Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2020**

MARK SCHEME

Maximum Mark: 80

Published

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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.

Mark schemes should usually be read together with the Principal Examiner Report for Teachers. However, because students did not sit exam papers, there is no Principal Examiner Report for Teachers for the June 2020 series.

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

Cambridge International is publishing the mark schemes for the June 2020 series for most Cambridge IGCSE™ and Cambridge International A & 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.

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.

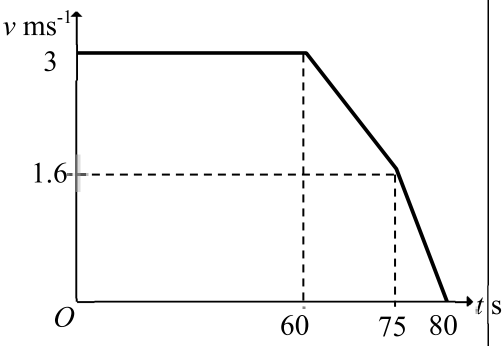
When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation '**dep**' is used to indicate that a particular M or B mark is dependent on an earlier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

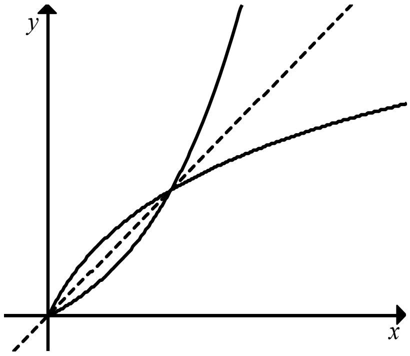
Abbreviations

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	Partial Marks
1	Valid method to find *m* $m = \frac{34-9}{3-0.5}[=10]$ oe	**M1**	
	Valid method to find *c*, e.g. 34 = *their* 10 × 3 + *c*	**M1**	
	$\sqrt[4]{y} = (their10)\frac{1}{x} + their4$	**M1**	
	$y = \left(\frac{10}{x}+4\right)^4$ oe, cao	**A1**	
2(a)	$9\left(x-\frac{2}{3}\right)^2+1$ oe	**B3**	**B1** for each of *p*, *q*, *r* correct in correctly formatted expression; allow correct equivalent values If **B0** then **SC2** for $9\left(x-\frac{2}{3}\right)+1$ or **SC1** for correct values but other incorrect format
2(b)	$their\left(\frac{2}{3},1\right)$ oe	**B1**	**FT** *their* (a)
3(a)	Finds p (– 1)	**M1**	
	24	**A1**	
3(b)(i)	p (– 2) = 15 (– 8) + 22(4) – 15 (– 2) + 2 = 0	**B1**	
3(b)(ii)	Attempt to find the quadratic factor	**M1**	
	$15x^2 - 8x + 1$	**A1**	
	(*x* + 2)(3*x* – 1)(5*x* – 1) oe, cao	**A1**	If zero scored, **SC1** for an answer of (*x* + 2)(3*x* – 1)(5*x* – 1) without working.
4(a)	${}^5C_2 \times {}^8C_4$ oe	**M1**	
	700	**A1**	
4(b)	3 × 6! oe	**M1**	
	2160	**A1**	
5(a)	$4\alpha - 12 = \alpha + 3$ and $4 - \beta = -2$	**M1**	
	$\alpha = 5$	**A1**	
	$\beta = 6$	**A1**	

Question	Answer	Marks	Partial Marks
5(b)	$\sqrt{\text{their}\left(\alpha+3\right)^2+\left(-2\right)^2}$	**M1**	
	$\dfrac{2\mathbf{j}-\text{their}\,8\mathbf{i}}{\sqrt{\text{their}\,68}}$	**A1**	**FT** *their* α
6	$3x^2+8x+5=kx-7$	**M1**	
	$3x^2+(8-k)\,x+12$ [= 0] soi	**A1**	
	$(8-k)^2-4\,(3)\,(12)$	**M1**	
	$k^2-16k-80*0$	**M1**	
	Critical values: –4 and 20 soi	**A1**	
	$-4<k<20$	**A1**	Alternative method: **M1** for $k=6x+8$ oe **M1** for $y=(6x+8)x-7$ **M1** for $3x^2+8x+5=(6x+8)x-7$ **A1** for $x=\pm2$ **A1** for $k=-4$, $k=20$ **A1** for $-4<k<20$
7(a)	$x+2y=\lg5$ or $3x+4y=\lg50$	**B1**	
	Solves *their* linear simultaneous equations	**M1**	
	$x=\lg2$ or equivalent simplified form	**A1**	
	$y=\frac{1}{2}\lg\frac{5}{2}$ or equivalent simplified form	**A1**	If **A0 A0** then **SC1** for a correct pair of unsimplified values or a correct pair of decimal values correct to at least 3sf
7(b)	$\left(x^{\frac{1}{3}}+2\right)\left(2x^{\frac{1}{3}}-5\right)$ oe	**M1**	
	$x^{\frac{1}{3}}=-2,\ \frac{5}{2}$	**M1**	
	$x=-8,\ \frac{125}{8}$	**A1**	
8(a)	$32-80x+80x^2-40x^3+10x^4-x^5$	**B3**	**B2** for any four or five terms correct or **B1** for any three terms correct or **M1** for a fully correct but unsimplified expansion

Question	Answer	Marks	Partial Marks
8(b)	Combines powers sufficiently to be able to take logs or applies correct log laws	M1	
	For making use of *their* expansion from part (a)	M1	
	$40x^2(2-x)$ [= 0] oe	M1	**FT** *their* (a) if possible
	$x=0$, $x=2$ cao	A1	
9(a)		B3	**B1** for correct shape with three distinct linear sections **B1** for 3 and 1.6 on vertical axis **B1** for 60, 75, 80 on horizontal axis
9(b)	$3\times60+15(1.6)+0.5(15)(1.4)+0.5(5)(1.6)$ or $3\times60+0.5(3+1.6)(15)+0.5(5)(1.6)$	M2	**M1** for attempting at least two terms of the sum:
	218.5 (metres)	A1	
9(c)	0.32 (ms^{-2})	B1	
10(a)	$a=3$, $b=1$	B2	B1 for each
10(b)	$\int_0^{their\ b} 4x^{\frac{2}{3}}\,dx+\int_{their\ b}^{their\ a}(x-3)^2\,dx$	M1	
	$\left[\frac{3}{5}\times4x^{\frac{5}{3}}\right]_0^{their\ b}+\left[\frac{(x-3)^3}{3}\right]_{their\ b}^{their\ a}$ soi	M2	M1 for each, soi
	$\frac{12}{5}(their\ b)-\frac{12}{5}(0)+\frac{(their\ a-3)^3}{3}-\frac{(their\ b-3)^3}{3}$	M1	
	$\frac{76}{15}$ or $5\frac{1}{15}$ or 5.07 or 5.06 rot to four or more figs; cao	A1	

Question	Answer	Marks	Partial Marks
11(a)		B3	**B1** for correct shape of f or f^{-1} **B1** for symmetry **B1** for drawn over correct domain **Maximum of 2 marks if not fully correct**
11(b)(i)	$[\pm]\sqrt{x-1}=y-4$ soi	M1	
	$g^{-1}(x)=4-\sqrt{x-1}$	A1	
	[Range] $g^{-1} \leqslant 4$	B1	
	[Domain] $x \geqslant 1$	B1	
11(b)(ii)	$\ln(2[(x-4)^2+1]+1)$	M1	
	$\ln(2x^2-16x+35)$	A1	
11(b)(iii)	Valid explanation, e.g. some of the values in the range of f are outside the domain of g	B1	
12(a)	$\frac{\mathrm{d}\left(\mathrm{e}^{3x}\right)}{\mathrm{d}x}=3\mathrm{e}^{3x}$	B1	
	$\frac{\mathrm{d}(2x+3)^6}{\mathrm{d}x}=k(2x+3)^5$	M1	
	their $(3\mathrm{e}^{3x})(2x+3)^6+$ (e^{3x}) (*their* $12(2x+3)^5$)	M1	
	$(3\mathrm{e}^{3x})(2x+3)^6+(\mathrm{e}^{3x})(12(2x+3)^5)$	A1	
	$(3\mathrm{e}^{3x})(2x+3)^5(2x+7)=0$	M1	
	$x=-1.5, -3.5$	A1	
12(b)	$x=0.5 \quad \mathrm{f}''(0.5)[=-5]<0 \Rightarrow$ max $x=3 \quad \mathrm{f}''(3)[=5]>0 \Rightarrow$ min	B2	**B1** for either one correct

Question	Answer	Marks	Partial Marks
12(c)	$h = \frac{10}{x^2}$	B1	
	$S = 8x^2 + 10x\left(their\ \frac{10}{x^2} \right)$	B1	
	$\frac{\mathrm{d}S}{\mathrm{d}x} = 16x - 100x^{-2}$ oe	M1	
	$16x - 100x^{-2} = 0$, $x = \sqrt[3]{\frac{25}{4}}$ oe	A1	**FT** *their* $\frac{\mathrm{d}S}{\mathrm{d}x} = 0$ if possible
	81.4 or 81.4325… rot to four or more figs	A1	

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rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1	$\frac{dy}{dx} = \cos x - e^{-x}$	B2	**B1** for $\cos x$ or $-e^{-x}$
	$\delta y = their \left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{4}} \times h$	M1	
	$0.251h$	A1	
2	Squares: $\left(1-\sqrt{5}\right)^2 = 1-\sqrt{5}-\sqrt{5}+5$	B1	or rationalises $\frac{10+2\sqrt{5}}{\left(1-\sqrt{5}\right)^2} \times \frac{\left(1+\sqrt{5}\right)^2}{\left(1+\sqrt{5}\right)^2}$
	Rationalises, e.g. $\frac{10+2\sqrt{5}}{6-2\sqrt{5}} \times \frac{6+2\sqrt{5}}{6+2\sqrt{5}}$	B1	or squares $\left(1+\sqrt{5}\right)^2 = 1+\sqrt{5}+\sqrt{5}+5$
	Multiplies out, e.g. $\frac{60+20\sqrt{5}+12\sqrt{5}+4(5)}{36-20}$	M1	Multiplies out $\left[\frac{10+2\sqrt{5}}{\left(1-\sqrt{5}\right)^2} \times \frac{6+2\sqrt{5}}{\left(1+\sqrt{5}\right)^2} = \right]$ $\frac{60+20\sqrt{5}+12\sqrt{5}+4(5)}{(1-5)^2}$
	$5+2\sqrt{5}$	A2	A1 for $k+2\sqrt{5}$ or $5+k\sqrt{5}$
3	$x-3 = k^2x^2+5kx+1$	M1	
	$k^2x^2+\left(5k-1\right)x+4=0$ soi	A1	
	$(5k-1)^2-4(k^2)(4)$	M1	
	$9k^2-10k+1*0$	M1	
	Critical values: $\frac{1}{9}$ and 1 soi	A1	
	$k<\frac{1}{9}$ or $k>1$	A1	

Question	Answer	Marks	Partial Marks
4	Factorised form: $(x+n)(x-n)(2x-1)$ oe	**B1**	
	Multiplies out correctly	**M1**	**FT** *their* factorised form provided of equivalent difficulty
	Correct expanded form in terms of *n*: $2x^3-x^2-2n^2x+n^2$	**A1**	
	Uses (*their* n^2) = 4 in *their* expression	**M1**	
	$2x^3-x^2-8x+4$	**A1**	If **A0A0** then **SC1** for $(x+n)(x-n)(x-0.5)$ giving $n^2=8$ leading to $x^3-\frac{1}{2}x^2-8x+4$
			Alternative method: **B1** for factorised form: $(x+n)(x-n)(2x-1)$
			M1 for *their* $n^2=4$
			A1 for $n=2$
			M1 for multiplying out $(x+\textit{their}\,2)(x-\textit{their}\,2)(2x-1)$
			A1 for $2x^3-x^2-8x+4$ If **A0A0** then **SC1** for $(x+n)(x-n)(x-0.5)$ giving $n^2=8$ leading to $x^3-\frac{1}{2}x^2-8x+4$
5(a)	Finds coordinates of mid-point (8, –2)	**B1**	
	$m_{AB}=\frac{3+7}{4-12}\left[=-\frac{5}{4}\right]$ oe soi	**B1**	
	$m_L=\frac{-1}{-5/4}$ oe	**M1**	
	$y+2=\frac{4}{5}(x-8)$ oe isw	**A1**	

Question	Answer	Marks	Partial Marks
5(b)	$y-12=-\frac{5}{4}(x-5)$	B1	
	Attempts to solve *their* equations	M1	
	(13, 2)	A2	**A1** for $x = 13$ or $y = 2$
6(a)	$\frac{dy}{dx}=\sec^2 2x$	B1	
	$their \left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{8}} = their 2$	B1	**FT** *their* $\frac{dy}{dx}$
	$x=\frac{\pi}{8}, \quad y=4$	B1	
	$y - their 4 = (their 2)\left(x-\frac{\pi}{8}\right)$ oe	M1	
	$2x-y=\frac{\pi}{4}-4$	A1	
6(b)	$\sqrt{\left(\frac{\pi}{8}-2\right)^2+\left(4-\frac{\pi}{4}\right)^2}$ oe	M1	
	3.59 or 3.59[03…] rot to four or more figs	A1	
7(a)	2ln(5*x* + 2)	B2	**B1** for $k\ln(5x+2)$
	$2(\ln(22)-\ln(2))$ oe soi	M1	
	$2\ln 11$ or $\ln 121$ or $\ln 11^2$	A1	
7(b)	$\int e^{8x+4}dx$	M1	
	$\left[\frac{1}{8}e^{8x+4}\right]_0^{\ln 2}$	M1	
	$\frac{1}{8}\left(e^{\ln 2^8}\times e^4-e^4\right)$ oe	M2	**M1** for $\frac{1}{8}\left(e^{\ln 2^8+4}-e^4\right)$
	$\frac{255}{8}e^4$ or exact equivalent	A1	

Question	Answer	Marks	Partial Marks
8(a)	$3(\text{cosec}^2 x - 1) - 14\,\text{cosec}\, x - 2 [= 0]$	**M1**	
	$3\text{cosec}^2 x - 14\text{cosec}\, x - 5 = 0$	**A1**	
	$(\text{cosec}x - 5)(3\text{cosec}x + 1)$	**M1**	
	$\sin x = \frac{1}{5}$ nfww	**A1**	
	11.5 and 168.5 nfww	**A1**	
8(b)	Correct use of $\sin^2 y + \cos^2 y = 1$	**B1**	
	Factorises using the difference of 2 squares	**B1**	
	Uses $\frac{1}{\cot y} = \tan y$ or $\cot y = \frac{\cos y}{\sin y}$ correctly	**B1**	
	Full and correct completion to given answer: $\tan y - 2\cos y \sin y$	**B1**	
9(a)	$\frac{3^{10x}}{3^{3x-6}} [= 243]$ oe or $\log 9^{5x} - \log 27^{x-2} = \log 243$ oe	**B1**	
	$3^{7x+6} = 3^5$ soi oe or $5x(\log 9) - (x-2)\log 27 = \log 243$	**M1**	
	$x = -\frac{1}{7}$	**A1**	

Question	Answer	Marks	Partial Marks
9(b)	$\frac{1}{2}\log_a b - \frac{1}{2} = \frac{1}{\log_a b}$ or $\frac{\frac{1}{2}}{\log_b a} - \frac{1}{2} = \log_b a$	**B2**	**B1** for bringing down the power of $\frac{1}{2}$ e.g. $\frac{1}{2}\log_a b$ or for a change of base e.g. $\frac{1}{\log_a b}$
	Clears the fraction and rearranges $\frac{1}{2}(\log_a b)^2 - \frac{1}{2}\log_a b = 1$ oe $(\log_a b)^2 - \log_a b - 2 = 0$ oe or let $x = \log_a b$ $x^2 - x - 2 = 0$ oe or $\frac{1}{2} - \frac{1}{2}\log_b a = (\log_b a)^2$ $0 = 2(\log_b a)^2 + \log_b a - 1$ oe or let $y = \log_b a$ $2y^2 + y - 1 = 0$	**M1**	
	$(\log_a b - 2)(\log_a b + 1)$ oe or $(2\log_b a - 1)(\log_b a + 1)$	**M1**	
	[$\log_a b = 2$, $\log_a b = -1$ or $\log_b a = \frac{1}{2}$, $\log_b a = -1$ leading to] $b = a^2$, $b =$ oe	**A1**	
10(a)(i)	$4 \times (-0.5)^{19}$	**M1**	
	$-\frac{1}{131072}$ or -7.63×10^{-6} or $-7.62939... \times 10^{-6}$ rot to four or more figs	**A1**	
10(a)(ii)	Valid explanation e.g. the common ratio is between –1 and 1	**B1**	
	$\frac{4}{1-(-0.5)} = \frac{8}{3}$	**B1**	

Question	Answer	Marks	Partial Marks
10(b)(i)	$a+9d=15(a+d)$	**B1**	
	$\frac{6}{2}\{2a+5d\}=87$	**B1**	
	Solves *their* equations for *d* e.g. $2\left(-\frac{3}{7}d\right)+5d=29$	**M1**	
	$d = 7$	**A1**	
10(b)(ii)	$a=-3$ soi	**B1**	
	$6990 = their(-3)+(n-1)(their\,7)$	**M1**	
	$n = 1000$	**A1**	
11(a)	[perimeter =] $\frac{4}{3}\pi r$ soi	**B2**	**B1** for angle $ACB = \frac{2}{3}\pi$
	$\left(their\,\frac{4}{3}\pi r\right)=4\pi$ oe	**M1**	
	$r = 3$	**A1**	
11(b)	$\frac{1}{2}\times their\,3^2\times their\,\frac{2\pi}{3}$ oe	**M1**	
	$\frac{1}{2}\times their\,3^2\times \sin their\,\frac{2\pi}{3}$ oe	**M1**	
	For subtracting and doubling: $their\,3^2\times their\,\frac{2\pi}{3} - their\,3^2\times\sin their\,\frac{2\pi}{3}$	**M1**	
	$6\pi-\frac{9}{2}\sqrt{3}$ or exact equivalent	**A1**	

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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.

Mark schemes should usually be read together with the Principal Examiner Report for Teachers. However, because students did not sit exam papers, there is no Principal Examiner Report for Teachers for the June 2020 series.

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GENERIC MARKING PRINCIPLE 2:

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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:

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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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.

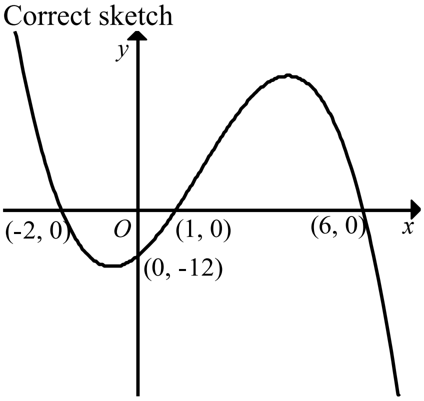
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

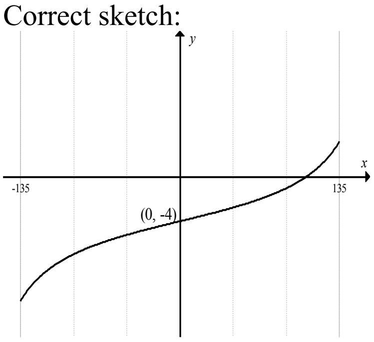
B Mark for a correct result or statement independent of Method marks.

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	Partial Marks
1	Coordinates of mid-point $(-2, 1)$	**B1**	
	$m_{AB} = \frac{9 - -7}{-8 - 4}\left[= -\frac{16}{12}\right]$	**B1**	
	$m_{\perp} = \frac{-1}{-16/12}$	**M1**	
	$y - 1 = \frac{3}{4}(x + 2)$ oe	**A1**	
2	Uses $b^2 - 4ac$ $(-4k)^2 - 4(4)(2k + 3)$ soi	**M1**	
	Correctly simplifies $16k^2 - 32k - 48$	**A1**	**FT** provided of equivalent difficulty
	$16(k + 1)(k - 3)$ oe	**M1**	
	CV $-1, 3$	**A1**	
	$-1 < k < 3$	**A1**	**FT** *their* lower CV $< k <$ *their* upper CV
3(a)	Correct sketch 	**B2**	**B1** for correct shape **B1** for correct coordinates (–2, 0), (1, 0), (6, 0) and (0, –12)
3(b)	$-2 \leqslant x \leqslant 1$ and $x \geqslant 6$	**B2**	**B1** for $-2 \leqslant x \leqslant 1$ or $x \geqslant 6$ with no contradictions
4(a)(i)	6720	**B2**	**B1** for $8 \times 7 \times 6 \times 5 \times 4$ or ${}^8P_5$
4(a)(ii)	2520	**B2**	**B1** for $3 \times 7 \times 6 \times 5 \times 4$ or ${}^3P_1 \times {}^7P_4$
4(b)	${}^4C_1 \times {}^5C_2 + {}^5C_3$	**M1**	
	50	**A1**	

Question	Answer	Marks	Partial Marks
5(a)	$\frac{\sqrt{128}}{\sqrt{72}} = \frac{\sqrt{64\times 2}}{\sqrt{36\times 2}}$ or simplifies $\sqrt{\frac{128}{72}}$ to $\sqrt{\frac{16}{9}}$	**M1**	
	correct completion to $\frac{4}{3}$	**A1**	
5(b)	$\frac{3+2\sqrt{3}-\sqrt{3}\left(1+\sqrt{3}\right)}{\left(1+\sqrt{3}\right)\left(3+2\sqrt{3}\right)}$	**M1**	
	$\frac{\sqrt{3}}{3+2\sqrt{3}+3\sqrt{3}+6}$	**M1**	
	$\frac{\sqrt{3}}{9+5\sqrt{3}}\times\frac{9-5\sqrt{3}}{9-5\sqrt{3}}$	**M1**	
	$\frac{9\sqrt{3}-15}{6}$ or equivalent	**A1**	
			Alternative method **M1** for $\frac{1-\sqrt{3}}{\left(1+\sqrt{3}\right)\left(1-\sqrt{3}\right)}-\frac{\sqrt{3}\left(3-2\sqrt{3}\right)}{\left(3+2\sqrt{3}\right)\left(3-2\sqrt{3}\right)}$
			M1 for $\frac{1-\sqrt{3}}{1-3}-\frac{3\sqrt{3}-6}{9-12}$
			M1 for writing with a common denominator
			A1 for $\frac{9\sqrt{3}-15}{6}$ or equivalent
6(a)	$a=20$ $b=2$ $c=-3$	**B3**	**B1** for each
6(b)	Correct sketch: 	**B2**	**B1** for correct tan shape with one continuous section only **B1** for correct y-intercept $(0, -4)$

Question	Answer	Marks	Partial Marks
7(a)	$\ln y = \ln(Ax^n)$ and so $\ln y = \ln A + \ln x^n$	M1	
	$\ln y = \ln A + n \ln x$	A1	
7(b)	$\ln A = 0.5$	M1	
	$A = e^{0.5}$ or 1.6	A1	
	$n = \dfrac{1.7 - 0.5}{3.2 - 0}$	M1	
	$n = \dfrac{3}{8}$ oe	A1	
7(c)	$y = their\, e^{0.5}(11)^{their \frac{3}{8}}$ oe	M1	
	4.05 or 4.05200... rot to four or more figs	A1	
8(a)	$\sec^2(x+4) - 3\cos x$	B2	**B1** for each
8(b)	$\dfrac{d(\ln(2x+5))}{dx} = \dfrac{2}{2x+5}$	B1	
	$\dfrac{d(2e^{3x})}{dx} = 6e^{3x}$	B1	
	$\dfrac{dy}{dx} = \dfrac{2e^{3x}\left(their \dfrac{2}{2x+5}\right) - their\, 6e^{3x}\ln(2x+5)}{4e^{6x}}$	M1	**FT** *their* derivatives of $\ln(2x+5)$ and $2e^{3x}$
	$\dfrac{dy}{dx} = \dfrac{2e^{3x}\left(\dfrac{2}{2x+5}\right) - 6e^{3x}\ln(2x+5)}{4e^{6x}}$	A1	
	$\delta y = their \left.\dfrac{dy}{dx}\right\|_{x=1} \times h$	M1	
	$-0.138h$	A1	
9(a)	–540	B2	**B1** for $\dfrac{6\times5\times4}{3!}(3x)^3\left(-\dfrac{1}{x}\right)^3$ oe

Question	Answer	Marks	Partial Marks
9(b)	$\frac{n(n-1)(n-2)(n-3)(n-4)(n-5)}{6!}\times\left(\frac{1}{2}\right)^6$	B1	
	$\frac{n(n-1)(n-2)(n-3)}{4!}\times\left(\frac{1}{2}\right)^4$	B1	
	Forms a correct equation with *their* coefficients in terms of n	M1	
	Simplifies their equation to $(n-4)(n-5)=240$ or better	M1	
	Factorises or attempts to solve *their* 3-term quadratic	M1	
	$n=20$	A1	
10(a)	$5(1+\tan^2 A)+14\tan A-8=0$ soi	B1	
	Solves or factorises *their* 3-term quadratic in $\tan A$ oe	M1	
	11.3 and 108.4 or 11.30[99...] and 108.43[49...] rot to four or more decimal places	A2	with no extras in range; not from clearly wrong working but allow recovery from minor slips or **A1** for either, ignoring extras
10(b)	$4B-\frac{\pi}{8}=\sin^{-1}\left(-\frac{2}{5}\right)$ soi	B1	
	–0.411[516...] rot to three or more figs	M1	
	–0.00470[444...] rot to three or more figs	A1	
	–0.584[344...] rot to three or more figs	A1	
11(a)	$R=\frac{1}{2}(w+180)$	B1	
	$V=\frac{1}{3}\pi(\textit{their } R)^2(w+180)$ $-\frac{1}{3}\pi(90)^2(180)$	M1	
	Correct completion to given answer: $V=\frac{\pi}{12}(w+180)^3-486000\pi$	A1	

Question	Answer	Marks	Partial Marks
11(b)	$\frac{\mathrm{d}V}{\mathrm{d}w} = 3\frac{\pi}{12}(w+180)^2$ oe	B1	
	$\frac{\mathrm{d}w}{\mathrm{d}t} = \frac{\mathrm{d}w}{\mathrm{d}V} \times \frac{\mathrm{d}V}{\mathrm{d}t}$ soi	M1	
	$\frac{\mathrm{d}w}{\mathrm{d}t} = \frac{1}{\mathit{their}\left(\frac{\mathrm{d}V}{\mathrm{d}w}\right)\Big\vert_{w=10}} \times 10\,000$	M1	
	0.353 [cms^{-1}] or 0.3526[97...] [cms^{-1}] rot to four or more figs	A1	
12(a)(i)	$\frac{-(-\sin x)}{\cos^2 x}$ oe	B2	**B1** for $\frac{-\sin x}{\cos^2 x}$ oe
	Correct completion to given answer: $\tan x \sec x$	B1	dep on all previous marks having been awarded
12(a)(ii)	$\sqrt[4]{\mathrm{e}^{3x}} = \mathrm{e}^{\frac{3x}{4}}$ oe	B1	
	$\frac{3}{\cos x} - \int \mathrm{e}^{\frac{3x}{4}}\,\mathrm{d}x = \frac{3}{\cos x} - k\mathrm{e}^{\frac{3x}{4}}$ oe	M1	
	$\frac{3}{\cos x} - \frac{4}{3}\mathrm{e}^{\frac{3x}{4}} + c$ oe	A1	
12(b)	$[\ln(px+10)]_2^5 = \ln 2$	M1	
	$\ln(5p+10) - \ln(2p+10) = \ln 2$	M1	
	$\ln\left(\frac{5p+10}{2p+10}\right) = \ln 2$	M1	
	$5p+10 = 2(2p+10)$	M1	
	$p = 10$	A1	

Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/22**

Paper 22 **March 2020**

MARK SCHEME

Maximum Mark: 80

Published

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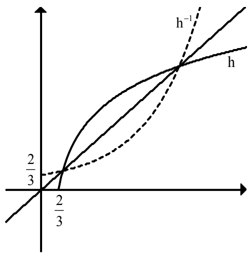
Question	Answer	Marks	Partial Marks
1	Expands right hand side and attempts to collect terms	**M1**	
	Factorises or solves *their* 3-term quadratic	**M1**	
	correct CVs $\frac{2}{5}, \frac{3}{2}$	**A1**	
	$\frac{2}{5} < x < \frac{3}{2}$ mark final answer	**A1**	**FT** *their* CVs, provided both M marks awarded

