ii)	 $\mathrm{f}^{-1}(x)=(2-x)^2-5$ Domain $2-\sqrt{5}<x\leqslant 2$ Range y or $-5\leqslant \mathrm{f}^{-1}(x)<0$	M1 A1 B1 B1	for a correct method to find the inverse Must be using the correct variables for the B marks
(iii)	$\mathrm{fg}(x)=\mathrm{f}\left(\frac{4}{x}\right)$ $=2-\sqrt{\frac{4}{x}+5}$ leading to $x=-4$	 M1 DM1 A1	 for correct order of functions for solution of equation
7 (i)	Finding an angle of 68.2° or 21.8° $\frac{4.5}{\sin 68.2}=\frac{2.4}{\sin\alpha}$ leading to $\alpha=29.7^\circ$ (allow ± 0.1) Direction is 82.1° to the bank, upstream(allow $\pm 0.1^\circ$)	B1 B1 B1 B1	 for the sine rule
(ii)	$\frac{4.5}{\sin 68.2}=\frac{2.4}{\sin 29.7}=\frac{v_r}{\sin 82.1}$ leading to $v_r=4.8$ time taken = $\frac{80.78}{4.8}=16.8$ Alternative method: Finding an angle of 68.2° or 21.8° $4.5^2=2.4^2+v_r^2-(2\times 2.4\times v_r\cos 68.2)$ leading to $v_r=4.8$ Use of sine rule to obtain angle and direction to obtain direction is 82.1° to the bank, upstream Use of time taken = $\frac{80.78}{4.8}=16.8$	B1 B1 M1 A1 B1 B1 B1 B1 B1 B1 M1 A1	for the sine rule for resultant velocity for attempt to find AB and hence the time taken for correct use of the cosine rule for resultant velocity for use of the sine rule for $\alpha=29.7^\circ$ for 82.1° for attempt to find AB and hence the time taken

Question	Answer	Marks	Guidance
8 (i)	$y-6=-\frac{4}{12}(x+8)$ ($3y+x=10$)	**M1** **A1**	for a correct method allow unsimplified
(ii)	$y-7=3(x+1)$ $(y=3x+10)$	**DM1** **A1**	for attempt at a perpendicular line using $(-1, 7)$ allow unsimplified
(iii)	point of intersection $(-2, 4)$ which is the midpoint of *AB*	**M1** **M1** **A1**	for attempt to find the point of intersection using simultaneous equations for attempt to find midpoint for all correct
	Alternative method: Midpoint $(-2, 4)$ Verification that this point lies on *CP*.	**M1** **M1** **A1**	for attempt to find midpoint for full verification for all correct
(iv)	$CP=\sqrt{10}$ or 3.16	**B1**	
(v)	Area = $\frac{1}{2}\times\sqrt{10}\times4\sqrt{10}$ $=20$	**M1** **A1**	for correct method **using *CP*** for 19.9 – 20.1

Question	Answer	Marks	Guidance
9 (i)	$2\cos x\cot x = \cot x + 2\cos x$		
	$2\cos x\dfrac{\cos x}{\sin x} + 1 = \dfrac{\cos x}{\sin x} + 2\cos x$	M1	for use of $\cot x = \dfrac{\cos x}{\sin x}$ for both terms
	$2\cos^2 x + \sin x = \cos x + 2\cos x\sin x$	DM1	for multiplication throughout by $\sin x$
	$2\cos^2 x - 2\cos x\sin x = \cos x - \sin x$		
	$2\cos x(\cos x - \sin x) = \cos x - \sin x$	DM1	for attempt to factorise
	$(2\cos x - 1)(\cos x - \sin x) = 0$	A1	for completely correct solution www
	Alternative method:		
	$a\cos^2 x - a\cos x\sin x - b\cos x + b\sin x = 0$	M1	for expansion of RHS
	$a\cos x\cot x - a\cos x - b\cot x + b = 0$	DM1	for division by $\sin x$
		DM1	for comparing like terms to obtain both *a* and *b*
	$a = 2,\quad b = 1$	A1	for both correct www
(ii)	$(2\cos x - 1)(\cos x - \sin x) = 0$		
	$\cos x = \dfrac{1}{2}$, $\tan x = 1$	M1	for either
	$x = \dfrac{\pi}{3}$, $x = \dfrac{\pi}{4}$	A1,A1	**A1** for each, penalise extra solutions within the range by withholding the last A mark
	Alternative method:		
	$(2\cos x - 1)(\cot x - 1) = 0$		
	Leading to $\cos x = \dfrac{1}{2}$, $\tan x = 1$	M1	for attempt to factorise the original equation and attempt to solve
	$x = \dfrac{\pi}{3}$, $x = \dfrac{\pi}{4}$	A1,A1	**A1** for each, penalise extra solutions within the range by withholding the last A mark
10 (i)	$f(-2) = -32 - 2k + p = 0$	M1	for attempt at $f(-2)$
	$f'\left(\dfrac{1}{2}\right) = \dfrac{12}{4} + k = 0$	M1	for attempt at $f'\left(\dfrac{1}{2}\right)$
	leading to $k = -3$ and $p = 26$	A1,A1	**A1** for each
(ii)		B1FT	**FT** for *their* $\dfrac{p}{2}$
	$(x+2)(4x^2 - 8x + 13)$	B1	all correct
(iii)	Showing that $4x^2 - 8x + 13 = 0$ has no real roots	M1,	M1 for a valid attempt at solution of equation leading to no solution or consideration of the discriminant
	so $x = -2$ only www	A1	

Question	Answer	Marks	Guidance
11 (i)	$AB = 2r\sin\theta$ or $\sqrt{r^2 + r^2 - 2r^2\cos 2\theta}$ or $\dfrac{r\sin 2\theta}{\sin\left(\frac{\pi}{2} - \theta\right)}$ or $\dfrac{r\sin 2\theta}{\cos\theta}$	B1	
(ii)	$2r\sin\theta + 2r\theta = 20$ $r = \dfrac{10}{\theta + \sin\theta}$	M1 A1	for use of (i) + arc length = 20, oe must be convinced
(iii)	$\dfrac{dr}{d\theta} = -\dfrac{10(1+\cos\theta)}{(\theta + \sin\theta)^2}$ When $\theta = \dfrac{\pi}{6}$, $\dfrac{dr}{d\theta} = -17.8$	M1 A2,1,0 A1	for a correct attempt to differentiate –1 each error allow awrt -17.8
(iv)	$\dfrac{dr}{dt} = 15$ $\dfrac{d\theta}{dt} = \dfrac{dr}{dt} \div \dfrac{dr}{d\theta}$ $\dfrac{d\theta}{dt} = -0.842$	B1 M1 A1	may be implied for use of $\dfrac{15}{\textit{their (iii)}}$ allow -0.84 or -0.843

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the March 2016 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 12, maximum raw mark 80

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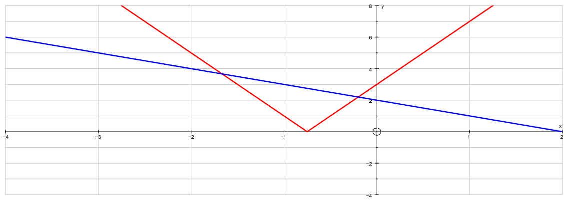
Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

Question	Answer	Marks	Guidance
1	$ax+9=-2x^2+3x+1$ $2x^2+(a-3)x+8=0$	M1	for attempt to equate the line and the curve and obtain a 3 term quadratic equation
	For 2 distinct roots, $(a-3)^2>64$	M1	for use of the discriminant
	Critical values -5 and 11	A1	for critical values
	$a>11,\quad a<-5$	A1	for correct range
2	$a=-\frac{13}{6},\ b=0,\ c=1$	B3	**B1** for each
3	$\log_5\sqrt{x}+\log_{25}x=3$		
	$\frac{1}{2}\log_5 x+\frac{\log_5 x}{\log_5 25}=3$	B1,B1	**B1** for $\frac{1}{2}\log_5 x$ **B1** for $\frac{\log_5 x}{\log_5 25}$
	$\log_5 x=3$		
	$x=125$ cao	B1	for final answer
	Alternative scheme:		
	$\frac{\log_{25}\sqrt{x}}{\log_{25}5}+\log_{25}x=3$	B1	for change of base
	$\frac{\frac{1}{2}\log_{25}x}{\log_{25}5}+\log_{25}x=3$	B1	for $\frac{1}{2}\log_{25}x$ (must be from correct work)
	$\log_{25}x=\frac{3}{2}$		
	$x=125$ cao	B1	for final answer

Question	Answer	Marks	Guidance
4 (i)		B1 B1 B1 B1	for a line in correct position for $(0, 2)$, $(2, 0)$ for correct shape for $y=\lvert 3+2x\rvert$, touching the x-axis for $(-1.5, 0)$, $(0, 3)$
(ii)	$2-x=3+2x$ leading to $x=-\frac{1}{3}$	B1	for $x=-\frac{1}{3}$
	$2-x=-3-2x$ leading to $x=-5$	M1 A1	for correct attempt to deal with 'negative' branch. for $x=-5$
	Alternative: $(2-x)^2=(3+4x)^2$ leading to $15x^2+28x+5=0$ $x=-\frac{1}{3}$, $x=-5$	M1 A1,A1	for equating and squaring to obtain a 3 term quadratic equation **A1** for each.
5 (a) (i)	${}^9P_6=60480$	B1	Must be evaluated
(ii)	${}^4P_2\times{}^3P_2\times 2=144$	M1,A1	**M1** for attempt a product of 3 perms
(iii)	840×2 1680	B1,B1	**B1** for either 840, or realising that there are 2 possible positions for the symbols
(b) (i)	${}^{10}C_6\times{}^5C_3$ 2100	M1 A1	for unsimplified form
(ii)	${}^8C_4\times{}^4C_2$ 420	M1 A1	for unsimplified form
6 (i)	$\mathrm{f}(x)>6$	B1	Allow **B1** for $y>6$
(ii)	$\mathrm{f}^{-1}(x)=\frac{1}{4}\ln(x-6)$	M1 A1	for a complete method must be $\mathrm{f}^{-1}(x)=$ or $y=\ldots$
	Domain: $x>6$ Range: $\mathrm{f}^{-1}(x)\in\mathbb{R}$	B1 B1	must be using the correct variable in both
(iii)	$\mathrm{f}'(x)=4\mathrm{e}^{4x}$	B1	
(iv)	$6+\mathrm{e}^{4x}=4\mathrm{e}^{4x}$ leading to $x=\frac{1}{4}\ln 2$	M1 A1	for a complete, correct method

Question	Answer	Marks	Guidance
7 (i)	$\mathrm{f}\left(\frac{1}{2}\right)=\frac{a}{8}+\frac{7}{4}-\frac{9}{2}+b \quad (=0)$ $a+8b=22$	M1	for attempt at $\mathrm{f}\left(\frac{1}{2}\right)$
	$8a+28-18+b=5(-a+7+9+b)$ $13a-4b=70$	M1	for attempt at $\mathrm{f}(2)=5\mathrm{f}(-1)$ Allow if the 'wrong way' round
		DM1	for attempt to solve simultaneous equations
	leading to $a=6,\ b=2$	A1	**A1** for both
(ii)	$(2x-1)(3x^2+5x-2)$	B2,1,0	–1 each error
(iii)	$(2x-1)(3x-1)(x+2)$	M1 A1FT	for attempt to factorise their quadratic factor must be 3 linear factors
8 (i)	$\lg y=\lg A+b\lg x$ Gradient = 1.2 so $b=1.2$	B1 M1 A1	may be implied by later work for attempt at gradient for $b=1.2$
	Intercept $=1.44$ $A=27.5$	M1 A1	for attempt to find y-intercept for , allow awrt 28
(ii)	when $x=100$, $\lg x=2$ $\lg y=3.84$ (allow 3.8 to 3.9)	M1 A1	for correct use of graph or equation
(iii)	when $y=8000$, $\lg 8000=3.9$, $\lg x=2.05$ leading to $x=113,\ 10^{2.05}$ or 112	M1 A1	for correct use of graph or equation

Question	Answer	Marks	Guidance
9 (i)	$\frac{7}{2}r^2\theta = \frac{1}{2}r^2(2\pi - \theta)$	M1	for a valid method
	$\theta = \frac{\pi}{4}$ oe	A1	allow in degrees
(ii)	$r + r + \frac{\pi}{4}r = 20$, leading to	M1	for valid method
	$r = 7.180(3..)$	A1	Must show enough accuracy to get **A1**
(iii)	Perimeter $= \frac{\pi}{4}r + 2r\tan\frac{\pi}{8}$ $= 5.6394 + 5.9484$	B1,B1	**B1** for arc length, **B1** for twice *AC*
	$= 11.6$	B1	for 11.6
(iv)	Area $= (r \times AC) - \frac{1}{2}r^2\frac{\pi}{4}$ $= 21.356 - 20.246$ or equivalent method using triangles	B1,B1	**B1** for area of quadrilateral, allow unsimplified, **B1** for sector area
	$1.08 \leqslant \text{Area} \leqslant 1.11$	B1	for area in given range
10 (i)	$x \times \frac{3}{2} \times 2(2x-1)^{\frac{1}{2}} + (2x-1)^{\frac{3}{2}}$	B1	for $\frac{3}{2} \times 2(2x-1)^{\frac{1}{2}}$
		M1	for attempt at differentiation of a product
		A1	for all else correct
(ii)	$3\int x(2x-1)^{\frac{1}{2}}\,dx = x(2x-1)^{\frac{3}{2}} - \int(2x-1)^{\frac{3}{2}}\,dx$	M1	for attempt to use part (i)
	$= x(2x-1)^{\frac{3}{2}} - \frac{1}{2} \times \frac{2}{5}(2x-1)^{\frac{5}{2}}$	B1,B1	**B1** for $x(2x-1)^{\frac{3}{2}}$, allow if divided by 3 **B1** for $\frac{1}{2} \times \frac{2}{5}(2x-1)^{\frac{5}{2}}$, allow if divided by 3
	$\int x(2x-1)^{\frac{1}{2}}\,dx = \frac{1}{3}(2x-1)^{\frac{3}{2}}\left(x - \frac{1}{5}(2x-1)\right)$	M1	for taking out a common factor of $(2x-1)^{\frac{3}{2}}$
	$= \frac{(2x-1)^{\frac{3}{2}}}{15}(3x+1)$	DM1 A1	for attempt to obtain a linear factor
(iii)	$\left(\frac{1}{15} \times 4\right) - 0$	M1	for attempt to use limits correctly
		A1FT	**FT** on *their* $\frac{px+q}{15}$

Question	Answer	Marks	Guidance
11 (i)	$\frac{1}{\text{cosec}\theta-1}-\frac{1}{\text{cosec}\theta+1}=\frac{\text{cosec}\theta+1-\text{cosec}\theta+1}{\text{cosec}^2\theta-1}$	M1	for attempt to obtain a single fraction
		A1	all correct as shown
	$=\frac{2}{\cot^2\theta}$	M1	for use of correct identity
	$=2\tan^2\theta$	A1	for 'finishing off'
	Alternative scheme:		
	$\frac{1}{\text{cosec}\theta-1}-\frac{1}{\text{cosec}\theta+1}=\frac{\sin\theta}{1-\sin\theta}-\frac{\sin\theta}{1+\cos\theta}$	M1	for attempt to obtain a single fraction in terms of $\sin\theta$ only
	$=\frac{\left(\sin\theta+\sin^2\theta\right)-\left(\sin\theta-\sin^2\theta\right)}{1-\sin^2\theta}$	A1	all correct as shown
	$=\frac{2\sin^2\theta}{\cos^2\theta}$	M1	for use of correct identity
	$=2\tan^2\theta$	A1	for 'finishing off'
(ii)	$2\tan^2\theta=6+\tan\theta$ $\left(2\tan\theta+3\right)\left(\tan\theta-2\right)=0$	M1	for attempt to use (i), to obtain a quadratic equation and valid attempt to solve
	$\tan\theta=-\frac{3}{2}$, $\tan\theta=2$	DM1	for attempt to solve trig equation
	$\theta=63.4^\circ$, 123.7°, 243.4°, 303.7°	A1,A1	for each 'pair'

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2015 series

0606 ADDITIONAL MATHEMATICS

0606/11 Paper 1, maximum raw mark 80

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Abbreviations

awrt	answers which round to
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dep	dependent
FT	follow through after error
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

1	$kx^2 + (2k-8)x + k = 0$	M1	for attempt to obtain a 3 term quadratic in the form $ax^2 + bx + c = 0$,where b contains a term in k and a constant
	$b^2 - 4ac > 0$ so $(2k-8)^2 - 4k^2 (>0)$	DM1	for use of $b^2 - 4ac$
	$4k^2 - 32k + 64 - 4k^2 (>0)$	DM1	for attempt to simplify and solve for k
	leading to $k < 2$ only	A1	A1 must have correct sign
2	$\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right) = -5x(+c)$	M1	for attempt to integrate, do not penalise omission of arbitrary constant.
	When $x = -1$, $\frac{\mathrm{d}y}{\mathrm{d}x} = 2$ leading to		
	$\frac{\mathrm{d}y}{\mathrm{d}x} = -5x - 3$	A1	Must have $\frac{\mathrm{d}y}{\mathrm{d}x} = ...$
	$y = -\frac{5x^2}{2} - 3x + d$	DM1	for attempt to integrate *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$, but penalise omission of arbitrary constant.
	When $x = -1, y = 3$ leading to		
	$y = \frac{5}{2} - \frac{5x^2}{2} - 3x$	A1	
	Alternative scheme:		
	$y = ax^2 + bx + c$ so $\frac{\mathrm{d}y}{\mathrm{d}x} = 2ax + b$	M1	for use of $y = ax^2 + bx + c$, differentiation and use of conditions to give an equation in a and b
	When $x = -1$, $\frac{\mathrm{d}y}{\mathrm{d}x} = 2$		
	so $-2a + b = 2$	A1	for a correct equation
	$\frac{\mathrm{d}^2 y}{\mathrm{d}x^2} = 2a$	DM1	for a second differentiation to obtain a
	so $a = -\frac{5}{2}$, $b = -3$, $c = \frac{5}{2}$	A1	for a, b and c all correct

3	$\sqrt{(\sec^2\theta - 1)} + \sqrt{(\text{cosec}^2\theta - 1)} = \sec\theta\,\text{cosec}\,\theta$		
	$\text{LHS} = \tan\theta + \cot\theta$	B1	may be implied by the next line
	$= \dfrac{\sin\theta}{\cos\theta} + \dfrac{\cos\theta}{\sin\theta}$	B1	for dealing with $\tan\theta$ and $\cot\theta$ in terms of $\sin\theta$ and $\cos\theta$
	$= \dfrac{\sin^2\theta + \cos^2\theta}{\sin\theta\cos\theta}$	M1	for attempt to obtain as a single fraction
	$= \dfrac{1}{\sin\theta\cos\theta}$	M1	for the use of $\sin^2\theta + \cos^2\theta = 1$ in correct context
	$= \sec\theta\,\text{cosec}\,\theta$	A1	Must be convinced as AG
	Alternate scheme:		
	$\text{LHS} = \tan\theta + \cot\theta$		
	$= \tan\theta + \dfrac{1}{\tan\theta}$	B1	may be implied by subsequent work
	$= \dfrac{\tan^2\theta + 1}{\tan\theta}$	M1	for attempt to obtain as a single fraction
	$= \dfrac{\sec^2\theta}{\tan\theta}$	B1	for use of the correct identity
	$= \dfrac{\sec\theta}{\tan\theta} \times \sec\theta$	M1	for 'splitting' $\sec^2\theta$
	$= \text{cosec}\,\theta\sec\theta$	A1	Must be convinced as AG
4 (a) (i)	28	B1	
(ii)	20160	B1	
(iii)	$6 \times (5 \times 4 \times 3)$ oe to give 360	B1	for realising that the music books can be arranged amongst themselves and consideration of the other 5 books
	$6 \times (5 \times 4 \times 3) \times 2$		
	$= 720$	B1	for the realisation that the above arrangement can be either side of the clock.
(b)	Either $^{10}C_6 - {}^7C_6 = 210 - 7$	B1, B1	B1 for $^{10}C_6$, B1 for $^7C_6$
	$= 203$	B1	
	Or 1W 5M $= 63$	B1	for 1 case correct, must be considering more than 1 different case, allow C notation
	2W 4M $= 105$		
	3W 3M $= 35$	B1	for the other 2 cases, allow C notation
	Total $= 203$	B1	for final result

5 (i)	$\frac{dy}{dx} = (x-3)\frac{4x}{2x^2+1} + \ln(2x^2+1)$	B1 M1	for correct differentiation of ln function for attempt to differentiate a product
	when $x = 2$, $\frac{dy}{dx} = -\frac{8}{9} + \ln 9$ oe	A1	for correct product, terms must be bracketed where appropriate
	or 1.31 or better	A1	for correct final answer
(ii)	$\partial y \approx$ (answer to **(i)**) × 0.03	M1	for attempt to use small changes
	$= 0.0393$, allow awrt 0.039	A1FT	follow through on *their* numerical answer to **(i)** allow to 2 sf or better
6 (i)	$A \cap B = \{3\}$	B1	
(ii)	$A \cup C = \{1, 3, 5, 6, 7, 9, 11, 12\}$	B1	
(iii)	$A' \cap C = \{1, 5, 7, 11\}$	B1	
(iv)	$(D \cup B)' = \{1, 9\}$	B1	
(v)	Any set containing up to 5 positive even numbers $\leqslant 12$	B1	
7 (i)	Gradient $= \frac{0.2}{0.8} = 0.25$	M1	for attempt to find the gradient
	$b = 0.25$	A1	
	Either $6 = 0.25(2.2) + c$ Or $5.8 = 0.25(1.4) + c$	M1	for a correct substitution of values from either point and attempt to obtain c or solution by simultaneous equations
	leading to $A = 233$ or $e^{5.45}$	A1	dealing with $c = \ln A$
	Alternative schemes:		
	Either $6 = b(2.2) + c$, $5.8 = b(1.4) + c$ Or $e^6 = A\left(e^{2.2}\right)^b$, $e^{5.8} = A\left(e^{1.4}\right)^b$	M1	for 2 simultaneous equations as shown
		DM1	for attempt to solve to get at least one solution for one unknown
	Leading to $A = 233$ or $e^{5.45}$ and $b = 0.25$	A1, A1	A1 for each
(ii)	Either $y = 233 \times 5^{0.25}$ Or $\ln y = 0.25 \ln 5 + \ln 233$	M1	for correct use of either equation in attempt to obtain y using *their* value of A and of b found in **(i)**
	leading to $y = 348$	A1	

8	$\frac{dy}{dx}=\frac{2(x^2+5)^{\frac{1}{2}}-\frac{1}{2}(2x)(x^2+5)^{-\frac{1}{2}}(2x-1)}{x^2+5}$ or $\frac{dy}{dx}=2(x^2+5)^{-\frac{1}{2}}-\frac{1}{2}(2x)(x^2+5)^{-\frac{3}{2}}(2x-1)$	B1 M1 A1	for $\frac{1}{2}(2x)\left(x^2+5\right)^{-\frac{1}{2}}$ for a quotient or $-\frac{1}{2}(2x)\left(x^2+5\right)^{-\frac{3}{2}}$ for a product allow if either seen in separate working for attempt to differentiate a quotient or a **correct** product for all correct, allow unsimplified
	When $x=2, y=1$ and $\frac{dy}{dx}=\frac{4}{9}$ (allow 0.444 or 0.44)	B1, B1	B1 for each
	Equation of tangent: $y-1=\frac{4}{9}(x-2)$ $(9y=4x+1)$	M1 A1	for attempt at straight line, must be tangent using *their* gradient and y allow unsimplified.
9 **(i)**	$\frac{2}{3}(4+x)^{\frac{3}{2}}\ (+c)$	B1,B1	B1 for $k(4+x)^{\frac{3}{2}}$ only, B1 for $\frac{2}{3}(4+x)^{\frac{3}{2}}$ only Condone omission of c
(ii)	Area of trapezium $=\left(\frac{1}{2}\times 5\times 5\right)$ $=12.5$	M1 A1	for attempt to find the area of the trapezium
	Area $=\left[\frac{2}{3}(4+x)^{\frac{3}{2}}\right]_0^5-\left(\frac{1}{2}\times 5\times 5\right)$	M1	for correct use of limits using $k(4+x)^{\frac{3}{2}}$ only (must be using 5 and 0)
	$=\left(\frac{2}{3}\times 27\right)-\frac{16}{3}-\frac{25}{2}$	A1	for $18-\frac{16}{3}$ or equivalent
	$=\frac{1}{6}$ or awrt 0.17	A1	
	Alternative scheme:		
	Equation of AB $y=\frac{1}{5}x+2$	M1	for a correct attempt to find the equation of AB
	Area $=\int_0^5 \sqrt{4+x}-\left(\frac{1}{5}x+2\right)dx$	M1	for correct use of limits using $k(4+x)^{\frac{3}{2}}$ only (must be using 5 and 0)
	$=\left[\frac{2}{3}(4+x)^{\frac{3}{2}}-\frac{x^2}{10}-2x\right]_0^5$		
	$=\left(\frac{2}{3}\times 27\right)-\frac{16}{3}-\frac{25}{2}$	A1 A1	for $18-\frac{16}{3}$ or equivalent for 12.5 or equivalent
	$=\frac{1}{6}$ or awrt 0.17	A1	

10 (i)	All sides are equal to the radii of the circles which are also equal	B1	for a convincing argument
(ii)	Angle $CBE = \frac{2\pi}{3}$	B1	must be in terms of π, allow 0.667π, or better
(iii)	$DE = 10\sqrt{3}$	M1 A1	for correct attempt to find *DE* using *their* angle *CBE* for correct *DE*, allow 17.3 or better
	Arc $CE = 10 \times \frac{2\pi}{3}$	M1	for attempt to find arc length with *their* angle *CBE* (20.94)
	Perimeter $= 20 + 10\sqrt{3} + \frac{20\pi}{3}$	M1	for 10 + 10 + *DE* + an arc length
	$= 58.3$ or 58.2	A1	allow unsimplified
(iv)	Area of sector: $\frac{1}{2} \times 10^2 \times \frac{2\pi}{3} = \frac{100\pi}{3}$	M1	for sector area using *their* angle *CBE* allow unsimplified, may be implied
	Area of triangle: $\frac{1}{2} \times 10^2 \times \sin\frac{2\pi}{3} = 25\sqrt{3}$	M1	for triangle area using *their* angle *DBE* which must be the same as *their* angle *CBE*, allow unsimplified, may be implied
	Area $= \frac{100\pi}{3} + 25\sqrt{3}$ or awrt 148	A1	allow in either form

11 (a) (i)	$(x+3)^2 - 5$	B1, B1	B1 for 3, B1 for -5
(ii)	$y \geqslant 4$ or $f \geqslant 4$	B1	Correct notation or statement must be used
(iii)	$y = \sqrt{x+5} - 3$	M1 A1	for a correct attempt to find the inverse function must be in the correct form and positive root only
	Domain $x \geqslant 4$	B1FT	Follow through on *their* answer to **(ii),** must be using x
(b)	$h^2g(x) = h^2(e^x)$ $= h(5e^x + 2)$ $= 25e^x + 12$ $25e^x + 12 = 37$, leading to $x = 0$	M1 M1 DM1 A1	for correct order for dealing with h^2 for solution of equation (dependent on both previous M marks)
	Alternative scheme 1: $hg(x) = h^{-1}(37)$ $h^{-1}(37) = 7$ $5e^x + 2 = 7$, leading to $x = 0$	M1 M1 DM1 A1	for correct order for dealing with $h^{-1}(37)$ for solution of equation (dependent on both previous M marks)
	Alternative scheme 2: $g(x) = h^{-2}(37)$ $h^{-2}(37) = 1$ $e^x = 1$, leading to $x = 0$	M1 M1 DM1 A1	for correct order for dealing with $h^{-2}(37)$ for solution of equation (dependent on both previous M marks)

12	$x^2+6x-16=0$ or $y^2+10y-75=0$ leading to	M1	for attempt to obtain a 3 term quadratic in terms of one variable only
	$(x+8)(x-2)=0$ or $(y-5)(y+15)=0$	DM1	for attempt to solve quadratic equation
	so $x=2, y=5$ and $x=-8, y=-15$	A1, A1	A1 for each 'pair' of values.
	Midpoint $(-3,-5)$	B1	
	Gradient $=2,$ so perpendicular gradient $=-\frac{1}{2}$		
	Perpendicular bisector: $y+5=-\frac{1}{2}(x+3)$	M1	for attempt at straight line equation, must be using midpoint and perpendicular gradient
	$(2y+x+13=0)$	M1	for use of $y=0$ in *their* line equation
	Point C $(-13,0)$		(but not $2x-y+1=0$)
	Area $=\frac{1}{2}\begin{vmatrix}-13 & 2 & -8 & -13\\ 0 & 5 & -15 & 0\end{vmatrix}$	M1	for correct attempt to find area, may be using *their* values for A, B and C (C must lie on the x-axis)
	$=125$	A1	
	Alternative method for area:		
	$CM^2=125,\ AB^2=500$	M1	for correct attempt to find area may be using *their* values for A, B and C
	Area $=\frac{1}{2}\times\sqrt{125}\times\sqrt{500}$		
	$=125$	A1	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2015 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 1, maximum raw mark 80

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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
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

1	$kx^2 + (2k-8)x + k = 0$	M1	for attempt to obtain a 3 term quadratic in the form $ax^2 + bx + c = 0$,where b contains a term in k and a constant
	$b^2 - 4ac > 0$ so $(2k-8)^2 - 4k^2 (> 0)$	DM1	for use of $b^2 - 4ac$
	$4k^2 - 32k + 64 - 4k^2 (> 0)$	DM1	for attempt to simplify and solve for k
	leading to $k < 2$ only	A1	A1 must have correct sign
2	$\left(\frac{dy}{dx}\right) = -5x(+c)$	M1	for attempt to integrate, do not penalise omission of arbitrary constant.
	When $x = -1$, $\frac{dy}{dx} = 2$ leading to		
	$\frac{dy}{dx} = -5x - 3$	A1	Must have $\frac{dy}{dx} = ...$
	$y = -\frac{5x^2}{2} - 3x + d$	DM1	for attempt to integrate *their* $\frac{dy}{dx}$, but
	When $x = -1, y = 3$ leading to		penalise omission of arbitrary constant.
	$y = \frac{5}{2} - \frac{5x^2}{2} - 3x$	A1	
	Alternative scheme:		
	$y = ax^2 + bx + c$ so $\frac{dy}{dx} = 2ax + b$	M1	for use of $y = ax^2 + bx + c$, differentiation and use of conditions to give an equation in a and b
	When $x = -1$, $\frac{dy}{dx} = 2$		
	so $-2a + b = 2$	A1	for a correct equation
	$\frac{d^2y}{dx^2} = 2a$	DM1	for a second differentiation to obtain a
	so $a = -\frac{5}{2}$, $b = -3$, $c = \frac{5}{2}$	A1	for a, b and c all correct