Question	Answer	Marks	Partial Marks
2	Valid method to find m $m = \frac{9-7}{10-6}\left[=\frac{1}{2}\right]$	**M1**	
	Valid method to find c e.g. $7 = their\frac{1}{2}\times 6 + c$	**M1**	**FT** *their m*
	$\lg y = \left(their\frac{1}{2}\right)x^3 + their 4$	**M1**	
	$y = 10^{\frac{1}{2}x^3+4}$ oe, isw	**A1**	
3	Rewrites in quadratic form soi e.g. $y = 3^x$ then $y^2 - 3y - 4 = 0$ or $(3^x)^2 - 3(3^x) - 4 = 0$	**M1**	
	Factorises or solves *their* 3-term quadratic e.g. $(y + 1)(y - 4)$ [= 0] or $(3^x + 1)(3^x - 4)$ [= 0]	**M1**	
	$3^x = 4$	**A1**	ignore $3^x = -1$
	$x = \log_3 4$ or $\frac{\ln 4}{\ln 3}$ oe, only	**A1**	
4	$\overrightarrow{OC} - \overrightarrow{OA} = 4\left(\overrightarrow{OC} - \overrightarrow{OB}\right)$ soi	**B1**	
	$[\overrightarrow{OC} =]$ $\begin{pmatrix}15\\-3\end{pmatrix}$	**B2**	**B1** for [x =] 15 or [y =] –3
	$\left\|\overrightarrow{OC}\right\| = \sqrt{their 15^2 + their(-3)^2}$	**M1**	
	$\frac{1}{\sqrt{234}}\begin{pmatrix}15\\-3\end{pmatrix}$ oe	**A1**	**FT** *their* $\begin{pmatrix}15\\-3\end{pmatrix}$ and *their* $\sqrt{234}$
5(a)	Correct V shape with vertex on positive x-axis	**B1**	
	(0, 7)	**B1**	
	$\left(\frac{7}{5}, 0\right)$	**B1**	

Question	Answer	Marks	Partial Marks
5(b)	$x = 2$	B1	
	$5x - 7 = their(-3)$ oe, soi or $25x - 35 = their(-15)$ oe, soi	M1	
	$x = \frac{4}{5}$ oe	A1	
	Alternative method		
	$25x^2 - 70x + 40 = 0$ oe	(B1	
	factorising e.g. $(5x-4)(x-2)$	M1	
	$x = 2, \frac{4}{5}$	A1)	
6(a)	$2(6) + 6\theta = 2(6 + 5\pi)$ oe	M1	
	$\theta = \frac{5}{3}\pi$ oe, soi	A1	
	$\frac{1}{2} \times 6^2 \times their\left(\frac{5\pi}{3}\right)$	M1	
	94.2 or 30π	A1	
	Alternative method		
	arc $AB = 10\pi$	(M1	
	sector is $\frac{10\pi}{12\pi} = \frac{5}{6}$ of the circle	B1	
	$\frac{5}{6} \times 36\pi$	M1	
	94.2 or 30π	A1)	
6(b)	$2\left(7\sin\frac{\pi}{8}\right) + \frac{7\pi}{4}$ oe, soi	M2	**M1** for $2\left(7\sin\frac{\pi}{8}\right) + their\left(\frac{7\pi}{4}\right)$ or $their\left(2\left(7\sin\frac{\pi}{8}\right)\right) + \frac{7\pi}{4}$
	10.9 or 10.85 to 10.86	A1	

Question	Answer	Marks	Partial Marks
7	Eliminates one variable e.g. $x^2 = 5(x^2 - 2x + 1) - 1$ or $y = 5y - 1 - 2\sqrt{5y-1} + 1$	**M1**	
	Collects terms ready to solve e.g. $4x^2 - 10x + 4 = 0$ or $4y^2 - 5y + 1 = 0$	**A1**	
	Factorises, applies the formula or completes the square e.g. $2(2x-1)(x-2)$ or $(4y-1)(y-1)$	**M1**	
	Both $(0.5,\ 0.25)$ and $(2, 1)$	**A2**	**A1** for either $(0.5, 0.25)$ or $(2, 1)$ provided nfww or $x = 0.5, 2$ or $y = 0.25, 1$
8(a)	Valid explanation e.g. Each value of x is mapped to a unique value of y.	**B1**	
8(b)	$-5 \leqslant \mathrm{f} \leqslant 1$	**B1**	
8(c)	$a = 3, b = 0.75$ oe, $c = -2$	**B4**	**B1** for $a = 3$ **B1** for $c = -2$ **M1** for $\frac{2\pi}{b} = \frac{8\pi}{3}$ oe **A1** for $b = 0.75$ oe

Question	Answer	Marks	Partial Marks
9	$\frac{\mathrm{d}(\mathrm{e}^{3x})}{\mathrm{d}x} = 3\mathrm{e}^{3x}$ soi	**B1**	
	Applies product rule to e.g. numerator: *their*$(3\mathrm{e}^{3x})\sin x + \mathrm{e}^{3x}\cos x$	**M1**	or to $x^{-2}\sin x$: $x^{-2}\cos x + (-2x^{-3})\sin x$ or to $\mathrm{e}^{3x} \times x^{-2}$: $\mathrm{e}^{3x} \times (-2x^{-3}) + their(3\mathrm{e}^{3x}) \times x^{-2}$
	Correct quotient rule: $\frac{x^2\left(their\left(3\mathrm{e}^{3x}\sin x + \mathrm{e}^{3x}\cos x\right)\right) - 2x(\mathrm{e}^{3x}\sin x)}{x^4}$	**M1**	or applies product rule for a second time e.g. : $x^{-2}(their\left(3\mathrm{e}^{3x}\right)\sin x + \mathrm{e}^{3x}\cos x) +$ $(-2x^{-3})(\mathrm{e}^{3x}\sin x)$
	Fully correct derivative; isw	**A1**	
	$\delta y = their\left(\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\|_{x=0.5}\right) \times h$	**M1**	
	7.14*h* or 7.137[66...]*h* with coefficient rot to 4 or more figs isw	**A1**	Answer only, without working, scores **SC1**
10(a)(i)	Correct method to find inverse	**M1**	
	$\mathrm{g}^{-1}(x) = \frac{1}{x-3}$ oe	**A1**	
10(a)(ii)	$\mathrm{g}^{-1} \geqslant 1$ or $[1, \infty)$	**B1**	
10(a)(iii)	$3 < x \leqslant 4$ or $(3, 4]$	**B2**	**B1** for 3 and 4 in an incorrect inequality or for $x > 3$ or $x \leqslant 4$

Question	Answer	Marks	Partial Marks
10(b)	Correct graph for h	**B1**	
	h^{-1} the reflection of h in $y = x$	**B1**	**FT** *their* h
	Both graphs drawn over the correct domain	**B1**	**FT** *their* h and h^{-1}
		**B1**	Correct graphs intersecting twice
11	$h = \frac{1000}{\pi r^2}$ or $r = \sqrt{\frac{1000}{\pi h}}$ soi	**B1**	
	$S = \pi r^2 + 2\pi r\left(\frac{1000}{\pi r^2}\right)$ oe or $S = \pi\left(\frac{1000}{\pi h}\right) + 2\pi\sqrt{\frac{1000}{\pi h}}(h)$ oe	**M1**	
	$S = \pi r^2 + 2\left(\frac{1000}{r}\right)$ or better or $S = \frac{1000}{h} + 2\pi\sqrt{\frac{1000}{\pi}}\left(h^{\frac{1}{2}}\right)$	**A1**	
	$\frac{dS}{dr} = 2\pi r - 2000r^{-2}$ or $\frac{dS}{dh} = -1000h^{-2} + \sqrt{1000\pi}\, h^{-\frac{1}{2}}$	**B2**	**B1 FT** for each term correct
	$\frac{dS}{dr} = 0, \quad r^3 = \frac{1000}{\pi}$ oe or $\frac{dS}{dh} = 0, \quad h^{\frac{3}{2}} = \sqrt{\frac{1000}{\pi}}$ oe	**M1**	
	$S = \pi\left(\sqrt[3]{\frac{1000}{\pi}}\right)^2 + \frac{2000}{\sqrt[3]{\frac{1000}{\pi}}}$ or $S = \frac{1000}{\sqrt[3]{\frac{1000}{\pi}}} + 2\sqrt{1000\pi}\left(\sqrt[3]{\frac{1000}{\pi}}\right)^{\frac{1}{2}}$	**M1**	
	439 or 439.3 to 439.4	**A1**	

Question	Answer	Marks	Partial Marks
12(a)	$v = -6t + c$ soi	**B1**	
	$v = -6t + 18$	**M1**	
	$-6t + 18 = 0$, $t = 3$	**A1**	
12(b)	$s = \frac{-6t^2}{2} + 18t$ soi	**B1**	
	$\left(-3(3)^2 + 18(3)\right) - \left(-3(2)^2 + 18(2)\right)$	**M1**	**FT** *their s* provided it is from an attempt to integrate
	3 (metres)	**A1**	Not from wrong working
13(a)(i)	$a + ar = 10$ soi	**B1**	
	$ar^2 = 9$ soi	**B1**	
	Solves *their* equations	**M1**	
	$r = -\frac{3}{5}, \frac{3}{2}$ and $a = 25, 4$	**A2**	**A1** for either $r = -\frac{3}{5}, \frac{3}{2}$ or $a = 25, 4$ or for $r = -\frac{3}{5}$ **and** $a = 25$ or for $r = \frac{3}{2}$ **and** $a = 4$
13(a)(ii)	$\frac{125}{8}$ or 15.625 or $15\frac{5}{8}$ only	**B1**	

Question	Answer	Marks	Partial Marks
13(b)	$d = 8$	**B1**	
	$[S_{200} - S_{99} =]$ $\frac{200}{2}\{2(-10)+199(their 8)\} -$ $\frac{99}{2}\{2(-10)+98(their 8)\}$ oe	**M2**	**M1** for either sum correct or correct **FT** *their d*
	119382 cao	**A1**	
	Alternative method 1		
	$d = 8$	**(B1**	
	$u_{100} = -10+99\times 8[=782]$ and $u_{200} = -10+199\times 8[=1582]$ and $n = 101$	**M1**	
	$\frac{1}{2}(101)(782+1582)$	**M1**	
	119382 cao	**A1)**	
	Alternative method 2		
	$d = 8$	**(B1**	
	$u_{100} = -10+99\times 8[=782]$ and $n = 101$	**M1**	
	$\frac{1}{2}(101)(2\times 782+(101-1)\times 8)$	**M1**	
	119382 cao	**A1)**	

Cambridge IGCSE

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/21**
Paper 2	**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.

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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.
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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.

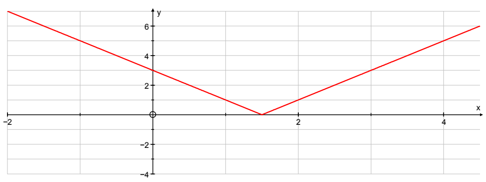
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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)		**B2**	**B1** shape **B1** Correct intersection with axes.
1(ii)	$7 = 2x - 3 \rightarrow x = 5$	**B1**	
	Uses $7 = 3 - 2x$ oe	**M1**	
	$x = -2$	**A1**	
2	$p = 2$ $q = 4$ $r = 3$	**B3**	**B1** for each

Question	Answer	Marks	Partial Marks
3(a)	obtain $e^{5x-3} = 3$	M1	**OR** Take logs $\rightarrow 2x + 1 = \ln 3 + 4 - 3x$
	take logs correctly $\rightarrow 5x - 3 = \ln 3$	M1	**OR** Collect like terms $\rightarrow 5x = 3 + \ln 3$
	$x = \frac{3+\ln 3}{5}$ or $x = 0.820$	A1	
3(b)`	Use of laws of logs $\rightarrow \lg(y-6)(y+15) = 2$	M1	
	Uses $10^2 = 100$ $\rightarrow [(y-6)(y+15)] = 100$	B1	
	Obtain correct quadratic $\rightarrow y^2 + 9y - 190 = 0$	A1	
	Solve a three term quadratic	M1	
	$y = 10$ only	A1	
4	Eliminate x or y	M1	
	$x = \frac{7+5\sqrt{2}}{3+2\sqrt{2}}$ or $y = \frac{1}{3+2\sqrt{2}}$	A1	
	Multiply numerator and denominator by $3-2\sqrt{2}$	M1	
	$x = 1+\sqrt{2}$	A1	
	$y = 3-2\sqrt{2}$	A1	
5(i)	Differentiate	M1	Obtain $2\cos 2t$ or $-2\sin 2t$
	$v = 6\cos 2t - 8\sin 2t$	A1	
	$a = -12\sin 2t - 16\cos 2t$	A1	
5(ii)	Equate v to 0 and attempt to solve	M1	
	$\tan 2t = 0.75$	A1	or $\sin 2t = 0.6$ or $\cos 2t = 0.8$
	$t = 0.32(2)$	A1	Must be in radians
5(iii)	Insert value of t into expression for a	M1	Radians or degrees
	$a = -20$	A1	Must have used radians

Question	Answer	Marks	Partial Marks
6	Eliminate y	**M1**	
	$x^2 - x - 5 = 0$	**A1**	
	Use formula	**M1**	
	$x = \frac{1 \pm \sqrt{21}}{2}$	**A1**	
	$y = \frac{21 \pm \sqrt{21}}{2}$	**A1**	
	Find mid-point	**M1**	$(0.5, 10.5)$
	Show that mid-point lies on $x + y = 11$	**A1**	
7(a)(i)	$f(0.5) = 0.5 + 4.5 - 5 = 0$	**B1**	
7(a)(ii)	Factorise to obtain $2x^2$ and 5	**M1**	
	$(2x-1)(2x^2 + x + 5)$	**A1**	
7(b)(i)	Replace $\tan x$ by $\frac{\sin x}{\cos x}$ and $\sec x$ by $\frac{1}{\cos x}$	**M1**	$13\frac{\sin x}{\cos^2 x} - 4\sin x - \frac{5}{\cos^2 x} = 0$
	Uses $\cos^2 x = 1 - \sin^2 x$	**M1**	$13\sin x - 4\sin x(1 - \sin^2 x) - 5 = 0$
	$4\sin^3 x + 9\sin x - 5 = 0$	**A1**	Completed correctly
7(b)(ii)	$2\sin^2 x + \sin x + 5 = 0$ no real roots	**B1**	Suitable statement seen
	$2\sin x - 1 = 0$	**M1**	Attempt to solve
	$x = \frac{\pi}{6}$	**A1**	
	$x = \frac{5\pi}{6}$	**A1**	
8(i)	$-2e^{-2x}$ seen	**B1**	
	Product rule	**M1**	Clear attempt
	$e^{-2x}(1 - 2x)$	**A1**	

Question	Answer	Marks	Partial Marks
8(ii)	Set $\frac{dy}{dx}=0$ and attempt to solve	**M1**	Must have two terms
	$\left(\frac{1}{2}, \frac{1}{2e}\right)$	**A1**	
8(iii)	Attempt to find $\frac{dy}{dx}$ at $x=1$	**M1**	
	$y-\frac{1}{e^2}=\frac{-1}{e^2}(x-1)$ or $y=-\frac{1}{e^2}x+\frac{2}{e^2}$	**A1**	
8(iv)	Integrate **part(i)** $xe^{-2x}=\int\left(-2xe^{-2x}+e^{-2x}\right)dx$	**M1**	
	Integrate e^{-2x} and make $\int xe^{-2x}dx$ the subject	**M1**	
	$\frac{-xe^{-2x}}{2}-\frac{e^{-2x}}{4}+c$	**A1**	
9(i)	$\frac{1}{3}$	**B1**	
	$\times\begin{pmatrix}-3 & -2\\ 9 & 5\end{pmatrix}$	**B1**	
9 (ii)	$\mathbf{B}^2=\begin{pmatrix}10 & 7\\ 42 & 31\end{pmatrix}$	**B2**	Minus one each error
9(iii)	$\mathbf{C}=\mathbf{B}^2-\mathbf{BA}$	**M1**	
	$\mathbf{BA}=\begin{pmatrix}1 & 1\\ -15 & -3\end{pmatrix}$	**A1**	
	$\mathbf{C}=\begin{pmatrix}9 & 6\\ 57 & 34\end{pmatrix}$	**A1**	
9(iv)	$\mathbf{D}=\mathbf{B}^2\mathbf{A}^{-1}$	**M1**	
	$\mathbf{D}=\frac{1}{3}\begin{pmatrix}33 & 15\\ 153 & 71\end{pmatrix}$	**A2**	Minus one each error
10(i)	$81+108x+54x^2+12x^3+x^4$	**B3**	**B1** for coefficients **B1** for powers **B1** for all Correct

Question	Answer	Marks	Partial Marks
10(ii)	Identify and select two terms in x and equate to zero	**M1**	$81 - 54p = 0$
	$p = 1.5$	**A1**	
10(iii)	Constant term = $-108p = -162$	**A1**	**FT** using *their p*
10(iv)	Correctly identify two terms in x^2	**M1**	x^2 term = $108 - 12p$
	$108 - 18 = 90$	**A1**	
11(i)	Uses correct triangle with v_w opposite 10° Sides of 300 and 280 include 10°	**M1**	
	Use cosine rule	**M1**	${v_w}^2 = 300^2 + 280^2 - 2 \times 300 \times 280 \cos 10$
	$v_w = 54.3$	**A1**	
11(ii)	Use sine rule	**M1**	$\frac{280}{\sin\alpha} = \frac{54.3}{\sin 10°}$
	$\alpha = 63°$ or $64°$	**A1**	
	Bearing 117° or 116°	**A1**	

Cambridge Assessment International Education
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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **October/November 2019**

MARK SCHEME

Maximum Mark: 80

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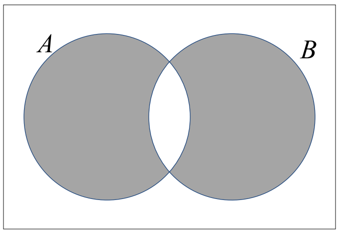
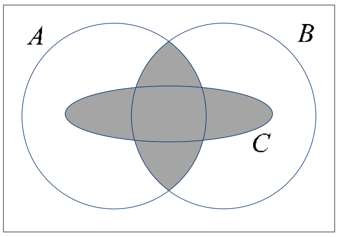
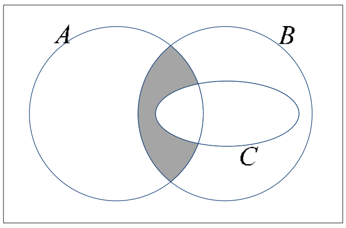
Abbreviations

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

Question	Answer	Marks	Guidance
1		**B1**	
		**B1**	
		**B 1**	
2	$\frac{dy}{dx} = 6\cos 3x$	**B1**	
	$-3\sin 3x$	**B1**	
	$\frac{d^2y}{dx^2} = -18\sin 3x - 9\cos 3x$	**B1**	**FT** Correct derivative of *their* $\frac{dy}{dx}$
	Insert and collect like terms	**M1**	Must insert for y, *their* $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ correctly resulting in 6 terms.
	$k = -15$	**A1**	Allow $-15\sin 3x$ seen nfww
3(i)	${}^{14}P_5$ or $14 \times 13 \times 12 \times 11 \times 10$	**M1**	
	240 240	**A1**	cao
3(ii)	${}^{3}P_1 \times {}^{5}P_2 \times {}^{6}P_2$ or $3 \times (5 \times 4) \times (6 \times 5)$	**M1**	Two of the three elements multiplied by …
	= 1800	**A1**	
3(iii)	${}^{6}P_2 \times {}^{8}P_3$ or $(6 \times 5) \times (8 \times 7 \times 6)$	**M1**	One element multiplied by … Clear intention to multiply
	= 10 080	**A1**	

Question	Answer	Marks	Guidance
4	$kx + 3 = x^2 + 5x + 12$ $\rightarrow x^2 + (5 - k)x + 9 (= 0)$	M1	Equate and attempt to simplify to all terms on one side.
	Use discriminant of *their* quadratic.	M1	**dep**
	$(5 - k)^2 - 36$ oe	A1	Unsimplified
	$k = -1$ and 11	A1	Both boundary values
	$-1 < k < 11$	A1	Must be in terms of k.
	OR $2x + 5 \sim k$	M1	Connect gradients of line and curve
	$y = (2x+5)x + 3 \rightarrow$ $2x^2 + 5x + 3 = x^2 + 5x + 12$	M1	Eliminate k and y.
	$x^2 = 9 \rightarrow x = \pm 3$	A1	
	$k = 11$ or $k = -1$	A1	
	$-1 < k < 11$	A1	
5(i)	$\frac{dy}{dx} = \frac{-2k}{(x+1)^3}$	B1	oe Unsimplified
	Gradient of normal = $\frac{(x+1)^3}{2k}$ or Gradient of tangent = -3	M1	Gradient of normal = $\frac{-1}{\text{gradient of tangent}}$
	$\frac{8}{2k} = \frac{1}{3}$ or $\frac{2k}{8} = -3$	M1	Equate gradient of normal to $\frac{1}{3}$ at $x = 1$ or equate gradient of tangent to –3 at $x = 1$
	$k = 12$	A1	
5(ii)	$x = 2 \rightarrow \frac{dy}{dx} = -\frac{8}{9}$ or *their* $\frac{-2k}{27}$	B1	**FT**
	$y = \frac{4}{3}$ or *their* $\frac{k}{9}$	B1	**FT**
	$\frac{y - \frac{4}{3}}{x - 2} = -\frac{8}{9}$ or $y = -\frac{8}{9}x + \frac{28}{9}$	B1	isw

Question	Answer	Marks	Guidance
6(i)	$\dfrac{\frac{\sin x}{\cos x}}{\frac{1}{\cos x}+1}+\dfrac{\frac{1}{\cos x}+1}{\frac{\sin x}{\cos x}}$	M1	Use $\tan x=\dfrac{\sin x}{\cos x}$ and $\sec x=\dfrac{1}{\cos x}$ throughout
	$\dfrac{\sin x}{1+\cos x}+\dfrac{1+\cos x}{\sin x}$	M1	**dep** Multiply by cos*x*
	$\dfrac{\sin^2 x+1+2\cos x+\cos^2 x}{(1+\cos x)\sin x}$	M1	**dep** Add *their* fractions correctly and expand $(1+\cos x)^2$ correctly
	$\dfrac{2(1+\cos x)}{(1+\cos x)\sin x}$	M1	**dep** Use $\sin^2 x+\cos^2 x=1$ and take out a factor of 2.
	All correct AG	A1	Do not award if brackets missing at any point **or** *x* missing more than twice **or** *x* misplaced. Do not credit mixed variables.
	OR $\dfrac{\tan^2 x+(\sec x+1)^2}{\tan x(\sec x+1)}$	M1	Add fractions
	$=\dfrac{2\sec^2 x+2\sec x}{\tan x(\sec x+1)}$	M1	**dep** Expand brackets correctly and use $1+\tan^2 x=\sec^2 x$
	$\dfrac{2\sec x}{\tan x}$	M1	**dep** Cancel $\sec x+1$
	$\dfrac{2}{\cos x}\times\dfrac{\cos x}{\sin x}$	M1	**dep** Use $\tan x=\dfrac{\sin x}{\cos x}$ and $\sec x=\dfrac{1}{\cos x}$ oe
	All correct AG	A1	Do not award if brackets missing at any point **or** *x* missing more than twice **or** *x* misplaced. Do not credit mixed variables.
6(ii)	$3\sin^2 x+\sin x-2=0$ oe	B1	Obtain three term quadratic.
	$(3\sin x-2)(\sin x+1)=0$	M1	Solve three term quadratic
	41.8° awrt	A1	
	138.2° awrt	A1	Mark final answers This mark is not awarded if there are more solutions in the range.

Question	Answer	Marks	Guidance
7(a)	$2 \times 4 \times p = 40 \rightarrow p = 5$	B1	May be obtained later.
	$(x-2)(x-4)(x-p) = 0$	M1	Factorise cubic
	$a = -11$	A1	Expand and identify
	$b = 38$	A1	
	OR $2 \times 4 \times p = 40 \rightarrow p = 5$	B1	May be obtained later.
	Obtain equations $4a + 2b = 32$ $16a + 4b = -24$ and attempt to solve	M1	
	$a = -11$	A1	
	$b = 38$	A1	
7(b)	Find $x = -1$	M1	Trial value/s and finds a root or shows that $(x+1)$ or $(x+4)$ or $(x-10)$ divides into $x^3 - 5x^2 - 46x - 40$.
	$(x+1)(x^2 - 6x - 40)$ $(= 0)$ or $(x+4)(x^2 - 9x - 10)(= 0)$ or $(x-10)(x^2 + 5x + 4)(= 0)$	A1	Factorise to give linear and quadratic factor
	$(x+1)(x+4)(x-10)$ $(= 0)$	M1	Solve the quadratic to give 2 roots
	$x = -1, -4, 10$	A1	
	OR Uses factor theorem to find a root $(-1)^3 - 5(-1^2) - 46(-1) - 40$ or $-1 - 5 + 46 - 40 = 0$ $\rightarrow x = -1$	M1	This may be awarded for $x = -4$ or $x = 10$.
	Uses factor theorem to attempt to find further roots	M1	At least two more trials.
	$(-4)^3 - 5(-4)^2 - 46(-4) - 40$ or $-64 - 80 + 184 - 40 = 0$ $\rightarrow x = -4$	A1	
	$(10)^3 - 5(10)^2 - 46(10) - 40$ or $1000 - 500 - 460 - 40 = 0$ $\rightarrow x = 10$	A1	

Question	Answer	Marks	Guidance
8(i)	$\sqrt{5^2+12^2}=13$	M1	
	$\boldsymbol{v}_A=-\frac{5}{2}\mathbf{i}-6\mathbf{j}$ or $\frac{1}{2}(-5\mathbf{i}-12\mathbf{j})$	A1	
8(ii)	$\lvert v_B\rvert=\sqrt{12^{12}+(-9)^2}$	M1	Use Pythagoras
	15	A1	Do not allow ± 15. Mark final answer.
8(iii)	$\boldsymbol{r}_A=\begin{pmatrix}20\\-7\end{pmatrix}+t\begin{pmatrix}-2.5\\-6\end{pmatrix}$ or $\boldsymbol{r}_A=(20-2.5t)\mathbf{i}+(-7-6t)\mathbf{j}$	B1	**FT** on *their* $\boldsymbol{v}_A$ only if of the form $k(-5\mathbf{i}-12\mathbf{j})$ where $k\neq 1$ or 0.
	$\boldsymbol{r}_B=\begin{pmatrix}-67\\11\end{pmatrix}+t\begin{pmatrix}12\\-9\end{pmatrix}$ or $\boldsymbol{r}_B=(-67+12t)\mathbf{i}+(11-9t)\mathbf{j}$	B1	
8(iv)	$20-2.5t=-67+12t$ or $-7-6t=11-9t$	M1	Equate x or y coordinates. Must have two terms in both coordinates.
	$t=6$	A1	nfww Ignore other value of t.
	$\boldsymbol{r}=\begin{pmatrix}5\\-43\end{pmatrix}$ only or $\boldsymbol{r}=5\mathbf{i}-43\mathbf{j}$	A1	**A0** if further value of $\boldsymbol{r}$ found.
9(i)	Midpoint (1, 2)	B1	May be seen on diagram
	Gradient of $AB=-\frac{3}{4}$	B1	
	Gradient of PM $=\frac{-1}{\textit{their}\text{ gradient of }AB}=\frac{4}{3}$	M1	Use $m_1\times m_2=-1$
	Equation PM $\frac{y-2}{x-1}=\frac{4}{3}$	M1	**dep** Attempt to find equation of line with *their* midpoint and *their* gradient of *PM*. If $y=mx+c$ used c must be found.
	$y=\frac{4}{3}x+\frac{2}{3}$	A1	
9(ii)	$s=\frac{4}{3}r+\frac{2}{3}$	B1	**FT** Insert (r, s) into *their* linear equation to

Question	Answer	Marks	Guidance
			obtain s =…
9(iii)	$(r-1)^2+(s-2)^2=100$ oe	**B1**	**FT** Use Pythagoras with *their* (1, 2)
	Eliminate r or s	**M1**	From one linear and one quadratic expression. Unsimplified
	$25r^2-50r-875=0$ oe or $25s^2-100s-1500=0$ oe	**A1**	
	$(5r+25)(5r-35)=0$ oe or $(5s-50)(5s+30)=0$ oe	**M1**	Solve three term quadratic Can be implied by correct solution.
	$r=7$, $s=10$	**A1**	Do not award if negative values of r and s are also given nfww
	OR Equivalent method such as: $\overrightarrow{MP}=\begin{pmatrix}a\\b\end{pmatrix}\to a^2+b^2=100$ and $\frac{b}{a}=\frac{4}{3}$	**B1**	Using distance =10 and gradient = $\frac{4}{3}$.
	Eliminate a or b	**M1**	
	$a^2+\left(\frac{4a}{3}\right)^2=100$ or $\left(\frac{3b}{4}\right)^2+b^2=100$	**A1**	
	$\to a=(\pm)6$ and $b=(\pm)8$	**M1**	Solve
	$r=7$, $s=10$	**A1**	
10(i)	Quotient rule or product rule	**M1**	
	$\frac{x-2x\ln x}{x^4}$ or $\frac{x-\ln x.2x}{x^4}$ oe isw	**A2/1/0**	Minus one each error. Allow unsimplified.
10(ii)	$x-2x\ln x=0$	**M1**	Set $\frac{dy}{dx}=0$ and attempt to solve. Must have two terms and obtain $\ln x=k$ only.
	$x=1.65$ awrt or $\sqrt{e}$	**A1**	
	$y=0.184$ awrt or $\frac{1}{2e}$	**A1**	

Question	Answer	Marks	Guidance
10(iii)	$\frac{\ln x}{x^2} = \int \frac{1}{x^3} - \frac{2\ln x}{x^3} \mathrm{d}x$	**M1**	Integrate *their* derivative from (i) which must have two terms. Condone omission of dx.
	$\frac{-1}{2x^2}$	**A1**	Find $\int \frac{1}{x^3}\mathrm{d}x$
	$\int \frac{\ln x}{x^3}\mathrm{d}x = -\frac{1}{4x^2} - \frac{\ln x}{2x^2} + (C)$	**A1**	oe Rearrange and complete
10(iv)	Insert limits and subtract correctly	**M1**	**dep** Must be inserting into **two** terms in x from (iii). Values explicitly seen if expression is incorrect.
	$\frac{3}{16} - \frac{\ln 2}{8}$ or 0.101 awrt	**A1**	
11	$(\sqrt{5}-3)(\sqrt{5}+3) = -4$	**B1**	Seen anywhere
	Attempt formula	**M1**	
	$x = \frac{-3 \pm 5}{2(\sqrt{5}-3)}$	**A1**	
	Multiply by *their* $(\sqrt{5}+3)$	**M1**	Attempt must be seen with a further line of working. oe
	$x = \sqrt{5}+3$	**A1**	oe Mark final answer
	$x = \frac{-1(\sqrt{5}+3)}{4}$	**A1**	oe Mark final answer

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/23**
Paper 2	**October/November 2019**
MARK SCHEME	
Maximum Mark: 80	

Published

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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 **7** printed pages.