3	$\sqrt{(\sec^2\theta - 1)} + \sqrt{(\text{cosec}^2\theta - 1)} = \sec\theta\,\text{cosec}\,\theta$		
	$\text{LHS} = \tan\theta + \cot\theta$	B1	may be implied by the next line
	$= \frac{\sin\theta}{\cos\theta} + \frac{\cos\theta}{\sin\theta}$	B1	for dealing with $\tan\theta$ and $\cot\theta$ in terms of $\sin\theta$ and $\cos\theta$
	$= \frac{\sin^2\theta + \cos^2\theta}{\sin\theta\cos\theta}$	M1	for attempt to obtain as a single fraction
	$= \frac{1}{\sin\theta\cos\theta}$	M1	for the use of $\sin^2\theta + \cos^2\theta = 1$ in correct context
	$= \sec\theta\,\text{cosec}\,\theta$	A1	Must be convinced as AG
	Alternate scheme:		
	$\text{LHS} = \tan\theta + \cot\theta$		
	$= \tan\theta + \frac{1}{\tan\theta}$	B1	may be implied by subsequent work
	$= \frac{\tan^2\theta + 1}{\tan\theta}$	M1	for attempt to obtain as a single fraction
	$= \frac{\sec^2\theta}{\tan\theta}$	B1	for use of the correct identity
	$= \frac{\sec\theta}{\tan\theta} \times \sec\theta$	M1	for 'splitting' $\sec^2\theta$
	$= \text{cosec}\,\theta\sec\theta$	A1	Must be convinced as AG
4 (a) (i)	28	B1	
(ii)	20160	B1	
(iii)	$6 \times (5 \times 4 \times 3)$ oe to give 360	B1	for realising that the music books can be arranged amongst themselves and consideration of the other 5 books
	$6 \times (5 \times 4 \times 3) \times 2$ $= 720$	B1	for the realisation that the above arrangement can be either side of the clock.
(b)	Either $^{10}C_6 - {}^{7}C_6 = 210 - 7$	B1, B1	B1 for $^{10}C_6$, B1 for $^{7}C_6$
	$= 203$	B1	
	Or 1W 5M $= 63$ 2W 4M $= 105$	B1	for 1 case correct, must be considering more than 1 different case, allow C notation
	3W 3M $= 35$	B1	for the other 2 cases, allow C notation
	Total $= 203$	B1	for final result

5 **(i)**	$\frac{dy}{dx} = (x-3)\frac{4x}{2x^2+1} + \ln(2x^2+1)$	B1 M1	for correct differentiation of ln function for attempt to differentiate a product
	when $x = 2$, $\frac{dy}{dx} = -\frac{8}{9} + \ln 9$ oe	A1	for correct product, terms must be bracketed where appropriate
	or 1.31 or better	A1	for correct final answer
(ii)	$\partial y \approx$ (answer to **(i)**) × 0.03 $= 0.0393$, allow awrt 0.039	M1 A1FT	for attempt to use small changes follow through on *their* numerical answer to **(i)** allow to 2 sf or better
6 **(i)**	$A \cap B = \{3\}$	B1	
(ii)	$A \cup C = \{1, 3, 5, 6, 7, 9, 11, 12\}$	B1	
(iii)	$A' \cap C = \{1, 5, 7, 11\}$	B1	
(iv)	$(D \cup B)' = \{1, 9\}$	B1	
(v)	Any set containing up to 5 positive even numbers $\leqslant 12$	B1	
7 **(i)**	Gradient $= \frac{0.2}{0.8} = 0.25$	M1	for attempt to find the gradient
	$b = 0.25$	A1	
	Either $6 = 0.25(2.2) + c$ Or $5.8 = 0.25(1.4) + c$	M1	for a correct substitution of values from either point and attempt to obtain c or solution by simultaneous equations
	leading to $A = 233$ or $e^{5.45}$	A1	dealing with $c = \ln A$
	Alternative schemes:		
	Either $6 = b(2.2) + c$, $5.8 = b(1.4) + c$ Or $e^6 = A\left(e^{2.2}\right)^b$, $e^{5.8} = A\left(e^{1.4}\right)^b$	M1	for 2 simultaneous equations as shown
		DM1	for attempt to solve to get at least one solution for one unknown
	Leading to $A = 233$ or $e^{5.45}$ and $b = 0.25$	A1, A1	A1 for each
(ii)	Either $y = 233 \times 5^{0.25}$ Or $\ln y = 0.25 \ln 5 + \ln 233$	M1	for correct use of either equation in attempt to obtain y using *their* value of A and of b found in **(i)**
	leading to $y = 348$	A1	

8	$\frac{dy}{dx}=\frac{2(x^2+5)^{\frac{1}{2}}-\frac{1}{2}(2x)(x^2+5)^{-\frac{1}{2}}(2x-1)}{x^2+5}$ or $\frac{dy}{dx}=2(x^2+5)^{-\frac{1}{2}}-\frac{1}{2}(2x)(x^2+5)^{-\frac{3}{2}}(2x-1)$	B1 M1 A1	for $\frac{1}{2}(2x)(x^2+5)^{-\frac{1}{2}}$ for a quotient or $-\frac{1}{2}(2x)(x^2+5)^{-\frac{3}{2}}$ for a product allow if either seen in separate working for attempt to differentiate a quotient or a **correct** product for all correct, allow unsimplified
	When $x=2, y=1$ and $\frac{dy}{dx}=\frac{4}{9}$ (allow 0.444 or 0.44)	B1, B1	B1 for each
	Equation of tangent: $y-1=\frac{4}{9}(x-2)$ $(9y=4x+1)$	M1 A1	for attempt at straight line, must be tangent using *their* gradient and y allow unsimplified.
9 **(i)**	$\frac{2}{3}(4+x)^{\frac{3}{2}}\ (+c)$	B1,B1	B1 for $k(4+x)^{\frac{3}{2}}$ only, B1 for $\frac{2}{3}(4+x)^{\frac{3}{2}}$ only Condone omission of c
(ii)	Area of trapezium $=\left(\frac{1}{2}\times5\times5\right)$ $=12.5$	M1 A1	for attempt to find the area of the trapezium
	Area $=\left[\frac{2}{3}(4+x)^{\frac{3}{2}}\right]_0^5-\left(\frac{1}{2}\times5\times5\right)$ $=\left(\frac{2}{3}\times27\right)-\frac{16}{3}-\frac{25}{2}$ $=\frac{1}{6}$ or awrt 0.17	M1 A1 A1	for correct use of limits using $k(4+x)^{\frac{3}{2}}$ only (must be using 5 and 0) for $18-\frac{16}{3}$ or equivalent
	Alternative scheme: Equation of AB $y=\frac{1}{5}x+2$	M1	for a correct attempt to find the equation of AB
	Area $=\int_0^5\sqrt{4+x}-\left(\frac{1}{5}x+2\right)dx$ $=\left[\frac{2}{3}(4+x)^{\frac{3}{2}}-\frac{x^2}{10}-2x\right]_0^5$	M1	for correct use of limits using $k(4+x)^{\frac{3}{2}}$ only (must be using 5 and 0)
	$=\left(\frac{2}{3}\times27\right)-\frac{16}{3}-\frac{25}{2}$ $=\frac{1}{6}$ or awrt 0.17	A1 A1 A1	for $18-\frac{16}{3}$ or equivalent for 12.5 or equivalent

10 (i)	All sides are equal to the radii of the circles which are also equal	B1	for a convincing argument
(ii)	Angle $CBE = \frac{2\pi}{3}$	B1	must be in terms of π, allow 0.667π, or better
(iii)	$DE = 10\sqrt{3}$	M1 A1	for correct attempt to find *DE* using *their* angle *CBE* for correct *DE*, allow 17.3 or better
	Arc $CE = 10 \times \frac{2\pi}{3}$	M1	for attempt to find arc length with *their* angle *CBE* (20.94)
	Perimeter $= 20 + 10\sqrt{3} + \frac{20\pi}{3}$	M1	for 10 + 10 + *DE* + an arc length
	$= 58.3$ or 58.2	A1	allow unsimplified
(iv)	Area of sector: $\frac{1}{2} \times 10^2 \times \frac{2\pi}{3} = \frac{100\pi}{3}$	M1	for sector area using *their* angle *CBE* allow unsimplified, may be implied
	Area of triangle: $\frac{1}{2} \times 10^2 \times \sin\frac{2\pi}{3} = 25\sqrt{3}$	M1	for triangle area using *their* angle *DBE* which must be the same as *their* angle *CBE*, allow unsimplified, may be implied
	Area $= \frac{100\pi}{3} + 25\sqrt{3}$ or awrt 148	A1	allow in either form

11 **(a)** **(i)**	$(x+3)^2-5$	B1, B1	B1 for 3, B1 for -5
(ii)	$y \geqslant 4$ or $f \geqslant 4$	B1	Correct notation or statement must be used
(iii)	$y=\sqrt{x+5}-3$	M1	for a correct attempt to find the inverse function
		A1	must be in the correct form and positive root only
	Domain $x \geqslant 4$	B1FT	Follow through on *their* answer to **(ii),** must be using x
(b)	$h^2g(x)=h^2(e^x)$	M1	for correct order
	$=h(5e^x+2)$	M1	for dealing with h^2
	$=25e^x+12$		
	$25e^x+12=37,$	DM1	for solution of equation (dependent on both previous M marks)
	leading to $x=0$	A1	
	Alternative scheme 1:		
	$hg(x)=h^{-1}(37)$	M1	for correct order
	$h^{-1}(37)=7$	M1	for dealing with $h^{-1}(37)$
	$5e^x+2=7,$	DM1	for solution of equation (dependent on both previous M marks)
	leading to $x=0$	A1	
	Alternative scheme 2:		
	$g(x)=h^{-2}(37)$	M1	for correct order
	$h^{-2}(37)=1$	M1	for dealing with $h^{-2}(37)$
	$e^x=1,$	DM1	for solution of equation (dependent on both previous M marks)
	leading to $x=0$	A1	

12	$x^2+6x-16=0$ or $y^2+10y-75=0$ leading to	M1	for attempt to obtain a 3 term quadratic in terms of one variable only
	$(x+8)(x-2)=0$ or $(y-5)(y+15)=0$	DM1	for attempt to solve quadratic equation
	so $x=2, y=5$ and $x=-8, y=-15$	A1, A1	A1 for each 'pair' of values.
	Midpoint $(-3,-5)$	B1	
	Gradient $=2,$ so perpendicular gradient $=-\frac{1}{2}$ Perpendicular bisector: $y+5=-\frac{1}{2}(x+3)$ $(2y+x+13=0)$	M1	for attempt at straight line equation, must be using midpoint and perpendicular gradient
	Point C $(-13, 0)$	M1	for use of $y=0$ in *their* line equation (but not $2x-y+1=0$)
	Area $=\frac{1}{2}\begin{vmatrix}-13 & 2 & -8 & -13\\ 0 & 5 & -15 & 0\end{vmatrix}$	M1	for correct attempt to find area, may be using *their* values for A, B and C (C must lie on the x-axis)
	$=125$	A1	
	Alternative method for area: $CM^2=125,\ AB^2=500$ Area $=\frac{1}{2}\times\sqrt{125}\times\sqrt{500}$	M1	for correct attempt to find area may be using *their* values for A, B and C
	$=125$	A1	

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MARK SCHEME for the October/November 2015 series

0606 ADDITIONAL MATHEMATICS

0606/13 Paper 1, maximum raw mark 80

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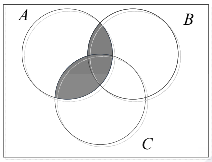
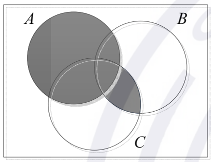
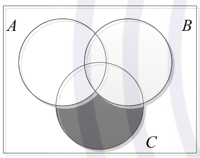
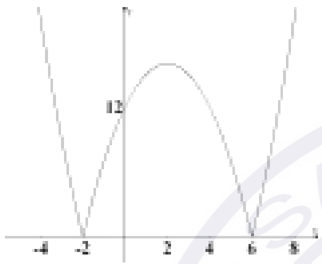
www	without wrong working

1 (i)		B1	
(ii)		B1	
(iii)		B1	
2	$\cos\left(3x-\frac{\pi}{4}\right)=(\pm)\frac{1}{\sqrt{2}}$ oe	M1	division by 2 and square root
	$3x-\frac{\pi}{4}=-\frac{\pi}{4},\ \frac{\pi}{4},\ \frac{3\pi}{4}$		
	$x=\left(-\frac{\pi}{4}+\frac{\pi}{4}\right)\div 3,\ \left(\frac{\pi}{4}+\frac{\pi}{4}\right)\div 3,\ \left(\frac{3\pi}{4}+\frac{\pi}{4}\right)\div 3$ oe	DM1	correct order of operations in order to obtain a solution
	$x=0$ and $\frac{\pi}{6}$ (or 0 and 0.524)	A2/1/0	A2 for 3 solutions and no extras in the range A1 for 2 solutions
	$x=\frac{\pi}{3}$ (or 1.05)		A0 for one solution or no solutions

3	**(a)**	$\begin{pmatrix} 12 & 16 & 4 \\ 30 & 32 & 10 \end{pmatrix}$	B2,1,0	B2 for 6 elements correct, B1for 5 elements correct
	(b)	$\begin{pmatrix} 28 & -24 \\ -8 & 76 \end{pmatrix} = m\begin{pmatrix} 4 & 6 \\ 2 & -8 \end{pmatrix} + n\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$	B2,1,0	B2 for 4 correct elements in $\mathbf{X}^2$ B1 for 3 correct elements in $\mathbf{X}^2$
		$-24 = 6m$ or $-8 = 2m$ giving $m = -4$	B1	For $m = -4$ using correct **I**
		$28 = 4m + n$ or $76 = -8m + n$ $n = 44$	M1 A1	complete method to obtain n
	(c)	$a^2 - 6 = 0$ so $a = \pm\sqrt{6}$	B2,1,0	B2 for $a = \pm\sqrt{6}$ or $a = \pm 2.45$, with no incorrect statements seen or B1 for $a = \pm\sqrt{6}$ or $a = \pm 2.45$ seen or B1 for $a = \sqrt{6}$ and no incorrect working
4	**(i)**	$\frac{1}{2}\left(4\sqrt{3}+1\right) \times BC = \frac{47}{2}$	B1	correct use of the area
		$BC = \frac{47}{\left(4\sqrt{3}+1\right)} \times \frac{\left(4\sqrt{3}-1\right)}{\left(4\sqrt{3}-1\right)}$	M1	correct rationalisation
		$BC = 4\sqrt{3} - 1$	A1	Dependent on all method being seen
		Alternative method		
		$\frac{1}{2}\left(4\sqrt{3}+1\right) \times BC = \frac{47}{2}$ $\left(4\sqrt{3}+1\right)\left(a\sqrt{3}+b\right) = 47$	B1	
		Leading to $12a + b = 47$ and $a + 4b = 0$ Solution of simultaneous equations	M1	
		$BC = 4\sqrt{3-1}$	A1	Dependent on all method seen including solution of simultaneous equations
	(ii)	$\left(4\sqrt{3}+1\right)^2 + \left(4\sqrt{3}-1\right)^2$		
		$= \left(48 + 8\sqrt{3} + 1\right) + \left(48 - 8\sqrt{3} + 1\right)$	B1FT	6 correct FT terms seen
		$AC^2 = 98$ $AC = 7\sqrt{2}$ **or** $p = 7$	B1cao	98 and $7\sqrt{2}$ or 98 and $p = 7$

5	When $x=\frac{\pi}{4}$, $y=2$	B1	$y=2$
	$\frac{dy}{dx}=5\sec^2 x$	B1	$5\sec^2 x$
	When $x=\frac{\pi}{4}$, $\frac{dy}{dx}=10$	B1	10 from differentiation
	Equation of normal $y-2=-\frac{1}{10}\left(x-\frac{\pi}{4}\right)$	M1	$y - their2 = -\frac{1}{their10}\left(x-\frac{\pi}{4}\right)$
	$10y+x-20-\frac{\pi}{4}=0$ or $10y+x-20.8=0$ oe	A1	allow unsimplified
6 (i)		B1 B1 B1	shape intercepts on x-axis intercept on y-axis for a curve with a maximum and two arms
(ii)	$(2, 16)$	M1 A1	(2, ±16) seen or $(2, k)$ where $k>0$ (2, 16) or $x = 2$ **and** $y = 16$ only
(iii)	$k=0$	B1	
	$k>16$	B1	

7	$\frac{dy}{dx} = 2\sin 3x \quad (+c)$	B1	$2\sin 3x$
	$4\sqrt{3} = 2\frac{\sqrt{3}}{2} + c$	M1	finding constant using $\frac{dy}{dx} = k\sin 3x + c$ making use of $\frac{dy}{dx} = 4\sqrt{3}$ and $x = \frac{\pi}{9}$
	$\frac{dy}{dx} = 2\sin 3x + 3\sqrt{3}$	A1	Allow with $c = 5.20$ or $\sqrt{27}$
	$y = -\frac{2}{3}\cos 3x + 3\sqrt{3}x \quad (+d)$	B1FT	FT integration of *their* $k\sin 3x$
	$-\frac{1}{3} = -\frac{2}{3}\cos\frac{\pi}{3} + 3\sqrt{3}\left(\frac{\pi}{9}\right) + d$	M1	finding constant d for $k\cos 3x + cx + d$
	$y = -\frac{2}{3}\cos 3x + 3\sqrt{3}x - \frac{\sqrt{3}}{3}\pi$	A1	Allow $y = -0.667\cos 3x + 5.20x - 0.577\pi$ or better
8 **(a)**	$(2+kx)^8 = 256 + 1024kx + 1792k^2x^2 + 1792k^3x^3$		
	$k = \frac{1}{4}$	B1	
	$p = 112$	B1FT	FT 1792 multiplied by *their* k^2
	$q = 28$	B1FT	FT 1792 multiplied by *their* k^3
(b)	${}^9C_3 x^6\left(-\frac{2}{x^2}\right)^3$	M1	correct term seen
	$84x^6\left(-\frac{8}{x^6}\right)$ leading to	DM1	Term selected and 2^3 and ${}^9C_3$ correctly evaluated
	-672	A1	

9 (a) (i)	Number of arrangements with Maths books as one item = 4! or 4 × 3!	M1	$4!(\times 2)$ or $4\times 3!(\times 2)$ oe
	or Maths books can be arranged 2! ways and History 3! ways = 2! × 3!		$2!\times 3!(\times 4)$ or $2\times 3!(\times 4)$ oe
	2 × 4! or 2 × 4 × 3! or 4 × 2 × 3! = 48	A1	A1 for 48
(ii)	$5! - 48$ or $6\times 2\times 3!$	M1	5! – *their* answer to (i) or for $6\times 2\times 3$
	72	A1	
(b) (i)	3003	B1	
(ii)	$3003-6-135$	M1 B1	*their* answer to (i) $- 6 - {}^6C_4\times 9$ 135 subtracted
	2862	A1	
	or 2M 3W = 720 3M 2W = 1260 4M 1W = 756 5M = 126 2862	M1 B1 A1	complete correct method using 4 cases, may be implied by working. Must have at least one correct any 3 correct

10 (i)	$10^2 = 6^2 + 6^2 - 2 \times 6 \times 6 \times \cos ABC$ or $\sin\left(\frac{ABC}{2}\right) = \frac{5}{6}$ or $ABC = \pi - \sin^{-1}\frac{10\sqrt{11}}{36}$	M1	correct cosine rule statement or correct statement for $\sin\frac{ABC}{2}$ or equating areas oe
	$ABC = 1.9702$	A1	1.9702 or better
(ii)	$XY = 2$	B1	for *XY* (may be implied by later work, allow on diagram)
	Arc length $6\left(\frac{\pi - 1.970}{2}\right)$ oe	B1	correct arc length (unsimplified)
	Perimeter = $2 + 2\left(6\left(\frac{\pi - 1.970}{2}\right)\right)$	M1	*their* 2 + 2 × 6 × *their* angle *C*
	$= 9.03$	A1	
(iii)	$\left(\frac{1}{2} \times 6^2\left(\frac{\pi - 1.970}{2}\right) - \frac{1}{2} \times 5 \times \sqrt{11}\right) \times 2$	M1 M1	sector area using *their C* area of Δ *ABM* where *M* is the midpoint of *AC*, or (Δs *ABY* and *BXY*) or Δ*ABC*
	= 4.50 or 4.51 or better	A1	Answers to 3sf or better

11	$x^2 - 2x - 3 = 0$ or $y^2 - 6y + 5 = 0$	M1	substitution and simplification to obtain a three term quadratic equation in one variable
	leading to (3, 5) and (–1, 1)	A1,A1	A1 for each 'pair' from a correct quadratic equation, correctly obtained.
	Midpoint (1, 3)	B1cao	midpoint
	(Gradient – 1) Perpendicular bisector $y = 4 - x$	M1	perpendicular bisector, must be using *their* perpendicular gradient and *their* midpoint
	Meets the curve again if $x^2 + 10x - 15 = 0$ or $y^2 - 18y + 41 = 0$	M1	substitution and simplification to obtain a three term quadratic equation in one variable.
	leading to $x = -5 \pm 2\sqrt{10}$, $y = 9 \mp 2\sqrt{10}$	A1,A1	A1 for each 'pair'
	$CD^2 = \left(4\sqrt{10}\right)^2 + \left(4\sqrt{10}\right)^2$	M1	Pythagoras using *their* coordinates from solution of second quadratic. $\left(x_1 - x_2\right)^2 + \left(y_1 - y_2\right)^2$ must be seen if not using correct coordinates.
	$CD = 8\sqrt{5}$	A1	A1 for $8\sqrt{5}$ from $\sqrt{320}$ and all correct so far.

12	**(a)**	$2^{2x-1} \times 2^{2(x+y)} = 2^7$ and $\frac{3^{2(2y-x)}}{3^{3(y-4)}} = 1$	M1	expressing 4^{x+y}, 128 as powers of 2 and 9^{2y-x}, 27^{y-4} as powers of 3
		$2x - 1 + 2(x+y) = 7$ oe	A1	Correct equation from correct working
		$2(2y - x) = 3(y-4)$ oe	A1	Correct equation from correct working
		leading to $x = 4$, $y = -4$	A1	for both
		<u>Example of Alternative method</u>		
		Method mark as above	M1	As before
		$2x - 1 + 2(x+y) = 7$	A1	One of the correct equations in x and y
		leading to $y = \frac{(8-4x)}{2}$		
		Correctly substituted in $\frac{3^{2(2y-x)}}{3^{3(y-4)}} = 1$		
		Leading to $2\left(\frac{2(8-4x)}{2} - x\right) = 3\left(\frac{(8-4x)}{2} - 4\right)$	A1	Correct, unsimplified, equation in x or y only
		Leading to $x = 4$ and $y = -4$	A1	Both answers
	(b)	$(2(5^z) - 1)(5^z + 1) = 0$	M1	solution of quadratic
		leading to $2.5^z = 1$ $\quad (5^z = -1)$	A1	correct solution
		$5^z = 0.5$	DM1	correct attempt to solve $2.5^z = k$, where k is positive
		$z = \frac{\log 0.5}{\log 5}$ or $z = -0.431$ or better	A1	must have one solution only

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the May/June 2015 series

0606 ADDITIONAL MATHEMATICS

0606/11 Paper 1, maximum raw mark 80

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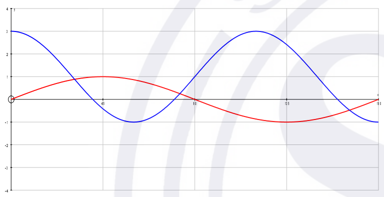
Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

1 (i)	180° or π radians or 3.14 radians (or better)	**B1**	
(ii)	2	**B1**	
(iii) (a)		**B1**	$y = \sin 2x$ all correct
(b)		**B1**	for either ↑↓↑starting at their highest value and ending at their lowest value Or a curve with highest value at $y = 3$ and lowest value at $y = -1$
		B1	completely correct graph
(iv)	3	**B1**	
2 (i)	$\tan\theta = \frac{(8+5\sqrt{2})(4-3\sqrt{2})}{(4+3\sqrt{2})(4-3\sqrt{2})}$ $= \frac{32-24\sqrt{2}+20\sqrt{2}-30}{16-18}$	**M1**	attempt to obtain $\tan\theta$ and rationalise. Must be convinced that no calculators are being used
	$= 1 + 2\sqrt{2}$ cao	**A1**	

(ii)	$\sec^2\theta = 1+\tan^2\theta$ $= 1+\left(-1+2\sqrt{2}\right)^2$ $= 1+1-4\sqrt{2}+8$ $= 10-4\sqrt{2}$	 **M1** **DM1** **A1**	attempt to use $\sec^2\theta = 1+\tan^2\theta$, with *their* answer to **(i)** attempt to simplify, must be convinced no calculators are being used. Need to expand $\left(-1+2\sqrt{2}\right)^2$ as 3 terms
	Alternative solution: $AC^2 = \left(4+3\sqrt{2}\right)^2 + \left(8+5\sqrt{2}\right)^2$ $= 148+104\sqrt{2}$ $\sec^2\theta = \frac{148+104\sqrt{2}}{\left(4+3\sqrt{2}\right)^2}$ $= \frac{148+104\sqrt{2}}{\left(4+3\sqrt{2}\right)^2} \times \frac{34-24\sqrt{2}}{34-24\sqrt{2}}$ $= 10-4\sqrt{2}$	 **M1** **DM1** **A1**	
3 (i)	$64+192x^2+240x^4+160x^6$	**B3,2,1,0**	–1 each error
(ii)	$\left(64+192x^2+240x^4\right)\left(1-\frac{6}{x^2}+\frac{9}{x^4}\right)$	**B1**	expansion of $\left(1-\frac{3}{x^2}\right)^2$
	Terms needed $64-(192\times 6)+(240\times 9)$ $= 1072$	**M1** **A1**	attempt to obtain 2 or 3 terms using *their* **(i)**

4 **(a)**	$\mathbf{X}^2=\begin{pmatrix}4-4k & -8\\ 2k & -4k\end{pmatrix}$	**B2,1,0**	–1 each incorrect element
(b)	Use of $\mathbf{AA}^{-1}=\mathbf{I}$ $\begin{pmatrix}a & 1\\ b & 5\end{pmatrix}\begin{pmatrix}\frac{5}{6} & -\frac{1}{6}\\ -\frac{2}{3} & \frac{1}{3}\end{pmatrix}=\begin{pmatrix}1 & 0\\ 0 & 1\end{pmatrix}$	**M1**	use of $\mathbf{AA}^{-1}=\mathbf{I}$ and an attempt to obtain at least one equation.
	Any 2 equations will give $a=2$, $b=4$	**A1,A1**	
	Alternative method 1: $\frac{1}{5a-b}\begin{pmatrix}5 & -1\\ b & a\end{pmatrix}=\begin{pmatrix}\frac{5}{6} & -\frac{1}{6}\\ -\frac{2}{3} & \frac{1}{3}\end{pmatrix}$	**M1**	correct attempt to obtain $\mathbf{A}^{-1}$ and comparison of at least one term.
	Compare any 2 terms to give $a=2$, $b=4$	**A1,A1**	
	Alternative method 2: Inverse of $\frac{1}{6}\begin{pmatrix}5 & -1\\ -4 & 2\end{pmatrix}=\begin{pmatrix}2 & 1\\ 4 & 5\end{pmatrix}$	**M1** **A1,A1**	reasoning and attempt at inverse
5	$3x-1=x(3x-1)+x^2-4$ or $y=\left(\frac{y+1}{3}\right)y+\left(\frac{y+1}{3}\right)^2-4$		
	$4x^2-4x-3=0$ or $4y^2-4y-35=0$	**M1**	equate and attempt to obtain an equation in 1 variable
	$(2x-3)(2x+1)=0$ or $(2y-7)(2y+5)=0$	**DM1**	forming a 3 term quadratic equation and attempt to solve
	leading to $x=\frac{3}{2}, x=-\frac{1}{2}$ and	**A1**	x values
	$y=\frac{7}{2}, y=-\frac{5}{2}$	**A1**	y values
	Midpoint $\left(\frac{1}{2},\frac{1}{2}\right)$	**B1**	for midpoint, allow anywhere
	Perpendicular gradient $=-\frac{1}{3}$	**M1**	correct attempt to obtain the gradient of the perpendicular, using AB
	Perp bisector: $y-\frac{1}{2}=-\frac{1}{3}\left(x-\frac{1}{2}\right)$	**M1**	straight line equation through the midpoint; must be convinced it is a perpendicular gradient.
	$(3y+x-2=0)$	**A1**	allow unsimplified

6 (i)	$f\left(\frac{1}{2}\right)=\frac{a}{8}-\frac{15}{4}+\frac{b}{2}-2=0$ leading to $a+4b=46$ $f(1)=a-15+b-2=5$ leading to $a+b=22$	**M1** **A1**	correct use of either $f\left(\frac{1}{2}\right)$ or f(1) paired correctly both equations correct (allow unsimplified)
	giving $b=8$ (AG), $a=14$	**M1,A1**	M1 for solution of equations A1 for both *a* and *b*. **AG** for *b*.
(ii)	$(2x-1)(7x^2-4x+2)$	**M1,A1**	M1 for valid attempt to obtain g(*x*), by either observation or by algebraic long division.
(iii)	$7x^2-4x+2=0$ has no real solutions as $b^2<4ac$ $16<56$	**M1** **A1**	use of b^2-4ac correct conclusion; must be from a correct g(*x*) or 2g(*x*) www
7 (i)	$\frac{dy}{dx}=\frac{(x-1)\frac{8x}{(4x^2+2)}-\ln(4x^2+3)}{(x-1)^2}$	**M1** **B1** **A1**	differentiation of a quotient (or product) correct differentiation of $\ln(4x^2+3)$ all else correct
	When $x=0$, $y=-\ln 3$ oe	**B1**	for *y* value
	$\frac{dy}{dx}=-\ln 3$ so gradient of normal is $\frac{1}{\ln 3}$ (allow numerical equivalent)	**M1**	valid attempt to obtain gradient of the normal
	normal equation $y+\ln 3=\frac{1}{\ln 3}x$ or $y=0.910x-1.10$, or $y=\frac{10}{11}x-\frac{11}{10}$ cao (Allow $y=0.91x-1.1$)	**M1** **A1**	attempt at normal equation must be using a perpendicular
(ii)	when $x=0$, $y=-\ln 3$ when $y=0$, $x=(\ln 3)^2$ Area = ±0.66 or ±0.67 or awrt these or $\frac{1}{2}(\ln 3)^3$	**M1** **A1**	valid attempt at area

8 (i)	Range for f: $y \geq 3$ Range for g: $y \geq 9$	**B1** **B1**	
(ii)	$x = -2 + \sqrt{y-5}$	**M1**	attempt to obtain the inverse function
	$g^{-1}(x) = -2 + \sqrt{x-5}$ Domain of g^{-1}: $x \geq 9$	**A1** **B1**	Must be correct form for domain
	Alternative method: $y^2 + 4y + 9 - x = 0$	**M1**	attempt to use quadratic formula and find inverse
	$y = \frac{-4 + \sqrt{16 - 4(9-x)}}{2}$	**A1**	must have + not ±
(iii)	Need $g\left(3e^{2x}\right)$	**M1**	correct order
	$\left(3e^{2x} + 2\right)^2 + 5 = 41$ or $9e^{4x} + 12e^{2x} - 32 = 0$ $\left(3e^{2x} - 4\right)\left(3e^{2x} + 8\right) = 0$	**DM1**	correct attempt to solve the equation
	leading to $3e^{2x} + 2 = \pm 6$ so $x = \frac{1}{2}\ln\frac{4}{3}$	**M1**	dealing with the exponential correctly in order to reach a solution for x
	or $e^{2x} = \frac{4}{3}$ so $x = \frac{1}{2}\ln\frac{4}{3}$	**A1**	Allow equivalent logarithmic forms
	Alternative method: Using $f(x) = g^{-1}(41)$, $g^{-1}(41) = 4$	**M1**	correct use of g^{-1}
	leading to $3e^{2x} = 4$, so $x = \frac{1}{2}\ln\frac{4}{3}$	**DM1**	dealing with $g^{-1}(41)$ to obtain an equation in terms of e^{2x}
		M1 **A1**	dealing with the exponential correctly in order to reach a solution for x Allow equivalent logarithmic forms
(iv)	$g'(x) = 6e^{2x}$ $g'(\ln 4) = 96$	**B1** **B1**	B1 for each