Cambridge Assessment International Education

Generic Marking Principles

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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	$x = 1$	**B1**	
	$-3x - 2 = x + 4$ oe	**M1**	
	$x = -1.5$ oe	**A1**	
2(i)	$\dfrac{\frac{1}{\sin} - \frac{\cos x}{\sin x}}{1-\cos x}$	**M1**	express in terms of sin*x* and cos*x*
	$\dfrac{(1-\cos x)}{\sin(1-\cos x)}$	**A1**	rewrite not as a fraction within a fraction
	$\dfrac{1}{\sin x} = \operatorname{cosec} x$	**A1**	correct completion **answer given**
2(ii)	$\left[\sin x = \dfrac{1}{2}\right]$ $x = 30°$	**B1**	
	$x = 150°$ nfww	**B1**	no extra answers
3	$(1 + ax)^5 = 1 + 5ax + 10a^2x^2 + 10a^3x^3$ soi	**B1**	4 terms not ${}^nC_r$ notation
	$[2] + (10a + b)x + (5ab + 20a^2)x^2$	**M1**	obtain expansion with 2 terms in x, 2 terms in x^2
	equate terms in x and x^2 to give two equations in a and b each consisting of three terms	**M1**	
	$10a + b = 32$ $5ab + 20a^2 = 210$	**A1**	correct equations imply previous two M marks
	eliminate b	**M1**	
	obtain $3a^2 - 16a + 21 = 0$ correctly	**A1**	**answer given**
	$a = 3$ and $b = 2$	**B1**	
	$c = 720$ only	**B1**	no additional answers
4(i)	$y = 2(x - 1)^2 - 9$	**B3**	$a = 2$, $b = 1$, $c = -9$ in correct form. **B1** for each
4(ii)	minimum *their* -9	**B1**	**FT** from *their* correct form, with $a > 0$
	when $x =$ *their* 1	**B1**	**FT** from *their* correct form, with $a > 0$

Question	Answer	Marks	Guidance
4(iii)	$x = \sqrt{p}$ or $p = x^2$ soi	**B1**	
	$(x-1) = \sqrt{\frac{9}{2}}$ or $\left(\sqrt{p}-1\right) = \sqrt{\frac{9}{2}}$ oe	**M1**	$(x-b) = \sqrt{\frac{-c}{a}}$ $\left(\sqrt{p}-b\right) = \sqrt{\frac{-c}{a}}$ using *their* values of *a*, *b*, *c* from (i)
	$p = 9.74$	**A1**	completion not involving use of quadratic formula
5(a)	$\tan\left(y-\frac{\pi}{4}\right) = (\pm)\sqrt{3}$	**M1**	± 1.73…
	$y-\frac{\pi}{4} = \frac{\pi}{3}$ or $\frac{2\pi}{3}$	**A1**	1.04(7…) or 2.09(4…)
	$y = \frac{7\pi}{12}$ or 1.83	**A1**	
	$y = \frac{11\pi}{12}$ or 2.88	**A1**	
5(b)	correctly rewrite equation in terms of sin*z* and cos*z*	**M1**	
	use $\sin^2 z = 1 - \cos^2 z$	**M1**	appropriate use of Pythagorean identity for forming an equation in one trig ratio
	$6\cos^2 z - 7\cos z + 1 = 0$ **oe**	**A1**	
	$(6\cos z - 1)(\cos z - 1) = 0$	**M1**	solve three term quadratic in cos*z*
	80.4°	**A1**	
	279.6°	**A1**	
6(i)	$[\tan ACB =] \frac{3+\sqrt{3}}{3-\sqrt{3}}$	**B1**	
	rationalise with $3+\sqrt{3}$	**M1**	
	simplify showing at least 3 terms in numerator to $2+\sqrt{3}$	**A1**	
6(ii)	$(AC)^2 = \left(3+\sqrt{3}\right)^2 + \left(3-\sqrt{3}\right)^2$ oe	**M1**	Pythagoras
	at least 4 terms $12+6\sqrt{3}+12-6\sqrt{3}$	**A1**	

Question	Answer	Marks	Guidance
	$AC = 2\sqrt{6}$	A1	
7(i)	evidence of differentiation $(3x + 2)^{-3}$	M1	
	$-12(3x + 2)^{-3} \times 3$	A1	may use PR or QR on fraction part
	+1	B1	
	set *their* $\frac{dy}{dx} = 0$	M1	$1 - 36(3x + 2)^{-3} = 0$
	$x = 0.43$ nfww	A1	
	$y = 0.98$ only	A1	
7(ii)	$\frac{-2}{3x+2}$ oe	B1	
	$\frac{1}{2}x^2$	B1	
	$\left[\frac{-2}{6+2}+2\right]-\left[\frac{-2}{2}\right]$	M1	insert correct limits into *their* two term integral and subtract two non-zero terms in correct order
	2.75 nfww	A1	2.75 following B1 B1implies M1
8(i)	$p = -4$	B1	
8(ii)	$(x - 2)(x - 3)(x + 4)$	M1	**FT** $(x - 2)(x - 3)(x - p)$
	$(x^2 - 5x + 6)(x + 4)$	A1	**FT** $(x^2 - 5x + 6)(x - p)$ multiply out two factors
	correctly obtain $a = -1$ $x^3 - x^2 - 14x + 24$	A1	**answer given**
	$b = -14$ stated	B1	
8(iii)	$\frac{dy}{dx} = 3x^2 - 2x - 14$	B1	**FT** *their* numerical b $3x^2 - 2x + b$
8(iv)	set *their* $\frac{dy}{dx}$ equal to 2	M1	**FT** *their* numerical b
	$x = 2$	A1	
	$y = 40$ only	A1	no additional answers
8(v)	$y - 40 = 2(x + 2)$ $(y = 2x + 44)$	B1	
9(i)	$\overrightarrow{AD} = 2\mathbf{a} + \mathbf{b}$	B1	

Question	Answer	Marks	Guidance
	$\overrightarrow{OX} = \mathbf{a} + \lambda(2\mathbf{a} + \mathbf{b})$	B1	
9(ii)	$\overrightarrow{BC} = 3\mathbf{a} - 2\mathbf{b}$	B1	
	$\overrightarrow{OX} = 2\mathbf{b} + \mu(3\mathbf{a} - 2\mathbf{b})$	B1	
9(iii)	$\overrightarrow{OX} = \overrightarrow{OX}$ and equate for **a** or **b**	M1	
	$1 + 2\lambda = 3\mu$ and $\lambda = 2 - 2\mu$	A1	
	solve correct equations for λ or μ	M1	
	$\lambda = \frac{4}{7}$ and $\mu = \frac{5}{7}$	A1	
9(iv)	$\frac{4}{3}$ or 4 : 3	B1	**FT** $\lambda/(1-\lambda)$ $0 < \lambda < 1$
10(i)	$\mathrm{gf}(x) = \mathrm{e}^{2(\ln(3x+2))} - 4$	B1	
	their gf = 5	M1	
	use $\ln a^p = p\ln a$ or $\mathrm{e}^{\ln a} = a$ or $\ln \mathrm{e}^a = a$	B1	correct use of log/exponential relationship seen anywhere
	$3x + 2 = 3$ or $(3x + 2)^2 = 9$	A1	3 may take the form of $\mathrm{e}^{0.5\ln 9}$ 9 may take the form of $\mathrm{e}^{\ln 9}$
	$x = \frac{1}{3}$ only	A1	
10(ii)	$x = \frac{\mathrm{e}^y - 2}{3}$	M1	find x in terms of y
	$\frac{\mathrm{e}^x - 2}{3}\ \left(= \mathrm{f}^{-1}(x) \text{ or } = y\right)$	A1	interchange x and y correct completion
10(iii)	$\frac{\mathrm{e}^x - 2}{3} = \mathrm{e}^{2x} - 4$	M1	*their* $\mathrm{f}^{-1}(x) = \mathrm{g}(x)$
	$3\mathrm{e}^{2x} - \mathrm{e}^x - 10\ (= 0)$	A1	obtain quadratic in e^x must be arranged as a three term quadratic in order shown
	$(3\mathrm{e}^x + 5)(\mathrm{e}^x - 2)\ (= 0)$	M1	solve for e^x
	$x = \ln 2$ or 0.693 only	A1	

Cambridge IGCSE

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/11**
Paper 1	**May/June 2019**
MARK SCHEME	
Maximum Mark: 80	

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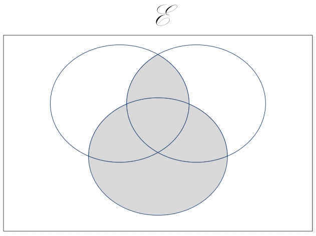
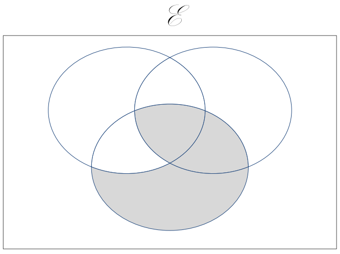
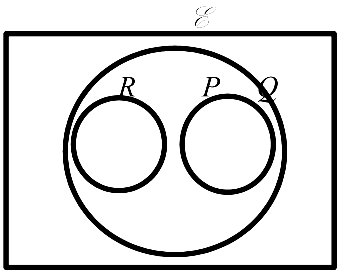
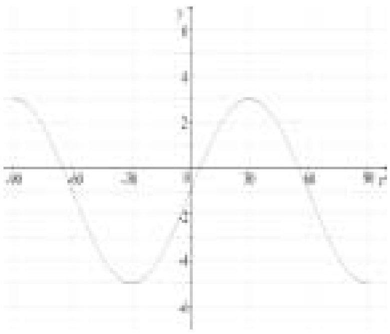
rot	rounded or truncated
SC	Special Case
soi	seen or implied

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 $(\mathit{their}256\times \mathit{their}(-12))+(\mathit{their}112\times \mathit{their}9)$
	$=-2064$	**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 = $\int_{-\frac{2}{3}}^{2}3x^2-2x+1\,\mathrm{d}x$	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 $\log_4\left(3y^2 - 10\right) = \log_4\left(y-1\right)^2 + \frac{1}{2}$	**B1**	use of power rule
	$\log_4 \frac{3y^2 - 10}{\left(y-1\right)^2} = \frac{1}{2}$	**B1**	**DepB1** for use of division rule
	$\frac{3y^2 - 10}{\left(y-1\right)^2} = 2$	**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 $\log_4\left(3y^2 - 10\right) = \log_4\left(y-1\right)^2 + \frac{1}{2}$	**B1**	use of power rule
	$\log_4\left(3y^2 - 10\right) = \log_4\left(y-1\right)^2 + \log_4 2$	**B1**	for $\log_4 2$
	$3y^2 - 10 = 2\left(y-1\right)^2$	**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)	Method 1 $600\pi = 2\pi r^2 + 2\pi rh$	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)	<u>Method 3</u> $\lg y - 4 = 3(x^2 - 2)$ 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. $\frac{dy}{dx}=(x^2+1)\mathrm{f}(x)+2x(2x-3)^{\frac{1}{2}}$
	$=(2x-3)^{-\frac{1}{2}}\left(x^2+1+2x(2x-3)\right)$	**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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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.

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

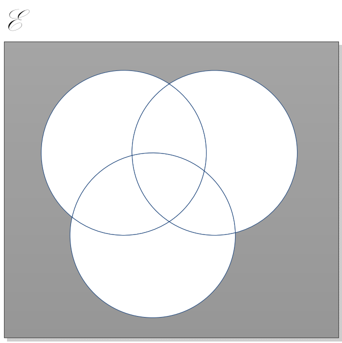
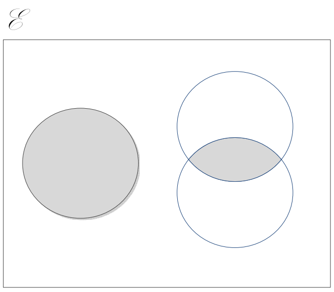
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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

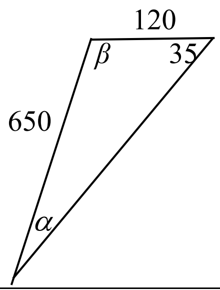
awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Guidance
1(a)		**B1**	
		**B1**	

Question	Answer	Marks	Guidance
1(b)	$P = \{30^{o}, 150^{o}, 210^{o}, 330^{o}\}$	B1	May be seen or implied in a Venn diagram Allow without set notation
	$Q = \{30^{o}, 150^{o}\}$	B1	May be seen or implied in a Venn diagram Allow without set notation
	$P \cap Q = \{30^{o}, 150^{o}\}$	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)	$\left(e^{2t}+1\right)\left(e^{2t}-4\right)=0$	M1	For attempt to factorise and solve, dealing with exponential correctly, to obtain $e^{2t} = ...$
	$t = \ln 2,\ \frac{1}{2}\ln 4$ 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 $kx^{\frac{1}{2}} = ...$ or $ky^{-\frac{1}{2}} = ...$ 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:** $\int_{-\frac{\pi}{9}}^{\frac{\pi}{9}} 4 + 2\cos 3x - 5 \, dx$	**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 $-\frac{1}{\textit{their } m}$ 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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Paper 1	**May/June 2019**
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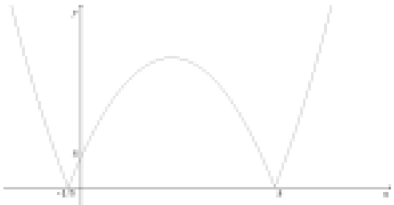
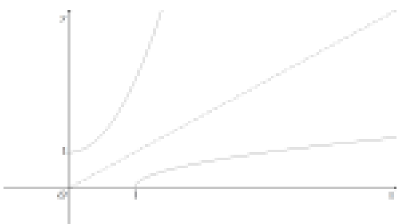
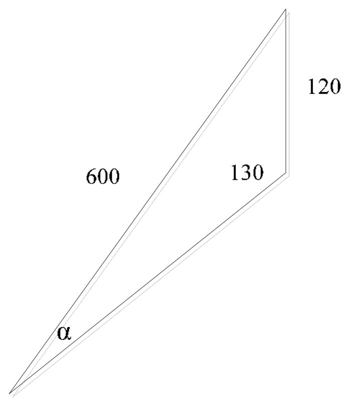
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

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)	$\tan ACB = \frac{2\sqrt{5}-1}{2+\sqrt{5}} \times \frac{2-\sqrt{5}}{2-\sqrt{5}}$	**M1**	For attempt at tan *ACB* and rationalisation
	$= \frac{4\sqrt{5}-2-10+\sqrt{5}}{4-5}$ 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)	$\mathrm{g} \geqslant 1$	**B1**	Must be using correct notation
8(ii)	$\mathrm{g}\left(\sqrt{62}\right) = 125$	**B1**	
	$\mathrm{f}^{-1}(x) = \frac{1}{3}\ln x$	**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)	$3\mathrm{e}^{3x} = 24$	**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**	

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ADDITIONAL MATHEMATICS **0606/22**

Paper 22 **March 2019**

MARK SCHEME

Maximum Mark: 80

Published

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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:

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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:

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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.

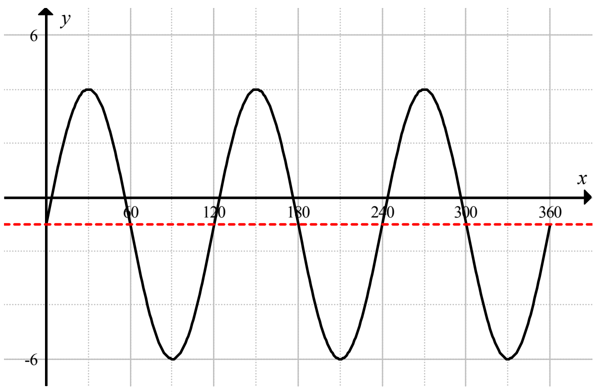
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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)	1 081 575	**B1**	
1(ii)	40 320	**B1**	
1(iii)	2730	**B1**	
2(i)	$\frac{\mathrm{d}}{\mathrm{d}x}(\ln x) = \frac{1}{x}$, $\frac{\mathrm{d}}{\mathrm{d}x}(\mathrm{e}^x) = \mathrm{e}^x$ soi	**B2**	**B1** for each
	$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{e}^x \times \textit{their}\,\frac{1}{x} - (\ln x) \times \textit{their}\,\mathrm{e}^x}{(\mathrm{e}^x)^2}$	**M1**	
	correct completion to given answer, $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1 - x\ln x}{x\mathrm{e}^x}$	**A1**	
2(ii)	$\delta y = \left(\frac{1-2\ln 2}{2\mathrm{e}^2}\right) \times h$ soi	**M1**	
	–0.0261[…]h isw	**A1**	
3(i)	Fully correct curve 	**B3**	**B1** for correct shape for sine with y-intercept at –1 **B1** for curve with period 120° **B1** for curve with amplitude 5 Maximum of 2 marks if not fully correct.
3(ii)	$a = -1$ $b = 5$ $c = 3$	**B2**	**B1** for any 2 correct
4(a)	Expands, rearranges to form a 3-term quadratic on one side $4x^2 + x - 3[*0]$	**M1**	
	Critical values $\frac{3}{4}$ and –1	**A1**	
	$-1 \leqslant x \leqslant \frac{3}{4}$ final answer	**A1**	**FT** *their* critical values

Question	Answer	Marks	Partial Marks
4(b)	$k^2 - 4\left(\frac{1}{4}\right)\left(k^2+1\right)$	**M1**	
	–1	**A1**	
	discriminant independent of *k* and negative oe	**A1**	**FT** *their* –1
5	$[m_{AB} =]\ \frac{2+4}{3-7}$ oe or $-\frac{3}{2}$ soi	**M1**	
	$[m_{CD} =]$ *their* $\frac{2}{3}$ oe, soi	**M1**	
	their $\frac{2}{3} = \frac{3+3}{k-2}$ oe or $3 + 3 =$ *their* $\frac{2}{3}(x-2)$ oe	**M1**	
	$k = 11$ nfww	**A1**	
	$\left(\frac{(their\,11)+2}{2}, \frac{3+-3}{2}\right)$ oe	**M1**	
	$y = -\frac{3}{2}\left(x - 6.5\right)$ oe isw	**A1**	**FT** *their* m_{AB} and (*their* 6.5, 0)
6(i)	Takes logs, to any base, of both sides and applies the addition/multiplication law for logs $\ln y = \ln(Ab^x) \Rightarrow \ln y = \ln A + \ln b^x$	**M1**	
	$\Rightarrow \ln y = \ln A + x \ln b$	**A1**	
6(ii)	$\ln y = 1.4x + 2.2$ oe or $\ln y = x\ln 4 + \ln 9$ oe	**B2**	**B1** for either $m = 1.4$ or $\ln b = 1.4$ or $c = 2.2$ or $\ln A = 2.2$
	$[A = e^{their\,2.2} =]\ 9$ and $[b = e^{their\,1.4} =]\ 4$	**B2**	**FT** *their* 2.2 and *their* 1.4 **B1 FT** for $A = e^{their\,2.2}$ or $b = e^{their\,1.4}$ or correct FT decimal rounded to more than 1 sf
6(iii)	$\ln y = 6$ or $y = their\,9(their\,4^{2.7})$ or $y = e^{their\,2.2}(e^{their\,1.4 \times 2.7})$ or $\ln y = their\,1.4(2.7) + their\,2.2$ or $\ln y = (2.7)\ln(their\,4) + \ln(their\,9)$	**M1**	
	awrt 400 correct to 1 sf	**A1**	

Question	Answer	Marks	Partial Marks
7(i)	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\sqrt{x^2+1}\right)=\frac{1}{2}\left(x^2+1\right)^{-\frac{1}{2}}\times 2x$	**B2**	**B1** for $\frac{\mathrm{d}}{\mathrm{d}x}\left(\sqrt{x^2+1}\right)=kx\left(x^2+1\right)^{-\frac{1}{2}}$ where $k\neq 1$
	$\sqrt{x^2+1}$ $+x\times \mathit{their}\left(\frac{1}{2}\left(x^2+1\right)^{-\frac{1}{2}}\times 2x\right)$	**M1**	
	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\frac{2x^2+1}{\left(x^2+1\right)^{\frac{1}{2}}}$ or $a=2, b=1, p=\frac{1}{2}$ nfww	**A1**	
7(ii)	Complete argument e.g. For stationary points $\frac{\mathrm{d}y}{\mathrm{d}x}=0$ and when a and b are positive, ax^2+b cannot be 0 or $2x^2$ cannot be -1	**B2**	**FT** *their* positive a and b **B1 FT** for a partially correct argument e.g. Because $\frac{\mathrm{d}y}{\mathrm{d}x}$ cannot be 0.
8(i)	$6\mathbf{i}-4\mathbf{j}-(2\mathbf{i}+12\mathbf{j})$ oe	**M1**	
	$4\mathbf{i}-16\mathbf{j}$ oe, isw	**A1**	
8(ii)	$\left[\overrightarrow{OC}=\right]\overrightarrow{OA}+\frac{1}{4}\overrightarrow{AB}$ oe or $\left[\overrightarrow{OC}=\right]\overrightarrow{OB}-\frac{3}{4}\overrightarrow{AB}$ oe or $\left[\overrightarrow{OC}=\right]\frac{1}{4}\overrightarrow{OB}+\frac{3}{4}\overrightarrow{OA}$ oe or $3(x-2)=6-x$ and $3(y-12)=-4-y$	**M1**	
	$3\mathbf{i}+8\mathbf{j}$ oe	**A1**	
	$\left\lvert\overrightarrow{OC}\right\rvert=\sqrt{\mathit{their}3^2+\mathit{their}8^2}$	**M1**	
	$\mathit{their}\frac{3\mathbf{i}+8\mathbf{j}}{\sqrt{73}}$	**A1**	**FT** *their* $3\mathbf{i}+8\mathbf{j}$ and *their* $\sqrt{73}$
8(iii)	$-\frac{\lambda}{1+\lambda}(2\mathbf{i}+12\mathbf{j})$ oe, isw	**B2**	**B1** for $\frac{\lambda}{1+\lambda}(2\mathbf{i}+12\mathbf{j})$ seen or $\overrightarrow{OD}=\frac{1}{1+\lambda}(2\mathbf{i}+12\mathbf{j})$ oe

Question	Answer	Marks	Partial Marks
9(a)(i)	Valid explanation e.g. Each x is mapped to a unique value of y [and so g is a function] but the inverse does not exist because it is many to one oe	**B2**	**B1** for either each x is mapped to a unique value of y oe or for inverse does not exist because it is many to one oe
9(a)(ii)	$\left[g^2(x)=\right]\quad 6(6x^4+5)^4+5$ isw for all real x	**B2**	**B1** for $\left[g^2(x)=\right]\quad 6(6x^4+5)^4+5$ isw **B1** for correct domain
9(a)(iii)	$[k=]\ 0$	**B1**	
9(a)(iv)	$x^4=\dfrac{y-5}{6}$ soi	**M1**	or $y^4=\dfrac{x-5}{6}$
	$x=\pm\sqrt[4]{\dfrac{y-5}{6}}$	**A1**	or $y=\pm\sqrt[4]{\dfrac{x-5}{6}}$
	$h^{-1}(x)=-\sqrt[4]{\dfrac{x-5}{6}}$	**A1**	If **M1 A0 A0**, allow **SC1** for an answer of $h^{-1}(x)=\sqrt[4]{\dfrac{x-5}{6}}$ or $y=\sqrt[4]{\dfrac{x-5}{6}}$
9(b)(i)	p > 2	**B1**	
9(b)(ii)	For p: Correct exponential shape tending to $y=2$ passing through (0, 5)	**B2**	**B1** for each
	For the inverse function: Approximate reflection of p in the dotted line passing through (*their* 5, 0)	**B1**	
9(b)(iii)	Valid explanation e.g. The graphs do not intersect and so there are no solutions oe	**B1**	
10(i)	Eliminates x or y e.g. $3x+3=x+5\sqrt{x}+1$ or $3+3u^2=u^2+5u+1$	**M1**	
	Rearranges to a 3-term quadratic e.g. $0=2x-5\sqrt{x}+2$ or $0=2u^2-5u+2$	**A1**	
	Factorises or solves $0=2x-5\sqrt{x}+2$ oe or $0=2u^2-5u+2$ oe	**M1**	
	$\sqrt{x}=0.5$, $\sqrt{x}=2$ or $u=0.5$, $u=2$	**A1**	

Question	Answer	Marks	Partial Marks
	$A(0.25, 3.75)$ $B(4, 15)$ oe	**A2**	**A1** for each or for $x = 0.25$ and $x = 4$

Question	Answer	Marks	Partial Marks
10(ii)	**Method 1: Finding the area of the trapezium and subtracting**		
	Valid method to find the area of the trapezium soi	**M1**	
	$\frac{1125}{32}$ or $35\frac{5}{32}$ or 35.2 or 35.15625 rot to 4 or more figs, soi	**A1**	
	Attempts to integrate $\int_{their\,0.25}^{their\,4}(x+5\sqrt{x}+1)\,\mathrm{d}x\,[-their\,35.2]$	**M1**	
	$\left[\frac{x^2}{2}+\frac{5x^{\frac{3}{2}}}{\frac{3}{2}}+x\right]_{their\,0.25}^{their\,4}$ $[-their\,35.2]$ oe	**A1**	
	F(*their* 4) – F(*their* 0.25) $[-their\,35.2]$	**M1**	
	$\frac{45}{16}$ or $2\frac{13}{16}$ or 2.8125 isw or 2.81, or 2.812	**A1**	
	Method 2: Finding the difference of two integrals		
	Attempts to integrate $\int_{their\,0.25}^{their\,4}(x+5\sqrt{x}+1-(3+3x))\,\mathrm{d}x$ or $\int_{their\,0.25}^{their\,4}(-2x+5\sqrt{x}-2)\,\mathrm{d}x$ oe	**M2**	**M1** for an attempt to form the difference with at most one error and attempts to integrate
	$\left[their\left(\frac{-2x^2}{2}+\frac{5x^{\frac{3}{2}}}{\frac{3}{2}}-2x\right)\right]_{their\,0.25}^{their\,4}$ oe	**A1**	**FT** dep on at least M1 already awarded; must be at least 3 terms and, if FT, must be of equivalent difficulty
	F(*their* 4) – F(*their* 0.25)	**M1**	
	$\frac{45}{16}$ or $2\frac{13}{16}$ or 2.81, 2.812 or 2.8125	**A2**	

Question	Answer	Marks	Partial Marks
11(a)	$\frac{x^2(x^6+1)}{x^6}=x^2+\frac{1}{x^4}$ soi	**B1**	
	$\frac{x^3}{3}+\frac{x^{-3}}{-3}+c$ oe, isw	**B2**	**B1** for any two out of three terms correct
11(b)(i)	$k\sin(4\theta-5)$ where $k>0$ or $k=-\frac{1}{4}$	**M1**	
	$\frac{\sin(4\theta-5)}{4}$ $(+c)$	**A1**	
11(b)(ii)	$\frac{\sin(4(2)-5)}{4}-\frac{\sin(4(1.25)-5)}{4}$ or $\frac{\sin(3)}{4}-\frac{\sin(0)}{4}$	**M1**	**FT** *their* **(b)(i)**, **dep** on **M1** awarded in **(b)(i)**
	0.0353 or 0.03528[…] oe, cao	**A1**	

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2018**

MARK SCHEME

Maximum Mark: 80

Published

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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	$x^2 + 7x - 8\ (>0)$	**2**	**M1** for expanding and collecting terms
	$x < -8$ or $x > 1$	**2**	**M1** for factorising $(x+8)(x-1) > 0$
2(a)	Take logs: $\left(\frac{x}{2}-1\right)\log 3 = \log 10$	**M1**	
	Make x the subject: $x = 2\left(\frac{\log 10}{\log 3}+1\right)$	**M1**	
	6.19	**A1**	
2(b)	$e^{5y+1} = \frac{2}{3}$	**2**	**M1** for attempt to combine exponential terms
	–0.281	**2**	**M1** for taking natural logs: $5y+1 = \ln\left(\frac{2}{3}\right)$
3(a)	Expand 4 terms: $8 + 8\sqrt{10} - 3\sqrt{10} - 30$	**M1**	
	–22	**A1**	
	$5\sqrt{10}$	**A1**	
3(b)	$\frac{(4-3\sqrt{6})}{(\sqrt{3}+\sqrt{2})} \times \frac{(\sqrt{3}-\sqrt{2})}{(\sqrt{3}-\sqrt{2})}$	**M1**	Multiply numerator and denominator by $(\sqrt{3}-\sqrt{2})$
	$\frac{4\sqrt{3}-3\sqrt{18}-4\sqrt{2}+3\sqrt{12}}{3-2}$	**M1**	Expand
	$10\sqrt{3} - 13\sqrt{2}$	**A2**	**A1** for each term

Question	Answer	Marks	Partial Marks
4	$\frac{1}{\cos x} = \frac{\cos x}{\sin x} - 5\frac{\sin x}{\cos x}$	**B1**	Correctly converts 3 terms into $\sin x$ and $\cos x$
		M1	Uses $\cos^2 x = 1 - \sin^2 x$
	$6\sin^2 x + \sin x - 1 = 0$	**A1**	
	$(3\sin x - 1)(2\sin x + 1) = 0$	**M1**	
	19.5°, 160.5°, 210°, 330°	**A2**	**A1** for 2 correct **A1** for further 2 correct
5(i)	$A^2 = \begin{pmatrix} 7 & 8 \\ -4 & -1 \end{pmatrix}$	**2**	Minus 1 each error.
5(ii)	$7p + 3q = 1$ $8p + 2q = 0$ $-4p - q = 0$, $-p + q = 1$	**2**	**M1** forms two equations in p and q **A1** Both correct
	$p = -\frac{1}{5}$, $q = \frac{4}{5}$	**2**	**M1** solves equations to find p and q
6(i)	120	**2**	**B2** $5 \times 4 \times 3 \times 2$ or **B1** for pattern $n(n-1)(n-2)(n-3)$
6(ii)	720	**2**	**B1** $4 \times 3 \times 2$ **B1 dep** $\times 6 \times 5 =$ 720
6(iii)	2520	**2**	**B1** $4 \times \ldots \times \ldots \times \ldots \times 3$ **B1 Dep** $\times 7 \times 6 \times 5 = 2520$
7(i)	$\frac{(1+\cos x)-(1-\cos x)}{(1-\cos x)(1+\cos x)}$	**M1**	Taking common denominator
	$= \frac{2\cos x}{1-\cos^2 x}$	**A1**	
	$= \frac{2\cos x}{\sin^2 x}$	**M1**	Using $1 - \cos^2 x = \sin^2 x$
	$= \frac{2\cos x}{\sin x} \times \frac{1}{\sin x}$ $= 2\operatorname{cosec} x \cot x$	**A1**	Fully correct completion AG

Question	Answer	Marks	Partial Marks
7(ii)	$2\operatorname{cosec}x\cot x = \sec x$	**M1**	
	$\cot^2 x = \frac{1}{2}$	**A1**	
	0.955, 2.19, 4.10, 5.33	**A2**	**A1** for 2 correct values **A1** for further 2 correct values
8(i)	$\frac{dy}{dx} = 1 - 2e^{2-5x}$	**B1**	
	$x = 2.5 \rightarrow \frac{dy}{dx} = -1$ and $y = 3.5$	**B1**	
	Grad of normal = $\frac{-1}{\frac{dy}{dx}}$	**M1**	
	$y = x + 1$	**A1**	Equation of normal
8(ii)	Area of trapezium $= \frac{1}{2} \times 2.5 \times 4.5$	**M1**	
	5.625 sq units	**A1**	
	$\int_{2.5}^{5} x + e^{(5-2x)} dx$	**M1**	Area under curve
	$= \left[\frac{x^2}{2} - \frac{1}{2} e^{(5-2x)} \right]_{2.5}^{5}$	**A1**	
		M1	insert limits and subtract (= 9.87)
	Shaded area $= 15.5$	**A1**	5.625 + 9.87
9(i)	$2y + 2r + \pi r = 5$	**B1**	
	$y = \frac{5 - 2r - \pi r}{2}$	**B1**	**Dep**

Question	Answer	Marks	Partial Marks
9(ii)	$A = 2yr + \frac{\pi r^2}{2}$	M1	
	$= r(5 - 2r - \pi r) + \frac{\pi r^2}{2}$ $= 5r - 2r^2 - \frac{\pi r^2}{2}$	A1	
9(iii)		M1	differentiate
	$\frac{dA}{dr} = 5 - \pi r - 4r$	A1	
	$\frac{dA}{dr} = 0$	M1	set to zero and attempt to solve
	$r = \frac{5}{\pi + 4} = 0.7$	A1	
	$A = 1.75$	A1	
10(i)	$12 - 2x = k + 6 + kx - x^2$ $\rightarrow x^2 - (2 + k)x + 6 - k = 0$	M1	* Equate and collect terms
	$b^2 - 4ac = 0$ $\rightarrow (2 + k)^2 = 4(6 - k)$	M1	**Dep***
	$k^2 + 8k - 20 = 0$	A1	
	$(k + 10)(k - 2) = 0$	M1	
	$k = -10$ or 2	A1	
10(ii)	$(-4, 20)$ and $(2, 8)$	3	**M1** Insert values of k in equations and solve for x **A1** $x^2 + 8x + 16 = 0 \rightarrow x = -4 \rightarrow y = 20$ **A1** $x^2 - 4x + 4 = 0 \rightarrow x = 2 \rightarrow y = 8$

Question	Answer	Marks	Partial Marks
10(iii)	Grad of perpendicular $=\frac{1}{2}$	**B1**	
	Midpoint $(-1, 14)$	**B1**	**FT**
	Eqn $\frac{y-14}{x+1}=\frac{1}{2} \to y=\frac{1}{2}x+14.5$	**B1**	**FT**
11	$\text{n}((R\cap H)\cap N')=14-x$	**B1**	
	$\text{n}((R\cap N)\cap H')=5$	**B1**	
	$\text{n}(N\cap(\text{R}\cup H)')=21-x$	**B1**	
	$x+9+x+15+14-x+5+21-x+x-2$ $=70$	**M1**	correctly form equation in x and attempt to solve
	$x=8$	**A1**	
	$\text{n}(N\cap(\text{R}\cup H)')=13$	**A1**	

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/22**
Paper 2	**October/November 2018**
MARK SCHEME	
Maximum Mark: 80	

Published

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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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- marks are awarded when candidates clearly demonstrate what they know and can do
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- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

Abbreviations

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

Question	Answer	Marks	Partial Marks
1	$x^2 + x - 12 > x + 13$	**M1**	expand and simplify
	$\to x^2 \ldots 25$	**A1**	
	$x > 5$ or $x < -5$ or $x > 5$, $x < -5$ or $x > 5$ and $x < -5$	**A1**	
2	$\mathrm{n}(F \cap C) = \mathrm{n}(F \cup C)' = x$	**B1**	
	$\mathrm{n}(C \cap F') = 40 - x$	**B1**	
	$\mathrm{n}(F \cap C') = 80 - 2x$ or $2(40 - x)$	**B1**	
	$x + x + 40 - x + 80 - 2x = 105$	**M1**	
	$x = 15$	**A1**	cao
3(i)	$\dfrac{3x^2 \sin 2x - x^3 \times 2\cos 2x}{(\sin 2x)^2}$	**3**	**M1** Quotient rule **A2/1/0** minus one each error isw
3(ii)	$y = \dfrac{\pi^3}{64}$ $[= 0.48\ldots]$	**B1**	
	$\dfrac{\mathrm{d}y}{\mathrm{d}x} = \dfrac{3\pi^2}{16}$ [=1.85] oe	**B1**	
	$y = \dfrac{3\pi^2}{16}x - \dfrac{\pi^3}{32}$ $[y = 1.85x - 0.97]$	**B1**	cao
4(i)	Take logs : $(3x - 1)\log 2 = \log 6$	**M1**	
	Make x the subject : $x = \dfrac{\dfrac{\log 6}{\log 2} + 1}{3}$ oe	**A1**	
	awrt 1.19 or awrt 1.195	**A1**	

Question	Answer	Marks	Partial Marks
4(ii)	$1 = \log_3 3$	**B1**	
	$\frac{2}{\log_y 3} = 2\log_3 y$	**B1**	
	$3y^2 - y - 14 = 0$	**B1**	
	$(3y-7)(y+2) = 0$	**M1**	Solve a three term quadratic
	$y = \frac{7}{3}$ only	**A1**	
5	$\frac{2^{3(p+1)}}{2^{2q}} = 2^{11}$ or $\frac{3^{2p+5}}{3^{3\left(\frac{1}{3}\right)}} = 3^{2(3q)}$	**M1**	
	Use $\frac{x^a}{x^b} = x^{a-b}$ or $x^a \times x^b = x^{a+b}$	**M1**	
	$3p + 3 - 2q = 11$ and $2p + 5 - 1 = 6q$	**A1**	Allow unsimplified
		M1	solve
	$p = 4$ and $q = 2$	**A1**	
6(a)	Number first $= 7 \times 6 \times 5 \times 6 \times 5$ or ${}^7P_3 \times {}^6P_2$ or 6300	**B1**	
	Letter first $= 6 \times 5 \times 4 \times 7 \times 6$ or ${}^6P_3 \times {}^7P_2$ or 5040	**B1**	
	6300 + 5040 = 11 340	**B1**	
6(b)	With 2 sisters = ${}^7C_5 \times {}^3C_2 = 63$ With 1 sister = ${}^7C_6 \times {}^3C_1 = 21$ With no sister = ${}^7C_7 = 1$ and Total 85	**3**	**B1** One combination evaluated **B1**Another combination evaluated **B1** Third combination and 85
	OR		
	Total no of ways = ${}^{10}C_7 = 120$	**B1**	
	With 3 sisters = ${}^7C_4 = 35$	**B1**	
	Without 3 sisters = $120 - 35 = 85$	**B1**	

Question	Answer	Marks	Partial Marks
7	$\left(1-\sqrt{3}\right)\left(1+\sqrt{3}\right)=-2$	**B1**	
		M1	* uses quadratic formula
	$x=\dfrac{-1\pm\sqrt{1-4\left(1-\sqrt{3}\right)\left(1+\sqrt{3}\right)}}{2\left(1-\sqrt{3}\right)}$	**A1**	
		M1	**Dep*** × numerator and denominator by *their* $\left(1+\sqrt{3}\right)$
	$x=1+\sqrt{3}$ or $x=-\dfrac{1}{2}-\dfrac{\sqrt{3}}{2}$	**A2**	**A1** for each
8(i)	$\dfrac{(1+\sin x)-(1-\sin x)}{(1-\sin x)(1+\sin x)}$	**M1**	
	$\dfrac{2\sin x}{1-\sin^2 x}$	**A1**	
	$\dfrac{2\sin x}{\cos^2 x}$	**M1**	
	$\dfrac{2\sin x}{\cos x}\times\dfrac{1}{\cos x}$ $=2\tan x\sec x$	**A1**	**AG**
8(ii)		**M1**	equate $2\sec x\tan x=\operatorname{cosec}x$
	$\tan^2 x=\dfrac{1}{2}$	**A1**	
	$35.3°, 144.7°, 215.3°, 324.7°$	**2**	**A1** two correct
9(i)	$\dfrac{dy}{dx}=x^{-\frac{1}{2}}$	**B1**	
	$x=4\rightarrow\dfrac{dy}{dx}=\dfrac{1}{2}$	**B1**	
	grad of normal $=-2$	**M1**	
	$\dfrac{y-4}{x-4}=-2\rightarrow[y=-2x+12]$	**A1**	

Question	Answer	Marks	Partial Marks
9(ii)	(6, 0)	**B1**	**FT**
9(iii)	Area of triangle $= \frac{1}{2} \times 2 \times 4 = 4$	**B1**	**FT**
	Area under curve $= \int 2x^{\frac{1}{2}} \, dx$	**M1**	
	$= \frac{4}{3} x^{\frac{3}{2}}$	**A1**	
	Total area $= 14\frac{2}{3}$ $[14.7]$	**A1**	**FT**
	OR		
	Area of trapezium *OBAP* $= \frac{1}{2}(6+4) \times 4 = 20$	**B1**	**FT**
	Area between curve and *y*- axis $= \int \frac{y^2}{4} \, dy$	**M1**	
	$= \frac{y^3}{12}$	**A1**	
	Total area $= 14\frac{2}{3}$ $[14.7]$	**A1**	**FT**

Question	Answer	Marks	Partial Marks
10(i)	$2k+1-kx=12-4x-x^2$ $x^2+4x-kx+2k-12+1$	**M1**	*
	b^2-4ac $\rightarrow(4-k)^2-4(2k-11)$	**M1**	**Dep***
	$k^2-16k+60$	**A1**	
	$(k-6)(k-10)$	**M1**	
	$k=6$ or 10	**A1**	
	OR		
	$k=4+2x$	**M1**	*
	$-4x-2x^2+8+4x+1=12-4x-x^2$ or $2k+1-k\left(\frac{k-4}{2}\right)=12-2(k-4)-\left(\frac{k-4}{2}\right)^2$	**M1**	**Dep***
	x^2-4x+3 or $k^2-16k+60$	**A1**	
	$(x-1)(x-3)$ or $(k-6)(k-10)$	**M1**	
	$x=1$ or $x=3\rightarrow k=$ 6 or 10	**A1**	
10(ii)	$k=6\rightarrow[y]=13-6x$	**B1**	**FT**
	$k=10\rightarrow[y]=21-10x$	**B1**	**FT**
		M1	solve
	$x=2$, $y=1$.	**2**	cao
11(i)	$\mathrm{gf}(x)=\frac{2(4x-3)+1}{3(4x-3)-1}$	**M1**	
	$=\frac{8x-5}{12x-10}$	**A1**	

Question	Answer	Marks	Partial Marks
11(ii)	$y(3x-1)=2x+1$ or $x(3y-1)=2y+1$	**B1**	
	$(3y-2)x=y+1$ or $(3x-2)y=x+1$	**M1**	
	$g^{-1}(x)=\dfrac{x+1}{3x-2}$	**A1**	
11(iii)	$4\left(\dfrac{2x+1}{3x-1}\right)-3[=x-1]$	**B1**	
	$3x^2-3x-6$ oe	**B1**	
	$3(x+1)(x-2)$	**M1**	
	$x=2$ only	**A1**	

Question	Answer	Marks	Partial Marks
12	Identifying angle with downward vertical of wind as $50°$	**B1**	
	Triangle drawn with sides $260, 40$ and included angle of $50°$.	**B1**	
	Cosine rule : $(v_r)^2 = 260^2 + 40^2 - 2 \times 260 \times 40\cos 50°$	**M1**	*
	$v_r = 236$	**A1**	
	Sine rule : $\frac{\sin\alpha}{40} = \frac{\sin 50°}{v_r}$ or Cosine rule : $40^2 = 260^2 + 236^2 - 2 \times 260 \times 236\cos\alpha$	**M1**	**dep***
	$\alpha = 7.5°$	**A1**	
	OR Using components		
	Identifying angle with downward vertical of wind as $50°$	**B1**	
	$v_w = \begin{pmatrix} 40\cos 40° \\ -40\cos 50° \end{pmatrix}$	**B1**	
	$\boldsymbol{v_r} = \sqrt{(40\cos 40°)^2 + (260 - 40\cos 50)^2}$ $\boldsymbol{v_r} = 236$	**M1** **A1**	
	$\tan\alpha = \frac{40\cos 40°}{260 - 40\cos 50°}$	**M1**	
	$\alpha = 7.5°$	**A1**	

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ADDITIONAL MATHEMATICS	**0606/23**
Paper 2	**October/November 2018**
MARK SCHEME	
Maximum Mark: 80	

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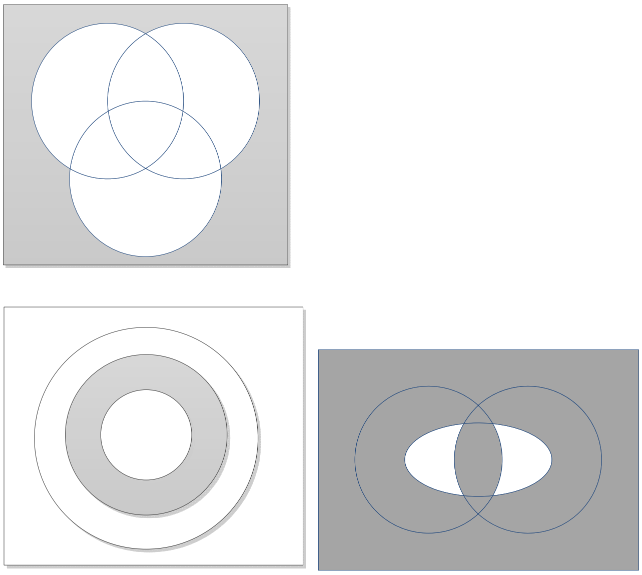
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1	$x = 2$	**B1**	
	$3 - 5x = -3x + 13$ oe	**M1**	
	$x = -5$	**A1**	
2		**3**	**B1** for each correct diagram
3(i)	$\frac{81}{4} - \left(x - \frac{7}{2}\right)^2$	**3**	**B1** $b = \frac{7}{2}$ **M1** $\pm 8 \pm \left(\frac{7}{2}\right)^2$ seen or expand given form and equate for 8 or 7 **A1** fully correct
3(ii)	maximum *their* $\frac{81}{4}$ when $x = their \frac{7}{2}$ from *their* correct form	**2**	**B1** **B1**
3(iii)	$\left(z^2 - \frac{7}{2}\right)^2 = \frac{81}{4}$ oe	**M1**	replace x by z^2 in *their* **(i)** and equate to zero.
	$z^2 = \frac{7}{2} \pm \frac{9}{2}$	**M1**	
	$z = \pm\sqrt{8}$	**A1**	

Question	Answer	Marks	Partial Marks
4(i)	integrate: increase in powers of at least one term	**M1**	*
	$\frac{dy}{dx} = x^2 - \frac{1}{(x+1)^3} + (C)$	**A1**	
	$C = \frac{1}{8}$	**A1**	
4(ii)	integrate *their* **(i)**: increase in powers of at least one term	**M1**	**Dep***
	$y = \frac{1}{3}x^3 + \frac{1}{2(x+1)^2} + \frac{1}{8}x + (D)$	**A1**	two correct terms in *x*
	$D = \frac{29}{12}$	**A1**	
5(i)	$\frac{1}{5}\begin{pmatrix} 4 & -3 \\ -1 & 2 \end{pmatrix}$	**2**	**B1** $\begin{pmatrix} 4 & -3 \\ -1 & 2 \end{pmatrix}$ **B1** $\frac{1}{5}$
5(ii)	post multiply by $\mathbf{A}^{-1}$ $\mathbf{C} = \mathbf{B}\mathbf{A}^{-1}$	**M1**	
	$\frac{1}{5}\begin{pmatrix} 0 & 5 \\ -13 & 16 \end{pmatrix}$	**A1**	
5(iii)	$\mathbf{I} - \mathbf{B} = \begin{pmatrix} 0 & -4 \\ 2 & -4 \end{pmatrix}$ or $\mathbf{AB} = \begin{pmatrix} -4 & 23 \\ -7 & 24 \end{pmatrix}$	**B1**	
	$\mathbf{D} = \mathbf{A}(\mathbf{I} - \mathbf{B})$ or $\mathbf{D} = \mathbf{A} - \mathbf{AB}$	**M1**	
	$\mathbf{D} = \begin{pmatrix} 6 & -20 \\ 8 & -20 \end{pmatrix}$	**A1**	

Question	Answer	Marks	Partial Marks
6	$\log_2 8 = 3$ or $\log 3x - \log y = \log \frac{3x}{y}$ (any base) or $\log_2 2 = 1$ soi	**B1**	implied by one correct equation
	$x + 2y = 8$	**B1**	
	$\frac{3x}{y} = 2$	**B1**	
	solve correct equations for x or y	**M1**	
	$x = 2$ and $y = 3$	**A1**	
7(i)	167 960	**1**	
7(ii)	evidence of selecting from 16	**M1**	
	[$^{16}C_7$ =] 11 440	**A1**	
7(iii)	2 × ^nC_r with n = 16 or r = 9	**M1**	
	$\left[2 \times {}^{16}C_9 =\right]$ 22880	**A1**	
7(iv)	4 × ^nC_r with n = 16 or r = 9	**M1**	
	$\left[4 \times {}^{16}C_9 =\right]$ 45760	**A1**	
8(i)	$\frac{12.1 - 5.5}{3.7 - 1.5}$ [= 3]	**B1**	correct expression for gradient
	$\frac{y^2 - 5.5}{e^{2x} - 1.5}$ = *their* grad or correctly use $y^2 = (\textit{their } m)\, e^{2x} + c$ with one point to find c	**M1**	
	$y = [\pm]\sqrt{3e^{2x} + 1}$	**A1**	
8(ii)	[±]34.8	**1**	

Question	Answer	Marks	Partial Marks
8(iii)	$50 = \sqrt{(their3)e^{2x} + their1}$ or $2500 = (their3)e^{2x} + their1$	**B1**	*
	$2x = \ln\left(\frac{2499}{3}\right)$	**M1**	**Dep*** obtain $2x$ explicitly
	3.36 cao	**A1**	
9(a)	$x + \frac{\pi}{4} = \frac{\pi}{3}$	**M1**	
	$\frac{\pi}{12}$ and $\frac{5\pi}{12}$ (0.262 and 1.31)	**A2**	**A1** for one correct
9(b)	correctly use $\sec y = \frac{1}{\cos y}$ and $\operatorname{cosec} y = \frac{1}{\sin y}$	**M1**	
	$\tan y = \frac{4}{3}$	**A1**	obtain expression for tan$y$ or y explicitly
	53.1° and 233.1°	**A1**	
9(c)	correctly rewrite equation in terms of sin$z$ and cos$z$	**M1**	
	use $\sin^2 z = 1 - \cos^2 z$	**M1**	appropriate use of pythagorean identity for forming an equation in one trig ratio
	$8\cos^2 z - 2\cos z - 1 = 0$ oe	**A1**	
	$(4\cos z + 1)(2\cos z - 1) = 0$	**M1**	solve 3 term quadratic in cos$z$
	60° and 300° and 104.5° and 255.5°	**A2**	**A1** for any two correct
10(i)	$\frac{d}{dx}\sqrt{3+x} = \frac{1}{2}(3+x)^{-\frac{1}{2}}$	**B1**	
	correctly substitute *their* $\frac{1}{2}(3+x)^{-\frac{1}{2}}$ and *their* $2x$ into product rule	**M1**	
	$\frac{dy}{dx} = x^2 \times \frac{1}{2}(3+x)^{-\frac{1}{2}} + 2x(3+x)^{\frac{1}{2}}$	**A1**	

Question	Answer	Marks	Partial Marks
10(ii)	$y = 2$	**B1**	
	$\frac{dy}{dx} = \frac{17}{4}$	**B1**	
	$\frac{y-2}{x-1} = \frac{17}{4}$ $\left(y = \frac{17}{4}x - \frac{9}{4} \right)$ oe or use $y = mx + c$ and find c	**B1**	**FT** on *their* 2 and *their* $\frac{17}{4}$ from *their* $\frac{dy}{dx}$
10(iii)	set *their* $\frac{dy}{dx} = 0$	**M1**	
	obtain correct quadratic equation $5x^2 + 12x$ [= 0] soi	**A1**	
	(0, 0) and (–2.4, 4.46)	**A2**	**A1** for one point or two correct values of x
11(i)	$-5x + k + 5 = 7 - kx - x^2$	**M1**	*
	$b^2 - 4ac\ (=0) \rightarrow (k-5)^2 - 4(k-2)\ (=0)$	**M1**	**Dep***
	$k^2 - 14k + 33\ (=0)$	**A1**	
	$(k-11)(k-3)\ (=0)$	**M1**	**Dep dep** * solve quadratic in k
	$k = 11$ and $k = 3$	**A1**	
11(ii)	$y = -5x + 16$ and $y = 7 - 11x - x^2$ $y = -5x + 8$ and $y = 7 - 3x - x^2$	**B2**	**FT** *their* k **B1** for any two correct
	solve one tangent/curve pair for one variable from quadratic equation with repeated root	**M1**	
	(–3, 31) and (1, 3)	**A2**	**A1** for one correct point or two correct x values
11(iii)	find distance between any two points found in **(ii)**	**M1**	
	$\sqrt{800}$ oe	**A1**	

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ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2018**

MARK SCHEME

Maximum Mark: 80

Published

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Cambridge Assessment International Education

Generic Marking Principles

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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

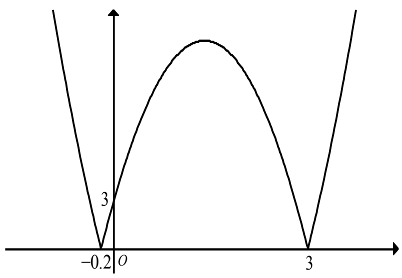
Abbreviations

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

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

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

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

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

Question	Answer	Marks	Partial Marks
10(ii)	Finding *s* when $t = \frac{\pi}{4}$ and $t = \frac{\pi}{2}$	**M1**	
	Finding *s* when $t = their\frac{\pi}{3}$ and correct plan	**M1**	Using *their* **(i)** correctly
	1.29 nfww	**A1**	
10(iii)	$a = \frac{dv}{dt} = -9\cos 3t$	**B1**	
	9	**B1**	**FT** *their* $k\cos 3t$
11(a)	$10(1-\sin^2 x)+3\sin x = 9$	**M1**	
	Solves $10\sin^2 x - 3\sin x - 1 = 0$ oe	**M1**	**dep** on first **M1** Solves *their* three term quadratic in $\sin x$
	$\sin x = \frac{1}{2},\ \sin x = -\frac{1}{5}$	**A1**	
	30º, 150º and 191.5º, 348.5º awrt	**A2**	**A1** for any two correct solutions
11(b)	$3\frac{\sin 2y}{\cos 2y} = 4\sin 2y$ oe	**M1**	
	Solves $3\sin 2y - 4\sin 2y\cos 2y\ [=0]$	**M1**	**dep** on first **M1**
	$\sin 2y = 0\ \ \cos 2y = \frac{3}{4}$	**A1**	
	Any two of π, 0.72273…, 5.56045… nfww	**A1**	
	$\frac{\pi}{2}$, 0.361, 2.78 awrt nfww	**A1**	**SC**: cancels out sin2*y* after **M1M0** allow **SC1** for 0.72273… and 5.56045... and **SC1**for 0.361 and 2.78
12(i)	$\tan 30 = \frac{h}{x/2}$ oe	**M1**	
	Correct completion to given answer	**A1**	
	$V = 5\sqrt{3}h^2$ isw	**B1**	

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

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ADDITIONAL MATHEMATICS	**0606/22**
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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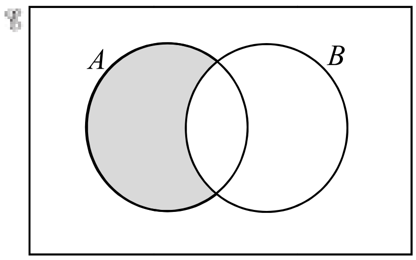
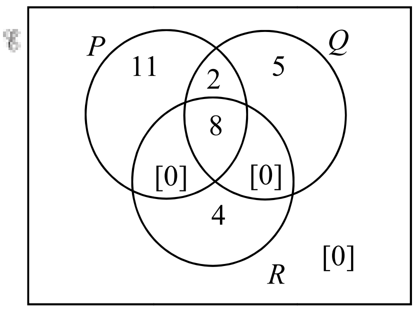
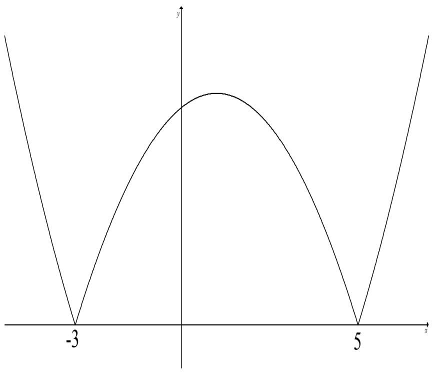
awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

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

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

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

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

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

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

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

Cambridge IGCSE

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ADDITIONAL MATHEMATICS	**0606/23**
Paper 2	**May/June 2018**
MARK SCHEME	
Maximum Mark: 80	

Published

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Cambridge Assessment International Education

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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.