9 **(i)**	$\frac{dy}{dx} = 3x^2 - 10x + 3$	**M1**	for differentiation
	When $x = 0$, for curve $\frac{dy}{dx} = 3$, gradient of line also 3 so line is a tangent.	**A1**	comparing both gradients
	Alternate method: $3x + 10 = x^3 - 5x^2 + 3x + 10$	**M1**	attempt to deal with simultaneous equations
	leading to $x^2 = 0$, so tangent at $x = 0$	**A1**	obtaining $x = 0$
(ii)	When $\frac{dy}{dx} = 0$, $(3x-1)(x-3) = 0$	**M1**	equating gradient to zero and valid attempt to solve
	$x = \frac{1}{3}$, $x = 3$	**A1,A1**	A1 for each
(iii)	Area = $\frac{1}{2}(10+19)3 - \int_0^3 x^3 - 5x^2 + 3x + 10\,dx$	**B1**	area of the trapezium
	$= \frac{87}{2} - \left[\frac{x^4}{4} - \frac{5x^3}{3} + \frac{3x^2}{2} + 10x\right]_0^3$	**M1**	attempt to obtain the area enclosed by the curve and the coordinate axes, by integration
	$= \frac{87}{2} - \left(\frac{81}{4} - 45 + \frac{27}{2} + 30\right)$	**A1** **DM1**	integration all correct correct application of limits (must be using *their* 3 from **(ii)** and 0)
	$= 24.7$ or 24.8	**A1**	
	Alternative method: Area $= \int_0^3 (3x+10) - \left(x^3 - 5x^2 + 3x + 10\right)dx$	**B1**	correct use of '*Y–y*'
	$= \int_0^3 -x^3 + 5x^2\,dx$	**M1** **A1**	attempt to integrate integration all correct
	$= \left[-\frac{x^4}{4} + \frac{5x^3}{3}\right]_0^3 = \frac{99}{4}$	**DM1** **A1**	correct application of limits
10 **(a)**	$\sin^2 x = \frac{1}{4}$		
	$\sin x = (\pm)\frac{1}{2}$	**M1**	using $\text{cosec}x = \frac{1}{\sin x}$ and obtaining $\sin x = \ldots$
	$x = 30°, 150°, 210°, 330°$	**A1,A1**	A1 for one correct pair, A1 for another correct pair with no extra solutions

(b)	$\left(\sec^2 3y - 1\right) - 2\sec 3y - 2 = 0$	**M1**	use of the correct identity
	$\sec^2 3y - 2\sec 3y - 3 = 0$ $(\sec 3y + 1)(\sec 3y - 3) = 0$	**M1**	attempt to obtain a 3 term quadratic equation in sec 3*y* and attempt to solve
	leading to $\cos 3y = -1$, $\cos 3y = \frac{1}{3}$	**M1**	dealing with sec and 3*y* correctly
	$3y = 180°, 540°\quad 3y = 70.5°, 289.5°, 430.5°$ $y = 60°, 180°, 23.5°, 96.5°, 143.5°$	**A1,A1** **A1**	A1 for a correct pair, A1 for a second correct pair, A1 for correct 5th solution and no other within the range
	Alternative 1: $\sec^2 3y - 2\sec 3y - 3 = 0$	**M1**	use of the correct identity
	leading to $3\cos^2 3y + 2\cos 3y - 1$	**M1**	attempt to obtain a quadratic equation in cos 3*y* and attempt to solve
	$(3\cos y - 1)(\cos y + 1) = 0$	**M1**	dealing with 3*y* correctly **A** marks as above
	Alternative 2: $\frac{\sin^2 y}{\cos^2 y} - \frac{2}{\cos y} - 2 = 0$ $\left(1 - \cos^2 x\right) - 2\cos x - 2\cos^2 x = 0$	**M1**	use of the correct identity, $\tan y = \frac{\sin y}{\cos y}$ and $\sec y = \frac{1}{\cos y}$, then as before
(c)	$z - \frac{\pi}{3} = \frac{\pi}{3}, \frac{4\pi}{3}$	**M1**	correct order of operations
	$z = \frac{2\pi}{3}, \frac{5\pi}{3}$ or 2.09 or 2.1, 5.24	**A1,A1**	A1 for a correct solution A1 for a second correct solution and no other within the range

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0606/12 Paper 1, maximum raw mark 80

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isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

1	$k^2 - 4(2k+5) \quad (<0)$ $k^2 - 8k - 20 \quad (<0)$	M1	use of $b^2 - 4ac$, (not as part of quadratic formula unless isolated at a later stage) with correct values for a, b and c Do not need to see < at this point
	$(k-10)(k+2) \quad (<0)$	M1	attempt to obtain critical values
	critical values of 10 and –2	A1	correct critical values
	$-2 < k < 10$	A1	correct range
	Alternative 1:		
	$\frac{dy}{dx} = 2(2k+5)x + k$	M1	attempt to differentiate, equate to zero and substitute x value back in to obtain a y value
	When $\frac{dy}{dx} = 0$, $x = \frac{-k}{2(2k+5)}$, $y = \frac{8k+20-k^2}{4(2k+5)}$	M1	consider $y = 0$ in order to obtain critical values
	When $y = 0$, obtain critical values of 10 and –2	A1	correct critical values
	$-2 < k < 10$	A1	correct range
	Alternative 2:		
	$y = (2k+5)\left(\left(x + \frac{k}{2(2k+5)}\right)^2 - \frac{k^2}{4(2k+5)}\right) + 1$	M1	attempt to complete the square and consider '$1 - \frac{k^2}{4(2k+5)}$'
	Looking at $1 - \frac{k^2}{4(2k+5)} = 0$ leads to	M1	attempt to solve above = to 0, to obtain critical values
	critical values of 10 and –2	A1	correct critical values
	$-2 < k < 10$	A1	correct range

2	$\dfrac{\tan\theta+\cot\theta}{\operatorname{cosec}\theta}=\dfrac{\frac{\sin\theta}{\cos\theta}+\frac{\cos\theta}{\sin\theta}}{\frac{1}{\sin\theta}}$	M1	for $\tan\theta=\dfrac{\sin\theta}{\cos\theta}$, $\cot\theta=\dfrac{\cos\theta}{\sin\theta}$ and $\operatorname{cosec}\theta=\dfrac{1}{\sin\theta}$; allow when used
	$=\dfrac{\frac{\sin^2\theta+\cos^2\theta}{\sin\theta\cos\theta}}{\frac{1}{\sin\theta}}$	M1	dealing correctly with fractions in the numerator; allow when seen
	$=\dfrac{1}{\cos\theta}$	M1	use of the appropriate identity; allow when seen
	$=\sec\theta$	A1	must be convinced it is from completely correct work (beware missing brackets)
	Alternative:		
	$\dfrac{\tan\theta+\cot\theta}{\operatorname{cosec}\theta}=\dfrac{\frac{\tan^2\theta+1}{\tan\theta}}{\operatorname{cosec}\theta}$	M1	for either $\tan\theta=\dfrac{1}{\cot\theta}$ or $\cot\theta=\dfrac{1}{\tan\theta}$ and $\operatorname{cosec}\theta=\dfrac{1}{\sin\theta}$; allow when used
	$=\dfrac{\sec^2\theta}{\tan\theta\frac{1}{\sin\theta}}$	M1	dealing correctly with fractions in numerator; allow when seen
	$=\dfrac{\sec^2\theta}{\sec\theta}$	M1	use of the appropriate identity; allow when seen
	$=\sec\theta$	A1	must be convinced it is from completely correct work
3	$\mathbf{A}^{-1}=\dfrac{1}{2}\begin{pmatrix}3 & -2\\-5 & 4\end{pmatrix}$	B1 B1	$\dfrac{1}{2}$ multiplied by a matrix for matrix
	$\begin{pmatrix}x\\y\end{pmatrix}=\dfrac{1}{2}\begin{pmatrix}3 & -2\\-5 & 4\end{pmatrix}\begin{pmatrix}8\\9\end{pmatrix}$	M1	attempt to use the inverse matrix, must be pre-multiplication
	$\begin{pmatrix}x\\y\end{pmatrix}=\dfrac{1}{2}\begin{pmatrix}6\\-4\end{pmatrix}$		
	$x=3, y=-2$	A1, A1	

4 **(i)**	Area = $\left(\frac{1}{2}\times 12^2 \times 1.7\right)+\left(\frac{1}{2}\times 12^2 \sin(2\pi - 1.7 - 2.4)\right)$	B1,B1	B1 for sector area, allow unsimplified B1 for correct angle *BOC*, allow unsimplified
		M1	correct attempt at area of triangle, allow unsimplified using *their* angle *BOC* (Their angle *BOC* must not be 1.7 or 2.4)
	= awrt 181	A1	
(ii)	$BC^2 = 12^2 + 12^2 - (2\times 12\times 12\cos 2.1832)$ or $BC = 2\times 12\times \sin\left(\frac{2\pi - 4.1}{2}\right)$	M1	correct attempt at *BC*, may be seen in **(i)**, allow if used in **(ii)**. Allow use of *their* angle *BOC*.
	$BC = 21.296$	A1	
	Perimeter = $(12\times 1.7)+12+12+21.296$	B1 M1	for arc length, allow unsimplified for a correct 'plan' (an arc + 2 radii and *BC*)
	= 65.7	A1	
5 **(a)** **(i)**	20160	B1	
(ii)	$3\times {}^6P_4 \times 2$ = 2160	B1,B1	B1 for ${}^6P_4$ (must be seen in a product) B1 for all correct, with no further working
(iii)	$5\times 2\times {}^6P_4$ = 3600	B1,B1 B1	B1 for ${}^6P_4$ (must be seen in a product) B1 for 5 (must be in a product) B1 for all correct, with no further working
	Alternative 1: ${}^6C_4 \times 5!\times 2$ = 3600	B2 B1	for ${}^6C_4 \times 5!$ for ${}^6C_4 \times 5!\ \times 2$
	Alternative 2: $\left({}^7P_5 - {}^6P_5\right)\times 2$ = 3600	B2 B1	for $\left({}^7P_5 - {}^6P_5\right)$ for $\left({}^7P_5 - {}^6P_5\right)\times 2$
	Alternative 3: $2!\left({}^6P_4 + \left({}^6P_1\times{}^5P_3\right)+\left({}^6P_2\times{}^4P_2\right)+\left({}^6P_3\times{}^3P_1\right)+{}^6P_4\right)$ = 3600	B2 B1	4 terms correct or omission of 2! in each term all correct

(b) (i)	${}^{14}C_4 \times {}^{10}C_4$ or ${}^{14}C_8 \times {}^{8}C_4$ (or numerical or factorial equivalent) $= 210210$	B1,B1	B1 for either ${}^{14}C_4$ or ${}^{14}C_8$ as part of a product B1 for correct answer, with no further working
(ii)	${}^{8}C_4 \times {}^{6}C_4$ $= 1050$	B1,B1	B1 for either ${}^{8}C_4$ or ${}^{6}C_4$ as part of a product B1 for correct answer with no further working
6 (i)	10ln4 or 13.9 or better	B1	
(ii)	$\left(\frac{\mathrm{d}x}{\mathrm{d}t}=\right)\frac{20t}{t^2+4}-4$	M1 B1	attempt to differentiate and equate to zero $\frac{20t}{t^2+4}$ or equivalent seen
	When $\frac{\mathrm{d}x}{\mathrm{d}t}=0, \frac{20t}{t^2+4}=4$	DM1	attempt to solve *their* $\frac{\mathrm{d}x}{\mathrm{d}t}=0$, must be a 2 or 3 term quadratic equation with real roots
	leading to $t^2-5t+4=0$ $t=1, t=4$	A1	for both

(iii)	If $(v=)\ \dfrac{20t}{t^2+4}-4$		
	$(a=)\ \dfrac{20\left(t^2+4\right)-20t\left(2t\right)}{\left(t^2+4\right)^2}$	M1	attempt to differentiate *their* $\dfrac{\mathrm{d}x}{\mathrm{d}t}$
		A1	$20\left(t^2+4\right)$
		A1	$20t\left(2t\right)$
	$20\left(4-t^2\right)$ or $80-20t^2$ or $4-t^2$ or equivalent expression involving $-t^2$	A1	$20\left(4-t^2\right)$ or $80-20t^2$ or $4-t^2$
	When acceleration is 0, $t=2$ only	B1	$t=2$, dependent on obtaining first and second A marks
	Alternative 1 for first 3 marks: If $(v=)\ \dfrac{20t-4t^2-16}{t^2+4}$	M1	attempt to differentiate *their* $\dfrac{\mathrm{d}x}{\mathrm{d}t}$
	$(a=)\dfrac{\left(t^2+4\right)\ \left(20-8t\right)-\left(20t-4t^2-16\right)\ \left(2t\right)}{\left(t^2+4\right)^2}$	A1	for $\left(t^2+4\right)\left(20-8t\right)$
		A1	for $\left(20t-4t^2-16\right)\left(2\mathrm{t}\right)$
	Alternative 2 for M1 mark: If $(v=)\ 20t\left(t^2+4\right)^{-1}-4$		
	$(a=)20t\left(-2t\left(t^2+4\right)^{-2}\right)+20\left(t^2+4\right)^{-1}$	M1	attempt to differentiate *their* $\dfrac{\mathrm{d}x}{\mathrm{d}t}$
	Alternative 3 for the first 3 marks If $(v=)\ \left(20t-4t^2-16\right)\left(t^2+4\right)^{-1}$		
	$(a=)\left(20t-4t^2-16\right)\left(-2t\left(t^2+4\right)^{-2}\right)+\left(20-8t\right)\left(t^2+4\right)^{-1}$	M1	attempt to differentiate *their* $\dfrac{\mathrm{d}x}{\mathrm{d}t}$
	Numerator $=-2t\left(20t-4t^2-16\right)+\left(20-8t\right)\ \left(t^2+4\right)$	A1	for $2t\left(20t-4t^2-15\right)$
		A1	for $\left(20-8t\right)\left(t^2+4\right)$
7 (i)	$\overrightarrow{DA}=3\mathbf{a}-\mathbf{b}$	B1	mark final answer, allow unsimplified
(ii)	$\overrightarrow{DB}=7\mathbf{a}-\mathbf{b}$	B1	mark final answer, allow unsimplified
(iii)	$\overrightarrow{AX}=\lambda\left(4\mathbf{a}+\mathbf{b}\right)$	B1	mark final answer, allow unsimplified
(iv)	$\overrightarrow{DX}=3\mathbf{a}-\mathbf{b}+\lambda\left(4\mathbf{a}+\mathbf{b}\right)$	M1	*their* **(i)** + *their* **(iii)** or equivalent valid method or $3\mathbf{a}-\mathbf{b}$ + *their* **(iii)**
		A1	Allow unsimplified

(v)	$3\mathbf{a}-\mathbf{b}+\lambda(4\mathbf{a}+\mathbf{b})=\mu(7\mathbf{a}-\mathbf{b})$ Equate like vectors: $3+4\lambda=7\mu$ $-1+\lambda=-\mu$ leads to $\lambda=\frac{4}{11}$, $\mu=\frac{7}{11}$	M1 DM1 A1,A1	equating *their* **(iv)** and $\mu\times$ *their* **(ii)** for an attempt to equate like vectors and attempt to solve 2 linear equations for λ and μ A1 for each
8 (i)	$5e^{2x}-\frac{1}{2}e^{-2k}\quad(+c)$	B1, B1	B1 for each term, allow unsimplified
(ii)	$\left(5e^{2k}-\frac{1}{2}e^{-2k}\right)-\left(5e^{-2k}-\frac{1}{2}e^{2k}\right)$	M1 A1	use of limits provided integration has taken place. Signs must be correct if brackets are not included. allow any correct form
(iii)	$\left(5e^{2k}-\frac{1}{2}e^{-2k}\right)\left(5e^{-2k}-\frac{1}{2}e^{2k}\right)=-60$ or $\frac{11}{2}e^{2k}-\frac{11}{2}e^{-2k}=-60$ or equivalent leading to $11e^{2k}-11e^{-2k}+120=0$	B1 DB1	correct expression from **(ii)** either simplified or unsimplified equated to – 60 , must be first line seen. must be convinced as **AG**
(iv)	$11y^2+120y-11=0$ $(11y-1)(y+11)=0$ leading to $k=\frac{1}{2}\ln\frac{1}{11}$, $\ln\frac{1}{\sqrt{11}}$, $-\ln\sqrt{11}$, $-\frac{1}{2}\ln 11$	M1 DM1 A1	attempt to obtain a quadratic equation in y or e^{2k} and solve to get y or e^{2k} (only need positive solution) attempt to deal with e to get k =. any of given answers only.

9	$\frac{dy}{dx} = 4 - 6\sin 2x$	M1,A1	M1 for attempt to differentiate A1 for all correct
	When $x = \frac{\pi}{4}$, $y = \pi$	B1	for y
	$\frac{dy}{dx} = -2$ so gradient of normal = $\frac{1}{2}$	DM1	for substitution of $x = \frac{\pi}{4}$ into *their* $\frac{dy}{dx}$ and use of '$m_1 m_2 = -1$', dependent on first M1
	Normal equation $y - \pi = \frac{1}{2}\left(x - \frac{\pi}{4}\right)$	DM1	correct attempt to obtain the equation of the normal, dependent on previous DM mark
	When $x = 0$, $y = \frac{7\pi}{8}$	A1	must be terms of π
	When $y = 0, x = -\frac{7\pi}{4}$	A1	must be terms of π
	Area = $\frac{1}{2} \times \frac{7\pi}{4} \times \frac{7\pi}{8} = \frac{49\pi^2}{64}$	B1ft	Follow through on *their* x and y intercepts; must be exact values
10 (a)	$\cos^2 3x = \frac{1}{2}$, $\cos 3x = (\pm)\frac{1}{\sqrt{2}}$ $3x = 45°, 135°, 225°, 315°$	M1	complete correct method, dealing with sec and 3, correctly
	$x = 15°, 45°, 75°, 105°$	A1,A1	A1 for each correct pair
(b)	$3(\cot^2 y + 1) + 5\cot y - 5 = 0$ Leading to	M1	use of a correct identity to get an equation in terms of one trig ratio only
	$3\cot^2 y + 5\cot y - 2 = 0$ or $2\tan^2 y - 5\tan y - 3 = 0$ $(3\cot y - 1)(\cot y + 2) = 0$ or $(\tan y - 3)(2\tan y + 1) = 0$	M1	for $\cot y = \frac{1}{\tan y}$ to obtain either a quadratic equation in $\tan y$ or solutions in terms of $\tan y$; allow where appropriate
	$\tan y = 3$, $\tan y = \frac{1}{2}$	M1	for solution of a quadratic equation in terms of either $\tan y$ or $\cot y$
	$y = 71.6°, 251.6°$ $153.4°, 333.4°$	A1,A1	A1 for each correct 'pair'
(c)	$\sin\left(z + \frac{\pi}{3}\right) = \frac{1}{2}$	M1	completely correct method of solution
	$z + \frac{\pi}{3} = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{13\pi}{6}$	A1	one correct solution in range
	$z = \frac{\pi}{2}, \frac{11\pi}{6}$	M1	correct attempt to obtain a second solution within the range
	(allow 1.57, 5.76)	A1	second correct solution (and no other)

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the May/June 2015 series

0606 ADDITIONAL MATHEMATICS

0606/13 Paper 1, maximum raw mark 80

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.

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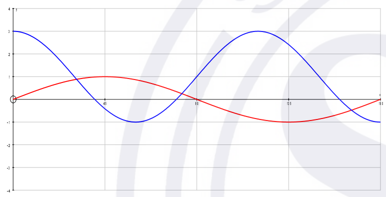
Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied
www without wrong working

1 (i)	180° or π radians or 3.14 radians (or better)	**B1**	
(ii)	2	**B1**	
(iii) (a)		**B1**	$y = \sin 2x$ all correct
(b)		**B1**	for either ↑↓↑starting at their highest value and ending at their lowest value Or a curve with highest value at $y = 3$ and lowest value at $y = -1$
		B1	completely correct graph
(iv)	3	**B1**	
2 (i)	$\tan\theta = \frac{(8+5\sqrt{2})(4-3\sqrt{2})}{(4+3\sqrt{2})(4-3\sqrt{2})}$ $= \frac{32-24\sqrt{2}+20\sqrt{2}-30}{16-18}$	**M1**	attempt to obtain $\tan\theta$ and rationalise. Must be convinced that no calculators are being used
	$= 1 + 2\sqrt{2}$ cao	**A1**	

(ii)	$\sec^2\theta = 1 + \tan^2\theta$ $= 1 + \left(-1 + 2\sqrt{2}\right)^2$ $= 1 + 1 - 4\sqrt{2} + 8$ $= 10 - 4\sqrt{2}$	 **M1** **DM1** **A1**	 attempt to use $\sec^2\theta = 1 + \tan^2\theta$, with *their* answer to **(i)** attempt to simplify, must be convinced no calculators are being used. Need to expand $\left(-1 + 2\sqrt{2}\right)^2$ as 3 terms
	Alternative solution: $AC^2 = \left(4 + 3\sqrt{2}\right)^2 + \left(8 + 5\sqrt{2}\right)^2$ $= 148 + 104\sqrt{2}$ $\sec^2\theta = \dfrac{148 + 104\sqrt{2}}{\left(4 + 3\sqrt{2}\right)^2}$ $= \dfrac{148 + 104\sqrt{2}}{\left(4 + 3\sqrt{2}\right)^2} \times \dfrac{34 - 24\sqrt{2}}{34 - 24\sqrt{2}}$ $= 10 - 4\sqrt{2}$	 **M1** **DM1** **A1**	
3 (i)	$64 + 192x^2 + 240x^4 + 160x^6$	**B3,2,1,0**	–1 each error
(ii)	$\left(64 + 192x^2 + 240x^4\right)\left(1 - \dfrac{6}{x^2} + \dfrac{9}{x^4}\right)$	**B1**	expansion of $\left(1 - \dfrac{3}{x^2}\right)^2$
	Terms needed $64 - (192 \times 6) + (240 \times 9)$ $= 1072$	**M1** **A1**	attempt to obtain 2 or 3 terms using *their* **(i)**

4 (a)	$\mathbf{X}^2 = \begin{pmatrix} 4-4k & -8 \\ 2k & -4k \end{pmatrix}$	**B2,1,0**	–1 each incorrect element
(b)	Use of $\mathbf{AA}^{-1} = \mathbf{I}$ $\begin{pmatrix} a & 1 \\ b & 5 \end{pmatrix}\begin{pmatrix} \frac{5}{6} & -\frac{1}{6} \\ -\frac{2}{3} & \frac{1}{3} \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$	**M1**	use of $\mathbf{AA}^{-1} = \mathbf{I}$ and an attempt to obtain at least one equation.
	Any 2 equations will give $a = 2$, $b = 4$	**A1,A1**	
	Alternative method 1: $\frac{1}{5a-b}\begin{pmatrix} 5 & -1 \\ b & a \end{pmatrix} = \begin{pmatrix} \frac{5}{6} & -\frac{1}{6} \\ -\frac{2}{3} & \frac{1}{3} \end{pmatrix}$	**M1**	correct attempt to obtain $\mathbf{A}^{-1}$ and comparison of at least one term.
	Compare any 2 terms to give $a = 2$, $b = 4$	**A1,A1**	
	Alternative method 2: Inverse of $\frac{1}{6}\begin{pmatrix} 5 & -1 \\ -4 & 2 \end{pmatrix} = \begin{pmatrix} 2 & 1 \\ 4 & 5 \end{pmatrix}$	**M1** **A1,A1**	reasoning and attempt at inverse
5	$3x-1 = x(3x-1)+x^2-4$ or $y = \left(\frac{y+1}{3}\right)y + \left(\frac{y+1}{3}\right)^2 - 4$		
	$4x^2-4x-3=0$ or $4y^2-4y-35=0$	**M1**	equate and attempt to obtain an equation in 1 variable
	$(2x-3)(2x+1)=0$ or $(2y-7)(2y+5)=0$	**DM1**	forming a 3 term quadratic equation and attempt to solve
	leading to $x=\frac{3}{2}, x=-\frac{1}{2}$ and	**A1**	x values
	$y=\frac{7}{2}, y=-\frac{5}{2}$	**A1**	y values
	Midpoint $\left(\frac{1}{2}, \frac{1}{2}\right)$	**B1**	for midpoint, allow anywhere
	Perpendicular gradient $= -\frac{1}{3}$	**M1**	correct attempt to obtain the gradient of the perpendicular, using AB
	Perp bisector: $y-\frac{1}{2} = -\frac{1}{3}\left(x-\frac{1}{2}\right)$	**M1**	straight line equation through the midpoint; must be convinced it is a perpendicular gradient.
	$(3y+x-2=0)$	**A1**	allow unsimplified

6 (i)	$f\left(\frac{1}{2}\right)=\frac{a}{8}-\frac{15}{4}+\frac{b}{2}-2=0$ leading to $a+4b=46$ $f(1)=a-15+b-2=5$ leading to $a+b=22$	**M1** **A1**	correct use of either $f\left(\frac{1}{2}\right)$ or f(1) paired correctly both equations correct (allow unsimplified)
	giving $b=8$ (AG), $a=14$	**M1,A1**	M1 for solution of equations A1 for both *a* and *b*. **AG** for *b*.
(ii)	$(2x-1)(7x^2-4x+2)$	**M1,A1**	M1 for valid attempt to obtain g(*x*), by either observation or by algebraic long division.
(iii)	$7x^2-4x+2=0$ has no real solutions as $b^2<4ac$ $16<56$	**M1** **A1**	use of b^2-4ac correct conclusion; must be from a correct g(*x*) or 2g(*x*) www
7 (i)	$\frac{dy}{dx}=\frac{(x-1)\frac{8x}{(4x^2+2)}-\ln(4x^2+3)}{(x-1)^2}$	**M1** **B1** **A1**	differentiation of a quotient (or product) correct differentiation of $\ln(4x^2+3)$ all else correct
	When $x=0$, $y=-\ln 3$ oe	**B1**	for *y* value
	$\frac{dy}{dx}=-\ln 3$ so gradient of normal is $\frac{1}{\ln 3}$ (allow numerical equivalent)	**M1**	valid attempt to obtain gradient of the normal
	normal equation $y+\ln 3=\frac{1}{\ln 3}x$ or $y=0.910x-1.10$, or $y=\frac{10}{11}x-\frac{11}{10}$ cao (Allow $y=0.91x-1.1$)	**M1** **A1**	attempt at normal equation must be using a perpendicular
(ii)	when $x=0$, $y=-\ln 3$ when $y=0$, $x=(\ln 3)^2$ Area = ±0.66 or ±0.67 or awrt these or $\frac{1}{2}(\ln 3)^3$	**M1** **A1**	valid attempt at area

8 (i)	Range for f: $y \geq 3$ Range for g: $y \geq 9$	B1 B1	
(ii)	$x = -2 + \sqrt{y-5}$	M1	attempt to obtain the inverse function
	$g^{-1}(x) = -2 + \sqrt{x-5}$ Domain of g^{-1}: $x \geq 9$	A1 B1	Must be correct form for domain
	Alternative method: $y^2 + 4y + 9 - x = 0$	M1	attempt to use quadratic formula and find inverse
	$y = \frac{-4 + \sqrt{16 - 4(9-x)}}{2}$	A1	must have + not ±
(iii)	Need $g\left(3e^{2x}\right)$	M1	correct order
	$\left(3e^{2x} + 2\right)^2 + 5 = 41$ or $9e^{4x} + 12e^{2x} - 32 = 0$ $\left(3e^{2x} - 4\right)\left(3e^{2x} + 8\right) = 0$	DM1	correct attempt to solve the equation
	leading to $3e^{2x} + 2 = \pm 6$ so $x = \frac{1}{2}\ln\frac{4}{3}$	M1	dealing with the exponential correctly in order to reach a solution for x
	or $e^{2x} = \frac{4}{3}$ so $x = \frac{1}{2}\ln\frac{4}{3}$	A1	Allow equivalent logarithmic forms
	Alternative method: Using $f(x) = g^{-1}(41)$, $g^{-1}(41) = 4$	M1	correct use of g^{-1}
	leading to $3e^{2x} = 4$, so $x = \frac{1}{2}\ln\frac{4}{3}$	DM1	dealing with $g^{-1}(41)$ to obtain an equation in terms of e^{2x}
		M1 A1	dealing with the exponential correctly in order to reach a solution for x Allow equivalent logarithmic forms
(iv)	$g'(x) = 6e^{2x}$ $g'(\ln 4) = 96$	B1 B1	B1 for each

9 (i)	$\frac{dy}{dx} = 3x^2 - 10x + 3$	**M1**	for differentiation
	When $x = 0$, for curve $\frac{dy}{dx} = 3$, gradient of line also 3 so line is a tangent.	**A1**	comparing both gradients
	Alternate method:		
	$3x + 10 = x^3 - 5x^2 + 3x + 10$	**M1**	attempt to deal with simultaneous equations
	leading to $x^2 = 0$, so tangent at $x = 0$	**A1**	obtaining $x = 0$
(ii)	When $\frac{dy}{dx} = 0$, $(3x-1)(x-3) = 0$	**M1**	equating gradient to zero and valid attempt to solve
	$x = \frac{1}{3}$, $x = 3$	**A1,A1**	A1 for each
(iii)	Area $= \frac{1}{2}(10+19)3 - \int_0^3 x^3 - 5x^2 + 3x + 10 \, dx$	**B1**	area of the trapezium
	$= \frac{87}{2} - \left[\frac{x^4}{4} - \frac{5x^3}{3} + \frac{3x^2}{2} + 10x\right]_0^3$	**M1**	attempt to obtain the area enclosed by the curve and the coordinate axes, by integration
	$= \frac{87}{2} - \left(\frac{81}{4} - 45 + \frac{27}{2} + 30\right)$	**A1** **DM1**	integration all correct correct application of limits (must be using *their* 3 from **(ii)** and 0)
	$= 24.7$ or 24.8	**A1**	
	Alternative method:		
	Area $= \int_0^3 (3x+10) - \left(x^3 - 5x^2 + 3x + 10\right) dx$	**B1**	correct use of '*Y*–*y*'
	$= \int_0^3 -x^3 + 5x^2 \, dx$	**M1** **A1**	attempt to integrate integration all correct
	$= \left[-\frac{x^4}{4} + \frac{5x^3}{3}\right]_0^3 = \frac{99}{4}$	**DM1** **A1**	correct application of limits
10 (a)	$\sin^2 x = \frac{1}{4}$		
	$\sin x = (\pm)\frac{1}{2}$	**M1**	using $\text{cosec}x = \frac{1}{\sin x}$ and obtaining $\sin x = \ldots$
	$x = 30°, 150°, 210°, 330°$	**A1,A1**	A1 for one correct pair, A1 for another correct pair with no extra solutions