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

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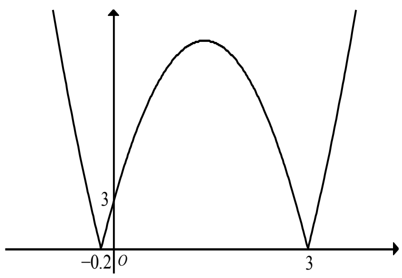
Abbreviations

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

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

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

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

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

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

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ADDITIONAL MATHEMATICS **0606/22**

Paper 22 **March 2018**

MARK SCHEME

Maximum Mark: 80

Published

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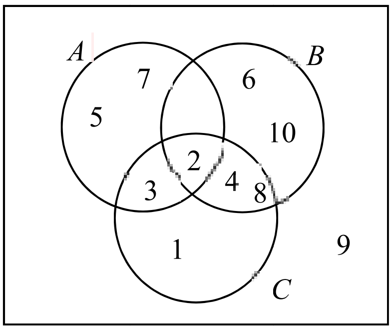
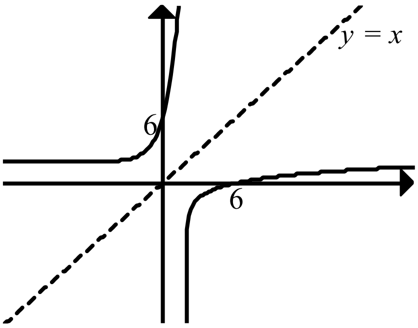
Question	Answer	Marks	Partial Marks
1(a)	$(P \cup Q) \cap R'$ oe	**B1**	
1(b)(i)		**B3**	**B3, 2, 1, 0:** key statements: 2 correctly placed 3, 4, 8 correctly placed 1, 5, 7, 6, 10 correctly placed 9 correctly placed
1(b)(ii)	1	**B1**	**FT** *their* (b)(i); do not allow (1) or {1} etc.
2	$(2k-3)^2 - 4(3-2k)(1)$	**M1**	
	$4k^2 - 4k - 3$	**A1**	
	$(2k-3)(2k+1)$	**M1**	
	critical values are –0.5 and 1.5	**A1**	
	$(their(-0.5) < k < their 1.5$	**A1**	**FT** *their* distinct critical values provided both M marks awarded; mark final answer; allow a pair of correctly connected inequalities e.g. $k > -0.5$ and $k < 1.5$
3(i)	${}^3P_2 \times {}^3P_1$ or 3 × 2 × 3 oe soi	**M1**	
	18	**A1**	If **M0** then **SC1** for ${}^3P_2 \times {}^2P_1$ = 12 or 3 × 2 × 2 = 12
3(ii)	24	**B1**	
3(iii)	2 × 4! oe soi	**M1**	
	48	**A1**	If **M0** then **SC1** for an answer following one omitted or incorrect factor/factorial e.g. 4! = 24 or ${}^4P_4 = 24$ or ${}^3P_3 \times 4 = 24$ or 2! × 3! = 12 or 2! × 4 = 8 or (2! × 3!) × 3 = 36
4(a)(i)	15	**B1**	
4(a)(ii)	180° or π (radians)	**B1**	
4(b)(i)	tan*x*, –tan*x*	**B2**	**B1** for each
4(b)(ii)	4	**B1**	

Question	Answer	Marks	Partial Marks
5	$\frac{104}{1.6}$ oe	**M1**	or e.g. $\frac{104}{\cos 17.354...} \div \sqrt{1.6^2 + 0.5^2}$
	65 or 64.9 to 65.1 (seconds)	**A1**	
	0.5 × *their* 65 oe	**M1**	or $\sqrt{\left(\frac{104}{\cos 17.354...}\right)^2 - 104^2}$ or finds a correct angle using trigonometry and then uses trigonometry again to find *BC* e.g. 104 × tan 17.354...
	32.5 or 32.49 to 32.6(metres)	**A1**	
6(i)	$\frac{d}{dx}\left(\tan\left(\frac{x}{3}\right)\right) = k\sec^2\left(\frac{x}{3}\right)$	**M1**	
	$\frac{1}{3}\sec^2\left(\frac{x}{3}\right)$ cao	**A1**	
6(ii)	$3\tan\left(\frac{x}{3}\right) + c$ oe	**B2**	**B1** for $3\tan\left(\frac{x}{3}\right) + 3$ or **M1** for $\int their \frac{dy}{dx} dx = \tan\left(\frac{x}{3}\right) +$ a constant
7(i)	$\frac{1}{2} \times 8^2 \times \theta = 20$ or $\pi \times 8^2 \times \frac{\theta}{360} = 20$	**M1**	
	$[\theta =] \frac{5}{8}$ or 0.625 rads oe	**A1**	
7(ii)	8 × *their* θ oe	**M1**	
	5 (cm) cao	**A1**	
7(iii)	$\frac{1}{2} \times 8^2 \times 1.4$ and $\frac{1}{2} \times 8^2 \times \sin 1.4$ soi	**M2**	**M1** for either area seen
	13.3 or 13.26 to 13.27 [cm^2]	**A1**	
8(a)(i)	$3x + 4 = \ln\left(\frac{14}{5}\right)$ oe OR $3x + 4 = \ln 14 - \ln 5$ oe	**M1**	
	$x = -0.99(012…)$ isw or exact equivalent	**A1**	

Question	Answer	Marks	Partial Marks
8(a)(ii)	$\lg(2y^2 - 7y) = \lg 3^2$ soi	**B2**	**B1** for each of 2 correct moves
	$2y^2 - 7y - 9 = 0$ and attempt to solve	**M1**	
	$y = 4.5$ oe only	**A1**	
8(b)	$\log_2\left(\frac{p}{q}\right)$ as final answer www	**B2**	**B1** for numerator correctly simplified to $\log_2 p - \log_2 q = \log_2\left(\frac{p}{q}\right)$ or change of base $\log_r 2 = \frac{1}{\log_2 r}$ oe soi
9(i)	$m_{PQ} = \frac{6-2}{11-8}$ or better	**M1**	
	$m_L = \frac{-1}{\textit{their}\ 4/3}$ oe	**M1**	
	$y - 2 = -\frac{3}{4}(x-8)$ isw or $y = -\frac{3}{4}x + c \quad c = 8$ isw	**A1**	

Question	Answer	Marks	Partial Marks
9(ii)	$PQ^2 = (11-8)^2 + (6-2)^2$	M1	or attempts to solve $\frac{1}{2}\begin{vmatrix} 8 & 11 & x & 8 \\ 2 & 6 & -\frac{3}{4}x+8 & 2 \end{vmatrix} = [\pm]12.5$ oe or $\frac{1}{2}\begin{vmatrix} 8 & 11 & x & 8 \\ 2 & 6 & y & 2 \end{vmatrix} = [\pm]12.5$
	$PQ = 5$ soi	A1	or expands correctly $\frac{1}{2}\left(8(6)+11\left(-\frac{3}{4}x+8\right)+2x - 2(11)-6x-8\left(-\frac{3}{4}x+8\right)\right) = [\pm]12.5$ oe or $\frac{1}{2}(8(6)+11y+2x -2(11)-6x-8y) = [\pm]12.5$ oe
	$PR = 5$ soi	A1	or simplifies to $\frac{1}{2}\left(-\frac{25}{4}x+50\right) = [\pm]12.5$ oe or $4x-3y=51$ or $3y-4x=-1$ oe
	Valid method of solution e.g. $R(8\pm4, 2\mp3)$ or attempts to solve *their* $y = -\frac{3}{4}x+8$ and $25 = (x-8)^2+(y-2)^2$ oe or attempts to solve e.g. $4x-3y=51$ $3x+4y=32$ oe	M1	
	(4, 5) (12, –1)	A2	**A1** for each or for $x = 4$, $x = 12$ or $y = 5$, $y = -1$
10(a)(i)	Valid comment referencing the graph e.g. the function f is not one to one, as shown by the fact that the graph has a turning point	B1	or equivalent statement or arrows marked on a diagram; must validly reference the graph in some way.
10(a)(ii)	$\sqrt{1+\left(\sqrt{1+x^2}\right)^2}$	M1	
	$\sqrt{2+x^2}$	A1	mark final answer; must be simplified as far as possible
10(b)(i)	Any value greater than or equal to 0	B1	
10(b)(ii)	Correct method for finding inverse	M1	
	$g^{-1}(x) = \sqrt{x^2-1}$	A1	mark final answer

Question	Answer	Marks	Partial Marks
10(c)	fully correct pair of graphs 	B4	**B1** for exponential shape of h; must cross y-axis **B1** for an attempt at the graph of h and (0, 6) soi **B1** for correct reflection of *their* h in the line $y = x$ or logarithmic shape of inverse **B1** for an attempt at the graph of h^{-1} and (6, 0) soi **Max 3 marks if not fully correct**
11(a)(i)	$(1-\sin A)(1+\sin A)$ $=1-\sin^2 A$ $=\cos^2 A$	M1	
	$\frac{\cos^2 A}{\sin A\cos A}=\frac{\cos A}{\sin A}\,(=\cot A)$	A1	
11(a)(ii)	$\frac{1}{\tan 3x}=\frac{1}{2}$ or better	M1	
	Any triple angle correct from 63.4(349…) 243.4(349…) 423.4(349…)	M1	
	21.1(4…) 81.1(4...) 141.1(4...)	A2	**A1** for 21.1(4...) and 81.1(4...) or for 141.1(4...)
11(b)	$10(\sec^2 y-1)-\sec y-1\ (=0)$ soi	M1	
	$(10\sec y-11)(\sec y+1)$ oe	M1	
	$\cos y=\frac{10}{11}\quad \cos y=-1$ nfww	A1	
	π, 0.43[0], 5.85	A2	**A1** for any one correct
12(i)	$\frac{\mathrm{d}V}{\mathrm{d}r}=4\pi r^2$ soi	B1	
	$\frac{\mathrm{d}r}{\mathrm{d}t}=\frac{\mathrm{d}r}{\mathrm{d}V}\times\frac{\mathrm{d}V}{\mathrm{d}t}$ oe attempted	M1	
	$\frac{\mathrm{d}r}{\mathrm{d}t}=\frac{1}{\textit{their}\,4\pi(10)^2}\times 200$ soi	M1	
	0.159 isw or 0.1591(54…) rot to 4 or more figs	A1	

Question	Answer	Marks	Partial Marks
12(ii)	$\frac{dS}{dr} = 8\pi r$ soi	**B1**	
	$\frac{dS}{dt} = 8\pi(10) \times \textit{their}\, 0.159$	**M1**	
	awrt 40	**A1**	following correct solution

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ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2017**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

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

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

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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **October/November 2017**

MARK SCHEME

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

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

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

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

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

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

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS	**0606/23**
Paper 2	**October/November 2017**
MARK SCHEME	
Maximum Mark: 80	

Published

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MARK SCHEME NOTES

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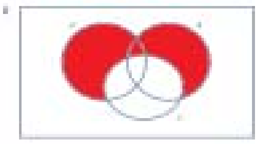
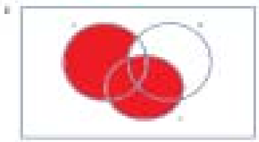
Abbreviations

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

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

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

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

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

Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2017**

MARK SCHEME

Maximum Mark: 80

Published

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

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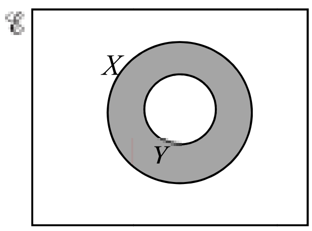
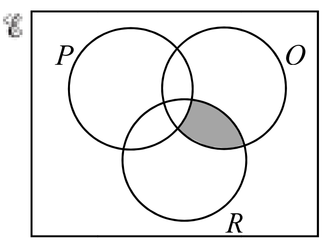
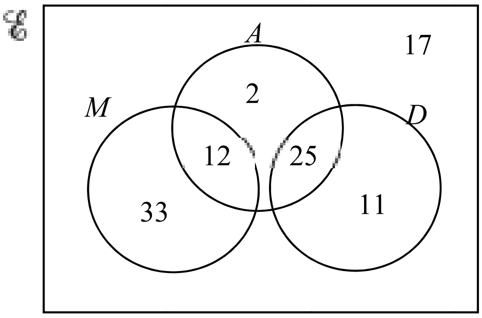
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

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

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

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

Question	Answer	Marks	Guidance
9(ii)	$[m =]\dfrac{1}{2}$ cao	**B1**	
	$\left(\dfrac{1}{3}, \dfrac{4}{3}\right)$	**B1**	**FT**
	$y - their\dfrac{4}{3} = their\dfrac{1}{2}\left(x - their\dfrac{1}{3}\right)$	**M1**	or $y = their\dfrac{1}{2}x + c$ and substitutes their midpoint and reaches $c = \ldots$
	$6y - 3x = 7$	**A1**	allow any equivalent form with integer coeffs/constant
10(i)	t: 1, 1.5, 2, 2.5 ln$P$: 1.48, 2.12, 2.76, 3.4(0)	**M1**	allow ln$P$ values to 1 dp rounded or truncated (1.5, 2.1, 2.8, 3.4)
	single ruled line drawn within tolerance at least for t between 1 and 2.5	**A1**	All points within 1 square of line / must **not** pass through origin
10(ii)	e^{their3}	**M1**	
	18 to 22.2	**A1**	
10(iii)	(0, c) with $0.1 \leqslant c \leqslant 0.3$ (0.2)	**B1**	allow $y = c$ condone $c = \ldots$
	m in the range $1.25 \leqslant m \leqslant 1.34$ (1.28)	**B1**	
10(iv)	$\ln P = (their1.28)t + their0.2$	**M1**	or $\ln P = (\ln b)t + \ln a$
	$P = e^{(their1.28)t + their0.2}$	**M1**	or $\ln b = m = their1.28$ and $\ln a = c = their0.2$
	$P = e^{their0.2}e^{(their1.28)t}$	**A1**	or $1.10 \leqslant a \leqslant 1.35$ $3.49 \leqslant b \leqslant 3.82$
10(v)	$1000 * e^{their0.2} \times e^{their1.28t}$ or $1000 * their\ a \times their\ b^t$	**M1**	A correct relationship e.g. $1.3t * \ln(1000) - 0.2$ where * is = or an inequality sign
	5.3	**A1**	5.2 to 5.5 must be to 1dp

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

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ADDITIONAL MATHEMATICS	**0606/22**
Paper 2	**May/June 2017**
MARK SCHEME	
Maximum Mark: 80	

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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.

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

Abbreviations

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

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

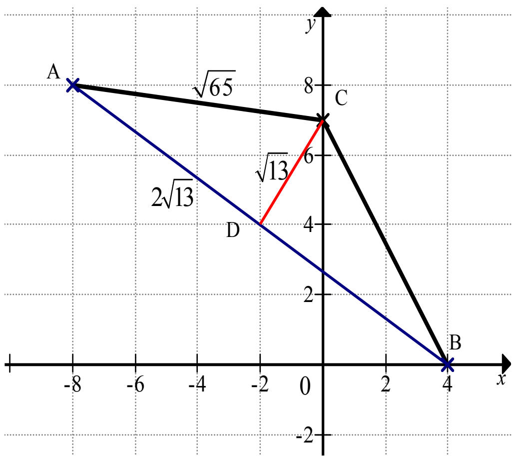
Question	Answer	Marks	Partial Marks
2	**Alternative method 1:** dealing with the negative index soi	B1	
	correctly squaring with at least 3 terms in the numerator and denominator $\frac{3-\sqrt{5}}{1+\sqrt{5}}\times\frac{3-\sqrt{5}}{1+\sqrt{5}}=\frac{9-6\sqrt{5}+5}{1+2\sqrt{5}+5}$ oe	B1	
	rationalising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

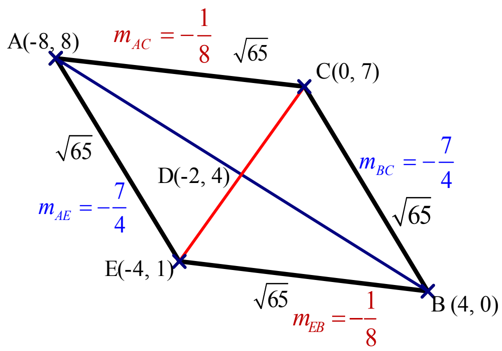
Question	Answer	Marks	Partial Marks
3	Correctly finding a correct linear factor or root	**B1**	from a valid method, e.g. factor theorem used or long division or synthetic division: $f(2)=10(2^3)-21(2^2)+4=0$ or $x-2\overline{)10x^3-21x^2\quad+4}$ with quotient $10x^2-x-2$ $\underline{10x^3-20x^2}$ $-x^2$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

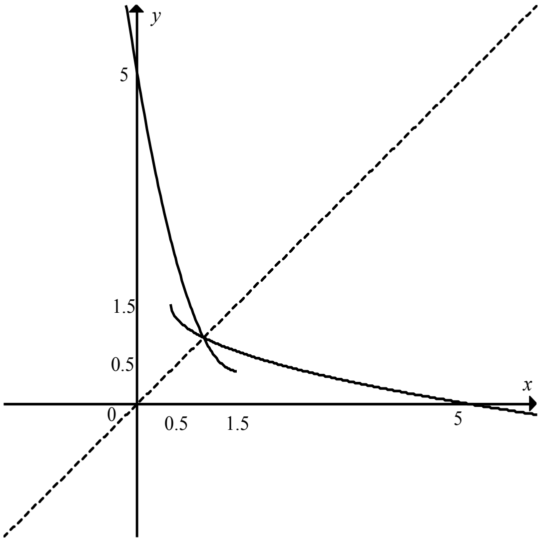
Question	Answer	Marks	Partial Marks
4	$\frac{dy}{dx}=6x-7$ soi	**B1**	
	$m_{\text{normal}}=-\frac{1}{5}$ soi	**B1**	finds or uses correct gradient of normal
	$m_{\text{tangent}}=5$ soi or $(6x-7)\left(-\frac{1}{5}\right)=-1$ oe	**M1**	uses $m_1m_2=-1$ with numerical gradients
	$6x-7=5$ oe $\Rightarrow x=2$	**A1**	
	$y=9$	**A1**	
	$k=47$	**A1**	
	Alternative method $m_{\text{normal}}=-\frac{1}{5}$	**B1**	
	$m_{\text{tangent}}=5$	**M1**	
	$3x^2-12x+11-c=0$ oe	**A1**	
	solving $3x^2-12x+12=0$ oe to find $x=2$	**A1**	
	$y=9$	**A1**	
	$k=47$	**A1**	
5(i)	$\left(\textit{their}\,2x^4\right)(0.2-\ln 5x)+0.4x^5\left(\textit{their}\,\frac{-5}{5x}\right)$ oe or $\textit{their}\,0.4x^4-\left(\left(\textit{their}\,2x^4\right)\ln 5x+0.4x^5\left(\textit{their}\,\frac{5}{5x}\right)\right)$ oe	**M1**	clearly applies correct form of product rule
	$-2x^4\ln 5x$ isw	**A1**	nfww
5(ii)	$3\ln 5x$ or $\ln 5x+\ln 5x+\ln 5x$	**B1**	

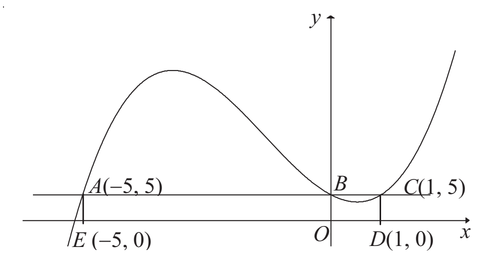
Question	Answer	Marks	Partial Marks
5(iii)	$\frac{3}{-2}\int\left(-2x^4\ln 5x\right)\mathrm{d}x$ oe	M1	**FT** $k = 2$ from (i) allow for $\frac{3}{2}\int\left(2x^4\ln 5x\right)\mathrm{d}x$ or, when $k = -2$, for $\int\left(x^4\ln 5x\right)\mathrm{d}x = -0.2x^5(0.2 - \ln 5x)$ or $-\frac{2}{3}\int\left(3x^4\ln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

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

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

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

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

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

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

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

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **May/June 2017**

MARK SCHEME

Maximum Mark: 80

Published

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

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

Cambridge will not enter into discussions about these mark schemes.

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

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.

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Abbreviations

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

Question	Answer	Marks	Guidance
4(a)(i)	$\begin{pmatrix} -4 \\ 3 \end{pmatrix}$	**B1**	
4(a)(ii)	$\sqrt{11^2 + (-15)^2}$ or better	**M1**	
	$\frac{1}{\sqrt{346}}\begin{pmatrix} 11 \\ -15 \end{pmatrix}$	**A1**	
4(b)	$\overrightarrow{OR} = \overrightarrow{OP} + \frac{3}{4}\overrightarrow{PQ}$ soi	**M1**	or $\overrightarrow{OR} = \overrightarrow{OQ} - \frac{1}{4}\overrightarrow{PQ}$ soi
	$\left[\overrightarrow{OR} =\right] \mathbf{p} + \frac{3}{4}(\mathbf{q} - \mathbf{p})$	**M1**	or $\left[\overrightarrow{OR} =\right] \mathbf{q} - \frac{1}{4}(\mathbf{q} - \mathbf{p})$
	$\left[\overrightarrow{OR} =\right] \frac{1}{4}\mathbf{p} + \frac{3}{4}\mathbf{q}$ oe	**A1**	
5(a)	$(9 \times 8 \times 7 \times 6 \times 1) + (8 \times 8 \times 7 \times 6 \times 1)$ soi	**M2**	**M1** for one correct product of the sum
	5712	**A1**	
5(b)	${}^9C_4 \times {}^5C_4 + {}^9C_3 \times {}^5C_5$ oe	**M2**	**M1** for one correct product of the sum
	[630 + 84 =] 714	**A1**	
6	$64 = 2^n$	**M1**	
	$n = 6$	**A1**	
	$their 6(2)^{their(6-1)} \times (-a) = -16b$ oe	**M1**	
	$their \frac{6 \times (6-1)}{2}(2)^{their(6-2)} \times (-a)^2 = 100b$ oe	**M1**	
	attempts to solve	**DM1**	dep on both M1 marks being awarded; must have correctly or correct FT eliminated one unknown
	$a = 5$	**A1**	
	$b = 60$	**A1**	

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

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

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

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/22**

Paper 22 **March 2017**

MARK SCHEME

Maximum Mark: 80

Published

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

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Cambridge is publishing the mark schemes for the March 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

Abbreviations

awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied
www without wrong working

Question	Answer	Marks	Guidance
1	$-\frac{5}{3}$ isw	**B1**	or exact equivalent
	Solve $5-3x=-10$ or $(5-3x)^2=100$	**M1**	
	$x=5$	**A1**	
2 (i)	\$12 000	**B1**	
(ii)	$\frac{8000}{12\,000}=e^{-0.2t}$ oe	**M1**	
	[t =] 2(.0273...) years	**A1**	

Question	Answer	Marks	Guidance
3 (i)	multiply out correctly	**B1**	or divide out correctly
(ii)	Finding another factor	**B1**	$(x-1)$ or $(x+2)$ or $(x-2)$; method must be seen
	Either $(x-1)^2(x^2-4)$ Or $(x-1)(x+2)(x^2-3x+2)$ Or $(x-1)(x-2)(x^2+x-2)$	**B1**	For stating a relevant quadratic factor for *their* linear factors
	Attempts to factorise quadratic	**M1**	
	$(x-1)^2(x+2)(x-2)$ oe	**A1**	mark final answer **Alternative method:** **B1** for finding a second linear factor using any valid method and **B1** for finding a third linear factor using any valid method and **B1** for finding the final linear factor using any valid method and **B1** for fully correct product stated; mark final answer If fully correct product stated but no method shown then **B1** only.
4	Eliminates y $3x+k=2x^2-3x+4$	**M1**	**Alternative calculus method:** Equates gradients $4x-3=3$
	Collects terms $2x^2-6x+4-k=0$ soi	**A1**	Finds point of tangency (1.5, 4)
	Applies b^2-4ac $(-6)^2-4(2)(4-k)$ or better	**M1**	Substitutes into $y=3x+k$ $4=3(1.5)+k$
	$k<-\frac{1}{2}$ oe	**A1**	

Question	Answer	Marks	Guidance
5	$\sqrt{20}=\sqrt{4\times5}=2\sqrt{5}$ seen	**B1**	may be later in working; must be convinced that calculator has not been used
	$\left(3+\sqrt{5}\right)x+\frac{1}{2}x\left(their\,2\sqrt{5}\right)=13+5\sqrt{5}$ oe leading to $\left(3+their\,2\sqrt{5}\right)x=13+5\sqrt{5}$	**M1**	equates *their* area to given area and factorises to collect x terms; may still have $\sqrt{20}$
	$[x=]\frac{13+5\sqrt{5}}{3+their\,2\sqrt{5}}\times\frac{3-their\,2\sqrt{5}}{3-their\,2\sqrt{5}}$	**M1**	divides and attempts to rationalise; may still have $\sqrt{20}$ or forms a pair of simultaneous equations e.g. $3p+10q=13$ $2p+3q=5$
	$[x=]\frac{39-26\sqrt{5}+15\sqrt{5}-50}{9-20}$	**M1**	numerator must have at least 3 terms; denominator may be -11 or solves their simultaneous equations to find one unknown
	$1+\sqrt{5}$ www	**A1**	or $p=1$, $q=1$
6 (a) (i)	$-2x^{\frac{5}{2}}$ oe or $a=-2$ and $b=\frac{5}{2}$ oe	**B2**	mark final answer **B1** for -2 and **B1** for $\frac{5}{2}$
(ii)	$[x=]\left(\frac{-6250}{their(-2)}\right)^{their\frac{2}{5}}$ oe	**M1**	may be in steps
	25	**A1**	
(b) (i)	Valid explanation	**B1**	e.g. If $x>0.75$ then all the arguments are positive as required. oe
(ii)	$1=\log_a a$	**M1**	may be seen in e.g. $\log_a(ax)=1+\log x$
	$2\log_a(4x-3)=\log_a(4x-3)^2$ soi	**M1**	
	completion to given result	**A1**	