(b)	$\left(\sec^2 3y - 1\right) - 2\sec 3y - 2 = 0$	**M1**	use of the correct identity
	$\sec^2 3y - 2\sec 3y - 3 = 0$ $(\sec 3y + 1)(\sec 3y - 3) = 0$	**M1**	attempt to obtain a 3 term quadratic equation in sec 3*y* and attempt to solve
	leading to $\cos 3y = -1$, $\cos 3y = \frac{1}{3}$	**M1**	dealing with sec and 3*y* correctly
	$3y = 180°, 540°$ $\quad 3y = 70.5°, 289.5°, 430.5°$ $y = 60°, 180°, 23.5°, 96.5°, 143.5°$	**A1,A1** **A1**	A1 for a correct pair, A1 for a second correct pair, A1 for correct 5th solution and no other within the range
	Alternative 1:		
	$\sec^2 3y - 2\sec 3y - 3 = 0$	**M1**	use of the correct identity
	leading to $3\cos^2 3y + 2\cos 3y - 1$	**M1**	attempt to obtain a quadratic equation in cos 3*y* and attempt to solve
	$(3\cos y - 1)(\cos y + 1) = 0$	**M1**	dealing with 3*y* correctly **A** marks as above
	Alternative 2:		
	$\frac{\sin^2 y}{\cos^2 y} - \frac{2}{\cos y} - 2 = 0$ $\left(1 - \cos^2 x\right) - 2\cos x - 2\cos^2 x = 0$	**M1**	use of the correct identity, $\tan y = \frac{\sin y}{\cos y}$ and $\sec y = \frac{1}{\cos y}$, then as before
(c)	$z - \frac{\pi}{3} = \frac{\pi}{3}, \frac{4\pi}{3}$	**M1**	correct order of operations
	$z = \frac{2\pi}{3}, \frac{5\pi}{3}$ or 2.09 or 2.1, 5.24	**A1,A1**	A1 for a correct solution A1 for a second correct solution and no other within the range

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the March 2015 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 12, maximum raw mark 80

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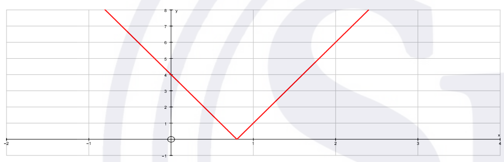
CAMBRIDGE
International Examinations

1 (i)	Members who play football or cricket , or both	**B1**	
(ii)	Members who do not play tennis	**B1**	
(iii)	There are no members who play both football and tennis	**B1**	
(iv)	There are 10 members who play both cricket and tennis.	**B1**	
2	$kx - 3 = 2x^2 - 3x + k$ $2x^2 - x(k+3) + (k+3) = 0$	**M1**	for attempt to obtain a 3 term quadratic equation in terms of x
	Using $b^2 - 4ac$, $(k+3)^2 - (4 \times 2 \times (k+3))$ (<0)	**DM1**	for use of $b^2 - 4ac$
	$(k+3)(k-5)$ (<0)	**DM1**	for attempt to solve quadratic equation, dependent on both previous M marks
	Critical values $k = -3, 5$	**A1**	for both critical values
	so $-3 < k < 5$	**A1**	for correct range
3 (i)		**B1** **B1** **B1**	for shape, must touch the x-axis in the correct quadrant for y intercept for x intercept
(ii)	$4 - 5x = \pm 9$ or $(4-5x)^2 = 81$	**M1**	for attempt to obtain 2 solutions, must be a complete method
	leading to $x = -1,\ x = \frac{13}{5}$	**A1, A1**	**A1** for each
4 (i)	$729 + 2916x + 4860x^2$	**B1,B1** **B1**	**B1** for each correct term
(ii)	2 × *their* 4860 – *their* 2916 = 6804	**M1** **A1**	for attempt at 2 terms, must be as shown

5 **(i)**	gradient = 4 Using either (2, 1) or (3, 5), $c = -7$ $e^y = 4x + c$ so $y = \ln(4x - 7)$	**B1** **M1** **M1,A1**	for gradient, seen or implied for attempt at straight line equation to obtain a value for c for correct method to deal with e^y
	Alternative method: $\frac{y-1}{5-1} = \frac{x-2}{3-2}$ or equivalent $e^y = 4x - 7$ so $y = \ln(4x - 7)$	**M1** **A1** **M1** **A1**	for attempt at straight line equation using both points allow correct unsimplified for correct method to deal with e^y
(ii)	$x > \frac{7}{4}$	**B1ft**	**ft** on *their* $4x - 7$
(iii)	$\ln 6 = \ln(4x - 7)$ so $x = \frac{13}{4}$	**B1ft**	**ft** on *their* $4x - 7$
6 **(i)**	$\frac{dy}{dx} = \frac{x(2\sec^2 2x) - \tan 2x}{x^2}$ **Or** $\frac{dy}{dx} = x^{-1}(2\sec^2 2x) + (-x^{-2})\tan 2x$	**M1** **A2,1,0**	for attempt to differentiate a quotient (or product) –1 each error
(ii)	When $x = \frac{\pi}{8}$, $y = \frac{8}{\pi}$ (2.546) When $x = \frac{\pi}{8}$, $\frac{dy}{dx} = \frac{\frac{\pi}{2} - 1}{\frac{\pi^2}{64}}$ $= \frac{32}{\pi} - \frac{64}{\pi^2}$ (3.701) Equation of the normal: $y - \frac{8}{\pi} = -\frac{\pi^2}{32(\pi - 2)}\left(x - \frac{\pi}{8}\right)$ $y = -0.27x + 2.65$ (allow 2.66)	**B1** **M1** **A1**	for y-coordinate (allow 2.55) for an attempt at the normal, must be working with a perpendicular gradient allow in unsimplified form in terms of π or simplified decimal form

7 (i)	$\text{p}\left(\frac{1}{2}\right): \frac{a}{8}+\frac{b}{4}-\frac{3}{2}-4=0$	**M1**	for correct use of $x=\frac{1}{2}$
	Simplifies to $a+2b=44$		
	$\text{p}(-2): -8a+4b+6-4=-10$	**M1**	for correct use of $x=-2$
	Simplifies to $2a-b=3$ oe	**DM1**	for solution of equations
	Leads to $a=10,\ b=17$	**A1**	for both, be careful as AG for *a*, allow verification
(ii)	$\text{p}(x)=10x^3+17x^2-3x-4$	**B2,1,0**	–1 each error
	$=(2x-1)(5x^2+11x+4)$		
(iii)	$x=\frac{1}{2}$	**B1**	
	$x=\frac{-11\pm\sqrt{41}}{10}$	**B1, B1**	
8 (a) (i)	Range $0 \leqslant y \leqslant 1$	**B1**	
(ii)	Any suitable domain to give a one-one function	**B1**	e.g. $0 \leqslant x \leqslant \frac{\pi}{4}$
(b) (i)	$y=2+4\ln x$ oe	**M1**	for a complete method to find the inverse
	$\ln x=\frac{y-2}{4}$ oe		
	$\text{g}^{-1}(x)=\text{e}^{\frac{x-2}{4}}$	**A1**	must be in the correct form
	Domain $x \in$	**B1**	
	Range $y>0$	**B1**	
(ii)	$\text{g}(x^2+4)=10$	**M1**	for correct order
	$2+4\ln(x^2+4)=10$	**DM1**	for attempt to solve
	leading to $x=1.84$ only	**A1**	for one solution only
	Alternative method:		
	$\text{h}(x)=x^2+4=\text{g}^{-1}(10)$	**M1**	for correct order
	$\text{g}^{-1}(10)=\text{e}^2$, so $x^2+4=\text{e}^2$	**DM1**	for attempt to solve
	leading to $x=1.84$ only	**A1**	for one solution only
(iii)	$\frac{4}{x}=2x$	**B1**	for given equation, allow in this form
	$x^2=2$	**M1**	for attempt to solve, must be using derivatives
	$x=\sqrt{2}$	**A1**	for one solution only, allow 1.41 or better.

9 (i)	Area of triangular face = $\frac{1}{2}x^2\frac{\sqrt{3}}{2}=\frac{\sqrt{3}x^2}{4}$	**B1**	for area of triangular face
	Volume of prism = $\frac{\sqrt{3}x^2}{4}\times y$	**M1**	for attempt at volume *their* area $\times y$
	$\frac{\sqrt{3}x^2}{4}\times y=200\sqrt{3}$		
	so $x^2y=800$	**A1**	for correct relationship between x and y
	$A=2\times\frac{\sqrt{3}x^2}{4}+2xy$	**M1**	for a correct attempt to obtain surface area using *their* area of triangular face
	leading to $A=\frac{\sqrt{3}x^2}{2}+\frac{1600}{x}$	**A1**	for eliminating y correctly to obtain **given** answer
(ii)	$\frac{dA}{dx}=\sqrt{3}x-\frac{1600}{x^2}$	**M1**	for attempt to differentiate
	When $\frac{dA}{dx}=0$, $x^3=\frac{1600}{\sqrt{3}}$	**M1**	for equating $\frac{dA}{dx}$ to 0 and attempt to solve
	$x=9.74$	**A1**	for correct x
	so A = 246	**A1**	for correct A
	$\frac{d^2A}{dx}=\sqrt{3}+\frac{3200}{x^3}$ which is positive for $x=9.74$	**M1**	for attempt at second derivative and conclusion, or alternate methods
	so the value is a minimum	**A1ft**	**ft** for a correct conclusion from completely correct work, follow through on *their* positive x value.
10 (i)	$\tan\theta=\frac{1+2\sqrt{5}}{6+3\sqrt{5}}\times\frac{6-3\sqrt{5}}{6-3\sqrt{5}}$ $=\frac{6-3\sqrt{5}+12\sqrt{5}-30}{36-45}$	**M1**	for attempt at $\cot\theta$ together with rationalisation. Must be convinced that a calculator is **not** being used.
	$=\frac{8}{3}-\sqrt{5}$	**A1, A1**	**A1** for each term
(ii)	$\tan^2\theta+1=\sec^2\theta$ $\frac{64}{9}-\frac{16\sqrt{5}}{3}+5+1=\text{cosec}^2\theta$	**M1**	for attempt to use the correct identity or correct use of Pythagoras' theorem together with *their* answer to **(i)**. Must be convinced that a calculator is **not** being used.
	so $\text{cosec}^2\theta=\frac{118}{9}-\frac{16\sqrt{5}}{3}$ Alternate solutions are acceptable	**A1, A1**	**A1** for each term

11 (a) (i)	LHS $= \dfrac{\frac{1}{\sin y}}{\frac{\cos y}{\sin y}+\frac{\sin y}{\cos y}}$	**M1**	for dealing with cosec, cot and tan in terms of sin and cos
	$= \dfrac{\frac{1}{\sin y}}{\frac{\cos^2 y+\sin^2 y}{\sin y\cos y}}$	**M1**	for use of $\sin^2 y+\cos^2 y=1$
	$= \dfrac{1}{\sin y}\times \sin y\cos y$ $=\cos y$	**A1**	for correct simplification to get the required result.
(ii)	$\cos 3z = 0.5$ $3z=\frac{\pi}{3},\ \frac{5\pi}{3},\ \frac{7\pi}{3}$	**M1**	for use of **(i)** and correct attempt to deal with multiple angle
	$z=\frac{\pi}{9},\ \frac{5\pi}{9},\ \frac{7\pi}{9}$	**A1, A1**	**A1** for each 'pair' of solutions
(b)	$2\sin x+8\left(1-\sin^2 x\right)=5$	**M1**	for use of correct identity
	$8\sin^2 x-2\sin x-3=0$ $(4\sin x-3)(2\sin x+1)=0$ $\sin x=\frac{3}{4}$, $\quad\sin x=-\frac{1}{2}$	**M1**	for attempt to solve quadratic equation
	$x=48.6°,\ 131.4°\quad 210°,\ 330°$	**A1, A1**	**A1** for each pair of solutions

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2014 series

0606 ADDITIONAL MATHEMATICS

0606/11 Paper 1, maximum raw mark 80

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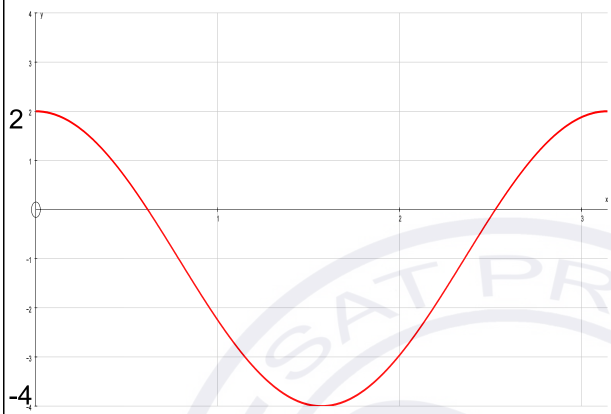
1	$\frac{dy}{dx} = 2x - \frac{16}{x^2}$	**M1**	for attempt to differentiate
		A1	all correct
	When $\frac{dy}{dx} = 0$,	**DM1**	for equating $\frac{dy}{dx}$ to zero and an attempt to solve for x.
	$x = 2, y = 12$	**A1**	**A1** for both, but no extra solutions
2 (a)		**B1**	for correct shape
		B1	for max value of 2, starting at (0, 2) and finishing at (180°, 2)
		B1	for min value of –4
(b) (i)	4	**B1**	must be positive
(ii)	$60°$ or $\frac{\pi}{3}$ or 1.05 rad	**B1**	
3 (i)	$y = 4(x+3)^{\frac{1}{2}} (+c)$	**M1, A1**	**M1** for $(x+3)^{\frac{1}{2}}$, **A1** for $4(x+3)^{\frac{1}{2}}$
	$10 = 4\left(9^{\frac{1}{2}}\right) + c$	**M1**	for a correct attempt to find *c*, but must be from an attempt to integrate
	$c = -2$		
	$y = 4(x+3)^{\frac{1}{2}} - 2$	**A1**	Allow **A1** for $c = -2$
(ii)	$6 = 4(x+3)^{\frac{1}{2}} - 2$ $x = 1$	**A1 ft**	**ft** for substitution into *their* equation to obtain x; must have the first **M1**

4	(i)	$5y^2 - 7y + 2 = 0$	B1, B1	**B1** for 5, **B1** for –7
	(ii)	$(5y-2)(y-1)=0$	M1	for solution of quadratic equation from **(i)**
		$y = \frac{2}{5}, x = \frac{\ln 0.4}{\ln 5}$	M1	for use of logarithms to solve equation of the type $5^x = k$
		$x = -0.569$	A1	must be evaluated to 3sf or better
		$y = 1, x = 0$	B1	
5	(i)	$\frac{dy}{dx} = 3x^2 - \frac{1}{x}$	M1	for attempt to differentiate
		When $x = 1$, $y = 1$ and $\frac{dy}{dx} = 2$	B1	for $y = 1$
		Tangent: $y - 1 = 2(x-1)$	DM1	for attempt to find equation of tangent
		$(y = 2x - 1)$	A1	allow equation unsimplified
	(ii)	Mid-point (5, 9)	B1	for midpoint from given coordinates
		$9 = 2(5) - 1$	B1	for checking the mid-point lies on tangent
		Alternative Method: Tangent equation $y = 2x - 1$ Equation of line joining (–2, 16) and (12, 2) $y = -x + 14$ Solve simultaneously $x = 5$, $y = 9$	B1	for a complete method to find the coordinates of the point of intersection
		Mid-point (5, 9)	B1	for midpoint from given coordinates
6	(i)	$(2+px)^6 = 64 + 192px + 240p^2x^2 \ldots$	B1	for $240p^2$ or $240p^2x^2$ or ${}^6C_2 \times 2^4 \times (px)^2$ or ${}^6C_2 \times 2^4 \times p^2$ or ${}^6C_2 \times 2^4 \times p^2x^2$
		$240p^2 = 60$	M1	for equating *their* term in x^2 to 60 and attempt to solve
		$p = \frac{1}{2}$	A1	
	(ii)	$(3-x)(64 + 192px + 240p^2x^2 \ldots)$	B1 ft	**ft** for $192p$, 96 or $192 \times$ *their* p
		Coefficient of x^2 is $180 - 192p$ = 84	M1 A1	for $180 - 192p$

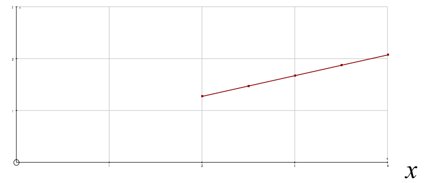
7	(i)	$\mathbf{A}^{-1} = \frac{1}{5ab}\begin{pmatrix} b & -2b \\ a & 3a \end{pmatrix}$	B1, B1	**B1** for $\frac{1}{5ab}$, **B1** for $\begin{pmatrix} b & -2b \\ a & 3a \end{pmatrix}$
	(ii)	$\mathbf{X} = \mathbf{BA}^{-1}$	M1	for post-multiplication by inverse matrix
		$= \begin{pmatrix} -a & b \\ 2a & 2b \end{pmatrix}\begin{pmatrix} \frac{1}{5a} & -\frac{2}{5a} \\ \frac{1}{5b} & \frac{3}{5b} \end{pmatrix}$	DM1	for correct attempt at matrix multiplication, needs at least one term correct for their BA^{-1} (allow unsimplified)
		$= \begin{pmatrix} 0 & 1 \\ \frac{4}{5} & \frac{2}{5} \end{pmatrix}$	A1 A1	for each correct pair of elements, must be simplified
8	(i)	$\overrightarrow{AB} = \begin{pmatrix} 12 \\ 16 \end{pmatrix}$, at P, $x = -2 + \frac{1}{4}(12)$ so at P, $x = 1$	B1	for convincing argument for $x = 1$
		$y = 3 + \frac{1}{4}(16)$, $y = 7$	B1	for $y = 7$
	(ii)	Gradient of $AB = \frac{16}{12}$, so perp gradient $= -\frac{3}{4}$	M1	for finding gradient of perpendicular
		Perp line: $y - 7 = -\frac{3}{4}(x - 1)$	M1	for equation of perpendicular through their P
		$(3x + 4y = 31)$	A1	Allow unsimplified
	(iii)	$Q\left(0, \frac{31}{4}\right)$	B1 ft	**ft** on their perpendicular line, may be implied
			M1	for any valid method of finding the area of the correct triangle, allow use of *their* Q; must be in the form $(0, q)$.
		Area AQB = 12.5	A1	

9 (i)

$\log y = \log a + x \log b$ — **B1** — for the statement, may be seen or implied in later work,

x	2	2.5	3	3.5	4
$\lg y$	1.27	1.47	1.67	1.87	2.07

	2	2.5	3	3.5	4
$\ln y$	2.93	3.39	3.84	4.31	4.76



M1 — for attempt to draw graph of x against log y

A2,1,0 — –1 each error in points plotted

(ii)

Gradient = log b
$\lg b = 0.4$ or $\ln b = 0.92$ — **DM1** — for attempt to find gradient and equate it to log b, dependent on **M1** in **(i)**

$b = 2.5$ (allow 2.4 to 2.6) — **A1**

Intercept = log a
$\lg a = 0.47$ or $\ln a = 1.10$ — **DM1** — for attempt to equate y-intercept to log a or use *their* equation with *their* gradient and a point on the line, dependent on **M1** in **(i)**

$a = 3$ (allow 2.8 to 3.2) — **A1**

Alternative method:
Simultaneous equations may be used provided points that are on the plotted straight line are used.

DM1 — for a pair of equations using points on the line, dependent on **M1** in **(i)**

DM1 — for solution of these equations, dependent on **M1** in **(i)**

$a = 3$ (allow 2.8 to 3.2) — **A1**
$b = 2.5$ (allow 2.4 to 2.6) — **A1**
A1 for each

10 (a) (i)	360	**B1**	
(ii)	60	**B1**	
(iii)	36	**B1**	
(b) (i)	${}^{8}C_{5} \times {}^{12}C_{5}$	**B1, B1**	**B1** for each, allow unevaluated with no extra terms
	$56 \times 792 = 44352$	**B1**	Final answer must be evaluated and from multiplication
(ii)	4 places are accounted for Gender no longer 'important'	**M1**	for realising that 4 places are accounted or that gender is no longer important
	Need ${}^{16}C_{6} = 8008$	**A1**	for 8008
	Alternative Method $\left({}^{6}C_{6} \times {}^{10}C_{0}\right) + \left({}^{6}C_{5} \times {}^{10}C_{1}\right) \ldots \left({}^{6}C_{0} \times {}^{10}C_{6}\right)$ $1 + 60 + 675 + 2400 + 3150 + 1512 + 210 = 8008$	**M1** **A1**	for at least 5 of the 7 cases, allow unsimplified
11 (a)	$2\cos 3x - \dfrac{\cos 3x}{\sin 3x} = 0$ $\cos 3x\left(2 - \dfrac{1}{\sin 3x}\right) = 0$	**M1**	for use of $\cot 3x = \dfrac{\cos 3x}{\sin 3x}$, may be implied
	Leading to $\cos 3x = 0,\ 3x = 90^\circ,\ 270^\circ$	**DM1**	for attempt to solve $\cos 3x = 0$ correctly from correct factorisation to obtain x
	$x = 30^\circ, 90^\circ$	**A1**	**A1** for both, no excess solutions in the range
	and $\sin 3x = \dfrac{1}{2},\ 3x = 30^\circ,\ 150^\circ$	**DM1**	for attempt to solve $\sin 3x = \dfrac{1}{2}$ correctly to obtain x
	$x = 10^\circ, 50^\circ$	**A1**	**A1** for both, condone excess solutions
(b)	$\cos\left(y + \dfrac{\pi}{2}\right) = -\dfrac{1}{2}$ $y + \dfrac{\pi}{2} = \dfrac{2\pi}{3}, \dfrac{4\pi}{3}$	**M1**	for dealing with sec $\left(y + \dfrac{\pi}{2}\right)$ correctly
		DM1	for correct order of operations, must not mix degrees and radians
	so $y = \dfrac{\pi}{6}, \dfrac{5\pi}{6}$ (0.524, 2.62)	**A1, A1**	

12 **(i)**	$\overrightarrow{AQ} = \lambda\mathbf{b} - \mathbf{a}$	**B1**	
(ii)	$\overrightarrow{BP} = \mu\mathbf{a} - \mathbf{b}$	**B1**	
(iii)	$\overrightarrow{OR} = \mathbf{a} + \frac{1}{3}(\lambda\mathbf{b} - \mathbf{a})$ or $\lambda\mathbf{b} - \frac{2}{3}(\lambda\mathbf{b} - \mathbf{a})$	**M1**	for $\mathbf{a} + \frac{1}{3}$ *their* **(i)**
	$= \frac{2}{3}\mathbf{a} + \frac{1}{3}\lambda\mathbf{b}$	**A1**	Allow unsimplified
(iv)	$\overrightarrow{OR} = \mathbf{b} + \frac{7}{8}(\mu\mathbf{a} - \mathbf{b})$ or $\mu\mathbf{a} - \frac{1}{8}(\mu\mathbf{a} - \mathbf{b})$	**M1**	for $\mathbf{b} + \frac{7}{8}$ *their* **(ii)**
	$= \frac{1}{8}\mathbf{b} + \frac{7}{8}\mu\mathbf{a}$	**A1**	Allow unsimplified
(v)	$\frac{2}{3}\mathbf{a} + \frac{1}{3}\lambda\mathbf{b} = \frac{1}{8}\mathbf{b} + \frac{7}{8}\mu\mathbf{a}$	**M1**	for equating **(iii)** and **(iv)** and then equating like vectors
	$\frac{2}{3} = \frac{7}{8}\mu,\ \mu = \frac{16}{21}$ Allow 0.762	**A1**	
	$\frac{1}{3}\lambda = \frac{1}{8},\ \lambda = \frac{3}{8}$ Allow 0.375	**A1**	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2014 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 1, maximum raw mark 80

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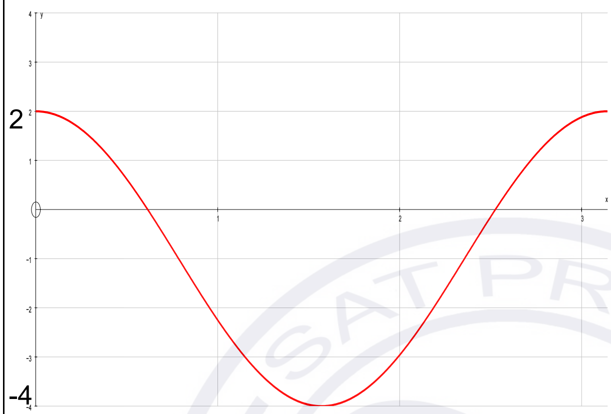
1	$\frac{dy}{dx} = 2x - \frac{16}{x^2}$	**M1** **A1**	for attempt to differentiate all correct
	When $\frac{dy}{dx} = 0$,	**DM1**	for equating $\frac{dy}{dx}$ to zero and an attempt to solve for x.
	$x = 2, y = 12$	**A1**	**A1** for both, but no extra solutions
2 (a)		**B1**	for correct shape
		B1	for max value of 2, starting at (0, 2) and finishing at (180°, 2)
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(b) (i)	4	**B1**	must be positive
(ii)	60° or $\frac{\pi}{3}$ or 1.05 rad	**B1**	
3 (i)	$y = 4(x+3)^{\frac{1}{2}} (+c)$	**M1, A1**	**M1** for $(x+3)^{\frac{1}{2}}$, **A1** for $4(x+3)^{\frac{1}{2}}$
	$10 = 4\left(9^{\frac{1}{2}}\right) + c$	**M1**	for a correct attempt to find c, but must be from an attempt to integrate
	$c = -2$ $y = 4(x+3)^{\frac{1}{2}} - 2$	**A1**	Allow **A1** for $c = -2$
(ii)	$6 = 4(x+3)^{\frac{1}{2}} - 2$ $x = 1$	**A1 ft**	**ft** for substitution into *their* equation to obtain x; must have the first **M1**

4	**(i)**	$5y^2 - 7y + 2 = 0$	**B1, B1**	**B1** for 5, **B1** for –7
	(ii)	$(5y-2)(y-1) = 0$	**M1**	for solution of quadratic equation from **(i)**
		$y = \frac{2}{5}, x = \frac{\ln 0.4}{\ln 5}$	**M1**	for use of logarithms to solve equation of the type $5^x = k$
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		$y = 1, x = 0$	**B1**	
5	**(i)**	$\frac{dy}{dx} = 3x^2 - \frac{1}{x}$	**M1**	for attempt to differentiate
		When $x = 1$, $y = 1$ and $\frac{dy}{dx} = 2$	**B1**	for $y = 1$
		Tangent: $y - 1 = 2(x-1)$	**DM1**	for attempt to find equation of tangent
		$(y = 2x - 1)$	**A1**	allow equation unsimplified
	(ii)	Mid-point (5, 9)	**B1**	for midpoint from given coordinates
		$9 = 2(5) - 1$	**B1**	for checking the mid-point lies on tangent
		Alternative Method: Tangent equation $y = 2x - 1$ Equation of line joining (–2, 16) and (12, 2) $y = -x + 14$ Solve simultaneously $x = 5$, $y = 9$	**B1**	for a complete method to find the coordinates of the point of intersection
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6	**(i)**	$(2 + px)^6 = 64 + 192px + 240p^2x^2 \ldots$	**B1**	for $240p^2$ or $240p^2x^2$ or ${}^6C_2 \times 2^4 \times (px)^2$ or ${}^6C_2 \times 2^4 \times p^2$ or ${}^6C_2 \times 2^4 \times p^2x^2$
		$240p^2 = 60$	**M1**	for equating *their* term in x^2 to 60 and attempt to solve
		$p = \frac{1}{2}$	**A1**	
	(ii)	$(3-x)(64 + 192px + 240p^2x^2 \ldots)$	**B1 ft**	**ft** for $192p$, 96 or 192 × *their p*
		Coefficient of x^2 is $180 - 192p$	**M1**	for $180 - 192p$
		= 84	**A1**	

7	(i)	$\mathbf{A}^{-1} = \frac{1}{5ab}\begin{pmatrix} b & -2b \\ a & 3a \end{pmatrix}$	B1, B1	**B1** for $\frac{1}{5ab}$, **B1** for $\begin{pmatrix} b & -2b \\ a & 3a \end{pmatrix}$
	(ii)	$\mathbf{X} = \mathbf{BA}^{-1}$	M1	for post-multiplication by inverse matrix
		$= \begin{pmatrix} -a & b \\ 2a & 2b \end{pmatrix}\begin{pmatrix} \frac{1}{5a} & -\frac{2}{5a} \\ \frac{1}{5b} & \frac{3}{5b} \end{pmatrix}$	DM1	for correct attempt at matrix multiplication, needs at least one term correct for their BA^{-1} (allow unsimplified)
		$= \begin{pmatrix} 0 & 1 \\ \frac{4}{5} & \frac{2}{5} \end{pmatrix}$	A1 A1	for each correct pair of elements, must be simplified
8	(i)	$\overrightarrow{AB} = \begin{pmatrix} 12 \\ 16 \end{pmatrix}$, at P, $x = -2 + \frac{1}{4}(12)$ so at P, $x = 1$	B1	for convincing argument for $x = 1$
		$y = 3 + \frac{1}{4}(16)$, $y = 7$	B1	for $y = 7$
	(ii)	Gradient of $AB = \frac{16}{12}$, so perp gradient $= -\frac{3}{4}$	M1	for finding gradient of perpendicular
		Perp line: $y - 7 = -\frac{3}{4}(x-1)$	M1	for equation of perpendicular through their P
		$(3x + 4y = 31)$	A1	Allow unsimplified
	(iii)	$Q\left(0, \frac{31}{4}\right)$	B1 ft	**ft** on their perpendicular line, may be implied
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		Area AQB = 12.5	A1	

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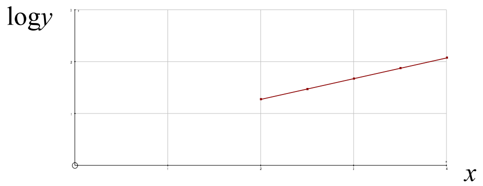
<tr><td></td><td>
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A1 for each</td></tr>
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(ii)	60	**B1**	
(iii)	36	**B1**	
(b) (i)	${}^{8}C_{5} \times {}^{12}C_{5}$	**B1, B1**	**B1** for each, allow unevaluated with no extra terms
	$56 \times 792 = 44352$	**B1**	Final answer must be evaluated and from multiplication
(ii)	4 places are accounted for Gender no longer 'important'	**M1**	for realising that 4 places are accounted or that gender is no longer important
	Need ${}^{16}C_{6} = 8008$	**A1**	for 8008
	Alternative Method $\left({}^{6}C_{6} \times {}^{10}C_{0}\right) + \left({}^{6}C_{5} \times {}^{10}C_{1}\right) \ldots \left({}^{6}C_{0} \times {}^{10}C_{6}\right)$	**M1**	for at least 5 of the 7 cases, allow unsimplified
	$1 + 60 + 675 + 2400 + 3150 + 1512 + 210 = 8008$	**A1**	
11 (a)	$2\cos 3x - \frac{\cos 3x}{\sin 3x} = 0$ $\cos 3x\left(2 - \frac{1}{\sin 3x}\right) = 0$	**M1**	for use of $\cot 3x = \frac{\cos 3x}{\sin 3x}$, may be implied
	Leading to $\cos 3x = 0,\ 3x = 90^\circ,\ 270^\circ$	**DM1**	for attempt to solve $\cos 3x = 0$ correctly from correct factorisation to obtain x
	$x = 30^\circ, 90^\circ$	**A1**	**A1** for both, no excess solutions in the range
	and $\sin 3x = \frac{1}{2},\ 3x = 30^\circ,\ 150^\circ$	**DM1**	for attempt to solve $\sin 3x = \frac{1}{2}$ correctly to obtain x
	$x = 10^\circ, 50^\circ$	**A1**	**A1** for both, condone excess solutions
(b)	$\cos\left(y + \frac{\pi}{2}\right) = -\frac{1}{2}$	**M1**	for dealing with sec $\left(y + \frac{\pi}{2}\right)$ correctly
	$y + \frac{\pi}{2} = \frac{2\pi}{3}, \frac{4\pi}{3}$	**DM1**	for correct order of operations, must not mix degrees and radians
	so $y = \frac{\pi}{6}, \frac{5\pi}{6}$ (0.524, 2.62)	**A1, A1**	