Question	Answer	Marks	Guidance
(iii)	$x^2(16x-24)=0$ oe or $x(16x-24)=0$ oe	M1	e.g. equates, anti-logs, rearranges and factorises or divides OR rearranges, combines using correct log law, anti-logs and factorises or divides
	$[x=]\frac{24}{16}$ or $\frac{3}{2}$ oe	A1	inclusion of $x = 0$ is **A0**
7 (a)	$[r^2=]\,5^2+10^2-2\times5\times10\times\cos120$ oe	M1	or for $[r^2=]\,5^2+10^2-2\times5\times10\times\cos60°$ or for $[r^2=]\,5^2+10^2-2\times5\times10\times\cos240°$
	[r =] 13.2 or 13.22875.... rot to 4 or more sf	A1	not from wrong working
	$\frac{\sin x}{5}=\frac{\sin120}{their13.2}$ or better	M1	or $\frac{\sin y}{10}=\frac{\sin120}{their13.2}$ or better
	[x =] awrt 19.1	A1	or [y =] awrt 40.9
	360 – 120 – *their x*	A1FT	or 180 + *their y*
(b)	94 [km/h] west	B2	**B1** for 94 [km/h]
8 (i)	$y-(-4)=\frac{1}{6}(x-6)$	B1	or $y=\frac{1}{6}x+c$ and $c=-5$
	$[m_{AB}=]\frac{7-4}{3-8}$ or $-\frac{3}{5}$ oe	M1	
	$y-7=-\frac{3}{5}(x-3)$ or $y-4=-\frac{3}{5}(x-8)$	A1	or $y=-\frac{3}{5}x+c$ and $c=\frac{44}{5}$
	$their\left(\frac{1}{6}x-5\right)=their\left(-\frac{3}{5}x+\frac{44}{5}\right)$	M1	valid method of solution for *their* equations; must be of equivalent difficulty
	$x=18$	A1	
	$y=-2$ isw	A1	

Question	Answer	Marks	Guidance
(ii)	$[m=]-\frac{3}{2}$	M1	
	$y - their(-2) = -\frac{3}{2}(x - their18)$ isw	A1FT	FT *their D*; $y=-\frac{3}{2}x+c$ and $c =$ *their* 25
9 (a)	ke^{2x+1} $(+c)$	M1	for some non-zero integer k where $k \neq 2$
	$k=\frac{1}{2}$	A1	
(b) (i)	$\frac{d(\ln x)}{dx}=\frac{1}{x}$ soi	B1	
	$\left[\frac{dy}{dx}=\right]\frac{(their1)\ln x - x\left(their\frac{1}{x}\right)}{(\ln x)^2}$	M1	correct form of quotient rule or equivalent product rule applied; brackets may be omitted or misplaced for **M1**
	correct, isw	A1	may be unsimplified; allow recovery of brackets
(ii)	$\int\frac{\ln x-1}{(\ln x)^2}dx+\int\frac{1}{x^2}dx=\frac{x}{\ln x}+\int\frac{1}{x^2}dx$	M1	rearranges and uses their answer to (i)
	$\int\frac{1}{x^2}dx=-\frac{1}{x}(+c)$	B1	
	$\frac{x}{\ln x}+\left(their-\frac{1}{x}\right)(+c)$	A1FT	correct or correct **FT** completion; $their-\frac{1}{x}$ must not be $\frac{1}{x^2}$

Question	Answer	Marks	Guidance
10 (i)	$\tan(2x-10)=\frac{4}{3}$	**B1**	
	$2x-10=\tan^{-1}\left(\frac{4}{3}\right)$ soi	**M1**	
	31.6 and 121.6 isw	**A1**	or for 31.6 and 211.6 isw
	211.6 and 301.6 isw	**A1**	or for 121.6 and 301.6 isw
			Penalty of 1 mark if all 4 angles given correctly but prematurely approximated OR if any extra angles are given besides the correct 4
			If **A0 A0** then allow **SC1** for 53.1(30...), 233.1(30...), 413.1(30...), 593.1(30...) seen OR for 63.1(30…), 243.1(30…), 423.1(30…), 603.1(30…) seen
(ii)	$1-\cos^2 x-\cos^2 x=\cos x$	**M1**	uses $\sin^2 x=1-\cos^2 x$
	$2\cos^2 x+\cos x-1=0$ oe	**A1**	
	$(2\cos x-1)(\cos x+1)[=0]$	**M1**	factorises or solves *their* 3-term quadratic in $\cos x$
	$[x=]\ 60, 300, 180$	**A2**	**A1** for any two correct
11 (i)	$g\geqslant-\frac{1}{2}$	**B1**	
(ii)	g(1) = 0 valid comment e.g. domain of f is $x\geqslant 2$	**B1** **B1**	**B1** for either
(iii)	$\dfrac{\left(\frac{x^2-2}{x}\right)^2-1}{2}$	**M1**	or $\dfrac{\left(x-\frac{2}{x}\right)^2-1}{2}$
	$\left(\frac{x^2-2}{x}\right)^2=\frac{x^4-4x^2+4}{x^2}$ soi	**B1**	or $\left(x-\frac{2}{x}\right)^2=x^2-4+\frac{4}{x^2}$
	$\frac{1}{2}x^2-\frac{5}{2}+\frac{2}{x^2}$	**A1**	or correct 3 term equivalent or $a=0.5$, $b=-2.5$, $c=2$

Question	Answer	Marks	Guidance
(iv)	$x \geqslant 2$	B1	
(v)	$x^2 - yx - 2 = 0$	B1	or $y^2 - xy - 2 = 0$
	$[x =]\dfrac{-(-y) \pm \sqrt{(-y)^2 - 4(1)(-2)}}{2}$	M1	or $[y =]\dfrac{-(-x) \pm \sqrt{(-x)^2 - 4(1)(-2)}}{2}$
	Explains why negative square root should be discarded	B1	at some point
	$\mathrm{f}^{-1}(x) = \dfrac{x + \sqrt{x^2 + 8}}{2}$	A1	allow $y = \dfrac{x + \sqrt{x^2 + 8}}{2}$ If zero scored, allow **SC2** for showing correctly that the inverse of the given f^{-1} is f.
12 (i)	[length of rectangle =] $\dfrac{20 - 3x}{2}$	B1	
	$[A =]\ x \times \mathit{their}\dfrac{20 - 3x}{2} - \dfrac{1}{2} \times x \times x \times \sin 60$ oe	M1	
	Correct completion to given answer $A = 10x - \left(\dfrac{6 + \sqrt{3}}{4}\right)x^2$	A1	
(ii)	$10 - 2\left(\dfrac{6 + \sqrt{3}}{4}\right)x$ oe	B1	
	$\mathit{their}\left(10 - 2\left(\dfrac{6 + \sqrt{3}}{4}\right)x\right) = 0$ oe	M1	
	$x = 2.6$	A1	allow 2.586635... rot to 3 or more sf
	$A = 13$	A1	allow 12.9331.... rot to 3 or more sf

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 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	Part Marks
1	$4x-3=x \rightarrow x=1$ $4x-3=-x$ $x=0.6$ **OR** $(4x-3)^2=x^2$ $15x^2-24x+9=0$ $3(x-1)(5x-3)=0$ $x=1$ and $x=0.6$	**B1** **M1** **A1** **B1** **M1** **A1**	www use of $-x$ or $-(4x-3)$ but not both. solve correct 3 term quadratic www
2	$a(\sqrt{3}-1)+b(\sqrt{3}+1)$ $=(\sqrt{3}-3)(\sqrt{3}-1)(\sqrt{3}+1)$ $=2(\sqrt{3}-3)$ oe $a+b=2$ $-a+b=-6$ $b=-2$ and $a=4$	**M1** **DM1** **A1** **DM1** **A1**	Common denominator or $\times(\sqrt{3}-1)(\sqrt{3}+1)$ equate constant terms and $\sqrt{3}$ terms. both correct solve two **linear** equations to obtain $a=$ or $b=$ both correct
3	$2\lg x=\lg x^2$ $1=\lg 10$ $\lg x^2-\lg\left(\frac{x+10}{2}\right)=\lg\left(\frac{2x^2}{x+10}\right)$ oe $2x^2-10x-100=0 \rightarrow 2(x+5)(x-10)=0$ $x=10$ only	**B1** **B1** **B1** **M1** **A1**	soi anywhere soi anywhere soi division; logs may be removed obtain correct 3 term quadratic equation and attempt to solve $x=-5$ must not remain.

Question	Answer	Marks	Part Marks
4 (i)	$t=10 \to N=7000+2000\mathrm{e}^{-0.5}$ $=8213$ or 8210	B1	Do not accept non integer responses.
(ii)	$N=7500 \to 7500=7000+2000\mathrm{e}^{-0.05t}$ $\mathrm{e}^{-0.05t}=\dfrac{500}{2000}$	M1	insert and make $\mathrm{e}^{-0.05t}$ subject
	$-0.05t=\ln 0.25 \to t=\dfrac{\ln 0.25}{-0.05}$	M1	take logs and make t the subject
	$=27.7$ (days)	A1	awrt 27.7
(iii)	$\dfrac{\mathrm{d}N}{\mathrm{d}t}=-100\mathrm{e}^{-0.05t}$	M1 A1	$k\mathrm{e}^{-0.05t}$ where k is a constant $k=-100$ or -0.05×2000
	$t=8 \to \dfrac{\mathrm{d}N}{\mathrm{d}t}=\pm 67$ (.0)	A1	awrt ± 67 mark final answer
5 (i)	$\dfrac{\mathrm{d}y}{\mathrm{d}x}=3x^2+4x-7$	B1	
	$x=-2 \to \dfrac{\mathrm{d}y}{\mathrm{d}x}=12-8-7=-3$	M1	insert $x=-2$ into *their* gradient and use $(-2, 16)$ and *their* gradient of tangent in equation of line.
	Equation of tangent : $\dfrac{y-16}{x+2}=-3 \to y=-3x+10$	A1	
(ii)	Tangent cuts curve again $x^3+2x^2-7x+2=-3x+10$	M1	equate curve and *their* linear answer from (i).
	$x^3+2x^2-4x-8=0$	A1	
	$(x+2)(x+2)(x-2)=0$	M1	factorise: $(x\pm 2)$ and a two or three term quadratic is sufficient. Allow long division
	$x=2, \quad y=4$	A1A1	withhold final **A1** if (2, 4) not clearly identified as their sole answer.
6 (i)	$\dfrac{\cos x}{1+\tan x}-\dfrac{\sin x}{1+\cot x}=\dfrac{\cos x}{1+\dfrac{\sin x}{\cos x}}-\dfrac{\sin x}{1+\dfrac{\cos x}{\sin x}}$	M1	$\tan x=\dfrac{\sin x}{\cos x}$ and $\cot x=\dfrac{\cos x}{\sin x}$
	$=\dfrac{\cos^2 x}{\cos x+\sin x}-\dfrac{\sin^2 x}{\cos x+\sin x}$	M1 A1	Attempt to multiply by $\cos x$ and $\sin x$
	$=\dfrac{(\cos x-\sin x)(\cos x+\sin x)}{(\cos x+\sin x)}$	A1	AG
(ii)	$-\sin x+\cos x=3\sin x-4\cos x$	M1	equate and collect $\sin x$ and $\cos x$ oe
	$5\cos x=4\sin x$ $\tan x=\dfrac{5}{4}$	A1	
	$x=51.3°, -128.7°$	A1A1	**FT** from tan $x=k$

Question	Answer	Marks	Part Marks
7 (i)	$h=\sqrt{9-x^2}$ $A=\frac{\sqrt{9-x^2}}{2}(14+x+x)=\sqrt{9-x^2}\,(7+x)$	B2/1/0	Must be clear that $\sqrt{9-x^2}$ is the height of the trapezium. $14+2x$ oe must be seen AG
(ii)	$\frac{dA}{dx}=\sqrt{9-x^2}+(7+x)\frac{1}{2}\left(9-x^2\right)^{-0.5}\times -2x$	M1 A2/1/0	product rule on correct function minus 1 each error , allow unsimplified.
	$\frac{dA}{dx}=0\rightarrow 9-x^2=7x+x^2$ $2x^2+7x-9=0$	M1 A1	equate to 0 and simplify to a linear or quadratic equation. correct three term quadratic obtained
	$x=1$ $A=16\sqrt{2}$ or $8\sqrt{8}$ or $\sqrt{512}$ or22.6	A1 A1	Extra positive answer loses penultimate **A1**. ignore negative solution.
8 (i)	$f'(x)=\frac{\left(x^3+1\right)9x^2-\left(3x^3-1\right)3x^2}{\left(x^3+1\right)^2}$	M1 A1	quotient rule or product rule all correct
	$=\frac{12x^2}{\left(x^3+1\right)^2}$	A1	www beware $9x^6-9x^6$ gets **A0**
(ii)	$\int_1^2\frac{x^2}{\left(x^3+1\right)^2}dx=\frac{1}{12}\left[\frac{3x^3-1}{x^3+1}\right]_1^2$	M1	$c\times\frac{3x^3-1}{x^3+1}$
		A1	**FT** $c=\frac{1}{their\,12}$
	$=\frac{1}{12}\left[\frac{23}{9}-\frac{2}{2}\right]$	DM1	top limit – bottom limit in *their* integral.
	$=\frac{7}{54}$	A1	or 0.130 or 0.1296 or 0.12
(iii)	$x=\frac{3y^3-1}{y^3+1}$ $y^3=\frac{x+1}{3-x}$	B1	make y^3 or x^3 the subject
	$f^{-1}(x)=\sqrt[3]{\frac{x+1}{3-x}}$	B1 B1	**FT** take cube root (as long as y^3 or x^3 equals a fraction with terms in x or y only) oe **FT** change x and y – can be done at any time
	Domain : $-1\leqslant x\leqslant 2\frac{6}{7}$	B1	Allow upper limit of 2.86 . Do not isw

Question	Answer	Marks	Part Marks
9 (i)	tangent touches circle $x^2+(kx-4)^2-2(kx-4)=8$	M1	eliminate y or x allow unsimplified
	$k^2x^2+x^2-8kx-2kx+16=0$ or better	A1	
	Equal roots as tangent touches circle : $b^2=4ac$	DM1	use of discriminant on 3 term quadratic soi
	$(-10k)^2=4(k^2+1)\times 16$	A1	
	$36k^2=64$		
	$k=+\frac{4}{3}$ only	A1	oe any inequality loses last **A1**
(ii)	$x=\frac{-b}{2a}\quad\to x=\frac{\frac{4}{3}\times 10}{\frac{25}{9}}$	M1	use $x=\frac{-b}{2a}$
	$x=\frac{12}{5}\qquad y=-\frac{4}{5}$	A1A1	
	OR tangent $y=\frac{4}{3}x-4$ cuts radius	M1	find equation of radius and attempt to solve with tangent
	$y=-\frac{3}{4}x+1$		
	at $x=\frac{12}{5}$	A1	
	$y=-\frac{4}{5}$	A1	
	OR Obtain $25x^2-120x+144=0$ oe	M1	obtain any 3 term quadratic using *their* non zero k and reach $x=\ldots$
	$(5x-12)(5x-12)=0$		
	$x=\frac{12}{5}\to y=-\frac{4}{5}$	A1A1	
(iii)	$TP=\sqrt{(0-2.4)^2+(-4+0.8)^2}=4$	M1A1	**M1** for using *their* T and $(0,-4)$. Signs must be correct.

Question	Answer	Marks	Part Marks
10 (i)	$r_j = \begin{pmatrix} 5000 \\ 1000p \end{pmatrix} + \begin{pmatrix} -2\cos40 \\ 2\cos50 \end{pmatrix} t$	B1 B1	x coordinate oe y coordinate oe
(ii)	$2.5t\cos70 = 5000 - 2t\cos40$	M1	equate *their* x values (must be 3 terms)
	$t = \dfrac{5000}{2.5\cos70 + 2\cos40}$	DM1	make t the subject allow one sign error
	$= 2095$ awrt or 2090 or 2100	A1	
	$(2.5\cos20 - 2\cos50) \times 2095 = 1000p$	M1	equate *their* y values(must be 3 terms) and insert *their* t or $\|t\|$.
	$p = 2.23$ awrt	A1	
11 (i)	Free choice : no. of ways ${}^6C_4 \times {}^5C_2 = 15 \times 10$ $= 150$	B1 B1	${}^6C_4 \times$ another ${}^nC_r$ term only $\times {}^5C_2$ and answer or vice versa
(ii)	Both Mr and Mrs Coldicott ${}^5C_3 \times {}^4C_1 = 10 \times 4$ $= 40$	B1 B1	${}^5C_3 \times$ another ${}^nC_r$ term only $\times {}^4C_1$ and answer or vice versa
(iii)	Mr C and not Mrs C ${}^5C_3 \times {}^4C_2 \, (= 60)$ Not Mr C and Mrs C ${}^5C_4 \times {}^4C_1 \, (= 20)$ Total = 80	B1 B1 B1	An incorrect final answer does not affect the awarding of the first two **B1** marks. www
	OR Total = (i) – (ii) – neither Neither = ${}^5C_4 \times {}^4C_2 = 30$ Total = 150 – 40 – 30 = 80	 M1 A1 A1	

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **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	$4x-3=x\to x=1$	**B1**	www
	$4x-3=-x$	**M1**	use of $-x$ or $-(4x-3)$ but not both.
	$x=0.6$	**A1**	
	OR $(4x-3)^2=x^2$	**B1**	
	$15x^2-24x+9=0$		
	$3(x-1)(5x-3)=0$	**M1**	solve correct 3 term quadratic
	$x=1$ and $x=0.6$	**A1**	www
2	$a(\sqrt{3}-1)+b(\sqrt{3}+1)$	**M1**	Common denominator or
	$=(\sqrt{3}-3)(\sqrt{3}-1)(\sqrt{3}+1)$		$\times(\sqrt{3}-1)(\sqrt{3}+1)$
	$=2(\sqrt{3}-3)$ oe		
	$a+b=2$	**DM1**	equate constant terms and $\sqrt{3}$ terms.
	$-a+b=-6$	**A1**	both correct
		DM1	solve two **linear** equations to obtain $a=$ or $b=$
	$b=-2$ and $a=4$	**A1**	both correct
3	$2\lg x=\lg x^2$	**B1**	soi anywhere
	$1=\lg 10$	**B1**	soi anywhere
	$\lg x^2-\lg\left(\dfrac{x+10}{2}\right)=\lg\left(\dfrac{2x^2}{x+10}\right)$ oe	**B1**	soi division; logs may be removed
	$2x^2-10x-100=0\to 2(x+5)(x-10)=0$	**M1**	obtain correct 3 term quadratic equation and attempt to solve
	$x=10$ only	**A1**	$x=-5$ must not remain.

Question	Answer	Marks	Part Marks
4 (i)	$t=10\to N=7000+2000e^{-0.5}$ $=8213$ or 8210	B1	Do not accept non integer responses.
(ii)	$N=7500\to 7500=7000+2000e^{-0.05t}$	M1	insert and make $e^{-0.05t}$ subject
	$e^{-0.05t}=\frac{500}{2000}$		
	$-0.05t=\ln 0.25\to t=\frac{\ln 0.25}{-0.05}$	M1	take logs and make *t* the subject
	$=27.7$ (days)	A1	awrt 27.7
(iii)	$\frac{dN}{dt}=-100e^{-0.05t}$	M1 A1	$ke^{-0.05t}$ where k is a constant $k=-100$ or -0.05×2000
	$t=8\to\frac{dN}{dt}=\pm 67$ (.0)	A1	awrt ± 67 mark final answer
5 (i)	$\frac{dy}{dx}=3x^2+4x-7$	B1	
	$x=-2\to\frac{dy}{dx}=12-8-7=-3$	M1	insert $x=-2$ into *their* gradient and use $(-2, 16)$ and *their* gradient of tangent in equation of line.
	Equation of tangent : $\frac{y-16}{x+2}=-3\to y=-3x+10$	A1	
(ii)	Tangent cuts curve again $x^3+2x^2-7x+2=-3x+10$	M1	equate curve and *their* linear answer from (i).
	$x^3+2x^2-4x-8=0$	A1	
	$(x+2)(x+2)(x-2)=0$	M1	factorise: $(x\pm 2)$ and a two or three term quadratic is sufficient. Allow long division
	$x=2,\quad y=4$	A1A1	withhold final **A1** if (2, 4) not clearly identified as their sole answer.
6 (i)	$\frac{\cos x}{1+\tan x}-\frac{\sin x}{1+\cot x}=\frac{\cos x}{1+\frac{\sin x}{\cos x}}-\frac{\sin x}{1+\frac{\cos x}{\sin x}}$	M1	$\tan x=\frac{\sin x}{\cos x}$ and $\cot x=\frac{\cos x}{\sin x}$
	$=\frac{\cos^2 x}{\cos x+\sin x}-\frac{\sin^2 x}{\cos x+\sin x}$	M1 A1	Attempt to multiply by $\cos x$ and $\sin x$
	$=\frac{(\cos x-\sin x)(\cos x+\sin x)}{(\cos x+\sin x)}$	A1	AG
(ii)	$-\sin x+\cos x=3\sin x-4\cos x$	M1	equate and collect $\sin x$ and $\cos x$ oe
	$5\cos x=4\sin x$		
	$\tan x=\frac{5}{4}$	A1	
	$x=51.3°, -128.7°$	A1A1	**FT** from tan $x=k$

Question	Answer	Marks	Part Marks
7 (i)	$h=\sqrt{9-x^2}$ $A=\frac{\sqrt{9-x^2}}{2}(14+x+x)=\sqrt{9-x^2}\,(7+x)$	B2/1/0	Must be clear that $\sqrt{9-x^2}$ is the height of the trapezium. $14+2x$ oe must be seen AG
(ii)	$\frac{\mathrm{d}A}{\mathrm{d}x}=\sqrt{9-x^2}+(7+x)\frac{1}{2}\left(9-x^2\right)^{-0.5}\times -2x$	M1 A2/1/0	product rule on correct function minus 1 each error , allow unsimplified.
	$\frac{\mathrm{d}A}{\mathrm{d}x}=0\rightarrow 9-x^2=7x+x^2$ $2x^2+7x-9=0$	M1 A1	equate to 0 and simplify to a linear or quadratic equation. correct three term quadratic obtained
	$x=1$ $A=16\sqrt{2}$ or $8\sqrt{8}$ or $\sqrt{512}$ or 22.6	A1 A1	Extra positive answer loses penultimate **A1**. ignore negative solution.
8 (i)	$\mathrm{f}'(x)=\frac{\left(x^3+1\right)9x^2-\left(3x^3-1\right)3x^2}{\left(x^3+1\right)^2}$	M1 A1	quotient rule or product rule all correct
	$=\frac{12x^2}{\left(x^3+1\right)^2}$	A1	www beware $9x^6-9x^6$ gets **A0**
(ii)	$\int_1^2\frac{x^2}{\left(x^3+1\right)^2}\mathrm{d}x=\frac{1}{12}\left[\frac{3x^3-1}{x^3+1}\right]_1^2$	M1 A1	$c\times\frac{3x^3-1}{x^3+1}$ **FT** $c=\frac{1}{\mathit{their}\,12}$
	$=\frac{1}{12}\left[\frac{23}{9}-\frac{2}{2}\right]$	DM1	top limit – bottom limit in *their* integral.
	$=\frac{7}{54}$	A1	or 0.130 or 0.1296 or 0.12
(iii)	$x=\frac{3y^3-1}{y^3+1}$ $y^3=\frac{x+1}{3-x}$	B1	make y^3 or x^3 the subject
	$\mathrm{f}^{-1}(x)=\sqrt[3]{\frac{x+1}{3-x}}$	B1 B1	**FT** take cube root (as long as y^3 or x^3 equals a fraction with terms in x or y only) oe **FT** change x and y – can be done at any time
	Domain : $-1\leqslant x\leqslant 2\frac{6}{7}$	B1	Allow upper limit of 2.86 . Do not isw

Question	Answer	Marks	Part Marks
9 (i)	tangent touches circle $x^2+(kx-4)^2-2(kx-4)=8$	M1	eliminate y or x allow unsimplified
	$k^2x^2+x^2-8kx-2kx+16=0$ or better	A1	
	Equal roots as tangent touches circle : $b^2=4ac$	DM1	use of discriminant on 3 term quadratic soi
	$(-10k)^2=4(k^2+1)\times 16$	A1	
	$36k^2=64$		
	$k=+\frac{4}{3}$ only	A1	oe any inequality loses last **A1**
(ii)	$x=\frac{-b}{2a} \rightarrow x=\frac{\frac{4}{3}\times 10}{\frac{25}{9}}$	M1	use $x=\frac{-b}{2a}$
	$x=\frac{12}{5}$ $y=-\frac{4}{5}$	A1A1	
	OR tangent $y=\frac{4}{3}x-4$ cuts radius	M1	find equation of radius and attempt to solve with tangent
	$y=-\frac{3}{4}x+1$		
	at $x=\frac{12}{5}$	A1	
	$y=-\frac{4}{5}$	A1	
	OR Obtain $25x^2-120x+144=0$ oe	M1	obtain any 3 term quadratic using *their* non zero k and reach $x=\ldots$
	$(5x-12)(5x-12)=0$		
	$x=\frac{12}{5}\rightarrow y=-\frac{4}{5}$	A1A1	
(iii)	$TP=\sqrt{(0-2.4)^2+(-4+0.8)^2}=4$	M1A1	**M1** for using *their* T and $(0,-4)$. Signs must be correct.

Question	Answer	Marks	Part Marks
10 (i)	$r_j = \begin{pmatrix} 5000 \\ 1000p \end{pmatrix} + \begin{pmatrix} -2\cos 40 \\ 2\cos 50 \end{pmatrix} t$	B1 B1	x coordinate oe y coordinate oe
(ii)	$2.5t\cos 70 = 5000 - 2t\cos 40$	M1	equate *their* x values (must be 3 terms)
	$t = \dfrac{5000}{2.5\cos 70 + 2\cos 40}$	DM1	make t the subject allow one sign error
	$= 2095$ awrt or 2090 or 2100	A1	
	$(2.5\cos 20 - 2\cos 50) \times 2095 = 1000p$	M1	equate *their* y values(must be 3 terms) and insert *their* t or $\lvert t \rvert$.
	$p = 2.23$ awrt	A1	
11 (i)	Free choice : no. of ways ${}^6C_4 \times {}^5C_2 = 15 \times 10$ $= 150$	B1 B1	${}^6C_4 \times$ another ${}^nC_r$ term only $\times {}^5C_2$ and answer or vice versa
(ii)	Both Mr and Mrs Coldicott ${}^5C_3 \times {}^4C_1 = 10 \times 4$ $= 40$	B1 B1	${}^5C_3 \times$ another ${}^nC_r$ term only $\times {}^4C_1$ and answer or vice versa
(iii)	Mr C and not Mrs C ${}^5C_3 \times {}^4C_2\ (= 60)$ Not Mr C and Mrs C ${}^5C_4 \times {}^4C_1\ (= 20)$ Total = 80	B1 B1 B1	An incorrect final answer does not affect the awarding of the first two **B1** marks. www
	OR Total = (i) – (ii) – neither Neither $= {}^5C_4 \times {}^4C_2 = 30$ Total = 150 – 40 – 30 = 80	 M1 A1 A1	

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **October/November 2016**

MARK SCHEME

Maximum Mark: 80

Published

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This document consists of **6** printed pages.