12 **(i)**	$\overrightarrow{AQ} = \lambda\mathbf{b} - \mathbf{a}$	**B1**	
(ii)	$\overrightarrow{BP} = \mu\mathbf{a} - \mathbf{b}$	**B1**	
(iii)	$\overrightarrow{OR} = \mathbf{a} + \frac{1}{3}(\lambda\mathbf{b} - \mathbf{a})$ or $\lambda\mathbf{b} - \frac{2}{3}(\lambda\mathbf{b} - \mathbf{a})$	**M1**	for $\mathbf{a} + \frac{1}{3}$ *their* **(i)**
	$= \frac{2}{3}\mathbf{a} + \frac{1}{3}\lambda\mathbf{b}$	**A1**	Allow unsimplified
(iv)	$\overrightarrow{OR} = \mathbf{b} + \frac{7}{8}(\mu\mathbf{a} - \mathbf{b})$ or $\mu\mathbf{a} - \frac{1}{8}(\mu\mathbf{a} - \mathbf{b})$	**M1**	for $\mathbf{b} + \frac{7}{8}$ *their* **(ii)**
	$= \frac{1}{8}\mathbf{b} + \frac{7}{8}\mu\mathbf{a}$	**A1**	Allow unsimplified
(v)	$\frac{2}{3}\mathbf{a} + \frac{1}{3}\lambda\mathbf{b} = \frac{1}{8}\mathbf{b} + \frac{7}{8}\mu\mathbf{a}$	**M1**	for equating **(iii)** and **(iv)** and then equating like vectors
	$\frac{2}{3} = \frac{7}{8}\mu,\ \mu = \frac{16}{21}$ Allow 0.762	**A1**	
	$\frac{1}{3}\lambda = \frac{1}{8},\ \lambda = \frac{3}{8}$ Allow 0.375	**A1**	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2014 series

0606 ADDITIONAL MATHEMATICS

0606/13 Paper 1, maximum raw mark 80

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1	$a = 3$ $b = 2$ $c = 4$	**B1** **B1** **B1**	
2	$x^2 = 16$ or $y^2 - 4y + 3 = 0$	**M1**	for correct elimination of one variable and attempt to form a quadratic equation in x or y.
	$x = \pm 4$ $y = 1, 3$ Points (–4, 1) and (4, 3)	**A1** **A1**	
	Line $AB = \sqrt{8^2 + 2^2}$	**M1**	for use of Pythagoras theorem
	$= \sqrt{68}$ or $2\sqrt{17}$	**A1**	allow either form
3 (i)	$\text{n}(A) = 2$ $\text{n}(B) = 3$ $\text{n}(C) = 0$	**B1** **B1** **B1**	**B0** for n(2), $\{2\}, \{0\}, \varnothing$, {} etc.
(ii)	$A \cup B = \{-1, -2, -3, 3\}$	**B1**	
(iii)	$A \cap B = \{-2\}$	**B1**	
(iv)	ξ, 'the universal set', R, 'real numbers', $\{x : x \in \quad\}$	**B1**	
4 (a)	$\tan x = -\frac{5}{3}$	**M1**	Correct statement or $\tan x = -1.67$
	$x = 121.0°,\ 301.0°$	**A1** **A1ft**	**A1** for either correct solution **ft** from *their* first solution
(b)	$\sin\left(3y + \frac{\pi}{4}\right) = \frac{1}{2}$	**M1**	for dealing correctly with cosec and attempt to solve subsequent equation
	$3y + \frac{\pi}{4} = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{13\pi}{6}, \frac{17\pi}{6}$	**A1**	for $\frac{\pi}{6}, \frac{5\pi}{6}$, or $\frac{13\pi}{6}$, or $\frac{17\pi}{6}$
	$3y = -\frac{\pi}{12}, \frac{7\pi}{12}, \frac{23\pi}{12}, \frac{31\pi}{12}$	**DM1**	for correct order of operations
	$y = \frac{7\pi}{36}, \frac{23\pi}{36}, \frac{31\pi}{36}$ (0.611, 2.01 and 2.71)	**A1, A1**	**A1** for one correct solution **A1** for both the other correct solutions and no others in range.

5 (a) (i)	$\begin{pmatrix}12 & 2 & 1\\9 & 3 & 0\\8 & 5 & 1\\11 & 2 & 0\end{pmatrix}\begin{pmatrix}0.5\\0.4\\0.45\end{pmatrix}=\begin{pmatrix}7.25\\5.70\\6.45\\6.30\end{pmatrix}$	M1	for correct compatible matrices in the correct order. Allow 1 error in each matrix. Allow if done in cents
	or $\begin{pmatrix}0.5 & 0.4 & 0.45\end{pmatrix}\begin{pmatrix}12 & 9 & 8 & 11\\2 & 3 & 5 & 2\\1 & 0 & 1 & 0\end{pmatrix}$	DM1	for a correct method for multiplying their matrices to obtain an appropriate 4 by 1 or 1 by 4 matrix.
	$=\begin{pmatrix}7.25 & 5.70 & 6.45 & 6.30\end{pmatrix}$	A2,1,0	**A2** all correct or **A1** 3 correct elements.
(ii)	25.70	B1	Allow 25.7
(b)	$\mathbf{Y}=\mathbf{X}^{-1}$ or $\mathbf{Y}=\mathbf{X}^{-1}\mathbf{I}$	M1	for matrix algebra
	$\mathbf{Y}=\frac{1}{22}\begin{pmatrix}1 & -4\\5 & 2\end{pmatrix}$ or $\begin{pmatrix}\frac{1}{22} & -\frac{4}{22}\\\frac{5}{22} & \frac{2}{22}\end{pmatrix}$	A1	for $\frac{1}{22}\begin{pmatrix} & \\ & \end{pmatrix}$
		A1	for $k\begin{pmatrix}1 & -4\\5 & 2\end{pmatrix}$
	Alternative method: $\begin{pmatrix}2 & 4\\-5 & 1\end{pmatrix}\begin{pmatrix}a & b\\c & d\end{pmatrix}=\begin{pmatrix}1 & 0\\0 & 1\end{pmatrix}$ $2a+4c=1,\ 2b+4d=0$ $-5a+c=0,\ -5b+d=1$	M1	for a complete method using simultaneous equations
		A1	$a=\frac{1}{22}$ and $c=\frac{5}{22}$ or $b=-\frac{4}{22}$ and $d=\frac{2}{22}$
	leading to $=\frac{1}{22}\begin{pmatrix}1 & -4\\5 & 2\end{pmatrix}$ oe	A1	for correct matrix

6 (i)	$\cos 0.9 = \frac{6}{OC}$ or $\frac{OC}{\sin 0.9} = \frac{12}{\sin(\pi - 1.8)}$ $OC = \frac{6}{\cos 0.9} = 9.652...$ or $OC = \frac{12 \sin 0.9}{\sin(\pi - 1.8)} = 9.652...$	**M1** **A1**	for correct use of cosine, sine rule, cosine rule or any other valid method for manipulating correctly to $OC = 9.652(35…)$ Must have 4th figure (or more) for rounding
(ii)	Perimeter = $(0.9 \times 12) + 9.652 + (12 - 9.652)$ $= 22.8$	**B1** **M1** **A1**	for arc length for attempt to add the correct lengths
(iii)	Area $= \left(\frac{1}{2} \times 12^2 \times 0.9\right) - \left(\frac{1}{2} \times 9.652^2 \sin(\pi - 1.8)\right)$ 64.8 – 45.36 = 19.4 to 19.5	**B1** **B1** **B1**	for area of sector, allow unsimplified for area of isosceles triangle $\frac{1}{2}(9.65(2...))^2 \sin(\pi - 1.8)$ or $\frac{1}{2}(12 \times 6 \tan 0.9)$ or $\frac{1}{2}(12 \times 9.65(2...) \times \sin 0.9)$, allow unsimplified. for answer in range 19.4 to 19.5
	Alternative Method: $\frac{1}{2}(12 - 9.652) \times 9.652 \times \sin 1.8$ $\frac{1}{2} 12^2 (0.9 - \sin 0.9)$ 11.04 + 8.40 Area =19.4 to 19.5	 **B1** **B1** **B1**	 for area of triangle *ACB*, unsimplified for area of segment, unsimplified answer in range 19.4 to 19.5
7	$1 + 2\log_5 x = \log_5(18x - 9)$ $\log_5 5 + \log_5 x^2 = \log_5(18x - 9)$ $5x^2 = 18x - 9$ $(5x - 3)(x - 3) = 0$ $x = \frac{3}{5},\ 3$	**B1, B1** **M1** **DM1** **A1**	**B1** for dealing with '1', **B1** for dealing with '2' for a correct use of addition or subtraction of logarithms for elimination of logarithms to form a 3 term quadratic and for solution of quadratic for both *x* values

8 (i)	$f'(x) = \left(x \times \frac{3x^2}{x^3}\right) + (\ln x^3)$	**M1**	for differentiation of a product
		B1	for differentiation of $\ln x^3$
	$= 3 + 3\ln x$, $= 3(1 + \ln x)$	**A1**	for simplification to gain <u>given answer</u>
	or $f(x) = 3x\ln x$	**B1**	for use of $\ln x^3 = 3\ln x$
	$f'(x) = \left(3x \times \frac{1}{x}\right) + 3\ln x$,	**M1**	for differentiation of a product
	$= 3(1 + \ln x)$	**A1**	for simplification to gain <u>given answer</u>
(ii)	$\int 3(1 + \ln x)\mathrm{d}x = x\ln x^3$ or $3x\ln x$	**M1**	for realising that differentiation is the reverse of integration and using **(i)**
	$\int 1 + \ln x\mathrm{d}x = \frac{1}{3}x\ln x^3$ or $x\ln x$	**A1**	
(iii)	$x\ln x - \int 1\mathrm{d}x$ or $\left[\frac{1}{3}x\ln x^3\right] - \int 1\mathrm{d}x$	**DM1**	for using answer to **(ii)** and subtracting $\int 1\mathrm{d}x$ dependent on M mark in **(ii)**
	$[x\ln x - x]_1^2$ or $\left[\frac{1}{3}x\ln x^3 - x\right]_1^2$	**DM1**	for correct application of limits
	$= 2\ln 2 - 2 + 1$ $= -1 + \ln 4$	**A1**	from correct working
9 (a)	$5^p = 625$, so $p = 4$	**B1**	
	${}^4C_1 5^{p-1}(-q) = -1500$ $4 \times 125(-q) = -1500$	**M1**	*their p* substituted in ${}^pC_1 5^{p-1}(-q)$ or in ${}^pC_1 5^{p-1}(-qx)$ unsimplified
	$q = 3$	**A1**	
	${}^4C_2 5^{p-2} q^2 = r$	**M1**	*their p* and *q* substituted in ${}^pC_2 5^{p-2}(-q)^2$ or ${}^pC_2 5^{p-2}(-qx)^2$ unsimplified
	$r = 1350$	**A1**	
(b)	${}^{12}C_3 (2x)^9 \left(\frac{1}{4x^3}\right)^3$	**M1**	for identifying correct term
		DM1	for attempt to evaluate correct expression
	Term is 1760	**A1**	must be evaluated

10	(a)	$\frac{5^x}{5^{2(3y-2)}}=1$ or $\frac{3^x}{3^{3(y-1)}}=3^4$ oe	M1	for obtaining one correct equation in powers of 5, 3, 25, 27 or 81
		$x=6y-4$	A1	for $x=6y-4$ oe linear equation
		$x=3y+1$	A1	for $x=3y+1$ oe linear equation
			M1	for attempt to solve linear simultaneous equations which have been obtained correctly
		Leads to $x=6,\ y=\frac{5}{3}$	A1	for both.
	(b)	Using the cosine rule: $(1+2\sqrt{3})^2=(2+\sqrt{3})^2+2^2-4(2+\sqrt{3})\cos A$	M1	for correct substitution in cosine rule, may use in form of $\cos A=...$
		$\cos A=\frac{(13+4\sqrt{3})-(7+4\sqrt{3})-4}{-4(2+\sqrt{3})}$ oe	DM1	for attempt to make cos$A$ subject and simplify
		$\cos A=\frac{-1}{2(2+\sqrt{3})}\times\frac{2-\sqrt{3}}{2-\sqrt{3}}$	DM1	for rationalisation.
		$\cos A=-1+\frac{\sqrt{3}}{2}$	A1	

11 (i)	$\frac{dy}{dx} = (x+5)2(x-1)+(x-1)^2$	**M1**	for differentiation of a product, allow unsimplified
		A1	correct
	$\frac{dy}{dx} = (x-1)(3x+9)$		
	When $\frac{dy}{dx} = 0$	**DM1**	for equating to zero and solution of quadratic
	$x = 1$	**A1**	
	$x = -3$	**A1**	
	Alternative method:		
	$y = x^3 + 3x^2 - 9x + 5$	**M1**	for expansion of brackets and differentiation of each term of a 4 term cubic
	$\frac{dy}{dx} = 3x^2 + 6x - 9$	**A1**	
	When $\frac{dy}{dx} = 0$	**DM1**	for equating to zero and solution of 3 term quadratic
	$x = 1$	**A1**	from correct quadratic equation
	$x = -3$	**A1**	from correct quadratic equation
(ii)	$\int x^3 + 3x^2 - 9x + 5 dx$	**M1**	for correct attempt to obtain and integrate a 4 term cubic
	$= \frac{x^4}{4} + x^3 - \frac{9x^2}{2} + 5x \ (+c)$	**A2,1,0**	**A2** for 4 correct terms or **A1** for 3 correct terms
(iii)	$\left[\frac{x^4}{4} + x^3 - \frac{9x^2}{2} + 5x\right]_{-5}^{1}$	**M1**	for correct substitution of limits 1 and –5 for *their* **(ii)**
	$= \left(\frac{1}{4} + 1 - \frac{9}{2} + 5\right) - \left(\frac{625}{4} - 125 - \frac{225}{2} - 25\right)$		
	$= 108$	**A1**	
(iv)	When $x = -3, y = 32$	**M1**	for realising that the *y*-coordinate of the maximum point is needed.
	$k > 32$	**A1**	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the May/June 2014 series

0606 ADDITIONAL MATHEMATICS

0606/11 Paper 1, maximum raw mark 80

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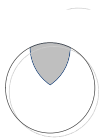
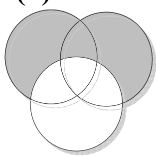
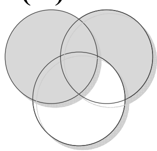
1	$\text{LHS} = \dfrac{\sin\theta}{\cos\theta} + \dfrac{\cos\theta}{1+\sin\theta}$	B1	**B1** for use of $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$
	$= \dfrac{\sin\theta(1+\sin\theta)+\cos^2\theta}{\cos\theta(1+\sin\theta)}$	M1	**M1** for attempt to obtain a single fraction
	$= \dfrac{1+\sin\theta}{\cos\theta(1+\sin\theta)}$	DM1	**DM1** for use of $\sin^2\theta+\cos^2\theta=1$
	$= \dfrac{1}{\cos\theta}$ leading to $\sec\theta$	A1	**A1** for 'finishing off'
	Alternative solution:		
	$\text{LHS} = \dfrac{\sin\theta}{\cos\theta} + \dfrac{\cos\theta\,(1\text{-}\sin\theta)}{(1+\sin\theta)(1\text{-}\sin\theta)}$	B1	**B1** for use of $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$
	$= \dfrac{\sin\theta}{\cos\theta} + \dfrac{\cos\theta(1-\sin\theta)}{\cos^2\theta}$	M1	**M1** for multiplication by $(1-\sin\theta)$
	$= \dfrac{\sin\theta}{\cos\theta} + \dfrac{(1-\sin\theta)}{\cos\theta}$	DM1	**DM1** for use of $\sin^2\theta+\cos^2\theta=1$
	$= \dfrac{1}{\cos\theta}$ leading to $\sec\theta$	A1	**A1** for 'finishing off'
	Alternative solution:		
	$\text{LHS} = \dfrac{\tan\theta(1+\sin\theta)+\cos\theta}{1+\sin\theta}$	M1	**M1** for attempt to obtain a single fraction
	$= \dfrac{\dfrac{\sin\theta}{\cos\theta}+\dfrac{\sin^2}{\cos\theta}+\cos\theta}{1+\sin\theta}$	B1	**B1** for use of $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$
	$= \dfrac{\sin\theta+\sin^2\theta+\cos^2\theta}{\cos\theta(1+\sin\theta)}$		
	$= \dfrac{1+\sin\theta}{\cos\theta(1+\sin\theta)}$	DM1	**DM1** for use of $\sin^2\theta+\cos^2\theta=1$
	$= \dfrac{1}{\cos\theta}$ leading to $\sec\theta$	A1	**A1** for 'finishing off'

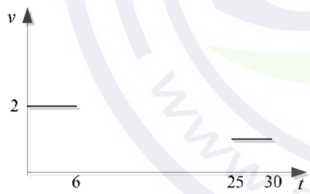
2	(i)	$\lvert\mathbf{a}\rvert = \sqrt{4^2 + 3^2} = 5$ $\lvert\mathbf{b}+\mathbf{c}\rvert = \sqrt{(-3)^2 + 4^2} = 5$	M1 A1	**M1** for finding the modulus of either **a** or **b** + **c** **A1** for completion
	(ii)	$\lambda\begin{pmatrix}4\\3\end{pmatrix} + \mu\begin{pmatrix}2\\2\end{pmatrix} = 7\begin{pmatrix}-5\\2\end{pmatrix}$		
		$4\lambda + 2\mu = -35$ and $3\lambda + 2\mu = 14$	M1	**M1** for equating like vectors and obtaining 2 linear equations
			DM1	**DM1** for solution of simultaneous equations
		leading to $\lambda = -49$, $\mu = 80.5$	A1	**A1** for both

3 (a) (i)  (ii)  (iii) 

(b) (i)

(ii)

6	(i)	$\mathbf{AB} = \begin{pmatrix} 10 & 19 \\ 32 & 37 \\ 14 & 14 \end{pmatrix}$	M1 A1	**M1** for at least 3 correct elements of a 3×2 matrix **A1** for all correct
	(ii)	$\mathbf{B}^{-1} = \frac{1}{7}\begin{pmatrix} 5 & -1 \\ -3 & 2 \end{pmatrix}$	B1 B1	**B1** for $\frac{1}{7}$, **B1** for $\begin{pmatrix} 5 & -1 \\ -3 & 2 \end{pmatrix}$
	(iii)	$2\begin{pmatrix} 2 & 1 \\ 3 & 5 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} -3 \\ -22 \end{pmatrix}$	M1	**M1** for obtaining in matrix form
		$\begin{pmatrix} x \\ y \end{pmatrix} = \frac{1}{7}\begin{pmatrix} 5 & -1 \\ -3 & 2 \end{pmatrix}\begin{pmatrix} -1.5 \\ -11 \end{pmatrix} = \frac{1}{7}\begin{pmatrix} 3.5 \\ -17.5 \end{pmatrix}$	M1	**M1** for pre-multiplying by $\mathbf{B}^{-1}$
		$x = 0.5,\ y = -2.5$	A1	**A1** for both
7	(i)	$y = 2x^2 - \frac{1}{x+1}(+c)$	B1 B1	**B1** for each correct term
		when $x = \frac{1}{2},\ y = \frac{5}{6}$ so $\frac{5}{6} = \frac{1}{2} - \frac{2}{3} + c$	M1	**M1** for attempt to find $+c$, must have at least 1 of the previous B marks
		leading to $c = 1$ $\left(y = 2x^2 - \frac{1}{x+1} + 1\right)$	A1	Allow **A1** for $c = 1$
	(ii)	When $x = 1,\ y = \frac{5}{2}$	M1	**M1** for using $x = 1$ in their **(i)** to find y
		$\frac{dy}{dx} = \frac{17}{4}$ so gradient of normal $= -\frac{4}{17}$	B1	**B1** for gradient of normal
		Equation of normal $y - \frac{5}{2} = -\frac{4}{17}(x-1)$	DM1	**DM1** for attempt at **normal** equation
		$(8x + 34y - 93 = 0)$	A1	**A1** – allow unsimplified (fractions must not contain decimals)

8	**(i)**	$\log p = n\log V + \log k$	**B1**	**B1** for statement, but may be implied by later work.
		<table><tr><td>ln$V$</td><td>2.30</td><td>3.91</td><td>4.61</td><td>5.30</td></tr><tr><td>ln$p$</td><td>4.55</td><td>2.14</td><td>1.10</td><td>0.10</td></tr></table> <table><tr><td>lg$V$</td><td>1</td><td>1.70</td><td>2</td><td>2.30</td></tr><tr><td>lg$p$</td><td>1.98</td><td>0.93</td><td>0.48</td><td>0.04</td></tr></table>		
		 	**M1** **A2,1,0**	**M1** for plotting a suitable graph –1 for each error in points plotted
	(ii)	Use of gradient = n $n = -1.5$ (allow –1.4 to –1.6)	**DM1** **A1**	**DM1** for equating numerical gradient to n
	(iii)	Allow 13 to 16	**DM1** **A1**	**DM1** for use of *their* graph or substitution into *their* equation.
9	**(a)**	Distance travelled = area under graph $= \frac{1}{2}(60+20)\times 12 = 480$	**M1** **A1**	**M1** for realising that area represents distance travelled and attempt to find area
	(b)	 	**B1** **B1** **B1**	**B1** for velocity of 2 ms^{-1} for $0 \leqslant t \leqslant 6$ **B1** for velocity of zero for *their* '6' to *their* '25' **B1** for velocity of 1 ms^{-1} for $25 \leqslant t \leqslant 30$
	(c) (i)	$v = 4 - \frac{16}{t+1}$ When $v = 0,\ t = 3$	**M1** **DM1** **A1**	**M1** for attempt at differentiation **DM1** for equating velocity to zero and attempt to solve
	(ii)	$a = \frac{16}{(t+1)^2}$ $0.25(t+1)^2 = 16$ $t = 7$	**M1** **A1**	**M1** for attempt at differentiation and equating to 0.25 with attempt to solve

10 (a)	1 digit even numbers 2	**B1**	
	2 digit even numbers $4 \times 2 = 8$	**B1**	
	3 digit even numbers $3 \times 3 \times 2 = 18$	**B1**	
	Total = 28	**B1**	
(b) (i)	3M 5W = 35 4M 4W = 175 5M 3W = 210	**B1** **B1** **B1**	
	Total = 420	**B1**	**B1** for addition to obtain final answer, must be evaluated.
	or ${}^{12}C_8$ – 6M 2W – 7M 1W 495 – 70 – 5 = 420		**or**: as above, final **B1** for subtraction to get final answer
(ii)	Oldest man in, oldest woman out and vice–versa		
	${}^{10}C_7 \times 2 = 240$	**B1, B1**	**B1** for ${}^{10}C_7$, B1 for realising there are 2 identical cases
	Alternative: 1 man out 1 woman in 6 men 4 women		
	6M 1W : ${}^6C_6 \times {}^4C_1 = 4$ 5M 2W : ${}^6C_5 \times {}^4C_2 = 36$ 4M 3W : ${}^6C_4 \times {}^4C_3 = 60$ 3M 4W : ${}^6C_3 \times {}^4C_4 = 20$ Total = 120	**B1**	All separate cases correct for **B1**
	There are 2 identical cases to consider, so 240 ways in all.	**B1**	**B1** for realising there are 2 identical cases, which have integer values

11 (a)			**In each case the last A mark is for a second correct solution and no extra solutions within the range**
	$5\sin 2x + 3\cos 2x = 0$	M1	**M1** for use of tan
	$\tan 2x = -0.6$	DM1	**DM1** for dealing with $2x$ correctly
	$2x = 149°, 329°$		
	$x = 74.5°, 164.5°$	A1,A1	**A1** for each
	Alternatives: $\sin(2x + 31°) = 0$ or $\cos(2x - 59°) = 0$	M1	**M1** for either, then mark as above
(b)	$2\cot^2 y + 3\text{cosec}y = 0$		
	$2(\text{cosec}^2 y - 1) + 3\text{cosec}y = 0$	M1	**M1** for use of correct identity
	$2\text{cosec}^2 y + 3\text{cosec}y - 2 = 0$		
	$(2\text{cosec}y - 1)(\text{cosec}y + 2) = 0$	M1	**M1** for attempt to factorise a 3 term quadratic equation
	One valid solution $\text{cosec}y = -2,\ \sin y = -\frac{1}{2}$		
	$y = 210°, 330°$	A1,A1	**A1** for each
	Alternative: $2\frac{\cos^2 y}{\sin^2 y} + \frac{3}{\sin y} = 0$	M1	**M1** for use of $\cot y = \frac{\cos y}{\sin y}$ and $\text{cosec}y = \frac{1}{\sin y}$
	leads to $2\sin^2 y - 3\sin y - 2 = 0$ and $\sin y = -\frac{1}{2}$ only	M1	**M1** for attempt to factorise a 3 term quadratic equation
	$y = 210°, 330°$	A1A1	
(c)	$3\cos(z + 1.2) = 2$		
	$\cos(z + 1.2) = \frac{2}{3}$		
	$(z + 1.2) = 0.8411, 5.442, 7.124$	M1	**M1** for correct order of operations to end up with 0.8411 radians or better
	$z = 4.24, 5.92$	A1	**A1** for one of 5.441 or 7.124 (or better)
		A1A1	**A1** for each valid solution

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the May/June 2014 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 1, maximum raw mark 80

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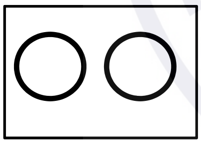
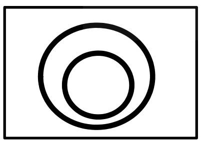
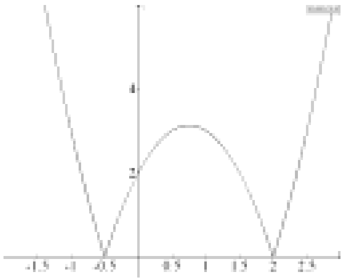
1	$\dfrac{\cos^2 A + (1+\sin A)^2}{(1+\sin A)\cos A}$	M1	**M1** for obtaining a single fraction, correctly
	$\dfrac{\cos^2 A + 1 + 2\sin A + \sin^2 A}{(1+\sin A)\cos A}$	M1	**M1** for expansion of $(1+\sin A)^2$ and use of identity
	$=\dfrac{2(1+\sin A)}{(1+\sin A)\cos A}$	DM1	**DM1** for factorisation and cancelling of $(1+\sin A)$ factor
	$=\dfrac{2}{\cos A} = 2\sec A$	A1	**A1** for use of $\dfrac{1}{\cos A} = \sec A$ and final answer
	Alternative:		
	$\dfrac{\cos A(1-\sin A)}{(1+\sin A)(1-\sin A)} + \dfrac{1+\sin A}{\cos A}$	M1	**M1** for multiplying first term by $\dfrac{1-\sin A}{1-\sin A}$
	$=\dfrac{\cos A(1-\sin A)}{1-\sin^2 A} + \dfrac{1+\sin A}{\cos A}$		
	$=\dfrac{\cos A(1-\sin A)}{\cos^2 A} + \dfrac{1+\sin A}{\cos A}$	M1	**M1** for expansion of $(1-\sin A)(1+\sin A)$ and use of identity
	$=\dfrac{1-\sin A}{\cos A} + \dfrac{1+\sin A}{\cos A}$	M1	**M1** for simplification of the 2 terms
	$=\dfrac{2}{\cos A} = 2\sec A$	A1	**A1** for use of $\dfrac{1}{\cos A} = \sec A$ and final answer
2 (a) (i)		B1	
(i)		B1	
(b) (i)	6	B1	
(ii)	5	B1	
(iii)	9	B1	

3 (i)		**B1** **B1** **B1**	**B1** for shape **B1** for $y = 2$ (must have a graph) **B1** for $x = -0.5$ and 2 (must have a graph)
(ii)	Maximum point occurs when $y = \frac{25}{8}$	**M1**	**M1** for obtaining the value of y at the maximum point, by either completing the square, differentiation, use of discriminant or symmetry.
	so $k > \frac{25}{8}$	**A1**	Must have the correct sign for **A1** Ignore any upper limits
4	$\int_0^a \sin 3x \, dx = \frac{1}{3} \, dx = \frac{1}{3}$	**B1,B1**	**B1** for $k\cos 3x$ **only**, **B1** for $-\frac{2}{3}\cos 3x$ **only**
	$\left[-\frac{2}{3}\cos 3x\right]_0^a = \frac{1}{3}$	**M1**	**M1** for correct substitution of the correct limits into their result
	$\left(-\frac{2}{3}\cos 3a\right) - \left(-\frac{2}{3}\right) = \frac{1}{3}$	**A1**	**A1** for correct equation
	$\cos 3a = 0.5$	**M1**	**M1** for correct method of solution of equation of the form $\cos ma = k$
	$3a = \frac{\pi}{3}$, $a = \frac{\pi}{9}$	**A1**	**A1** allow 0.349, must be a radian answer
5 (i)	$2^{5x} \times 2^{2y} = 2^{-3}$ leads to $5x + 2y = -3$	**B1, B1** **DB1**	**B1** for 2^{2y}, **B1** for 2^{-3}, **B1** for dealing with indices correctly to obtain given answer
(ii)	$7^x \times 49^{2y} = 1$ can be written as $x + 4y = 0$	**B1** **B1**	**B1** for either 7^{4y} or 7^0 seen **B1** for $x + 4y = 0$
	Solving $5x + 2y = -3$ and $x + 4y = 0$ leads to	**M1**	**M1** for solution of their simultaneous equations, must both be linear
	$x = -\frac{2}{3}$, $y = \frac{1}{6}$	**A1**	**A1** for both, allow equivalent fractions only

6	(a)	**YX** and **ZY**	B1,B1	**B1** for each, must be in correct order,
	(b)	$\mathbf{B} = \mathbf{A}^{-1}\begin{pmatrix} 3 & 9 \\ -6 & -3 \end{pmatrix}$,	M1	**M1** for pre-multiplication by $\mathbf{A}^{-1}$
		$= -\frac{1}{3}\begin{pmatrix} 1 & 2 \\ 4 & 5 \end{pmatrix}\begin{pmatrix} 3 & 9 \\ -6 & -3 \end{pmatrix}$	B1,B1	**B1** for $-\frac{1}{3}$, **B1** for $\begin{pmatrix} 1 & 2 \\ 4 & 5 \end{pmatrix}$
		$= -\frac{1}{3}\begin{pmatrix} -9 & 3 \\ -18 & 21 \end{pmatrix}$ or $\begin{pmatrix} 3 & -1 \\ 6 & -7 \end{pmatrix}$	DM1 A1	**DM1** for attempt at matrix multiplication **A1** allow in either form
		Alternative method:		
		$\begin{pmatrix} 5 & -2 \\ -4 & 1 \end{pmatrix}\begin{pmatrix} a & b \\ c & d \end{pmatrix} = \begin{pmatrix} 3 & 9 \\ -6 & -3 \end{pmatrix}$	M1	**M1** for a complete method to obtain 4 equations
		Leads to $5a - 2c = 3$, $5b - 2d = 9$ $-4a + c = -6$, $-4b + d = -3$	A2,1,0	–1 for each incorrect equation
		Solutions give matrix	M1	**M1** for solution to find 4 unknowns
		$-\frac{1}{3}\begin{pmatrix} -9 & 3 \\ -18 & 21 \end{pmatrix}$ or $\begin{pmatrix} 3 & -1 \\ 6 & -7 \end{pmatrix}$	A1	**A1** for a correct, final matrix