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	Mark	Part Marks
1	$\frac{(\sqrt{5}+3\sqrt{3})}{(\sqrt{5}+\sqrt{3})}\times\frac{(\sqrt{5}-\sqrt{3})}{(\sqrt{5}-\sqrt{3})}$	M1	rationalise with $(\sqrt{5}-\sqrt{3})$
	$=\frac{5+3\sqrt{15}-\sqrt{15}-9}{5-3}$	A1	numerator (3 or 4 terms)
	$=\frac{2\sqrt{15}-4}{2}=\sqrt{15}-2$	A1	denominator and completion
2	$\ln e^{3x}=\ln 6e^{x}$		
	$3x=\ln 6e^{x}$	M1	one law of indices/logs
	$3x=\ln 6+\ln e^{x}$	M1	second law of indices/logs
	$3x=\ln 6+x$		
	$x=\frac{1}{2}\ln 6$ or $\ln\sqrt{6}$ or 0.896	A1	www oe in base 10
3 (i)	$\frac{d}{dx}\left(\frac{\sin x}{1+\cos x}\right)=\frac{(1+\cos x)\cos x+\sin x\sin x}{(1+\cos x)^2}$	M1	Quotient Rule (or Product Rule from $(\sin x)(1+\cos x)^{-1}$)
		A1	correct unsimplified
	$=\frac{\cos x+\cos^2 x+\sin^2 x}{(1+\cos x)^2}$	B1	use of $\sin^2 x+\cos^2 x=1$ oe
	$=\frac{1+\cos x}{(1+\cos x)^2}$	A1	completion
(ii)	$\int_0^2\left(\frac{1}{1+\cos x}\right)dx=\left[\frac{\sin x}{1+\cos x}\right]_0^2$	M1	correct integrand
	awrt 1.56	A1	

Question	Answer	Mark	Part Marks
4 (i)	$\text{p}(2)=0 \to 8+4a+2b-24=0$ $\to (4a+2b=16)$	B1	
	$\text{p}(1)=-20 \to 1+a+b-24=-20$ $\to (a+b=3)$	B1	
		M1	solve *their* linear equations for a or b
	$a=5$ and $b=-2$	A1	
(ii)	$\text{p}(x)=x^3+5x^2-2x-24$	M1	find quadratic factor
	$=(x-2)(x^2+7x+12)$	A1	correct quadratic factor soi
	$=(x-2)(x+3)(x+4)$	M1	factorise quadratic factor and write as product of 3 linear factors
	$\text{p}(x)=0 \to x=2,\ -3,\ -4.$	A1	if 0 scored, **SC2** for roots only
5 (i)	$AB^2=\left(\sqrt{3}+1\right)^2+\left(\sqrt{3}-1\right)^2$ $-2\left(\sqrt{3}+1\right)\left(\sqrt{3}-1\right)\cos 60$	M1	use cosine rule
	$=3+1+2\sqrt{3}+3+1-2\sqrt{3}-2$	A1	at least 7 terms
	$=6$	A1	correct completion AG
(ii)	$\dfrac{\sin A}{\sqrt{3}-1}=\dfrac{\sin 60}{\sqrt{6}}$	M1	sine rule (or cosine rule)
	$\sin A=\dfrac{\left(\sqrt{3}-1\right)\sin 60}{\sqrt{6}}=\dfrac{\sqrt{6}-\sqrt{2}}{4}$ oe or 0.259 or 0.2588…	A1	correct explicit expression for $\sin A$ AG
(iii)	Area $=\dfrac{1}{2}\left(\sqrt{3}+1\right)\left(\sqrt{3}-1\right)\sin 60$	M1	correct substitution into $\dfrac{1}{2}ab\sin C$
	$=\dfrac{\sqrt{3}}{2}$	A1	
6 (i)	$\dfrac{\text{d}y}{\text{d}x}=\sec^2 x$	B1	
	$x=\dfrac{\pi}{4} \to \dfrac{\text{d}y}{\text{d}x}=\sec^2\dfrac{\pi}{4}=2$	B1	evaluated
	$y=8$	B1	
	Equation of tangent $\dfrac{y-8}{x-\dfrac{\pi}{4}}=2$ $(4-2y=\pi-16,\ y=2x+6.429\ldots,$ $\dfrac{\pi}{4}=0.7853\ldots)$	B1	

Question	Answer	Mark	Part Marks
(ii)	$\sec^2 x = \tan x + 7$ $\tan^2 x - \tan x - 6 = 0$ oe $(\tan x - 3)(\tan x + 2) = 0$ $\tan x = 3$ or $\tan x = -2$ $x = 1.25, \quad 2.03$	M1 M1 A1A1	use $\sec^2 x = 1 + \tan^2 x$ to obtain a 3 term quadratic in tan*x* solve three term quadratic for tan*x* extras in range lose final **A1**
7 (i)	$r^2 + h^2 = (0.5h + 2)^2$ oe $r^2 = 0.25h^2 + 2h + 4 - h^2$ $r^2 = 2h + 4 - 0.75h^2$	M1 A1	 correct expansion and r^2 subject and completion www AG
(ii)	$V = \frac{1}{3}\pi r^2 h = \frac{\pi}{3}\left(2h^2 + 4h - 0.75h^3\right)$ $\frac{\mathrm{d}V}{\mathrm{d}h} = \frac{\pi}{3}\left(4h + 4 - 2.25h^2\right)$ $\frac{\mathrm{d}v}{\mathrm{d}h} = 0 \rightarrow 2.25h^2 - 4h - 4 = 0$ $h = 2.49$ only	B1 M1 A1 M1 A1	any correct form in terms of *h* only differentiate *V* correct differentiation equate to 0 and solve 3 term quadratic cao
(iii)	$\frac{\mathrm{d}^2V}{\mathrm{d}h^2} = \frac{\pi}{3}(4 - 4.5h)$ when $h = 2.49$ (–7.545…) < 0 so maximum	M1 A1	differentiate *their* 3 term $\frac{\mathrm{d}V}{\mathrm{d}h}$ and substitute *their h* draw correct conclusion www
8 (i)	$\cos TOA = \frac{6}{10} \rightarrow$ $TOA = 0.927$	M1 A1	any method
(ii)	area of major sector = $\frac{1}{2}6^2\left(2\pi - 2 \times their\, 0.927\right)$ (= 79.7) area of half kite = $\frac{1}{2}(6)\sqrt{10^2 - 6^2}$ (=24) area of kite × 2 (=48) complete correct plan awrt 128	 M2 M1 DM1 DM1 A1	 or **M1** for $\frac{1}{2}\ 6^2(2 \times$ *their* $0.927)$ **DM1** for $\pi \times 6^2 - \frac{1}{2}\ 6^2(2 \times$ *their* $0.927)$ any method *their* major sector + *their* kite
(iii)	arc length = $6 \times (2\pi - 2 \times their\, 0.927) + 2 \times \sqrt{10^2 - 6^2}$) awrt 42.6	 M1 A1	 complete correct method

Question	Answer	Mark	Part Marks
9 (i)	$p=4$	**B1**	
(ii)	$\tan\alpha = \pm\frac{1}{3}$ or ± 3 or 18.4° or 71.6° seen	**M1**	could use cos or sin
	108	**A1**	
(iii)	$\boldsymbol{r_A} = \begin{pmatrix}1\\5\end{pmatrix} + t\begin{pmatrix}\textit{their } p\\-3\end{pmatrix}$	**B1**	
(iv)	$\boldsymbol{r_B} = \begin{pmatrix}q\\-15\end{pmatrix} + t\begin{pmatrix}3\\-1\end{pmatrix}$	**B1**	
(v)	$5-3t=-15-t$	**M1**	$\boldsymbol{r_A} = \boldsymbol{r_B}$ and equate y/**j** and solve for t
	$\rightarrow t=10$	**A1**	
(vi)	$\begin{pmatrix}41\\-25\end{pmatrix}$ only	**B1**	
(vii)	$q=11$ only	**B1**	
10 (i)	$\mathrm{fg}(x)=\ln(2\mathrm{e}^x+3)+2$	**B1**	isw
(ii)	$\mathrm{ff}(x)=\ln(\ln x+2)+2$	**B1**	isw
(iii)	$x=2\mathrm{e}^y+3$	**M1**	change x and y and make e^y the subject
	$\mathrm{e}^y=\frac{x-3}{2}$		
	$\mathrm{g}^{-1}(x)=\ln\left(\frac{x-3}{2}\right)$ oe	**A1**	
(iv)	e^2 or 7.39	**B1**	
(v)	$\mathrm{gf}(x)=2\mathrm{e}^{(\ln x+2)}+3=20$	**B1**	gf correct and equation set up correctly
	$2\mathrm{e}^{\ln x}\mathrm{e}^2+3=20$	**M1**	one law of indices/logs
	$2x\mathrm{e}^2=17$	**M1**	second law of indices/logs
	$x=\frac{17}{2\mathrm{e}^2}$ or 1.15	**A1**	
			www if 0 scored, **SC2** for 17.3…

Question	Answer	Mark	Part Marks
11 (i)	$\mathbf{A}^2 = \begin{pmatrix} 2 & q \\ p & 3 \end{pmatrix}\begin{pmatrix} 2 & q \\ p & 3 \end{pmatrix} = \begin{pmatrix} 4+pq & 2q+3q \\ 2p+3p & pq+9 \end{pmatrix}$	**B2,1,0**	–1 each error
	$\mathbf{A}^2 - 5\mathbf{A} = 2\mathbf{I} \to 4 + pq - 10 = 2$ or $9 + pq - 15 = 2$	**M1**	equate top left or bottom right elements
	$\to pq = 8$	**A1**	accept $p = \frac{8}{q}$, $q = \frac{8}{p}$
(ii)	$\det \mathbf{A} = 6 - pq$	**B1**	
	$6 - pq = -3p$ and solve	**M1**	*their* det $\mathbf{A} = -3p$ and use *their* $pq = k$ oe to solve for p or q
	$\to p = \frac{2}{3}$	**A1**	
	$q = 12$	**A1**	**FT** from *their* $pq = k$

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2016**

MARK SCHEME

Maximum Mark: 80

Published

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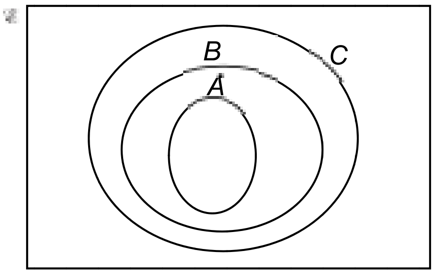
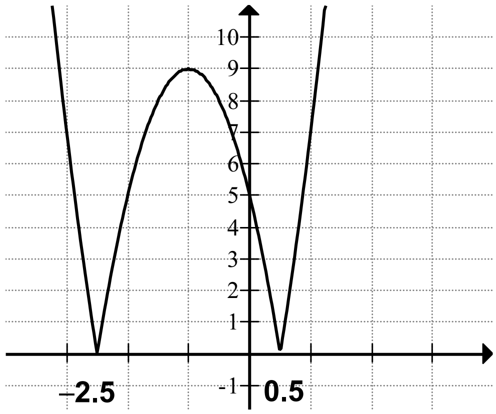
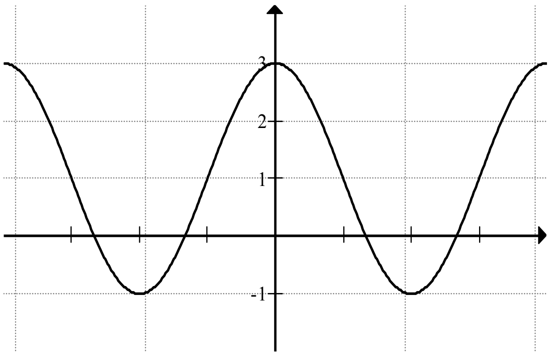
Abbreviations

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	$x^2 - 2x - 15$	M1	expands and rearranges to form a 3 term quadratic
	critical values –3 and 5	A1	not from wrong working
	$x < -3 \quad x > 5$	A1	mark final inequality; **A0** if spurious attempt to combine e.g. $5 < x < -3$
2 (a)		B1	It must be clear how the sets are nested
(b) (i)	$h \in P$	B1	Allow $\{m,a,t,h,s\}$ for P
(ii)	$n(P \cap Q) = 2$ cao	B1	
(iii)	{ t, h, s}	B1	
3 (i)	–2	B1	
(ii)	$-n$	B1	
(iii)	$\frac{\lg 5}{\log_5 10} = [(\lg y)^2]$ or $\frac{\lg 20 - \lg 4}{1/\lg 5} = [(\lg y)^2]$	M1	One log law used correctly
	correct completion to $(\lg 5)^2$ isw	A1	answer only does not score
(iv)	$[\log_r]6x^2 = [\log_r]600$	B1	Condone base missing
	$x = 10$ only	B1	

Question	Answer	Marks	Guidance
4 (i)	$\frac{\pi}{3}$ isw	B1	
(ii)	[Area triangle ABC =] $\frac{1}{2}\times 10^2\times\sin\left(their\frac{\pi}{3}\right)$ oe	M1	seen or implied by $25\sqrt{3}$ or 43.3(0...)
	[Area 1 sector =] $\frac{1}{2}\times 5^2\times their\frac{\pi}{3}$ oe or $\pi\times 5^2\times\frac{their\,60°}{360}$	M1	seen or implied by $\frac{25\pi}{6}$ or 13.0(8...) or 13.09
	Complete correct plan	M1	e.g. *their* triangle – 3(*their* sector)
	4.03(1...) or $25\sqrt{3}-\frac{25\pi}{2}$ isw	A1	Units not required
5 (a)	$\frac{\sqrt{8}}{(\sqrt{7}-\sqrt{5})}\times\frac{(\sqrt{7}+\sqrt{5})}{(\sqrt{7}+\sqrt{5})}$ and attempt to multiply	M1	
	$\frac{\sqrt{56}+\sqrt{40}}{2}$ oe	A1	not from wrong working
	$\sqrt{14}+\sqrt{10}$	A1	
(b)	$q^2+4q\sqrt{3}+12$ soi	B1	
	$28=q^2+12$ oe	M1	can be implied by 4 and 16 or –4 and –16
	$q=$ 4, –4 $p=$ 16, –16	A1	all values
6 (i)	$4(x+1)^2-9$	B3,2,1,0	one mark for each of p, q, r correct in a correctly formatted expression; allow correct equivalent values; If **B0** then **SC2** for $4(x+1)-9$ or **SC1** for correct 3 values seen in incorrect format e.g. $4(x+1x)-9$ or $4(x^2+1)-9$ or for a correct completed square form of the original expression in a different but correct format. e.g. $2(\sqrt{2}x+\sqrt{2})^2-9$

Question	Answer	Marks	Guidance
(ii)	$(-1, 9)$	B2FT	**B1FT** $(-q, -r)$ $r < 0$ for each correct coordinate
(iii)		B1	Correct symmetric W shape with cusps on x-axis
		B1	y-intercept marked at 5 only or coords indicated on graph
		B1	x-intercepts marked at –2.5 and 0.5 only x-axis or coords indicated on graph or close by
7 (i) (a)	$\mathbf{q} - \mathbf{p}$	B1	
(b)	$2\mathbf{q} - 2\mathbf{p}$ or $2(\mathbf{q} - \mathbf{p})$	B1	
(ii)	The points are collinear oe	B1	
	$\overrightarrow{PQ}$ is a (scalar) multiple of $\overrightarrow{QR}$ **and** they have a point in common. oe	B1	Condone $\overrightarrow{PQ}$ is parallel to $\overrightarrow{QR}$ **and** …
(iii)	[$\overrightarrow{OR}$ =] $4\mathbf{i} - 3\mathbf{j}$ oe soi	B1	
	$\sqrt{4^2 + (-3)^2}$ (=5)	M1	condone $\sqrt{4^2 + 3^2}$; may be implied by correct answer or correct FT answer
	$\frac{1}{5}(4\mathbf{i} - 3\mathbf{j})$ oe	A1	
8 (a) (i)	$a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$ final answer	B2,1,0	−1 each error/omission
(ii)	$6(2x)^2\left(\frac{1}{5x}\right)^2$ soi	M1	Could be in full expansion
	$\frac{24}{25}$ or 0.96 isw	A1	Must be explicitly identified
(b)	$\frac{1}{8}\left(\frac{n(n-1)(n-2)}{6}\right) = \frac{5n}{12}$ soi leading to a cubic or quadratic ($n^2 - 3n - 18 = 0$)	M1	Must attempt to expand and remove fractions
	Solves *their* quadratic [$(n - 6)(n + 3)$]	M1	must have come from a valid attempt
	[n =] 6 only, not from wrong working	A1	Must be n if labelled

Question	Answer	Marks	Guidance
9 **(a)**	$a = 2 \quad b = 4 \quad c = -2$	**B3**	**B1** for each correct value
(b) **(i)**		**B3,2,1,0**	sinusoidal curve symmetrical about y-axis clear intent to have amplitude of 2 2 cycles If not fully correct max **B2**
(ii)	$-\frac{\pi}{2}, -\frac{\pi}{6}, \frac{\pi}{6}, \frac{\pi}{2}, -\frac{\pi}{3}, \frac{\pi}{3}$ cao	**B2**	**B1** for any 4 correct
10 **(a)** **(i)**	$2 \times 4!$ or $\frac{2}{5} \times 5!$ oe	**M1**	
	48	**A1**	
(ii)	${}^5P_3$ or $\frac{5!}{2!}$ or $5 \times 4 \times 3$ oe	**M1**	
	60	**A1**	
(b) **(i)**	$4 \times 2[!] \times 3$oe	**M1**	Correct first step implied by a correct product of two elements
	24	**A1**	
(ii)	$3!$ or 3×3 seen	**M1**	
	18	**A1**	
11 **(i)**	$\frac{3x^2}{2} - \frac{2x^{5/2}}{5} (+c)$ isw	**B1+B1**	
(ii)	(9, 0) oe	**B1**	Not just $x = 9$
(iii)	Substitute (3, 9) into **both** lines Or solves simultaneously ($6x = 27 - 3x$ oe) to get $x = 3, y = 9$	**B1**	$3 \times 3 = 9$ **and** $\frac{27 - 3 \times 3}{2} = 9$

Question	Answer	Marks	Guidance
(iv)	[Area AOB =] $\frac{1}{2}\times 9\times 9$ oe ($\frac{81}{2}$ or 40.5)	M1	Uses *their* (ii). May split into 2 triangles (13.5 and 27). May integrate. Must be a complete method.
	their $\left[\frac{3(9)^2}{2}-\frac{2(9)^{5/2}}{5}\right]-[0]$ (= 24.3)	M1	lower limit may be omitted but must be correct if seen
	their $\frac{81}{2}$ − *their* $\frac{243}{10}$	M1	must be from genuine attempts at area of triangle and area under curve
	16.2	A1	
12 (i)	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\frac{2(x-1)-(2x-5)}{(x-1)^2}$	M1A1	Allow slips in $\frac{\mathrm{d}u}{\mathrm{d}x}$ and $\frac{\mathrm{d}v}{\mathrm{d}x}$ but must be explicit. Allow $(x-1)^2=x^2-2x+1$
	– 12 isw	B1	
	ALT using $y=\frac{-12x^2+14x-5}{x-1}$		
	$-24x+14$	B1	
	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\frac{(x-1)(-24x+14)-(-12x^2+14x-5)}{(x-1)^2}$	M1	
		A1FT	**FT** on their derivative of 3 term quadratic
(ii)	$\left[\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\right]k(x-1)^{-3}$	M1	No additional terms
	$k=-6$ isw	A1	

Question	Answer	Marks	Guidance
(iii)	*their* $\left[\frac{3}{(x-1)^2}-12\right]=0$ and find a value for x	**M1**	$12x^2-24x+9=0$ oe $(2x-3)(2x-1)=0$ oe
	$x = 0.5$ and $x = 1.5$	**A1**	
	$y = 2$ and $y = -22$	**A1**	if **A0 A0** then **A1** for a correct (x, y) pair
	$\frac{-6}{(-0.5)^3} > 0$ therefore min when $x = 0.5$ oe	**B1**	or $\left[\frac{-6}{(-0.5)^3}=\right]48$ therefore min when $x = 0.5$ oe
	$\frac{-6}{(0.5)^3} < 0$ therefore max when $x = 1.5$ oe	**B1**	or $\left[\frac{-6}{(0.5)^3}=\right]-48$ therefore max when $x = 1.5$ oe **M1A1** is possible from other methods

Cambridge International Examinations
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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **May/June 2016**

MARK SCHEME

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soi	seen or implied
www	without wrong working

Question	Answer	Marks	Guidance
1 (i)	$(2k)^2 - 4(1)(4k-3)$ [< 0] Correct completion to given inequality $k^2 - 4k + 3 < 0$ isw	M1 A1	clear attempt at $b^2 - 4ac$
(ii)	Critical values 1 and 3 soi $1 < k < 3$ as final answer	M1 A1	May be implied by incorrect inequalities
2 (i)	Clear attempt at quotient rule or equivalent product rule $\left[\frac{\mathrm{d}y}{\mathrm{d}x} =\right] \frac{14}{(3-x)^2}$ or $\left[\frac{\mathrm{d}y}{\mathrm{d}x} =\right] \frac{14}{x^2 - 6x + 9}$ cao or correct simplified equivalent	M1 A1	condone omission of brackets allow recovery from bracketing errors or omissions if implied in correct work to the correct answer
(ii)	$[y = 9]\ x = 2$ $\frac{0.07}{\delta x} \approx \left(their \left. \frac{\mathrm{d}y}{\mathrm{d}x} \right\|_{x=2} \right)$ oe 0.005 oe	B1 M1 A1	 condone $\frac{0.07}{\delta x} = \left(their \left. \frac{\mathrm{d}y}{\mathrm{d}x} \right\|_{x=2} \right)$ not from wrong working; answer only does not score
3	Any one of: $\left[{}^6C_0 \times\right] {}^7C_3 + {}^6C_1 \times {}^7C_2$ or 35 + 126 or ${}^{13}C_3 - {}^6C_2 \times {}^7C_1 - {}^6C_3$ or 286 – 105 – 20 161	M2 A1	**M1** for $\left[{}^6C_0 \times\right] {}^7C_3$ or ${}^6C_1 \times {}^7C_2$ or ${}^{13}C_3 - {}^6C_2 \times {}^7C_1$ or ${}^{13}C_3 - {}^6C_3$ or ${}^6C_2 \times {}^7C_1 + {}^6C_3$ or for the numerical equivalent of one of these calculations If **M0** then **B3** for answer only of 161

Question	Answer	Marks	Guidance
4 (i)	$2(2)^3 - 3(2)^2 + 2q + 56 = 0$ with one correct interim step leading to $q = -30$	**B1**	allow for only 16 – 12 + 2q + 56 = 0 $q = -30$ NB = 0 must be seen or may be implied by e.g. $-60 = 2q$ or $60 = -2q$; or convincingly showing $2(2)^3 - 3(2)^2 - 30(2) + 56 = 0$; allow for only 16 – 12 + 2(–30) + 56 = 0 or correct synthetic division at least as far as $\begin{array}{c\|cccc} 2 & 2 & -3 & q & 56 \\ & & 4 & 2 & 2q+4 \\ \hline & 2 & 1 & q+2 & 0 \end{array}$ then $q = -30$
(ii)	$2x^2 + x - 28$ $(x-2)(2x-7)(x+4)$	**B2** **M1**	**B1** for any two terms correct For factorising the correct equation; condone = 0; condone $(2x-7)(x+4)$ only for **M1** but for **A1 must see** all 3 factors in this part; do not allow $\left(x - \frac{7}{2}\right)$
	$x = 2$, $x = -4$, $x = 3.5$ oe	**A1**	not from wrong working; answers only do not score
5 (i)	(2, 8)	**B1, B1**	
(ii)	$\frac{their 8 - 0}{their 2 - p} = -2$ or better	**M1**	Condone $\frac{their 8 - 0}{their 2 - p} = \frac{-1}{their \text{ gradient } AB}$ oe
	[p =] 6	**A1**	

Question	Answer	Marks	Guidance
(iii)	$[MB=]\sqrt{(6-their2)^2+(10-their8)^2}$ soi or $\left[\frac{1}{2}AB=\right]\frac{1}{2}\sqrt{(6--2)^2+(10-6)^2}$ soi or $[MC=]\sqrt{(their2-their\ p)^2+(their8-0)^2}$ soi or $\tan[...]=\frac{8}{4}$ soi or $4.47^2=8.94^2+10^2-2(8.94)(10)\cos[...]$ or $8.94^2=10^2+10^2-2(10)(10)\cos[...]$	M1	implied by $[MB=]\sqrt{20}$ or $\left[\frac{1}{2}AB=\right]\frac{1}{2}\sqrt{80}$ e.g. 4.47, or $[MC=]\sqrt{80}$ or e.g. 8.94 or 63.4° or equivalents
	$\sin^{-1}\left(\frac{\sqrt{20}}{10}\right)$ oe soi	M1	or $\cos^{-1}\left(\frac{\sqrt{80}}{10}\right)$ or $\tan^{-1}\left(\frac{\sqrt{20}}{\sqrt{80}}\right)$ or $\tan^{-1}\left(\frac{4}{8}\right)$ or $90-\tan^{-1}\left(\frac{8}{4}\right)$ or equivalent complete correct method; implies first **M1**
	26.56 to 26.6° or 0.4636 to 0.464 rads cao	A1	Not from wrong working
6 (i)	Valid explanation	B1	e.g. arc length is greater than the radius or 7 is greater than 5
(ii)	$7=5\theta$	M1	
	$\theta=1.4$ oe	A1	implies **M1**
(iii)	$\frac{1}{2}\times5^2\times their1.4$ oe	M1	
	17.5oe	A1	

Question	Answer	Marks	Guidance
(iv)	[triangle area =] $\frac{1}{2} \times 5^2 \times \sin their 1.4$ or 12.3 to 12.32 or for [$\frac{1}{2}$ × base × height=] $\frac{1}{2} \times 6.4[4...] \times 3.8[2...]$ oe	M1	may be embedded in a difference calculation
	5.18 to 5.2 inclusive	A1	implies **M1**
7 (i)	$\begin{pmatrix} 12 & 15 \\ 9 & 6 \end{pmatrix} + \begin{pmatrix} 4 & 2 \\ 1 & 3 \end{pmatrix}$ soi	M1	if no method shown, may be implied by their answer with at least 2 correct elements
	$\begin{pmatrix} 16 & 17 \\ 10 & 9 \end{pmatrix}$	A1	
(ii)	det**A** = 4 × 2 – 3 × 5 = –7 or det**B** = 4 × 3 – 2 × 1= 10	B1	allow for e.g. (4 × 2 – 3 × 5) × (4 × 3 – 2 × 1) = –70 or det**A** = 8 – 15 = –7 or det**B** = 12 – 2= 10
	AB = $\begin{pmatrix} 21 & 23 \\ 14 & 12 \end{pmatrix}$	B2	or **B1** for two elements correct
	det(**AB**) = 21 × 12 – 23 × 14 = –70	B1	allow for det(**AB**) = 252 – 322 = –70 For full marks must conclude that det**AB** = det**A** × det**B** or show the product –7 × 10 = –70 otherwise max 3 marks
(iii)	$\frac{1}{their \det \mathbf{AB}} \times their \begin{pmatrix} 12 & -23 \\ -14 & 21 \end{pmatrix}$ isw	B2	correct or correct **FT**; **FT** *their* **AB** and *their non-zero* det **AB**; *their* **AB** must be an attempt at a matrix product e.g. $\begin{pmatrix} 16 & 10 \\ 3 & 6 \end{pmatrix}$ **B1** for $\frac{1}{their \det \mathbf{AB}} \times their \begin{pmatrix} & \\ & \end{pmatrix}$ or for $k \times their \begin{pmatrix} 12 & -23 \\ -14 & 21 \end{pmatrix}$

Question	Answer	Marks	Guidance
8	Eliminates y e.g. $4+\frac{5}{15x+10}+\frac{3}{x}=0$ or eliminates x e.g. $4+\frac{5}{y}+\frac{3}{(y-10)/15}=0$	M1	allow even after incorrect rearrangement of the equation of the curve (dependent on resulting equation still in terms of x and y); condone substitution of e.g. $\frac{y+10}{15}$
	Rearrange to a 3-term quadratic	M1	condone sign slips/arithmetic slips
	$60x^2+90x+30=0$ oe or $4y^2+10y-50=0$ oe	A1	
	Factorise or solve 3-term quadratic	M1	
	$x=-\frac{1}{2}$, $x=-1$ isw	A1	or $y=2\frac{1}{2}$, $y=-5$
	$y=2\frac{1}{2}$, $y=-5$ isw	A1	or $x=-\frac{1}{2}$, $x=-1$
			If final A marks not awarded then **A1** for a correct x, y pair
9 (a)	$\frac{x^2}{2}+x-\frac{1}{x}(+c)$ isw	B3	**B1** for each term allow $\frac{x^2}{2}+x+\frac{x^{-1}}{-1}(+c)$ isw for **B3**
(b) (i)	$k\cos(5x+\pi)$ where $k<0$ or $\frac{\cos(5x+\pi)}{5}$	M1	
	$\frac{-\cos(5x+\pi)}{5}(+c)$	A1	
(ii)	$\frac{-\cos(5(0)+\pi)}{5}-\frac{-\cos(5(-\pi/5)+\pi)}{5}$ or $\frac{-\cos(\pi)}{5}-\left(\frac{-\cos(0)}{5}\right)$	M1	correct substitution of the given limits into *their* expression of the form $k\cos(5x+\pi)$, dep on **M1** in (b)(i)
	0.4 oe	A1	answer only does not score
10 (a)	$2=p-q$ and $14=4p-2q$ oe	M1	
	$p=5$	A1	
	$q=3$	A1	
(b)	Factorise $10^{2x}-2(10^x)-24\,[=0]$ or factorise $u^2-2u-24\,[=0]$	M1	or applies the formula or completes the square
	$10^x=6$	A1	ignore $10^x=-4$ for this mark
	$x=\lg 6$ cao as final answer	A1	or exact equivalent