7	(i)	$\sin\frac{\theta}{2}=\frac{6}{8}$, $\frac{\theta}{2}=0.8481$ or better or $12^2=8^2+8^2-128\cos\theta$	M1	**M1** for a complete method to find either θ or $\frac{\theta}{2}$
		$\theta=1.6961$ or better	A1	Answer given.
		or using areas $\frac{1}{2}\times 12\times 2\sqrt{7}=\frac{1}{2}8^2\sin\theta$ oe $\sin\theta=0.9922$, $\theta=1.4455$ or 1.6961	M1 A1	**M1** for using the area of the triangle in 2 different forms **A1** for choosing the correct angle.
	(ii)	Arc length = $(2\pi-1.696)\times 8$	M1	**M1** for correct attempt at a minor or major arc length
		$(36.697 \text{ or } 36.7)$	A1	**A1** for correct major arc length, allow unsimplified
		Perimeter = $12+(2\pi-1.696)\times 8$ $=48.7$	A1	**A1** for 48.7 or better
	(iii)	Area $=\frac{8^2}{2}(2\pi-1.696)+\frac{8^2}{2}\sin 1.696$	M1,M1	**M1** for correct attempt to find area of major sector
		$=178.5,\ 178.6,$ awrt 179	A1	**M1** for correct attempt to find area of triangle, using any method
		Alternative: Area = $\pi 8^2-\left(\frac{1}{2}8^2(1.696)-\frac{8^2}{2}\sin 1.696\right)$		**M1** for attempt at area of circle – area of minor sector **M1** for area of triangle

8 (a) (i)	720	**B1**	
(ii)	240	**B1**	
(iii)	Starts with either a 2 or a 4: 48 ways	**B1**	allow unevaluated
	Does not start with either a 2 or a 4: 96 ways (i.e. starts with 1 or 5)	**B1**	allow unevaluated
	Total = 144	**B1**	must be evaluated
	Alternative 1:		
	Ends with a 2, starts with a 1,4 or 5 : 72 ways	**B1**	
	Ends with a 4, starts with a 1,2 or 5 : 72 ways	**B1**	
	Total =144	**B1**	
	Alternative 2:		
	$240-\left(2\times 2\times {}^4P_3\right)$ or $\left(4\times {}^4P_3\times 2\right)-\left(2\, {}^4P_3\right)$	**B2**	**B2** for correct expression seen, allow *P* notation
	$=144$	**B1**	
	Alternative 3:		
	${}^3P_1\times {}^4P_3\times {}^2P_1$ or $3\times 4\times 2$	**B2**	Allow *P* notation here, for **B2**
	$=144$	**B1**	
(b)	With twins : ${}^{16}C_4\ \ (=1820)$	**B1**	
	Without twins: ${}^{16}C_6\ \ (=8008)$	**B1**	
	Total: 9828	**B1**	
	Alternative:		
	${}^{18}C_6-\left(2\times {}^{16}C_5\right)$	**B1,B1**	**B1** for ${}^{18}C_6-\ldots$, , **B1** for $2\times {}^{16}C_5$
	$=9828$	**B1**	

9	(i)	$h = \dfrac{4000}{\pi r^2}$ or $\pi r^2 h = 4000$	B1	
		$A = 2\pi rh + 2\pi r^2$		
		$A = 2\pi r \dfrac{4000}{\pi r^2} + 2\pi r^2$	M1 A1	**M1** for substitution of h or πrh into *their* equation for A **A1** Answer given
	(ii)	$\dfrac{dA}{dr} = -\dfrac{8000}{r^2} + 4\pi r$	B1, B1	**B1** for each term correct
		When $\dfrac{dA}{dr} = 0$, $r^3 = \dfrac{8000}{4\pi}$	M1	**M1** for equating to zero and attempt to find r^3
		leading to $A = 1395,\ 1390$	M1 A1	**M1** for substitution of their r to obtain A. **A1** for 1390 or awrt 1395
		$\dfrac{d^2A}{dr^2} = \dfrac{16000}{r^3} + 4\pi$, which, is positive so a minimum.	√B1	√**B1** for a complete correct method and conclusion.

10	(i)	Velocity $= 26\times\frac{1}{13}(5\mathbf{i}+12\mathbf{j})$ $= 10\mathbf{i}+24\mathbf{j}$	M1 A1	**M1** for $\frac{1}{13}(5\mathbf{i}+12\mathbf{j})$
		Alternative 1: $\lvert 10\mathbf{i}+24\mathbf{j}\rvert=\sqrt{10^2+24^2}$ $=26$	M1	**M1** for working from given answer to obtain the given speed
		Showing that one vector is a multiple of the other, hence same direction	A1	**A1** for a completely correct method
		Alternative 2: $\sqrt{5^2+12^2}=13$, $13k=26$, so $k=2$ Velocity $=2(5\mathbf{i}+12\mathbf{j})$,	M1	**M1** for attempt to obtain the 'multiple' and apply to the direction vector
		Velocity $=10\mathbf{i}+24\mathbf{j}$	A1	**A1** for a completely correct method
		Alternative 3: Use of trig: $\tan\alpha=\frac{12}{5}$, $\alpha=67.4°$ Velocity $26\cos 67.4°\mathbf{i}+26\sin 67.4\mathbf{j}$	M1	**M1** for reaching this stage
		Velocity $= 10\mathbf{i}+24\mathbf{j}$	A1	**A1** for a completely correct method
	(ii)	Position vector $= 4(10\mathbf{i}+24\mathbf{j})$ or $40\mathbf{i}+96\mathbf{j}$	B1	Allow either form for **B1**
	(iii)	$(40\mathbf{i}+96\mathbf{j})+(10\mathbf{i}+24\mathbf{j})t$ oe	M1 A1	**M1** for *their* $(\mathbf{ii})+(10\mathbf{i}+24\mathbf{j})t$ or $(10\mathbf{i}+24\mathbf{j})\times(t+4)$ **A1** correct answer only
	(iv)	$(120\mathbf{i}+81\mathbf{j})+(-22\mathbf{i}+30\mathbf{j})t$ oe	B1	
	(v)	$40+10t=120-22t$ or $96+24t=81+30t$	M1	**M1** for equating like vectors
		$t=2.5$ or 18:30	A1	**A1** Allow for $t=2.5$
		Position vector $=65\mathbf{i}+156\mathbf{j}$	DM1 A1	**DM1** for use of t to obtain position vector **A1** cao

11 (a)	$\tan x(\tan x+5)=0$ $\tan x=0, \quad x=0°, 180°$ $\tan x=-5, \quad x=101.3°$	**B1,B1** **B1**	**B1** for each , must be from correct work
(b)	$2(1-\sin^2 y)-\sin y-1=0$ $2\sin^2 y+\sin y-1=0$ $(2\sin y-1)(\sin y+1)=0$	**M1**	**M1** for use of correct identity and attempt to solve resulting 3 term quadratic equation.
	$\sin y=\frac{1}{2}, y=30°, 150°$	**A1,A1**	
	$\sin y=-1, y=270°$	**A1**	
(c)	$\cos\left(2z-\frac{\pi}{6}\right)=\frac{1}{2}$ $\left(2z-\frac{\pi}{6}\right)=\frac{\pi}{3}$	**M1**	**M1** for dealing with sec correctly and obtaining $\frac{\pi}{3}$ or 1.05
	$z=\frac{\pi}{4}$ or 0.785 or better	**A1**	
	$\left(2z-\frac{\pi}{6}\right)=\frac{5\pi}{3}$	**M1**	**M1** for obtaining a second equation $\left(2z-\frac{\pi}{6}\right)=2\pi-\mathit{their}\,\frac{\pi}{3}$ oe
	$z=\frac{11\pi}{12}$ or 2.88 or better	**A1**	

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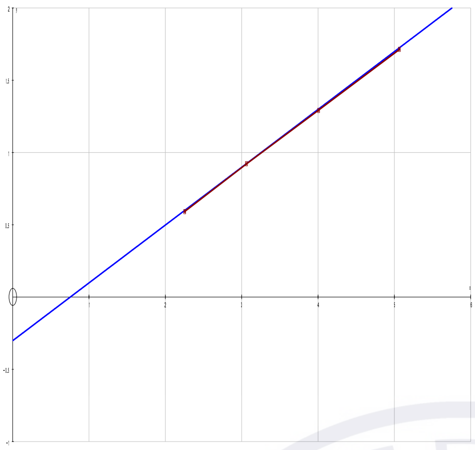
1 **(i)**	$y = 3(x-1)^2 + 2$ $a = 3,\ b = 1,\ c = 2$	**B1, B1, B1**	**B1** for each, may be given in the form $y = 3(x-1)^2 + 2$
(ii)	$(1, 2)$	√**B1**	Follow through on their answers to **(i)** If using differentiation, follow through on their x only.
2	$2^{4x} \times 4^y \times 8^{x-y} = 1$ Considering powers of either 2, 4 or 8 $7x - y = 0$	**M1**	**M1** for considering powers of either 2, 4 or 8 and forming an equation using these powers
	$3^{x+y} = \frac{1}{3}$ Considering powers of 3 $x + y = -1$	**B1**	**B1** for equation considering powers of 3
	Solving both simultaneously gives $x = -\frac{1}{8},\ y = -\frac{7}{8}$	**M1** **A1**	**M1** for attempt to solve their equations **A1** for both
3 **(i)**	$f(-3) = -27 + 9p - 3p^2 + 21$ $= 9p - 3p^2 - 6$	**M1** **A1**	**M1** for substitution of $x = -3$ **A1** answer must be simplified
(ii)	$9p - 3p^2 - 6 < 0$ $(p-1)(p-2) > 0$ Critical values 1 and 2 $p < 1,\ p > 2$	**M1** **A1** **A1**	**M1** for attempt to factorise **A1** for critical values **A1** for correct range
4 **(i)**	$V = x(24 - 2x)^2$ $= x(576 - 96x + 4x^2)$ $= 4x^3 - 96x^2 + 576x$	**M1** **A1**	**M1** for attempt at a product of 3 lengths, 2 of which must be the same **A1** for expansion to reach given answer
(ii)	$\frac{dV}{dx} = 12x^2 - 192x + 576$	**M1**	**M1** for attempt to differentiate
	When $\frac{dV}{dx} = 0$, $12x^2 - 192x + 576 = 0$	**DM1**	**DM1** for equating $\frac{dV}{dx}$ to zero and attempt to solve
	leading to $(x-4)(x-12) = 0$ with $x = 4$ the only possible solution $V = 1024$	**A1** **A1**	**A1** for $x = 4$ **A1** for $V = 1024$

5 **(i)**	$64 - 960x + 6000x^2$	**B1, B1, B1**	**B1** for each correct term
(ii)	$(64 - 960x + 6000x^2)(a^3 + 3a^2bx)$, $64a^3 = 512,\ \ a = 2$ $-960a^3 + 3a^2b(64) = 0$ leading to $b = 10$	**B1** **B1** **M1** **A1**	**B1** for first two terms of $(a+bx)^3$ **B1** for equating constant term to 512 and obtaining $a = 2$ **M1** for attempt to equate coefficient of x to zero, must have two terms involved **A1** for $b = 10$
6	When $x = 2,\ y = -4$ $\frac{dy}{dx} = x\left(\frac{2x}{3}\right)(x^2 - 12)^{-\frac{2}{3}} + (x^2 - 12)^{\frac{1}{3}}$ When $x = 2,\ \frac{dy}{dx} = -\frac{4}{3}$ Normal: $y + 4 = \frac{3}{4}(x - 2)$ $(4y = 3x - 22)$	**B1** **M1, B1** **A1** **M1** **A1**	**B1** for $y = -4$ **M1** for differentiation of a product **B1** for $\frac{2x}{3}(x^2 - 12)^{-\frac{2}{3}}$ **M1** for attempt at normal equation **A1** allow unsimplified
7 **(a)** **(i)**	15120	**B1**	
(ii)	$(5\times4)\times(4\times3\times2)$ 480	**M1** **A1**	**M1** for attempt to multiply number of ways of getting 4 letters by the number of ways of getting 2 digits.
(b) **(i)**	5456	**B1**	
(ii)	${}^{18}C_2 \times 15$ 2295	**M1** **A1**	**M1** for attempt at an appropriate product, at least one term must be correct.
(iii)	5456 – Number of ways only girls get tickets $5456 - 455 = 5001$ **Or** 1B 2G 1890 2B 1G 2295 3B 816 Total 5001	**M1** **A1** **M1** **A1**	**M1** for a complete correct method *their* **(i)** – number of ways only girls get tickets **M1** must be considering at least 2 of the cases shown

8	(i)	1	B1	
	(ii)	$a = 8e^{-2t}$	M1	M1 for attempt to differentiate
		$8e^{-2t} = 6$, $-2t = \ln \frac{3}{4}$	DM1	DM1 for correct attempt to solve equation in the form $e^{-2t} = \text{constant}$
		$t = 0.144$	A1	A1 must be at least 3 sf
	(iii)	$s = 5t + 2e^{-2t} \quad (+c)$	M1	M1 for attempt to integrate
		When $t = 0$, $s = 0$, so $c = -2$	DM1, A1	DM1 for attempt to find c, A1 c correct
		When $t = 1.5$, $s = 5.60$	M1, A1	M1 for substitution of $t = 1.5$
		Alternative: $s = \left[5t + 2e^{-2t}\right]_0^{1.5}$	M1 DM1 A1 M1	M1 for attempt to integrate DM1 for attempt to use limits A1 all correct M1 for evaluation of square bracket notation
		Leading to $s = 5.60$	A1	
	(iv)	Velocity is always +ve, so no change in direction	B1	Allow any valid argument.
9	(i)	$\cos x(3\sin x - 2) = 0$		
		$\cos x = 0$, $x = 90^\circ$	B1	B1 for 90°
		$\sin x = \frac{2}{3}$,	M1	M1 for attempt to solve $\sin x = \frac{2}{3}$
		$x = 41.8°$, $138.2°$	A1,√A1	Follow through on their first answer
	(ii)	$10\sin^2 y + \cos y = 8$ $10(1 - \cos^2 y) + \cos y = 8$	M1	M1 for use of correct identity
		$10\cos^2 y - \cos y - 2 = 0$	M1	M1 for attempt to reduce to a 3 term quadratic and attempt to solve quadratic
		$(2\cos y - 1)(5\cos y + 2) = 0$ $\cos y = \frac{1}{2}$, $\cos y = -\frac{2}{5}$	M1	M1 for attempt to solve using factors in terms of cos
		$y = 60^\circ$, 300° and $y = 113.6^\circ$, 246.4°	A1, A1	A1 for any 'pair'

10 (i)	<table><tr><td>x^2</td><td>2.25</td><td>3.06</td><td>4</td><td>5.06</td></tr><tr><td>lg y</td><td>0.59</td><td>0.92</td><td>1.29</td><td>1.71</td></tr></table>	**B1**	
(ii)		**M1** **A1, 0**	**M1** for plotting log$y$ against x^2 –1 each error, poor point plotting, poor line drawing
(iii)	Gradient: $\lg b = 0.4,\ b = 2.5$ (allow 2.45 to 2.55)	**M1** **A1**	**M1** for correct use of gradient
	Intercept : $\lg A = -0.3,\ A = 0.5$ (allow 0.4 to 0.6)	**M1** **A1**	**M1** for correct use intercept
(iv)	2.1 (allow 2 to 2.2)	**M1, A1**	

11	(i)	at A $\quad \sqrt{3}\sin 3x + \cos 3x = 0$	M1	**M1** for equating to zero and attempt to solve using tan
		$\tan 3x = -\frac{1}{\sqrt{3}},\ 3x = \frac{5\pi}{6}\quad 150°$	DM1	**DM1** for dealing with $3x$
		$x = \frac{5\pi}{18}(0.873)$ (allow $50°$)	A1	
	(ii)	$\frac{\mathrm{d}y}{\mathrm{d}x} = 3\sqrt{3}\cos 3x - 3\sin 3x$	B1, B1	**B1** for $\frac{\mathrm{d}y}{\mathrm{d}x}$
		When $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$, $\tan 3x = \sqrt{3},\ \ 3x = \frac{\pi}{3}$ or $3x = 60°$,	M1	**M1** for attempt to solve $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$
		$x = \frac{\pi}{9}\ (0.349)$ (allow $20°$)	A1	
	(iii)	Area = $\left[-\frac{\sqrt{3}}{3}\cos 3x + \frac{1}{3}x + \frac{1}{3}\sin 3x\right]_{\frac{\pi}{9}}^{\frac{5\pi}{18}}$	M1 A1, A1	**M1** for attempt to integrate **A1** for each term
		$= \left(-\frac{\sqrt{3}}{3}\cos\frac{5\pi}{6} + \frac{1}{3}\sin\frac{5\pi}{6}\right) - \left(-\frac{\sqrt{3}}{3}\cos\frac{\pi}{3} + \frac{1}{3}\sin\frac{\pi}{3}\right)$	DM1	**DM1** for correct application of their limits
		$= \frac{2}{3}$ or 0.667 or better	A1	

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0606 ADDITIONAL MATHEMATICS

0606/11 Paper 1, maximum raw mark 80

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 October/November 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

Mark Scheme Notes

Marks are of the following three types:

M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Accuracy 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 generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

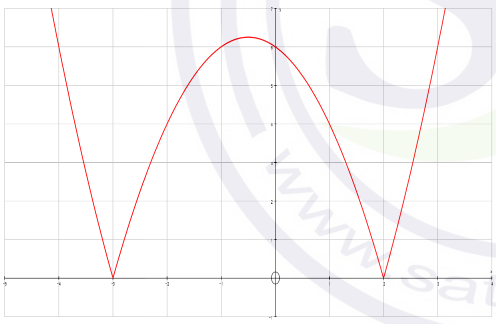
- The symbol implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously 'correct' answers or results obtained from incorrect working.

- Note: B2 or A2 means that the candidate can earn 2 or 0.
  B2, 1, 0 means that the candidate can earn anything from 0 to 2.

1	$a = 3,\ b = 2,\ c = 1$	B1, B1, B1 [3]	B1 for each
2	Using $b^2 - 4ac$, $9 = 4(k+1)^2$ $4k^2 + 8k - 5 = 0$ $k = -\frac{5}{2}, \left(\frac{1}{2}\right)$ To be below the x-axis $k < -\frac{5}{2}$ **Or**: $\frac{dy}{dx} = 2(k+1)x - 3$ when $\frac{dy}{dx} = 0$, $x = \frac{3}{2(k+1)}$ $\therefore y = (k+1)\frac{9}{4(k+1)^2} - \frac{9}{2(k+1)} + (k+1)$ To lie under the x-axis, $y < 0$ $\therefore (k+1)\frac{9}{4(k+1)^2} - \frac{9}{2(k+1)} + (k+1) < 0$ leading to $9 = 4(k+1)^2$ or equivalent then as for previous method	M1 DM1 A1 A1 [4] M1	M1 for any use of $b^2 - 4ac$ DM1 for solution of their quadratic in k A1 for critical value(s), $\frac{1}{2}$ not necessary A1 for $k < -\frac{5}{2}$ only M1 for a complete method to this point.

3 $\frac{1+\sin\theta}{\cos\theta}+\frac{\cos\theta}{1+\sin\theta}+\frac{(1+\sin\theta)^2+\cos^2\theta}{\cos\theta(1+\sin\theta)}$ $=\frac{1+2\sin\theta+\sin^2\theta+\cos^2\theta}{\cos\theta(1+\sin\theta)}$	M1	M1 for dealing with the fractions, denominator must be correct, be generous with numerator
$=\frac{2+2\sin\theta}{\cos\theta(1+\sin\theta)}$	DM1	M1 for expansion and use of $\cos^2\theta+\sin^2\theta=1$
$=\frac{2(1+\sin\theta)}{\cos\theta(1+\sin\theta)}$	DM1	M1 for attempt to factorise
$=2\sec\theta$	A1 [4]	A1 for obtaining final answer correctly
Alternative solution: $\sec\theta+\tan\theta+\frac{1}{\sec\theta+\tan\theta}$		
$=\frac{(\sec\theta+\tan\theta)^2+1}{\sec\theta+\tan\theta}$	M1	M1 for dealing with the fractions
$=\frac{\sec^2\theta+2\sec\theta\tan\theta+\tan^2\theta+1}{\sec\theta+\tan\theta}$		
$=\frac{2\sec^2\theta+2\sec\theta\tan\theta}{\sec\theta+\tan\theta}$	DM1	M1 for expansion and use of $\tan^2\theta+1=\sec^2\theta$
$=\frac{2\sec\theta(\sec\theta+\tan\theta)}{\sec\theta+\tan\theta}$	DM1	DM1 for attempt to factorise
$=2\sec\theta$	A1	A1 for obtaining final answer correctly
4 (i) n (A) = 3	B1 [1]	If elements listed for **(i)**, then they must be correct elements to get B1 leading to n (A) = 3. If they are not listed and correct answer given then B1.
(ii) n (B) = 4	B1 [1]	If elements listed for **(ii)**, then they must be correct elements leading to n (B) = 4 to get B1. If they are not listed and correct answer given then B1.
(iii) $A \cup B$ = {60°, 240°, 300, 420°, 600°}	√B1 [1]	Follow through on any sets listed in **(i)** and **(ii)**. Do not allow any repetitions.
(iv) $A \cap B$ = {60°, 420°}	√B1 [1]	Follow through on any sets listed in **(i)** and **(ii)**.

5 **(i)** $9x - \frac{1}{3}\cos 3x\,(+c)$	B1, B1, B1 [3]	B1 for $9x$, B1 for $\frac{1}{3}$ or $\cos 3x$ B1 for $-\frac{1}{3}\cos 3x$ Condone omission of $+ c$
(ii) $\left[9x - \frac{1}{3}\cos 3x\right]_{\frac{\pi}{9}}^{\pi}$		
$= \left(9\pi - \frac{1}{3}\cos 3\pi\right) - \left(\pi - \frac{1}{3}\cos\frac{\pi}{3}\right)$	M1	M1 for correct use of limits in their answer to **(i)**
$= 8\pi + \frac{1}{2}$	A1, A1 [3]	A1 for each term
6 $f\left(\frac{1}{2}\right) = \frac{a}{8} + 1 + \frac{b}{2} - 2$	M1	M1 for substitution of $x = \frac{1}{2}$ into $f(x)$
leading to $a + 4b - 8 = 0$	A1	A1 for correct equation in any form
$f(2) = 2f(-1)$	M1	M1 for attempt to substitute $x = 2$ **or** $x = -1$ into $f(x)$ **and** use $f(2) = \pm 2f(-1)$ or $2f(2) = \pm f(-1)$
$8a + 16 + 2b - 2 = 2(-a + 4 - b - 2)$	A1	A1 for a correct equation in any form
leading to $10a + 4b + 10 = 0$ or equivalent		
$\therefore a = -2,\ b = \frac{5}{2}$	DM1 A1 [6]	DM1 (on both previous M marks) for attempt to solve simultaneous equations to obtain either a or b A1 for both correct

7	**(a) (i)** 360	B1 [1]	
	(ii) 120	B1 [1]	
	(b) (i) 924	B1 [1]	
	(ii) 28	B1 [1]	
	(iii) $924 - \left({}^8C_3 \times {}^4C_3\right) - \left({}^8C_2 \times {}^4C_4\right)$ (i.e. 924 – 3M 3W – 2M 4W)	M1	M1 for 3 terms, at least 2 of which must be correct in terms of C notation or evaluated.
	$924 - 224 - 28$	A1	A1 for any pair (must be evaluated)
	$= 672$	A1 [3]	A1 for final answer
	Or: 4M 2W ${}^8C_4 \times {}^4C_2 = 420$	M1	M1 for 3 terms, at least 2 of which must be correct in terms of C notation or evaluated.
	5M 1W ${}^8C_5 \times {}^4C_1 = 224$	A1	A1 for any pair (must be evaluated)
	6M ${}^8C_6 = 28$		
	Total $= 672$	A1	A1 for final answer
8	**(i)** 	B1	B1 for correct shape
		B1	B1 for (–3, 0) or –3 seen on graph
		B1	B1 for (2, 0) or 2 seen on graph
		B1 [4]	B1 for (0, 6) or 6 seen on graph or in a table
	(ii) $\left(-\frac{1}{2}, \frac{25}{4}\right)$	B1, B1 [2]	B1 for each
	(iii) $k > \frac{25}{4}$ or $\frac{25}{4} < k \ (\leq 14)$	B1 [1]	

9 **(a)** $12x^2\ln(2x+1)+4x^3\left(\frac{2}{2x+1}\right)$	M1 A2, 1, 0 [3]	M1 for differentiation of a correct product –1 for each error
(b) **(i)** $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{(x+2)^{\frac{1}{2}}2-2x(x+2)^{-\frac{1}{2}}\frac{1}{2}}{x+2}$	M1, A1	M1 for differentiation of a quotient involving $(x+2)^{\frac{1}{2}}$
$=\frac{(x+2)^{-\frac{1}{2}}}{(x+2)}(2(x+2)-x)$	DM1	A1 all correct unsimplified DM1 for attempt to simplify
$=\frac{x+4}{(x+2)^{\frac{3}{2}}}$	A1 [4]	A1 for correct simplification to obtain the given answer
Or: $\frac{\mathrm{d}y}{\mathrm{d}x}=2x\left(-\frac{1}{2}\right)(x+2)^{-\frac{3}{2}}+(x+2)^{-\frac{1}{2}}(2)$	M1, A1	M1 for differentiation of a product involving $(x+2)^{-\frac{1}{2}}$
$=(x+2)^{-\frac{3}{2}}(2(x+2)-x)$		A1 all correct unsimplified
$=\frac{x+4}{(x+2)^{\frac{3}{2}}}$	DM1 A1	DM1 for attempt to simplify A1 for correct simplification to obtain the given answer
(ii) $\frac{10x}{\sqrt{x+2}}\ (+c)$	M1,A1 [2]	M1 for $\frac{1}{5}\times\frac{2x}{\sqrt{x+2}}$ or $5\times\frac{2x}{\sqrt{x+2}}$ A1 correct only, allow unsimplified. Condone omission of $+c$
(iii) $\left[\frac{10x}{\sqrt{x+2}}\right]_2^7=\frac{70}{3}-\frac{20}{2}$	M1	M1 for correct application of limits in their answer to **(b)(ii)**
$=\frac{40}{3}$	A1 [2]	

10 (i) $\sqrt{20}$ or 4.47	B1 [1]	
(ii) Grad $AB = \frac{1}{2}$, $\perp$ grad = –2	M1	M1 for attempt at a perp gradient
$\perp$ line $y - 4 = -2(x - 1)$	M1, A1	M1 for attempt at straight line equation, must be perpendicular and passing through *B*.
$(y = -2x + 6)$	[3]	A1 allow unsimplified
(iii) Coords of *C* (x, y) and $BC^2 = 20$ $(x-1)^2 + (y-4)^2 = 20$ **or** Coords of *C* (x, y) and $AC^2 = 40$	M1	M1 for attempt to obtain relationship using an appropriate length and the point (1, 4) or (–3, 2)
$(x+3)^2 + (y-2)^2 = 40$	A1	A1 for a correct equation
Need intersection with $y = -2x + 6$,	DM1	DM1 for attempt to solve with $y = -2x + 6$ and obtain a quadratic equation in terms of one variable only
leads to $5x^2 - 10x - 15 = 0$ **or** $5y^2 - 40y - = 0$		
giving $x = 3, -1$ and $y = 0, 8$	DM1 A1, A1 [6]	M1 for attempt to solve quadratic A1 for each 'pair'
Or, using vector approach: $\overrightarrow{AB} = \begin{pmatrix} 4 \\ 2 \end{pmatrix}$	B1	May be implied
$\overrightarrow{OC} = \begin{pmatrix} 1 \\ 4 \end{pmatrix} + \begin{pmatrix} -2 \\ 4 \end{pmatrix} = \begin{pmatrix} -1 \\ 8 \end{pmatrix}$	M1 A1, A1	M1 for correct approach A1 for each element correct
$\overrightarrow{OC} = \begin{pmatrix} 1 \\ 4 \end{pmatrix} + \begin{pmatrix} 2 \\ -4 \end{pmatrix} = \begin{pmatrix} 3 \\ 0 \end{pmatrix}$	A1,A1	A1 for each element correct

11 (a) (i) $\begin{pmatrix} 4 & 3 \\ 4 & 3 \end{pmatrix}$	B1 [1]	
(ii) $\mathbf{A}^2 = \begin{pmatrix} 16 & 9 \\ 12 & 13 \end{pmatrix}$	B1, B1 [2]	B1 for any 2 correct elements B1 for all correct
(iii) **B** is the inverse matrix of $\mathbf{A}^2$ $= \frac{1}{100}\begin{pmatrix} 13 & -9 \\ -12 & 16 \end{pmatrix}$	B1, B1 [2]	Follow through on their $\mathbf{A}^2$
(b) det **C** $= x(x-1) - (-1)(x^2 - x + 1)$ $= 2x^2 - 2x + 1$	M1 A1	M1 for attempt to obtain det **C** A1 for this correct quadratic expression from a correct det **C**
$b^2 - 4ac < 0$, $4 - 8 < 0$	DM1	DM1 for use of discriminant or attempt to solve using the formula, or attempt to complete the square in order to show there are no real roots.
No real solutions (so det $\mathbf{C} \neq 0$)	A1 [4]	A1 for correct reasoning or statement that there are no real roots.

12	(a)	(i)	f(–10) = 299, f(8) = 191 Min point at (0, –1) or when $y = -1$ $\therefore$ range $-1 \le y \le 299$	M1 B1 A1 [3]	M1 for substitution of either $x = -10$ or $x = 8$, may be seen on diagram B1 May be implied from final answer, may be seen on diagram Must have $\le$ for A1, do not allow x
		(ii)	$x \ge 0$ or equivalent	B1 [1]	Allow any domain which will make f a one-one function Assume upper and lower bound when necessary.
	(b)	(i)	$g^{-1}(x) = \ln\left(\frac{x+2}{4}\right)$ or $\frac{\lg\left(\frac{x+2}{4}\right)}{\lg e}$	M1 A1 [2]	M1 for complete method to find the form inverse function, must involve ln or lg if appropriate. May still be in terms of y. A1 must be in terms of x
		(ii)	gh(x) = g(ln5x) $= 4e^{\ln 5x} - 2$ $20x - 2 = 18,\ x = 1$	M1 A1 A1 [3]	M1 for correct order A1 for correct expression $4e^{\ln 5x} - 2$ A1 for correct solution from correct working
			Or h(x) = $g^{-1}(18)$ $\ln 5x = \ln 5$ leading to $x = 1$	M1 A1 A1	M1 for correct order A1 for correct equation A1 for correct solution **from correct working**

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the October/November 2013 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 1, maximum raw mark 80

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M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

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B Accuracy 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 generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

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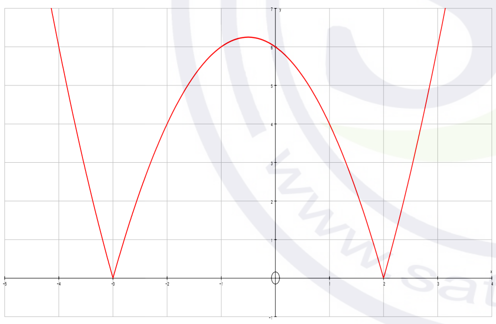
- Note: B2 or A2 means that the candidate can earn 2 or 0.
  B2, 1, 0 means that the candidate can earn anything from 0 to 2.

1	$a = 3,\ b = 2,\ c = 1$	B1, B1, B1 [3]	B1 for each
2	Using $b^2 - 4ac$, $9 = 4(k+1)^2$ $4k^2 + 8k - 5 = 0$ $k = -\frac{5}{2}, \left(\frac{1}{2}\right)$ To be below the x-axis $k < -\frac{5}{2}$ **Or**: $\frac{dy}{dx} = 2(k+1)x - 3$ when $\frac{dy}{dx} = 0$, $x = \frac{3}{2(k+1)}$ $\therefore\ y = (k+1)\frac{9}{4(k+1)^2} - \frac{9}{2(k+1)} + (k+1)$ To lie under the x-axis, $y < 0$ $\therefore (k+1)\frac{9}{4(k+1)^2} - \frac{9}{2(k+1)} + (k+1) < 0$ leading to $9 = 4(k+1)^2$ or equivalent then as for previous method	M1 DM1 A1 A1 [4] M1	M1 for any use of $b^2 - 4ac$ DM1 for solution of their quadratic in k A1 for critical value(s), $\frac{1}{2}$ not necessary A1 for $k < -\frac{5}{2}$ only M1 for a complete method to this point.

3 $\frac{1+\sin\theta}{\cos\theta}+\frac{\cos\theta}{1+\sin\theta}+\frac{(1+\sin\theta)^2+\cos^2\theta}{\cos\theta(1+\sin\theta)}$ $=\frac{1+2\sin\theta+\sin^2\theta+\cos^2\theta}{\cos\theta(1+\sin\theta)}$	M1	M1 for dealing with the fractions, denominator must be correct, be generous with numerator
$=\frac{2+2\sin\theta}{\cos\theta(1+\sin\theta)}$	DM1	M1 for expansion and use of $\cos^2\theta+\sin^2\theta=1$
$=\frac{2(1+\sin\theta)}{\cos\theta(1+\sin\theta)}$	DM1	M1 for attempt to factorise
$=2\sec\theta$	A1 [4]	A1 for obtaining final answer correctly
Alternative solution: $\sec\theta+\tan\theta+\frac{1}{\sec\theta+\tan\theta}$		
$=\frac{(\sec\theta+\tan\theta)^2+1}{\sec\theta+\tan\theta}$	M1	M1 for dealing with the fractions
$=\frac{\sec^2\theta+2\sec\theta\tan\theta+\tan^2\theta+1}{\sec\theta+\tan\theta}$		
$=\frac{2\sec^2\theta+2\sec\theta\tan\theta}{\sec\theta+\tan\theta}$	DM1	M1 for expansion and use of $\tan^2\theta+1=\sec^2\theta$
$=\frac{2\sec\theta(\sec\theta+\tan\theta)}{\sec\theta+\tan\theta}$	DM1	DM1 for attempt to factorise
$=2\sec\theta$	A1	A1 for obtaining final answer correctly
4 **(i)** n $(A)=3$	B1 [1]	If elements listed for **(i)**, then they must be correct elements to get B1 leading to n $(A)=3$. If they are not listed and correct answer given then B1.
(ii) n $(B)=4$	B1 [1]	If elements listed for **(ii)**, then they must be correct elements leading to n $(B)=4$ to get B1. If they are not listed and correct answer given then B1.
(iii) $A\cup B=\{60°, 240°, 300, 420°, 600°\}$	√B1 [1]	Follow through on any sets listed in **(i)** and **(ii)**. Do not allow any repetitions.
(iv) $A\cap B=\{60°, 420°\}$	√B1 [1]	Follow through on any sets listed in **(i)** and **(ii)**.

5 **(i)** $9x - \frac{1}{3}\cos 3x\,(+c)$	B1, B1, B1 [3]	B1 for $9x$, B1 for $\frac{1}{3}$ or $\cos 3x$ B1 for $-\frac{1}{3}\cos 3x$ Condone omission of $+\,c$
(ii) $\left[9x - \frac{1}{3}\cos 3x\right]_{\frac{\pi}{9}}^{\pi}$		
$= \left(9\pi - \frac{1}{3}\cos 3\pi\right) - \left(\pi - \frac{1}{3}\cos\frac{\pi}{3}\right)$	M1	M1 for correct use of limits in their answer to **(i)**
$= 8\pi + \frac{1}{2}$	A1, A1 [3]	A1 for each term
6 $f\left(\frac{1}{2}\right) = \frac{a}{8} + 1 + \frac{b}{2} - 2$	M1	M1 for substitution of $x = \frac{1}{2}$ into $f(x)$
leading to $a + 4b - 8 = 0$	A1	A1 for correct equation in any form
$f(2) = 2f(-1)$	M1	M1 for attempt to substitute $x = 2$ **or** $x = -1$ into $f(x)$ **and** use $f(2) = \pm 2f(-1)$ or $2f(2) = \pm f(-1)$
$8a + 16 + 2b - 2 = 2(-a + 4 - b - 2)$	A1	A1 for a correct equation in any form
leading to $10a + 4b + 10 = 0$ or equivalent		
$\therefore a = -2,\ b = \frac{5}{2}$	DM1 A1 [6]	DM1 (on both previous M marks) for attempt to solve simultaneous equations to obtain either a or b A1 for both correct

7 **(a)** **(i)** 360	B1 [1]	
(ii) 120	B1 [1]	
(b) **(i)** 924	B1 [1]	
(ii) 28	B1 [1]	
(iii) $924 - \left({}^8C_3 \times {}^4C_3\right) - \left({}^8C_2 \times {}^4C_4\right)$ (i.e. 924 – 3M 3W – 2M 4W)	M1	M1 for 3 terms, at least 2 of which must be correct in terms of *C* notation or evaluated.
$924 - 224 - 28$	A1	A1 for any pair (must be evaluated)
$= 672$	A1 [3]	A1 for final answer
Or: 4M 2W $\;{}^8C_4 \times {}^4C_2 = 420$	M1	M1 for 3 terms, at least 2 of which must be correct in terms of *C* notation or evaluated.
5M 1W $\;{}^8C_5 \times {}^4C_1 = 224$	A1	A1 for any pair (must be evaluated)
6M $\;{}^8C_6 = 28$		
Total $= 672$	A1	A1 for final answer
8 **(i)** 	B1	B1 for correct shape
	B1	B1 for (–3, 0) or –3 seen on graph
	B1	B1 for (2, 0) or 2 seen on graph
	B1 [4]	B1 for (0, 6) or 6 seen on graph or in a table
(ii) $\left(-\frac{1}{2}, \frac{25}{4}\right)$	B1, B1 [2]	B1 for each
(iii) $k > \frac{25}{4}$ or $\frac{25}{4} < k \; (\le 14)$	B1 [1]	

9 **(a)** $12x^2\ln(2x+1)+4x^3\left(\frac{2}{2x+1}\right)$	M1 A2, 1, 0 [3]	M1 for differentiation of a correct product –1 for each error
(b) **(i)** $\frac{dy}{dx}=\frac{(x+2)^{\frac{1}{2}}2-2x(x+2)^{-\frac{1}{2}}\frac{1}{2}}{x+2}$	M1, A1	M1 for differentiation of a quotient involving $(x+2)^{\frac{1}{2}}$
$=\frac{(x+2)^{-\frac{1}{2}}}{(x+2)}(2(x+2)-x)$	DM1	A1 all correct unsimplified DM1 for attempt to simplify
$=\frac{x+4}{(x+2)^{\frac{3}{2}}}$	A1 [4]	A1 for correct simplification to obtain the given answer
Or: $\frac{dy}{dx}=2x\left(-\frac{1}{2}\right)(x+2)^{-\frac{3}{2}}+(x+2)^{-\frac{1}{2}}(2)$	M1, A1	M1 for differentiation of a product involving $(x+2)^{-\frac{1}{2}}$
$=(x+2)^{-\frac{3}{2}}(2(x+2)-x)$		A1 all correct unsimplified
$=\frac{x+4}{(x+2)^{\frac{3}{2}}}$	DM1 A1	DM1 for attempt to simplify A1 for correct simplification to obtain the given answer
(ii) $\frac{10x}{\sqrt{x+2}}\ (+c)$	M1,A1 [2]	M1 for $\frac{1}{5}\times\frac{2x}{\sqrt{x+2}}$ or $5\times\frac{2x}{\sqrt{x+2}}$ A1 correct only, allow unsimplified. Condone omission of $+c$
(iii) $\left[\frac{10x}{\sqrt{x+2}}\right]_2^7=\frac{70}{3}-\frac{20}{2}$	M1	M1 for correct application of limits in their answer to **(b)(ii)**
$=\frac{40}{3}$	A1 [2]	

10 (i) $\sqrt{20}$ or 4.47	B1 [1]	
(ii) Grad $AB = \frac{1}{2}$, $\perp$ grad = –2	M1	M1 for attempt at a perp gradient
$\perp$ line $y - 4 = -2(x - 1)$	M1, A1	M1 for attempt at straight line equation, must be perpendicular and passing through *B*.
$(y = -2x + 6)$	[3]	A1 allow unsimplified
(iii) Coords of *C* (x, y) and $BC^2 = 20$ $(x-1)^2 + (y-4)^2 = 20$ **or** Coords of *C* (x, y) and $AC^2 = 40$	M1	M1 for attempt to obtain relationship using an appropriate length and the point (1, 4) or (–3, 2)
$(x+3)^2 + (y-2)^2 = 40$	A1	A1 for a correct equation
Need intersection with $y = -2x + 6$,	DM1	DM1 for attempt to solve with $y = -2x + 6$ and obtain a quadratic equation in terms of one variable only
leads to $5x^2 - 10x - 15 = 0$ **or** $5y^2 - 40y - = 0$		
giving $x = 3, -1$ and $y = 0, 8$	DM1 A1, A1 [6]	M1 for attempt to solve quadratic A1 for each 'pair'
Or, using vector approach: $\overrightarrow{AB} = \begin{pmatrix} 4 \\ 2 \end{pmatrix}$	B1	May be implied
$\overrightarrow{OC} = \begin{pmatrix} 1 \\ 4 \end{pmatrix} + \begin{pmatrix} -2 \\ 4 \end{pmatrix} = \begin{pmatrix} -1 \\ 8 \end{pmatrix}$	M1 A1, A1	M1 for correct approach A1 for each element correct
$\overrightarrow{OC} = \begin{pmatrix} 1 \\ 4 \end{pmatrix} + \begin{pmatrix} 2 \\ -4 \end{pmatrix} = \begin{pmatrix} 3 \\ 0 \end{pmatrix}$	A1,A1	A1 for each element correct

11 (a) (i) $\begin{pmatrix} 4 & 3 \\ 4 & 3 \end{pmatrix}$	B1 [1]	
(ii) $\mathbf{A}^2 = \begin{pmatrix} 16 & 9 \\ 12 & 13 \end{pmatrix}$	B1, B1 [2]	B1 for any 2 correct elements B1 for all correct
(iii) **B** is the inverse matrix of $\mathbf{A}^2$ $= \frac{1}{100}\begin{pmatrix} 13 & -9 \\ -12 & 16 \end{pmatrix}$	B1, B1 [2]	Follow through on their $\mathbf{A}^2$
(b) $\det \mathbf{C} = x(x-1) - (-1)(x^2 - x + 1)$ $= 2x^2 - 2x + 1$	M1 A1	M1 for attempt to obtain det **C** A1 for this correct quadratic expression from a correct det **C**
$b^2 - 4ac < 0,\ 4 - 8 < 0$	DM1	DM1 for use of discriminant or attempt to solve using the formula, or attempt to complete the square in order to show there are no real roots.
No real solutions (so $\det \mathbf{C} \neq 0$)	A1 [4]	A1 for correct reasoning or statement that there are no real roots.

12	(a)	(i)	$f(-10) = 299$, $f(8) = 191$ Min point at $(0, -1)$ or when $y = -1$ $\therefore$ range $-1 \le y \le 299$	M1 B1 A1 [3]	M1 for substitution of either $x = -10$ or $x = 8$, may be seen on diagram B1 May be implied from final answer, may be seen on diagram Must have $\le$ for A1, do not allow x
		(ii)	$x \ge 0$ or equivalent	B1 [1]	Allow any domain which will make f a one-one function Assume upper and lower bound when necessary.
	(b)	(i)	$g^{-1}(x) = \ln\left(\frac{x+2}{4}\right)$ or $\dfrac{\lg\left(\frac{x+2}{4}\right)}{\lg e}$	M1 A1 [2]	M1 for complete method to find the form inverse function, must involve ln or lg if appropriate. May still be in terms of y. A1 must be in terms of x
		(ii)	$gh(x) = g(\ln 5x)$ $= 4e^{\ln 5x} - 2$ $20x - 2 = 18$, $x = 1$ **Or** $h(x) = g^{-1}(18)$ $\ln 5x = \ln 5$ leading to $x = 1$	M1 A1 A1 [3] M1 A1 A1	M1 for correct order A1 for correct expression $4e^{\ln 5x} - 2$ A1 for correct solution from correct working M1 for correct order A1 for correct equation A1 for correct solution **from correct working**

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the October/November 2013 series

0606 ADDITIONAL MATHEMATICS

0606/13 Paper 1, maximum raw mark 80

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Mark Scheme Notes

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M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Accuracy 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 generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

The symbol √ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

Note: B2 or A2 means that the candidate can earn 2 or 0.
B2, 1, 0 means that the candidate can earn anything from 0 to 2.

1	**(i)** $^6C_2\,(2^4)\,(px)^2$ or $\binom{6}{2}2^4(px)^2$	B1	Seen or implied, unsimplified
	$240p^2 = 60$	M1	M1 for their coefficient of $x^2 = 60$ and attempt to solve
	$p = \frac{1}{2}$	A1 [3]	
	(ii) coefficients of the terms needed	M1	M1 for realising that 2 terms are involved
	$(-1)\,{}^6C_1\,(2)^5\,p + (3 \times 60)$	B1	B1 for $(-1)\,{}^6C_1\,(2)^5\,p$ or $-192p$, using their p.
	$= 84$	A1 [3]	
2	$\lg \frac{y^2}{5y+60} = \lg 10$	B1 B1	B1 for $2\lg y = \lg y^2$ B1 for $1 = \lg 10$ or equivalent, allow when seen
	Or $\lg y^2 = \lg 10\,(5y + 60)$	M1	M1 for use of $\log A - \log B = \log A/B$ or $\log A + \log B = \log AB$
	$y^2 - 50y - 600 = 0$ leading to $y = -10, 60$	DM1	DM1 for forming a 3 term quadratic equation and an attempt to solve
	y must be positive so $y = 60$	A1 [5]	A1 for $y = 60$ only

3 $\tan^2\theta - \sin^2\theta = \frac{\sin^2\theta}{\cos^2\theta} - \sin^2\theta$		**Marks are awarded only if they can lead to a complete proof for the methods other than those shown below**
$= \frac{\sin^2\theta - \sin^2\theta\cos^2\theta}{\cos^2\theta}$	M1	M1 for dealing with tan and a fraction
$= \frac{\sin^2\theta(1-\cos^2\theta)}{\cos^2\theta}$	M1	M1 for factorising
$= \frac{\sin^4\theta}{\cos^2\theta}$	M1	M1 for use of identity $\cos^2\theta + \sin^2\theta = 1$
$= \sin^4\theta\sec^2\theta$	A1 [4]	A1 for all correct
Alt solution 1		
Using $\tan^2\theta = \sin^2\theta\sec^2\theta$		
LHS $= \sin^2\theta\sec^2\theta - \sin^2\theta$	M1	M1 use of $\tan^2 x = \sin^2 x\sec^2 x$
$= \sin^2\theta(\sec^2\theta - 1)$	M1	M1 for factorising
$= \sin^2\theta\tan^2\theta$	M1	M1 for use of identity
$= \sin^4\theta\sec^2\theta$	A1	A1 for all correct
Alt solution 2		
RHS $= \sin^4\theta\sec^2\theta$		
$= \frac{\sin^2\theta\sin^2\theta}{\cos^2\theta}$	M1	M1 for splitting $\sin^4\theta$ and use of identity
$= \frac{\sin^2\theta(1-\cos^2\theta)}{\cos^2\theta}$	M1	M1 for multiplication
$= \frac{\sin^2\theta - \sin^2\theta\cos^2\theta}{\cos^2\theta}$	M1	M1 for writing as two terms and cancelling
$= \frac{\sin^2\theta}{\cos^2\theta} - \frac{\sin^2\theta\cos^2\theta}{\cos^2\theta}$	A1	A1 for all correct
$= \tan^2\theta - \sin^2\theta$		

4 **(i)** $\frac{dy}{dx}=\frac{(x+3)^2\,2e^{2x}-e^{2x}\,2(x+3)}{(x+3)^4}$	M1	M1 for attempt at quotient rule
	A2, 1, 0	–1 for each error
$=\frac{2e^{2x}(x+2)}{(x+3)^3}$, $A=2$	A1 [4]	Must be convinced of correct simplification e.g. sight of $(x+3-1)$ or $(x+2)(x+3)$
Alt solution		
$\frac{dy}{dx}=e^{2x}\left(-2(x+3)^{-3}\right)+2e^{2x}(x+3)^{-2}$	M1	M1 for attempt at product rule
	A2,1,0	–1 for each error
$=\frac{2e^{2x}(x+2)}{(x+3)^3}$, $A=2$	A1	Must be convinced of correct simplification e.g. sight of $(x+3-1)$ or $(x+2)(x+3)$
(ii) $x=-2$, $y=e^{-4}$	B1, B1 [2]	Accept $1/e^4$
5 **(i)** $f^2(x)=f(2x^3)$		
$=2(2x^3)^3$ or $2\left(2\left(\frac{1}{2}\right)^3\right)^3$	M1	M1 for $=2(2x^3)^3$ or $2\left(2\left(\frac{1}{2}\right)^3\right)^3$
$=2^{-5}$	A1 [2]	For 2^{-5} only
Alt method		
$f\left(\frac{1}{2}\right)=\frac{1}{4}$ $\quad$ $f\left(\frac{1}{4}\right)=2^{-5}$	M1	M1 for f of their f $\left(\frac{1}{2}\right)$
	A1	For 2^{-5} only
(ii) $f'(x)=g'(x)$	B1	B1 for $6x^2$
$6x^2=4-10x$	B1	B1 for $4-10x$
Leading to $(3x-1)(x+2)=0$	M1	M1 for solution of quadratic equation obtained from differentiation of both
$x=\frac{1}{3}, -2$	A1 [4]	A1 for both

6 Area under the curve:		
$\int_0^{\sqrt{2}} 4 - x^2 \ dx = \left[4x - \frac{x^3}{3}\right]_0^{\sqrt{2}}$	M1 A1	M1 for attempt to integrate
$= \left(4\sqrt{2} - \frac{2\sqrt{2}}{3}\right) - (0)$	DM1	DM1 for application of limits
$= \frac{10\sqrt{2}}{3}$		
Area of trapezium =		
$\frac{1}{2}(4+2)(\sqrt{2}) = 3\sqrt{2}$	B1	B1 for area of trapezium, allow unsimplified
Shaded area = $\frac{10\sqrt{2}}{3} - 3\sqrt{2}$	M1	M1 for subtraction of the two areas
Shaded area = $\frac{\sqrt{2}}{3}$	A1 [6]	Must be in this form
Or: Equation of chord:		
$y = 4 - \sqrt{2}x$	B1	B1 for the equation of the chord unsimplified
Shaded area = $\int_0^{\sqrt{2}} 4 - x^2 - 4 + \sqrt{2}x \, dx$	M1 M1	M1 for subtraction M1 for attempt to integrate
$\left[\frac{\sqrt{2}}{2}x^2 - \frac{x^3}{3}\right]_0^{\sqrt{2}} = \frac{\sqrt{2}}{3}$	√A1 DM1 A1 [6]	√A1 for $\left[-m\frac{x^2}{2} - \frac{x^3}{3}\right]$ or equivalent, where m is the gradient of their chord DM1 for application of limits

7	(i)	$2t^2 - 2(t^2 - t + 1)$	B1	Correct determinant seen unsimplified
		Leading to, $t = \frac{3}{2}$	M1 A1 [3]	M1 for simplification and solution A1 for solution of det **A**=1only, not 1/det **A**=1
	(ii)	$\mathbf{A} = \begin{pmatrix} 6 & 2 \\ 7 & 3 \end{pmatrix}$, $\mathbf{A}^{-1} = \frac{1}{4}\begin{pmatrix} 3 & -2 \\ -7 & 6 \end{pmatrix}$	B1, B1	B1 for $\frac{1}{4}$, B1 for matrix
		$\begin{pmatrix} 6 & 2 \\ 7 & 3 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 10 \\ 11 \end{pmatrix}$	B1	B1 for dealing correctly with the factor of 2
		$\begin{pmatrix} x \\ y \end{pmatrix} = \frac{1}{4}\begin{pmatrix} 3 & -2 \\ -7 & 6 \end{pmatrix}\begin{pmatrix} 10 \\ 11 \end{pmatrix}$	M1	M1 for pre-multiplying their $\begin{pmatrix} 10 \\ 11 \end{pmatrix}$ by their $\mathbf{A}^{-1}$ to obtain a column matrix
		$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 \\ -1 \end{pmatrix}$, leading to $x = 2$, $y = -1$	A1 [5]	Allow $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 \\ -1 \end{pmatrix}$ for A1
8	(i)	$\frac{1}{2}(4^2)\sin\theta = 7.5$	M1	M1 for attempt to find the area of the triangle and equate to 7.5
		$\sin\theta = \frac{15}{16}$, $\theta = 1.215\ldots$	A1 [2]	A1 for solution to obtain the given answer Solution must include 1.2153…. or 1.2154
	(ii)	$\sin\frac{\theta}{2} = \frac{\frac{1}{2}CD}{4}$, $(CD = 4.567)$	M1	M1 for attempt to find *CD*
		Arc length = 6(1.215)	B1	B1 for arc length
		Perimeter = 2 + 2 + 6(1.215) + their *CD*	M1	M1 for sum of 4 appropriate lengths
		= awrt 15.9	A1 [4]	
	(iii)	Area = $\frac{1}{2}6^2(1.215) - 7.5$	B1 M1	B1 for sector area M1 for subtraction of the 2 areas
		= 14.4 (awrt)	A1 [3]	

9 **(a)** **(i)** $6(1-\cos^2 x) = 5 + \cos x$ $6\cos^2 x + \cos x - 1 = 0$ $(3\cos x - 1)(2\cos x + 1) = 0$ $x = 70.5°$ $x = 120°$	M1 M1 A1, A1 [4]	M1 for use of $\sin^2 x = (1-\cos^2 x)$ correctly M1 for solution of a 3 term quadratic in cos and attempt at solution of a trig equation A1 for each correct solution
(ii) $\cos x = \sin y$ $\sin y = \frac{1}{3}$ only so $y = 19.5°, 160.5°$	 DM1 √A1, √A1 [3]	 DM1 for relating cos x and sin y or other correct method of solution
(b) $\cot z(4\cot z - 3) = 0$ $\cot z = 0,\quad z = \frac{\pi}{2}$ $\cot z = \frac{3}{4},\ \tan z = \frac{4}{3}$ so $z = 0.927$	M1 B1 M1 A1 [4]	M1 for attempt to use a factor B1 for $\frac{\pi}{2}$ (1.57) M1 dealing with cot and attempt at solution
10 **(i)** lg s	B1 [1]	Allow in table or on graph if no contradiction <u>No marks for graph unless lg$t$ against lg$s$ (or ln$t$ against ln$s$)</u>
(ii) lg$s$: 0.3, 0.6, 0.78, 0.9 lg$t$: 1.4, 0.8, 0.44, 0.19	M1 DM1 A1 [3]	M1 for 3 or more points correct DM1 for a line through 3 or 4 correct points A1 all points correct with a straight line extending at least from first point to last point
(iii) <u>No marks in this part unless lg$t$ v lg$s$ graph is used</u> Gradient : $n = -2$ (allow $-2.1 \to -1.9$) Intercept : log k, or other method $k = 100$ (allow $90 \to 120$)	 M1A1 M1, A1 [4]	 M1 calculates gradient A1 for $n = -2$ M1 for use of intercept and dealing with logarithm correctly (can use another point)
Alt method Using simultaneous equations, points used must lie on the plotted line.	M2 A1, A1	Must attempt to solve 2 valid equations. $k = 100$ and $n = -2$
(iv) When $t = 4$, lg $t = 0.6$ so lg $s = 0.69$ $s = 4.9$ (allow $4.8 \to 5.2$)	M1 A1 [2]	M1 for valid method using either the correct graph or using lg$t$ = $n$lg$s$ + lg$k$ or $t = ks^n$ using their n and their k

11 **(i)** $\left[e^{2x} + \frac{5}{4}e^{-2x}\right]_0^k$	B1, B1	B1 for each term integrated correctly, allow unsimplified
$\left(e^{2k} + \frac{5}{4}e^{-2k}\right) - \left(1 + \frac{5}{4}\right) = 3$	M1	M1 for application of limits to an integral of the form $Ae^{2x} \pm Be^{-2x}$
$e^{2k} + \frac{5}{4}\ e^{-2k} - \frac{12}{4} = 0$	M1	M1 for equating to $\frac{3}{4}$ and attempt to rearrange to obtain a 3 term equation. Must be using an integral of the form $Ae^{2x} \pm Be^{-2x}$
$4e^{4k} - 12e^{2k} + 5 = 0$	A1 [5]	Answer given, so must be convinced
(ii) $4y^2 - 12y + 5 = 0$	M1	M1 for solution of quadratic equation
leading to $e^{2k} = \frac{5}{2}$, $e^{2k} = \frac{1}{2}$	M1	M1 for solving equations involving exponentials
$k = 0.458$, -0.347	A1, A1 [4]	A1 for each

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the May/June 2013 series

0606 ADDITIONAL MATHEMATICS

0606/11 Paper 1, maximum raw mark 80

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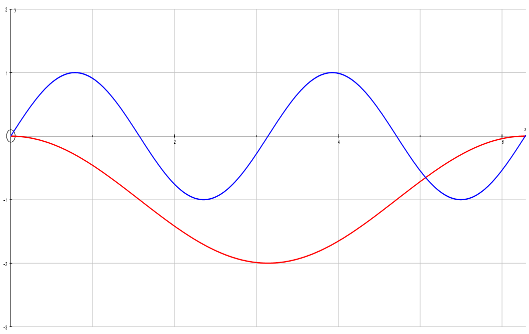
  B2, 1, 0 means that the candidate can earn anything from 0 to 2.

The following abbreviations may be used in a mark scheme or used on the scripts:

AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no "follow through" from a previous error is allowed)
ISW	Ignore Subsequent Working
MR	Misread
PA	Premature Approximation (resulting in basically correct work that is insufficiently accurate)
SOS	See Other Solution (the candidate makes a better attempt at the same question)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through √ " marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy.
OW –1,2	This is deducted from A or B marks when essential working is omitted.
PA –1	This is deducted from A or B marks in the case of premature approximation.
S –1	Occasionally used for persistent slackness – usually discussed at a meeting.
EX –1	Applied to A or B marks when extra solutions are offered to a particular equation. Again, this is usually discussed at the meeting.

Question	Answer	Marks	Notes
1 (i)		B1	correct shape for $y = \cos x - 1$
(ii)		B1	all correct
		B1	correct shape for $y = \sin 2x$
		B1	all correct
(iii)	3	B1	
2	**Either** gradient = 1	B1	
	intercept = 2	B1	
	$\ln b$ = gradient or $\ln A$ = intercept	M1	M1, need to equate either gradient to $\ln b$ or intercept to $\ln A$
	$b = \mathrm{e}$ or 2.72	A1	
	$A = \mathrm{e}^2$, $A = 7.39$	A1	
	Or $\mathrm{e}^4 = Ab^2$ and $\mathrm{e}^{10} = Ab^8$	[B1 B1	**B1** for each equation
	leading to $b^6 = \mathrm{e}^6$ or $\mathrm{e}^4 = \mathrm{e}^2 A$ or $\mathrm{e}^{10} = \mathrm{e}^8 A$	M1	**M1** for attempt to solve for either A or b
	$b = \mathrm{e}$ or 2.72	A1	
	$A = \mathrm{e}^2$, $A = 7.39$	A1]	
	Or $10 = 8\ln b + \ln A$	[B1	
	$4 = 2\ln b + \ln A$	B1	
	leading to $\ln b = 1$ or $6 = 3\ln A$	M1	**M1** for attempt to solve for either A or b
	$b = \mathrm{e}$ or 2.72	A1	
	$A = \mathrm{e}^2$, $A = 7.39$	A1]	

3 **(i)**	$^{14}C_6 = 3003$	**B1**	
(ii)	$^5C_3 \times {}^9C_3 = 840$	**M1 A1**	**M1** for product of 2 combinations
(iii)	**Either** $3003 - {}^9C_6 = 2919$	**M1 B1 A1**	**M1** for 3003 – number of committees containing no men **B1** for $^9C_6$
	Or 1M + 5W: $5 \times {}^9C_5 = 630$ 2M + 4W: $^5C_2 \times {}^9C_4 = 1260$ 3M + 3W: 840 (part **(ii)**) 4M + 2W: $^5C_4 \times {}^9C_2 = 180$ 5M + 1W: $1 \times {}^9C_1 = 9$ Total: 2919	**[B2 1 0** **B1]**	–1 each error **B1** for correct final answer
4 **(i)**	2	**B1**	
(ii)	$\log_4 y^2 - \log_4(5y - 12)$ $(=\log_4 2)$	**B1**	**B1** for power
	$\log_4\left(\frac{y^2}{5y-12}\right)$ $= (=\log_4 2)$	**M1**	correct division
	$y^2 - 10y + 24 = 0$	**M1**	attempt at solution of a 3 term quadratic
	$y = 4, 6$	**A1**	**A1** for both
5 **(i)**	$x + \frac{6}{x}(+c)$	**B1 B1**	**B1** for each term
(ii)	$\left(3k+\frac{6}{3k}\right) - \left(k+\frac{6}{k}\right)(=2)$	**M1**	correct use of limits
	$2k^2 - 2k - 4 = 0$	**M1**	attempt to obtain a 3 term quadratic from 2 brackets equated to 2
		DM1	**DM1** or solution of quadratic dependent on 2nd **M1**
	leading to $k = 2$	**A1**	

6 (i)	$A^{-1} = \frac{1}{13}\begin{pmatrix} 5 & 1 \\ -3 & 2 \end{pmatrix}$	B1 B1	**B1** for matrix, **B1** for multiplying by a correct determinant
(ii)	**Either** $\begin{pmatrix} a & b \\ c & -1 \end{pmatrix} = \frac{1}{13}\begin{pmatrix} 5 & 1 \\ -3 & 2 \end{pmatrix}\begin{pmatrix} 7 & 5 \\ 17 & d \end{pmatrix}$	M1	evidence of multiplication of both sides by A^{-1}
	$= \frac{1}{13}\begin{pmatrix} 52 & 25+d \\ 13 & -15+2d \end{pmatrix}$		
	leading to $a = 4, c = 1$	DM1	**DM1** for attempt to equate like elements
	and $b = 2, d = 1$	A3,2,1,0	–1 each error
	Or		
	$\begin{pmatrix} 2 & -1 \\ 3 & 5 \end{pmatrix}\begin{pmatrix} a & b \\ c & -1 \end{pmatrix} = \begin{pmatrix} 7 & 5 \\ 17 & d \end{pmatrix}$	[M1	**M1** for evidence of matrix multiplication
	$2a - c = 7,\ 3a + 5c = 17,\ a = 4,\ c = 1$	DM1	**DM1** for attempt to equate like elements –1 each error
	$2b + 1 = 5, 3b - 5 = d,\ b = 2, \mathrm{d} = 1$	A3,2,1,0]	
7 (i)	$\tan B = \frac{\sqrt{5}+1}{\sqrt{5}-2}$	B1	
	$= \frac{\sqrt{5}+1}{\sqrt{5}-2} \times \frac{\sqrt{5}+2}{\sqrt{5}+2}$	M1	attempt at rationalisation (Allow if inverse is used)
	$= 7 + 3\sqrt{5}$	A1	
(ii)	$(7 + 3\ \sqrt{5}\ )^2 + 1 = \sec^2 B$	M1 M1	**M1** for attempt to use the correct identity **M1** for simplification to give 3 or 4 terms
	$\sec^2 B = 95 + 42\sqrt{5}$	√A1 √A1	cao **A1** for 95, **A1** for $42\sqrt{5}$
	Or		
	$\sec^2 B = \frac{1}{\cos^2 B} = \frac{\left(\sqrt{5}+1\right)^2 + \left(\sqrt{5}-2\right)^2}{\left(\sqrt{5}-2\right)^2}$	[M1	**M1** for attempt to use to find BC^2
	$\sec^2 B = \frac{15-2\sqrt{5}}{9-4\sqrt{5}} \times \frac{9+4\sqrt{5}}{9+4\sqrt{5}}$	M1	**M1** for use of $\sec B = \frac{1}{\cos B}$
	$\sec^2 B = 95 + 42\ \sqrt{5}$	A1 A1]	**A1** for 95, **A1** for $52\sqrt{5}$

8	**(i)**	**Either** $\tan\frac{\theta}{2} = \frac{8}{6}$	**M1**	**M1** for use of trig to obtain half angle
		$\frac{\theta}{2} = 0.927...$		Can use $\sin\frac{\theta}{2} = \frac{8}{10}$ or $\cos\frac{\theta}{2} = \frac{6}{10}$
		$\theta = 1.855$	**A1**	**A1** Allow if done in degrees and converted
		Or Area of triangle *MEF* = 48	**[M1**	**M1** for a complete method to find the obtuse angle
		$\frac{1}{2}\times 10^2 \times \sin\theta = 48$		
		$\theta = 1.287, \pi - 1.287$		
		$\theta = 1.855$	**A1]**	
		Or $16^2 = 10^2 + 10^2 - (2 \times 10 \times \cos\theta)$	**[M1**	**M1** for use of the cosine rule, need to see working as answer given
		θ=1.855	**A1]**	
	(ii)	radius = 10	**B1**	**B1** for the radius, allow anywhere
		$P = (10 \times 1.855) + 10 + 10 + 16$	**M1 M1**	**M1** for use of arc length **M1** for method, must be arc +3 sides
		= 54.6 or 54.5 or 54.55	**A1**	
	(iii)	A $=256 - 2\left(\frac{1}{2}\times 8\times 6\right) - \frac{1}{2}10^2(1.855)$	**M1** **M1**	**M1** for area of sector **M1** for a correct plan to obtain the required area
		= 115.25 or 115.3 or 115 awrt 115	**A1**	

9	(i)	$\overrightarrow{AP} = \frac{3}{4}(\mathbf{b} - \mathbf{a})$	B1	
		$\overrightarrow{OP} = \mathbf{a} + \frac{3}{4}(\mathbf{b} - \mathbf{a})$, or	M1	**M1** for attempt at vector addition
		$\overrightarrow{OP} = \mathbf{a} - \frac{1}{4}(\mathbf{b} - \mathbf{a})$,		
		$= \frac{1}{4}(\mathbf{a} + 3\mathbf{b})$	A1	Answer given
	(ii)	$\overrightarrow{OQ} = \frac{2}{5}\mathbf{c}$, or $\overrightarrow{QC} = \frac{3}{5}\mathbf{c}$ or $\overrightarrow{CQ} = -\frac{3}{5}\mathbf{c}$	B1	**B1** for $\overrightarrow{OQ}$, $\overrightarrow{QC}$ or $\overrightarrow{CQ}$
		$\overrightarrow{PQ} = \overrightarrow{OQ} - \overrightarrow{OP}$	M1	**M1** for correct vector addition/subtraction
		$= \frac{2}{5}\mathbf{c} - \frac{\mathbf{a}}{4} - \frac{3\mathbf{b}}{4}$	A1	
	(iii)	$2\mathbf{c} - \frac{5\mathbf{a}}{4} - \frac{15\mathbf{b}}{4} = 6(\mathbf{c} - \mathbf{b})$	M1	**M1** for use of *their* vectors and attempt to get $k\,\mathbf{c}$
		$\mathbf{c} = \frac{9\mathbf{b} - 5\mathbf{a}}{16}$	A1	
10	(i)	When $x = 2$, $y = -5$	B1	**B1** for $y = -5$
		$\frac{dy}{dx} = 3x^2 - 8x + 1$	M1	**M1** for attempt to differentiate
		when $x = 2$, $\frac{dy}{dx} = -3$	DM1	**DM1** for attempt at tangent equation – must be tangent with use of $x = 2$
		Tangent: $y + 5 = -3\,(x - 2)$ $(y = 1 - 3x)$	A1	allow unsimplified
	(ii)	$1 - 3x = x^3 - 4x^2 + x + 1$	M1	**M1** for equating tangent and curve equations
		$x\,(x - 2)^2 = 0$	DM1	**DM1** for attempt to solve resulting cubic equation
		Meets at (0, 1)	A1 A1	**A1** for each coordinate

(iii)	Grad of perp = $\frac{1}{3}$	**√B1**	**√B1** on *their* gradient in **(i)** only
	Midpoint (1, –2)	**M1**	**M1** for attempt to find the midpoint
	Perp bisector $y+2=\frac{1}{3}(x-1)$	**M1 A1**	**M1** for attempt at line equation – must be perp bisector **A1** allow unsimplified
11 (a)	$\sin\left(x+\frac{\pi}{3}\right)=-\frac{1}{2}$	**B1**	
	$x+\frac{\pi}{3}=\frac{7\pi}{6},\frac{11\pi}{6}$	**B1**	**B1** for $\frac{7\pi}{6}$ and $\frac{11\pi}{6}$
	$x=\frac{5\pi}{6},\frac{3\pi}{2}$	**B1 B1**	**B1** for first correct solution **B1** for a second correct solution with all solutions in radians and with no excess solutions within the range
(b)	$\tan y-2=\frac{1}{\tan y}$	**B1**	**B1** for a correct equation
	$\tan^2 y-2\tan y-1=0$	**M1 A1**	**M1** for attempt to obtain a 3 term quadratic equation **A1** for a correct equation equated to zero
	$\tan y=1\pm\sqrt{2}$	**DM1**	**DM1** for solution of quadratic
	$y=67.5°,\ 157.5°$	**A1 A1**	**A1** for first correct solution **A1** for a second correct solution with all solutions in degrees and with no excess solutions within the range.

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the May/June 2013 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 1, maximum raw mark 80

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- The symbol √ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

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  B2, 1, 0 means that the candidate can earn anything from 0 to 2.

The following abbreviations may be used in a mark scheme or used on the scripts:

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ISW	Ignore Subsequent Working
MR	Misread
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1	**(i)**	$n(A \cap B) = 5$	**B1**	
	(ii)	$n(A) = 16$	**B1**	
	(iii)	$n(B' \cap A)$	**B1**	
2	**(i)**	$6 \times 5 \times 4 \times 3 = 360$ or ${}^6P_4 = 360$	**B1**	**B1** unsimplified/evaluated
	(ii)	Position: 1, 2, 3, 4; Number of ways: 5, 4, 3, 1		
		or $\frac{1}{6}$ **(i)** or ${}^5P_3$ or ${}^5C_3 \times {}^6C_1$	**M1**	**M1** for a correct attempt unsimplified
		Number of 4 digit numbers = 60	**A1**	
	(iii)	Position: 1, 2, 3, 4; Number of ways: 3, 4, 3, 1		
		or ${}^3P_1 \times {}^4P_2$	**M1**	**M1** for a correct attempt unsimplified
		Number of 4 digit numbers = 36	**A1**	
3		**EITHER**		
		$1 - 2\sin\theta - 2\cos\theta + \sin^2\theta + \cos^2\theta + 2\sin\theta\cos\theta$	**B1**	**B1** for correct expansion of $(1 - \cos\theta - \sin\theta)^2$
		Use of $\sin^2\theta + \cos^2\theta = 1$ in simplification = 0	**M1**	**M1** for use of $\sin^2\theta + \cos^2\theta = 1$ in this form
			A1	**A1** must be convinced as AG
		OR $(1 - \cos\theta - \sin\theta)^2 =$ $1 - 2\sin\theta - 2\cos\theta + \sin^2\theta + \cos^2\theta + 2\sin\theta\cos\theta$	**[B1**	**B1** for correct expansion of $(1 - \cos\theta - \sin\theta)^2$
		$= 2 - 2\sin\theta - 2\cos\theta + 2\sin\theta\cos\theta$	**M1**	**M1** for use of $\sin^2\theta + \cos^2\theta = 1$ in this form
		$= 2(1 - \sin\theta)(1 - \cos\theta)$	**A1]**	**A1** for simplification and factorising

4	**EITHER** $2x^2 + kx + 2k - 6 = 0$ has no real roots $k^2 - 16k + 48 < 0$ $(k - 4)(k - 12) < 0$	**M1** **DM1**	**M1** for attempted use of $b^2 - 4ac$ **DM1** for attempt to obtain critical values from a 3 term quadratic
	Critical values 4 and 12 $4 < k < 12$ or $k > 4$ **and** $k < 12$	**A1** **A1**	**A1** for both critical values **A1** for correct final answer
	OR $\left(x + \frac{k}{4}\right)^2 - \frac{k^2}{16} + k - 3 = 0$	**[M1]**	**M1** for attempting to complete the square and obtain a 3 term quadratic
	$-\frac{k^2}{16} + k - 3 > 0$ so $k^2 - 16k + 48 < 0$		Then as **EITHER**
	OR $\frac{dy}{dx} = 4x + k$	**[M1**	**M1** for differentiation, equating to zero and obtaining a quadratic equation in x
	When $\frac{dy}{dx} = 0$, $k = -4x$ By substitution $x^2 + 4x + 3 < 0$ leading to $x = -1$, $k = 4$	**DM1**	**DM1** for attempt to obtain critical values of k from a 3 term quadratic in x followed by substitution to obtain a value for k
	and $x = -3$, $k = 12$ $4 < k < 12$ or $k > 4$ **and** $k < 12$	**A1** **A1]**	**A1** for both critical values **A1** for correct final answer
	OR $\frac{dy}{dx} = 4x + k$	**[M1]**	**M1** for differentiation, equating to zero and obtaining a quadratic equation in k
	When $\frac{dy}{dx} = 0$, $x = -\frac{k}{4}$ leading to $k^2 - 16k + 48 < 0$		Then as **EITHER**

5	$2\left(\frac{15-4y}{3}\right)y=9$ or $2x\left(\frac{15-3x}{4}\right)=9$	**M1**	**M1** for attempt to obtain equation in one variable
	$8y^2 - 30y + 27 = 0$ or $3x^2 - 15x + 18 = 0$ $(4y - 9)(2y - 3) = 0$ or $(x - 3)(x - 2) = 0$	**DM1**	**DM1** for attempt to solve a 3 term quadratic in that variable
	$x = 2, y = \frac{9}{4}$ and $x = 3, y = \frac{3}{2}$	**A1, A1**	**A1** for each 'pair', x values must be simplified to single integer form
	$AB^2 = 1^2 + (0.75)^2$, $AB = 1.25$	**M1, A1**	**M1** for a correct attempt to find AB, must have non zero differences and be using points calculated previously.
6	$\frac{dy}{dx} = 3\sec^2 x$	**B1**	**B1** for $3\sec^2 x$
	When $x = \frac{3\pi}{4}$, $\frac{dy}{dx} = 6$	**B1**	**B1** for $\frac{dy}{dx} = 6$, may be implied by later work
	$y = 5$	**B1**	**B1** for y
	Perpendicular gradient = $-\frac{1}{6}$	**M1**	**M1** for perpendicular gradient from $\frac{dy}{dx}$
	Equation of normal $y + 5 = -\frac{1}{6}\left(x - \frac{3\pi}{4}\right)$	**M1**	**M1** for attempt at the normal using *their* y value correctly and $x = \frac{3\pi}{4}$ and substitution of $x = 0$
	When $x = 0$, $y = \frac{\pi}{8} - 5$ o.e.		
	or –4.61 or –4.6 but not –4.60	**A1**	**A1** for obtaining y value

7	**(i)**	f (–2) leads to $68 = b - 2a$	**M1**	attempt at f (–2) = 0 allow unsimplified
		f(1) leads to $26 = a + b$	**M1**	attempt at f (1) = 27 allow unsimplified
		$a = -14$, $b = 40$	**A1, B1**	**A1** for $b = 40$, **B1** for $a = -14$
	(ii)	$f(x) = (x + 2)(6x^2 - 17x + 20)$	**B2, 1, 0**	–1 each error
	(iii)	$6x^2 - 17x + 20 = 0$ has no real roots	**B1**	**B1** for dealing with quadratic factor either by use of formula, completing the square or use of $b^2 - 4ac$ to show that there are no real solutions
		$x = -2$	**B1**	
8	**(a) (i)**	$\begin{pmatrix} 22 & -2 \\ -3 & 31 \end{pmatrix}$	**B2, 1, 0**	–1 each element error
	(ii)	$\begin{pmatrix} 16 & 6 \\ 9 & -11 \end{pmatrix}$	**B2, 1, 0**	–1 each element error
	(b) (i)	$\frac{1}{18+9}\begin{pmatrix} 3 & -1 \\ 9 & 6 \end{pmatrix}$	**B1, B1**	**B1** for $\frac{1}{\text{determinant}}$ (allow unsimplified), **B1** for matrix
	(ii)	$\begin{pmatrix} x \\ y \end{pmatrix} = \frac{1}{27}\begin{pmatrix} 3 & -1 \\ 9 & 6 \end{pmatrix}\begin{pmatrix} 5 \\ 1.5 \end{pmatrix}$, $= \frac{1}{27}\begin{pmatrix} 13.5 \\ 54 \end{pmatrix}$	**M1**	**M1** for correct use of inverse matrix, including correct multiplication to solve equation
		$x = 0.5$, $y = 2$	**A1, A1**	**A1** for each

9 (i)	$\left(1+\frac{1}{2}x\right)^n = 1+n\left(\frac{x}{2}\right)+\frac{n(n-1)}{2}\left(\frac{x}{2}\right)^2$	B1, B1	**B1** for 1 + second term, **B1** for 3rd term Allow unsimplified
(ii)	$(1-x)\left(1+n\left(\frac{x}{2}\right)+\frac{n(n-1)}{2}\left(\frac{x}{2}\right)^2\right)$	M1	dealing with 2 terms involving x^2
	Multiply x and $\frac{n}{2}x$ to get $\frac{n}{2}\left(x^2\right)$	DM1	attempt to obtain one term
	Multiply 1 and $\frac{n(n-1)x^2}{8}$ or $\frac{n(n-1)x^2}{4}$	DM1	attempt to obtain a second term
	$\frac{n^2-n}{8}-\frac{n}{2}=\frac{25}{4}$		
	$n^2-5n-50=0$	A1	correct quadratic equation
	$n=10$	A1	**A1** for $n = 10$ only
10 (a) (i)	$\frac{1}{3}(2x-5)^{\frac{3}{2}}$	B1, B1	**B1** for $k(2x-5)^{\frac{3}{2}}$, **B1** for $\frac{1}{3}(2x-5)^{\frac{3}{2}}$
(ii)	$\frac{125}{3}-\frac{1}{3}=\frac{124}{3}$ Allow awrt 41.3	M1, A1	**M1** for correct use of limits
(b) (i)	$x^3\frac{1}{x}+3x^2\ln x$	B1, B1	**B1** for each term, allow unsimplified
(ii)	$\int 3x^2\ln x\,dx = x^3\ln x-\int x^2\,dx$ o.e.	M1	for a use of answer to **(i)**
	$\int x^2\,dx=\frac{x^3}{3}$ **or**	A1	**A1** for intergrating x^2 or dividing by 3
	$\int x^2\ln x\,dx=\frac{1}{3}\left(x^3\ln x-\int x^2\,dx\right)$ o.e.		
	$\int x^2\ln x\,dx=\frac{1}{3}\left(x^3\ln x-\frac{x^3}{3}\right)$ $(+c)$	A1	

11 (a)	$\cos 2x + \frac{2}{\cos 2x} + 3 = 0$	**M1**	dealing with sec or cos
	leading to $\cos^2 2x + 3\cos 2x + 2 = 0$ $2\sec^2 2x + 3\sec 2x + 1 = 0$	**A1**	simplification to correct 3 term quadratic in $\sec 2x$ or $\cos 2x$ (does not have to be equated to zero)
	$(\cos 2x + 2)(\cos 2x + 1) = 0$ or $(2\sec 2x + 1)(\sec 2x + 1) = 0$	**M1**	attempt to solve a 3 term quadratic, must obtain solutions in terms of $\cos 2x$
	leading to $\cos 2x = -1$ or $\sec 2x = -1$ only $2x = 180°, 540°$ $x = 90°, 270°$	**A1, A1**	
(b)	$\sin^2\left(y - \frac{\pi}{6}\right) = \frac{1}{2}$ so		
	$\sin\left(y - \frac{\pi}{6}\right) = \frac{1}{\sqrt{2}}$	**M1**	division by 2 and square root
	$\left(y - \frac{\pi}{6}\right) = \frac{\pi}{4}, \frac{3\pi}{4}$	**DM1**	correct order of operation and attempt to solve
	$y = \frac{5\pi}{12}, \frac{11\pi}{12}$ Allow awrt 1.31, 2.88	**A1, A1**	
12 (i)	$\frac{dy}{dt} = 36 - 6t$	**M1**	attempt to differentiate and equate to zero
	When $\frac{dy}{dt} = 0,\ t = 6$	**A1**	
(ii)	When $v = 0$, $t = 12$	**M1, A1**	**M1** for equating v to zero and attempt to solve
(iii)	$s = 18t^2 - t^3\ (+c)$	**M1, A1**	**M1** for a correct attempt to integrate at least one term, allow unsimplified **A1** for all correct
	When $t = 12$, $s = 864$		**A1** for $s = 864$
(iv)	When $s = 0$, $t = 18$	**M1**	**M1** for substitution of $s = 0$ into *their s* equation
		√A1	**√A1** on *their s*
	$v = -324$	**DM1**	**DM1** for substitution of *their t* back into v equation
	So speed is 324		**A1** for 324 only

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International General Certificate of Secondary Education

MARK SCHEME for the May/June 2013 series

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0606/13 Paper 1, maximum raw mark 80

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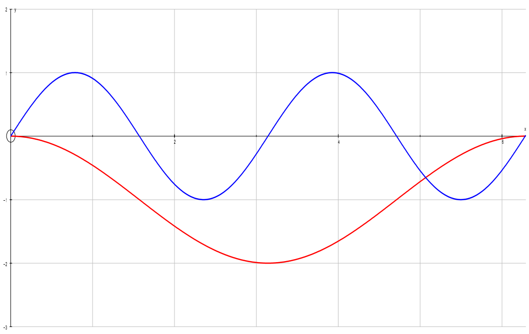
1 (i)		**B1**	correct shape for $y = \cos x - 1$
(ii)		**B1**	all correct
		B1	correct shape for $y = \sin 2x$
		B1	all correct
(iii)	3	**B1**	
2	**Either** gradient = 1	**B1**	
	intercept = 2	**B1**	
	$\ln b$ = gradient or $\ln A$ = intercept	**M1**	M1, need to equate either gradient to $\ln b$ or intercept to $\ln A$
	$b = \mathrm{e}$ or 2.72	**A1**	
	$A = \mathrm{e}^2$, $A = 7.39$	**A1**	
	Or $\mathrm{e}^4 = Ab^2$ and $\mathrm{e}^{10} = Ab^8$	**[B1 B1**	**B1** for each equation
	leading to $b^6 = \mathrm{e}^6$ or $\mathrm{e}^4 = \mathrm{e}^2 A$ or $\mathrm{e}^{10} = \mathrm{e}^8 A$	**M1**	**M1** for attempt to solve for either A or b
	$b = \mathrm{e}$ or 2.72	**A1**	
	$A = \mathrm{e}^2$, $A = 7.39$	**A1]**	
	Or $10 = 8\ln b + \ln A$	**[B1**	
	$4 = 2\ln b + \ln A$	**B1**	
	leading to $\ln b = 1$ or $6 = 3\ln A$	**M1**	**M1** for attempt to solve for either A or b
	$b = \mathrm{e}$ or 2.72	**A1**	
	$A = \mathrm{e}^2$, $A = 7.39$	**A1]**	

3	**(i)**	$^{14}C_6 = 3003$	**B1**	
	(ii)	$^{5}C_3 \times {^{9}C_3} = 840$	**M1 A1**	**M1** for product of 2 combinations
	(iii)	**Either** $3003 - {^{9}C_6} = 2919$	**M1 B1 A1**	**M1** for 3003 – number of committees containing no men **B1** for $^{9}C_6$
		Or 1M + 5W: $5 \times {^{9}C_5} = 630$ 2M + 4W: $^{5}C_2 \times {^{9}C_4} = 1260$ 3M + 3W: 840 (part **(ii)**) 4M + 2W: $^{5}C_4 \times {^{9}C_2} = 180$ 5M + 1W: $1 \times {^{9}C_1} = 9$ Total: 2919	**[B2 1 0** **B1]**	–1 each error **B1** for correct final answer
4	**(i)**	2	**B1**	
	(ii)	$\log_4 y^2 - \log_4 (5y - 12)$ $(=\log_4 2)$	**B1**	**B1** for power
		$\log_4\left(\dfrac{y^2}{5y-12}\right)$ $= (=\log_4 2)$	**M1**	correct division
		$y^2 - 10y + 24 = 0$	**M1**	attempt at solution of a 3 term quadratic
		$y = 4, 6$	**A1**	**A1** for both
5	**(i)**	$x + \dfrac{6}{x}(+c)$	**B1 B1**	**B1** for each term
	(ii)	$\left(3k+\dfrac{6}{3k}\right) - \left(k+\dfrac{6}{k}\right)(=2)$	**M1**	correct use of limits
		$2k^2 - 2k - 4 = 0$	**M1**	attempt to obtain a 3 term quadratic from 2 brackets equated to 2
			DM1	**DM1** or solution of quadratic dependent on 2nd **M1**
		leading to $k = 2$	**A1**	

6 (i)	$A^{-1} = \frac{1}{13}\begin{pmatrix}5 & 1\\ -3 & 2\end{pmatrix}$	**B1 B1**	**B1** for matrix, **B1** for multiplying by a correct determinant
(ii)	**Either** $\begin{pmatrix}a & b\\ c & -1\end{pmatrix} = \frac{1}{13}\begin{pmatrix}5 & 1\\ -3 & 2\end{pmatrix}\begin{pmatrix}7 & 5\\ 17 & d\end{pmatrix}$	**M1**	evidence of multiplication of both sides by A^{-1}
	$= \frac{1}{13}\begin{pmatrix}52 & 25+d\\ 13 & -15+2d\end{pmatrix}$		
	leading to $a = 4,\ c = 1$	**DM1**	**DM1** for attempt to equate like elements
	and $b = 2,\ d = 1$	**A3,2,1,0**	–1 each error
	Or $\begin{pmatrix}2 & -1\\ 3 & 5\end{pmatrix}\begin{pmatrix}a & b\\ c & -1\end{pmatrix} = \begin{pmatrix}7 & 5\\ 17 & d\end{pmatrix}$	**[M1**	**M1** for evidence of matrix multiplication
	$2a - c = 7,\ 3a + 5c = 17,\ a = 4,\ c = 1$	**DM1**	**DM1** for attempt to equate like elements –1 each error
	$2b + 1 = 5,\ 3b - 5 = d,\ b = 2,\ d = 1$	**A3,2,1,0]**	
7 (i)	$\tan B = \frac{\sqrt{5}+1}{\sqrt{5}-2}$	**B1**	
	$= \frac{\sqrt{5}+1}{\sqrt{5}-2} \times \frac{\sqrt{5}+2}{\sqrt{5}+2}$	**M1**	attempt at rationalisation (Allow if inverse is used)
	$= 7 + 3\sqrt{5}$	**A1**	
(ii)	$(7 + 3\sqrt{5})^2 + 1 = \sec^2 B$	**M1 M1**	**M1** for attempt to use the correct identity **M1** for simplification to give 3 or 4 terms
	$\sec^2 B = 95 + 42\sqrt{5}$	**√A1** **√A1**	cao **A1** for 95, **A1** for $42\sqrt{5}$
	Or $\sec^2 B = \frac{1}{\cos^2 B} = \frac{(\sqrt{5}+1)^2 + (\sqrt{5}-2)^2}{(\sqrt{5}-2)^2}$	**[M1**	**M1** for attempt to use to find BC^2
	$\sec^2 B = \frac{15-2\sqrt{5}}{9-4\sqrt{5}} \times \frac{9+4\sqrt{5}}{9+4\sqrt{5}}$	**M1**	**M1** for use of $\sec B = \frac{1}{\cos B}$
	$\sec^2 B = 95 + 42\sqrt{5}$	**A1 A1]**	**A1** for 95, **A1** for $52\sqrt{5}$

8 (i)	**Either** $\tan\frac{\theta}{2}=\frac{8}{6}$	**M1**	**M1** for use of trig to obtain half angle
	$\frac{\theta}{2}=0.927...$		Can use $\sin\frac{\theta}{2}=\frac{8}{10}$ or $\cos\frac{\theta}{2}=\frac{6}{10}$
	$\theta=1.855$	**A1**	**A1** Allow if done in degrees and converted
	Or Area of triangle *MEF* = 48	**[M1**	**M1** for a complete method to find the obtuse angle
	$\frac{1}{2}\times10^2\times\sin\theta=48$		
	$\theta=1.287, \pi-1.287$		
	$\theta=1.855$	**A1]**	
	Or $16^2=10^2+10^2-(2\times10\times\cos\theta)$	**[M1**	**M1** for use of the cosine rule, need to see working as answer given
	$\theta=1.855$	**A1]**	
(ii)	radius = 10	**B1**	**B1** for the radius, allow anywhere
	$P=(10\times1.855)+10+10+16$	**M1 M1**	**M1** for use of arc length **M1** for method, must be arc +3 sides
	= 54.6 or 54.5 or 54.55	**A1**	
(iii)	$A=256-2\left(\frac{1}{2}\times8\times6\right)-\frac{1}{2}10^2(1.855)$	**M1** **M1**	**M1** for area of sector **M1** for a correct plan to obtain the required area
	= 115.25 or 115.3 or 115 awrt 115	**A1**	

9 **(i)**	$\overrightarrow{AP} = \frac{3}{4}(\mathbf{b}-\mathbf{a})$	**B1**	
	$\overrightarrow{OP} = \mathbf{a} + \frac{3}{4}(\mathbf{b}-\mathbf{a})$, or	**M1**	**M1** for attempt at vector addition
	$\overrightarrow{OP} = \mathbf{a} - \frac{1}{4}(\mathbf{b}-\mathbf{a})$,		
	$= \frac{1}{4}(\mathbf{a}+3\mathbf{b})$	**A1**	Answer given
(ii)	$\overrightarrow{OQ} = \frac{2}{5}\mathbf{c}$, or $\overrightarrow{QC} = \frac{3}{5}\mathbf{c}$ or $\overrightarrow{CQ} = -\frac{3}{5}\mathbf{c}$	**B1**	**B1** for $\overrightarrow{OQ}$, $\overrightarrow{QC}$ or $\overrightarrow{CQ}$
	$\overrightarrow{PQ} = \overrightarrow{OQ} - \overrightarrow{OP}$	**M1**	**M1** for correct vector addition/subtraction
	$= \frac{2}{5}\mathbf{c} - \frac{\mathbf{a}}{4} - \frac{3\mathbf{b}}{4}$	**A1**	
(iii)	$2\mathbf{c} - \frac{5\mathbf{a}}{4} - \frac{15\mathbf{b}}{4} = 6(\mathbf{c}-\mathbf{b})$	**M1**	**M1** for use of *their* vectors and attempt to get $k\,\mathbf{c}$
	$\mathbf{c} = \frac{9\mathbf{b}-5\mathbf{a}}{16}$	**A1**	
10 **(i)**	When $x = 2$, $y = -5$	**B1**	**B1** for $y = -5$
	$\frac{dy}{dx} = 3x^2 - 8x + 1$	**M1**	**M1** for attempt to differentiate
	when $x = 2$, $\frac{dy}{dx} = -3$	**DM1**	**DM1** for attempt at tangent equation – must be tangent with use of $x = 2$
	Tangent: $y + 5 = -3\,(x - 2)$ $(y = 1 - 3x)$	**A1**	allow unsimplified
(ii)	$1 - 3x = x^3 - 4x^2 + x + 1$	**M1**	**M1** for equating tangent and curve equations
	$x\,(x-2)^2 = 0$	**DM1**	**DM1** for attempt to solve resulting cubic equation
	Meets at (0, 1)	**A1 A1**	**A1** for each coordinate

(iii)	Grad of perp = $\frac{1}{3}$	√B1	√**B1** on *their* gradient in **(i)** only
	Midpoint (1, –2)	M1	**M1** for attempt to find the midpoint
	Perp bisector $y+2=\frac{1}{3}(x-1)$	M1 A1	**M1** for attempt at line equation – must be perp bisector **A1** allow unsimplified
11 (a)	$\sin\left(x+\frac{\pi}{3}\right)=-\frac{1}{2}$	B1	
	$x+\frac{\pi}{3}=\frac{7\pi}{6},\frac{11\pi}{6}$	B1	**B1** for $\frac{7\pi}{6}$ and $\frac{11\pi}{6}$
	$x=\frac{5\pi}{6},\frac{3\pi}{2}$	B1 B1	**B1** for first correct solution **B1** for a second correct solution with all solutions in radians and with no excess solutions within the range
(b)	$\tan y-2=\frac{1}{\tan y}$	B1	**B1** for a correct equation
	$\tan^2 y-2\tan y-1=0$	M1 A1	**M1** for attempt to obtain a 3 term quadratic equation **A1** for a correct equation equated to zero
	$\tan y=1\pm\sqrt{2}$	DM1	**DM1** for solution of quadratic
	$y=67.5°,\ 157.5°$	A1 A1	**A1** for first correct solution **A1** for a second correct solution with all solutions in degrees and with no excess solutions within the range.