Question	Answer	Marks	Guidance
(c)	$\frac{x+1}{x}=2^3$ oe www	M2	combines logs and anti-logs or **B1** for one correct log move e.g. $\log_2\left(\frac{x+1}{x}\right)=3$ or $\log_2(x+1)-\log_2(x)=\log_2 8$ or $\log_2(x+1)-\log_2(x)=3\log_2 2$
	$x=\frac{1}{7}$ or 0.143 or 0.1428 to 0.1429	A1	
11 (a)	Valid method	M1	Completing the square as far as e.g. constant $-\left(x-\frac{1}{2}\right)^2$ or calculus as far as $1-2x=0$ or finding roots $x=0$ and $x=1$and using symmetry soi
	when $x=\frac{1}{2}$	A1	Implies **M1** if not clearly from wrong working
	[greatest value =] $\frac{1}{4}$	B1	
(b)	Valid comment e.g. when $x \geq 1$, f ′ is always decreasing	B1	Allow e.g. a sketch with a comment such as the curve is one-one [when $x \geq 1$] or e.g. the curve is one-one when $x>\frac{1}{2}$
(c) (i)	$k(10)=8$ or $5+\sqrt{10-1}=8$ or stating h(8)	M1	or $[hk(x)=]\ \lg(7+\sqrt{x-1})$
	$h(8)=1$ or $\lg(8+2)=1$ cao	A1	$[hk(10)=]\ \lg(7+\sqrt{10-1})=1$
(ii)	$(y-5)^2=x-1$	M1	or $(x-5)^2=y-1$
	$k^{-1}(x)=(x-5)^2+1$ isw or $k^{-1}(x)=x^2-10x+26$ isw	A1	
	$5<x<15$	B1, B1	**B1**for $5<x$ oe and **B1**for $x<15$ oe allow (5, 15); one mark for each limit of the interval; if **B0** then **SC1** for $5 \leqslant x \leqslant 15$ or '5 to 15' or [5, 15] etc.
	$1<k^{-1}(x)<101$	B1	allow (1, 101)

Question	Answer	Marks	Guidance
12 (i)	$8(1-\cos^2 A)+2\cos A=7$ or better	**B1**	
	Solves or factorises *their* 3-term quadratic in cos*A*	**M1**	
	60, 104.477... rounded or truncated to 1 dp or more;	**A2**	with no extras in range; not from clearly wrong working but allow recovery from minor slips or **A1** for either, ignoring extras
(ii)	$\sin(3B+1)=0.4$ soi	**B1**	may be implied by $\frac{1}{\sin(3B+1)}=2.5$
	[3*B* + 1 =] 0.41 or better	**M1**	implies **B1**
	0.577, 1.9[0], 2.67 or 0.57669..., 1.89823... , 2.67108... rounded or truncated to 4 or more sf	**A2**	with no extras in range; or **A1** for any one correct ignoring extras If **M0** then **B2** for all 3 correct angles found or **B1** for 1 or 2 correct angles found

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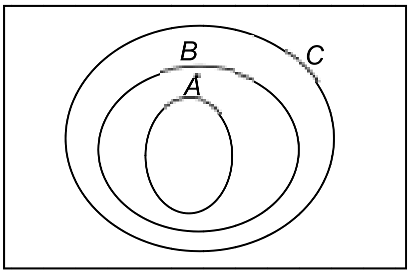
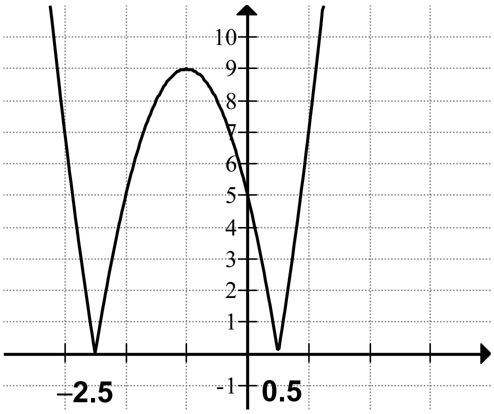
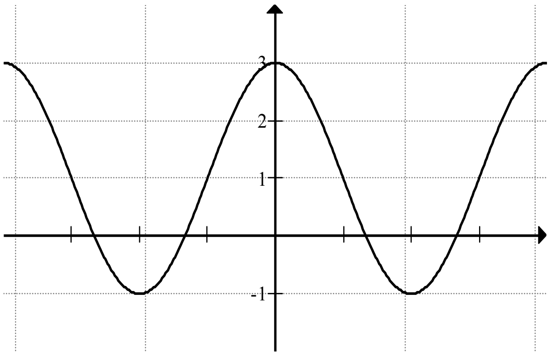
	critical values –3 and 5	A1	not from wrong working
	$x < -3 \quad x > 5$	A1	mark final inequality; **A0** if spurious attempt to combine e.g. $5 < x < -3$
2 (a)		B1	It must be clear how the sets are nested
(b) (i)	$h \in P$	B1	Allow $\{m,a,t,h,s\}$ for P
(ii)	$n(P \cap Q) = 2$ cao	B1	
(iii)	{ t, h, s}	B1	
3 (i)	–2	B1	
(ii)	$-n$	B1	
(iii)	$\frac{\lg 5}{\log_5 10} = [(\lg y)^2]$ or $\frac{\lg 20 - \lg 4}{1/\lg 5} = [(\lg y)^2]$	M1	One log law used correctly
	correct completion to $(\lg 5)^2$ isw	A1	answer only does not score
(iv)	$[\log_r]6x^2 = [\log_r]600$	B1	Condone base missing
	$x = 10$ only	B1	

Question	Answer	Marks	Guidance
4 (i)	$\frac{\pi}{3}$ isw	B1	
(ii)	[Area triangle ABC =] $\frac{1}{2}\times 10^2 \times \sin\left(their\frac{\pi}{3}\right)$ oe	M1	seen or implied by $25\sqrt{3}$ or 43.3(0...)
	[Area 1 sector =] $\frac{1}{2}\times 5^2 \times their\frac{\pi}{3}$ oe or $\pi \times 5^2 \times \frac{their\,60°}{360}$	M1	seen or implied by $\frac{25\pi}{6}$ or 13.0(8...) or 13.09
	Complete correct plan	M1	e.g. *their* triangle – 3(*their* sector)
	4.03(1...) or $25\sqrt{3}-\frac{25\pi}{2}$ isw	A1	Units not required
5 (a)	$\frac{\sqrt{8}}{\left(\sqrt{7}-\sqrt{5}\right)}\times\frac{\left(\sqrt{7}+\sqrt{5}\right)}{\left(\sqrt{7}+\sqrt{5}\right)}$ and attempt to multiply	M1	
	$\frac{\sqrt{56}+\sqrt{40}}{2}$ oe	A1	not from wrong working
	$\sqrt{14}+\sqrt{10}$	A1	
(b)	$q^2+4q\sqrt{3}+12$ soi	B1	
	$28=q^2+12$ oe	M1	can be implied by 4 and 16 or –4 and –16
	$q=$ 4, –4 $p=$ 16, –16	A1	all values
6 (i)	$4\left(x+1\right)^2-9$	B3,2,1,0	one mark for each of p, q, r correct in a correctly formatted expression; allow correct equivalent values; If **B0** then **SC2** for $4\left(x+1\right)-9$ or **SC1** for correct 3 values seen in incorrect format e.g. $4\left(x+1x\right)-9$ or $4\left(x^2+1\right)-9$ or for a correct completed square form of the original expression in a different but correct format. e.g. $2\left(\sqrt{2}x+\sqrt{2}\right)^2-9$

Question	Answer	Marks	Guidance
(ii)	$(-1, 9)$	B2FT	**B1FT** $(-q, -r)$ $r < 0$ for each correct coordinate
(iii)		B1 B1 B1	Correct symmetric W shape with cusps on *x*-axis *y*-intercept marked at 5 only or coords indicated on graph *x*-intercepts marked at –2.5 and 0.5 only *x*-axis or coords indicated on graph or close by
7 (i) (a)	$\mathbf{q} - \mathbf{p}$	B1	
(b)	$2\mathbf{q} - 2\mathbf{p}$ or $2(\mathbf{q} - \mathbf{p})$	B1	
(ii)	The points are collinear oe	B1	
	$\overrightarrow{PQ}$ is a (scalar) multiple of $\overrightarrow{QR}$ **and** they have a point in common. oe	B1	Condone $\overrightarrow{PQ}$ is parallel to $\overrightarrow{QR}$ **and** …
(iii)	[$\overrightarrow{OR}$ =] $4\mathbf{i} - 3\mathbf{j}$ oe soi	B1	
	$\sqrt{4^2 + (-3)^2}$ (=5)	M1	condone $\sqrt{4^2 + 3^2}$; may be implied by correct answer or correct FT answer
	$\frac{1}{5}(4\mathbf{i} - 3\mathbf{j})$ oe	A1	
8 (a) (i)	$a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$ final answer	B2,1,0	−1 each error/omission
(ii)	$6(2x)^2\left(\frac{1}{5x}\right)^2$ soi	M1	Could be in full expansion
	$\frac{24}{25}$ or 0.96 isw	A1	Must be explicitly identified
(b)	$\frac{1}{8}\left(\frac{n(n-1)(n-2)}{6}\right) = \frac{5n}{12}$ soi leading to a cubic or quadratic ($n^2 - 3n - 18 = 0$)	M1	Must attempt to expand and remove fractions
	Solves *their* quadratic $[(n-6)(n+3)]$	M1	must have come from a valid attempt
	[n =] 6 only, not from wrong working	A1	Must be *n* if labelled

Question	Answer	Marks	Guidance
9 (a)	$a = 2 \quad b = 4 \quad c = -2$	B3	**B1** for each correct value
(b) (i)		B3,2,1,0	sinusoidal curve symmetrical about y-axis clear intent to have amplitude of 2 2 cycles If not fully correct max **B2**
(ii)	$-\frac{\pi}{2}, -\frac{\pi}{6}, \frac{\pi}{6}, \frac{\pi}{2}, -\frac{\pi}{3}, \frac{\pi}{3}$ cao	B2	**B1** for any 4 correct
10 (a) (i)	$2 \times 4!$ or $\frac{2}{5} \times 5!$ oe	M1	
	48	A1	
(ii)	${}^5P_3$ or $\frac{5!}{2!}$ or $5 \times 4 \times 3$ oe	M1	
	60	A1	
(b) (i)	$4 \times 2[!] \times 3$oe	M1	Correct first step implied by a correct product of two elements
	24	A1	
(ii)	$3!$ or 3×3 seen	M1	
	18	A1	
11 (i)	$\frac{3x^2}{2} - \frac{2x^{5/2}}{5} (+c)$ isw	B1+B1	
(ii)	(9, 0) oe	B1	Not just $x = 9$
(iii)	Substitute (3, 9) into **both** lines Or solves simultaneously ($6x = 27 - 3x$ oe) to get $x = 3$, $y = 9$	B1	$3 \times 3 = 9$ **and** $\frac{27 - 3 \times 3}{2} = 9$

Question	Answer	Marks	Guidance
(iv)	$\left[\text{Area } AOB =\right] \frac{1}{2}\times 9\times 9$ oe ($\frac{81}{2}$ or 40.5)	M1	Uses *their* (ii). May split into 2 triangles (13.5 and 27). May integrate. Must be a complete method.
	$their\left[\frac{3(9)^2}{2}-\frac{2(9)^{5/2}}{5}\right]-[0]$ (= 24.3)	M1	lower limit may be omitted but must be correct if seen
	$their\frac{81}{2}-their\frac{243}{10}$	M1	must be from genuine attempts at area of triangle and area under curve
	16.2	A1	
12 (i)	$\left[\frac{dy}{dx}=\right]\frac{2(x-1)-(2x-5)}{(x-1)^2}$	M1A1	Allow slips in $\frac{du}{dx}$ and $\frac{dv}{dx}$ but must be explicit. Allow $(x-1)^2 = x^2-2x+1$
	– 12 isw	B1	
	ALT using $y=\frac{-12x^2+14x-5}{x-1}$		
	$-24x + 14$	B1	
	$\left[\frac{dy}{dx}=\right]\frac{(x-1)(-24x+14)-(-12x^2+14x-5)}{(x-1)^2}$	M1	
		A1FT	**FT** on their derivative of 3 term quadratic
(ii)	$\left[\frac{d^2y}{dx^2}=\right]k(x-1)^{-3}$	M1	No additional terms
	$k = -6$ isw	A1	

Question	Answer	Marks	Guidance
(iii)	*their* $\left[\frac{3}{(x-1)^2}-12\right]=0$ and find a value for x	**M1**	$12x^2-24x+9=0$ oe $(2x-3)(2x-1)=0$ oe
	$x = 0.5$ and $x = 1.5$	**A1**	
	$y = 2$ and $y = -22$	**A1**	if **A0 A0** then **A1** for a correct (x, y) pair
	$\frac{-6}{(-0.5)^3}>0$ therefore min when $x = 0.5$ oe	**B1**	or $\left[\frac{-6}{(-0.5)^3}=\right]48$ therefore min when $x = 0.5$ oe
	$\frac{-6}{(0.5)^3}<0$ therefore max when $x = 1.5$ oe	**B1**	or $\left[\frac{-6}{(0.5)^3}=\right]-48$ therefore max when $x = 1.5$ oe **M1A1** is possible from other methods

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the March 2016 series

0606 ADDITIONAL MATHEMATICS

0606/22 Paper 22, maximum raw mark 80

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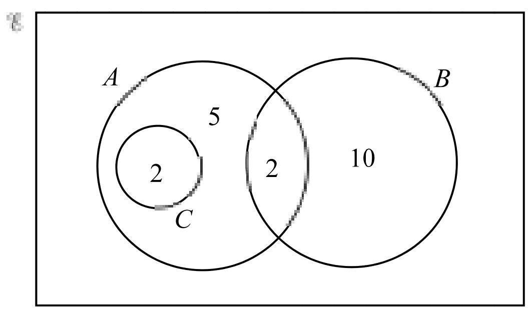
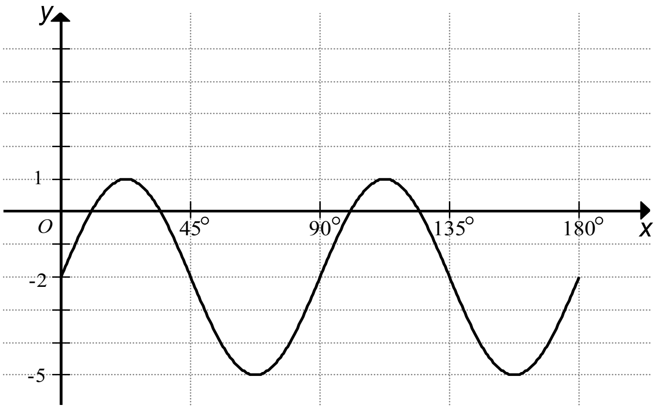
Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
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	Guidance
1 (i)	$\frac{\mathrm{d}y}{\mathrm{d}x} = k(x-9)^{-\frac{3}{2}}$	**M1**	If M0 then **SC1** for the correct answer with an extra term.
	$k = -\frac{5}{2}$ isw	**A1**	condone $5 \times -\frac{1}{2}$
(ii)	$\delta y = their\left(\frac{\mathrm{d}y}{\mathrm{d}x}\Big\vert_{x=13}\right) \times h$	**M1**	
	$-0.3125h$ oe	**A1**	
2		**B3,2,1,0**	**B2** for *C* as a proper subset of *A* *A* and *B* with an intersection *B* and *C* mutually exclusive Or **B1** for any two of the these and **B1** for the number of elements correctly placed
	5	**B1FT**	**FT** *their* 5
3	Integrates $9x^2 - 3x^{-2}$	**M1**	condone one rearrangement error
	$(y=)\frac{9x^3}{3} - \frac{3x^{-1}}{-1}(+c)$	**A1**	
	Substitute $x = 1$ and $y = 7$ into *their* expression with 'c'	**M1**	*their* expression must be from an attempt to integrate
	$y = 3x^3 + 3x^{-1} + 1$ oe isw	**A1**	condone $y = 3x^3 + 3x^{-1} + c$ and $c = 1$ seen, isw

Question	Answer	Marks	Guidance
4 (a)	$a = 10$ $b = 6$ $c = 4$ or $10\cos 6x + 4$	B2,1,0	for **B1** allow correct FT of c from a e.g. *their* c = 14 – *their* a
(b)		B3,2,1,0	Correct shape; two cycles; both maximum at 1 and minimum at –5; starting at (0, –2) and ending at (180, –2)
5 (i)	$2187 + 5103kx + 5103k^2x^2$	B3	**1** for each term; ignore extra terms
(ii)	$2(5103k) = 5103k^2$	M1	must not include x, x^2
	$k = 2$	A1	**A0** if $k = 0$ also given as a solution
6	$\frac{x}{1+3\sqrt{3}} = \frac{5-\sqrt{3}}{6+2\sqrt{3}}$ oe soi	M1	
	$(x =)\frac{-4+14\sqrt{3}}{6+2\sqrt{3}}$ oe	M1	
	$(x =)\frac{-4+14\sqrt{3}}{6+2\sqrt{3}} \times \frac{6-2\sqrt{3}}{6-2\sqrt{3}}$	M1	
	$p = -27$, $q = 23$ isw	A1 + A1	allow $(x =)\frac{-27+23\sqrt{3}}{6}$

Question	Answer	Marks	Guidance
7 (a)	$\begin{pmatrix} 4 & 6 & 8 \\ -2 & 0 & 4 \end{pmatrix} - \begin{pmatrix} 18 & 3 & 6 \\ 21 & -6 & 3 \end{pmatrix}$	M1	for attempt to multiply and subtract
	$\begin{pmatrix} -14 & 3 & 2 \\ -23 & 6 & 1 \end{pmatrix}$	A1	
(b) (i)	$-\frac{1}{2}\begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix}$ oe	B1 + B1	**1** mark for $-\frac{1}{2}\begin{pmatrix} & \\ & \end{pmatrix}$ and **1** mark for $k\begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix}$
(ii)	Valid method	M1	$\mathbf{XD}^{-1}\mathbf{D} = \mathbf{CD}$
	$\begin{pmatrix} -8 & -6 \\ 13 & 7 \end{pmatrix}$	A2,1,0	**–1** each error If M0 then **SC1** for $\mathbf{DC} = \begin{pmatrix} 4 & 3 \\ -14 & -5 \end{pmatrix}$
8 (i)	Eliminate x (or y)	M1	$3(2y-2)^2 + (2y-2)y - y^2 = 12$ $3x^2 + x\left(\frac{x+2}{2}\right) - \left(\frac{x+2}{2}\right)^2 = 12$
	$13y^2 - 26y = 0$ or $\frac{13}{4}x^2 - 13 = 0$ oe	A1	
	$13y(y-2)$ or $x^2 = 4$	M1	
	$x = -2$, $x = 2$ $y = 0$ $y = 2$ isw	A1 + A1FT	or for (–2, 0) or (2, 2) from correct working **FT** *their* x or y values to find *their* y or x values; or **A1** for (–2, 0) and (2, 2)
(ii)	*their* $m_{AB} = \frac{1}{2}$ or *their* $m_{BC} = -2$ soi	M1	may be unsimplified or Pythagoras' theorem correctly applied to *their* (0, –2), *their* (2, 2) and (0, 6)
	use of $(m_{AB}) \times (m_{BC}) = -1$ and conclusion	A1	or use of $h^2 = a^2 + b^2$ and conclusion

Question	Answer	Marks	Guidance
9 (i)	$RT = \frac{1}{\tan\theta}$	B1	or $RT = \cot\theta$
	$RS = \frac{1}{\sin\theta}$	B1	or $RS = \text{cosec}\,\theta$
	$x = 1 - \frac{1}{2\tan\theta} - \frac{1}{2\sin\theta}$ oe or $x = 1 - \frac{\cot\theta}{2} - \frac{\text{cosec}\,\theta}{2}$ oe	B1FT	**FT** *their RT* and *their RS*, provided both are functions of trig ratios
(ii)	$A = x + \frac{1}{2}\cot\theta$ oe soi	M1	
	correct completion to given answer $A = 1 - \frac{\text{cosec}\,\theta}{2}$	A1	
(iii)	$\text{cosec}\,\theta = \frac{2\sqrt{3}}{3}$ oe	M1	equivalent must be exact
	$\theta = \frac{\pi}{3}$ cao	A1	implies **M1**
10 (a) (i)	$(\alpha + \beta)\mathbf{i} - 20\mathbf{j} = 15\mathbf{i} + (2\alpha - 24)\mathbf{j}$	M1	implied by $\alpha + \beta = 15$ or $2\alpha - 24 = -20$
	$\alpha = 2$	A1	
	$\beta = 13$	A1	
(ii)	$\sqrt{(their\alpha + their\beta)^2 + (-20)^2}$ oe	M1	
	$\frac{15\mathbf{i} - 20\mathbf{j}}{25}$ oe	A1FT	**FT** *their* $\alpha + \beta$ provided non-zero
(b)	$\overrightarrow{OC} = \overrightarrow{OA} + \lambda\overrightarrow{AB}$ or $\overrightarrow{OC} = OB + (1-\lambda)\overrightarrow{BA}$	B1	
	$[\overrightarrow{OC} =]$ $\mathbf{a} + \lambda(\mathbf{b} - \mathbf{a})$ or $[\overrightarrow{OC} =]$ $\mathbf{b} + (1 - \lambda)(\mathbf{a} - \mathbf{b})$	M1	
	$[\overrightarrow{OC} =]$ $(1 - \lambda)\mathbf{a} + \lambda\,\mathbf{b}$	A1	
(c)	$\frac{2}{\mu + 3} = \frac{\mu}{9}$	M1	or multiplies one of the vectors by a general scale factor and finds a pair of simultaneous equations to solve
	Solves $\mu^2 + 3\mu - 18 = 0$	M1	or solves *their* correct equation to find *their* scale factor and attempts to use it to find μ
	$\mu = 3$	A1	A0 if -6 not discarded

Question	Answer	Marks	Guidance
11 (i)	$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{(x^2+1)(1)-(x)(2x)}{(x^2+1)^2}$ oe	M1*	Attempts to differentiate using the quotient rule
		A1	correct; allow unsimplified
	$their(1-x^2)=0$	M1 dep*	
	$x = 1, x = -1$	A1	from correct working only
	$y = 0.5$, $y = -0.5$ oe	A1	from correct working only or **A1** for each of (1, 0.5), (−1, −0.5) oe from correct working; unsupported answers do not score
(ii)	$\frac{\mathrm{d}}{\mathrm{d}x}\left((x^2+1)^2\right)=2(x^2+1)(2x)$ soi	B1	$\frac{\mathrm{d}}{\mathrm{d}x}(x^4+2x^2+1)=4x^3+4x$
	$\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=(x^2+1)\frac{(x^2+1)(their-2x)-(their(1-x^2))2(2x)}{(x^2+1)^4}$	M1	Applies quotient rule and factors out
	Correct completion to given answer $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\frac{2x^3-6x}{(x^2+1)^3}$	A1	
	When $x = 1$ $their\left.\frac{\mathrm{d}^2y}{\mathrm{d}x^2}\right\|_{x=1}=\frac{2(1)^3-6(1)}{(1^2+1)^3}$ oe < 0 therefore maximum	B1FT	Complete method including comparison to 0; **FT** *their* first or second derivative
	When $x = -1$ $their\left.\frac{\mathrm{d}^2y}{\mathrm{d}x^2}\right\|_{x=-1}=\frac{2(-1)^3-6(-1)}{((-1)^2+1)^3}$ oe > 0 therefore minimum	B1FT	Complete method including comparison to 0; **FT** *their* first or second derivative

Question	Answer	Marks	Guidance
12 (i)	$9t^2 - 63t + 90 = 0$ $(9t-18)(t-5)$	**M1**	
	showing that $t = 2$ is smaller value of t	**A1**	must see evidence of solving e.g. $t = 5$ and $t = 2$ or factors
(ii)	$(a =)\dfrac{\mathrm{d}v}{\mathrm{d}t}$ attempted	**M1**	
	18(3.5) – 63 = 0 cao	**A1**	
(iii)	$\int(9t^2 - 63t + 90)\,\mathrm{d}t$	**M1**	
	$(s =)\dfrac{9t^3}{3} - \dfrac{63t^2}{2} + 90t$ isw	**A2,1,0**	–1 for each error or for $+c$ left in
(iv) (a)	$(s =)\dfrac{9(2)^3}{3} - \dfrac{63(2)^2}{2} + 90(2)$	**M1**	or $\left[\dfrac{9t^3}{3} - \dfrac{63t^2}{2} + 90t\right]_0^2$ **FT** *their* **(iii)**
	78 [m]	**A1**	
(b)	$(s =)\dfrac{9(3)^3}{3} - \dfrac{63(3)^2}{2} + 90(3) = 67.5$	**M1**	**FT** *their* **(iii)**
	their 78 + 10.5 = 88.5 [m]	**A1FT**	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2015 series

0606 ADDITIONAL MATHEMATICS

0606/21 Paper 2, 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
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied
www without wrong working

1 (i)	$f(-2) = -32 - 16 + 30 + 18 = 0$	B1	All four evaluated terms must be seen. Allow if correct long division used
(ii)	$f(x) = (x+2)(4x^2 - 12x + 9)$	M1 A1	Coefficients 4 and 9 Coefficient –12
	$= (x+2)(2x-3)(2x-3)$	A1	All three factors together
	$f(x) = 0 \rightarrow x = -2,\ 1.5$ nfww	A1	Allow 1.5 mentioned just once
2 (i)	$(2-3x)^6 = 64 - 576x + 2160x^2$ isw	B1B1B1	
(ii)	$2160 - 2 \times 576 = 1008$	M1 A1	*their* final 2160 + 2 × *their* final –576
3 (i)	$\overrightarrow{AB} = \begin{pmatrix} -15 \\ 8 \end{pmatrix}$	B1	Allow $\overrightarrow{BA}$ May be implied by later work.
	$\lvert AB \rvert = \sqrt{15^2 + 8^2} \quad (=17)$ Speed $= 17 \times 3 = 51$ km/hr	M1 A1	Use of Pythagoras on *their AB* Must be exact
(ii)	$\overrightarrow{BC} = \begin{pmatrix} 16 \\ -30 \end{pmatrix}$	B1	Allow $\overrightarrow{CB}$
	$\lvert BC \rvert = \sqrt{16^2 + 30^2} \quad (=34)$	M1	Use of Pythagoras on *their BC*
	Time taken $= \frac{34}{51} \times 60 = 40$ mins (or $\frac{2}{3}$ hrs)	A1	Allow answers which round to 40 to 2sf. Accept 0.66 or 0.67 hrs. Mark final answer.

4 **(a)**	$2\mathbf{BA} = 2\begin{pmatrix} 1 & -2 & 4 \\ -2 & 3 & 0 \end{pmatrix}\begin{pmatrix} 2 & -1 \\ 3 & 5 \\ 7 & 4 \end{pmatrix}$ $= 2\begin{pmatrix} 24 & 5 \\ 5 & 17 \end{pmatrix} = \begin{pmatrix} 48 & 10 \\ 10 & 34 \end{pmatrix}$	B3,2,1,0	–1 each error in 2 × 2 result. Failure to multiply by 2 is one error
(b) **(i)**	$\mathbf{C}^{-1} = \frac{1}{8}\begin{pmatrix} 6 & -2 \\ 1 & 1 \end{pmatrix}$ isw	B1 B1	$\frac{1}{8}$ Matrix
(ii)	$\mathbf{I} - \mathbf{D} = \begin{pmatrix} -2 & 2 \\ -1 & -3 \end{pmatrix}$	B1	
	$\mathbf{X} = \mathbf{C}^{-1}(\mathbf{I} - \mathbf{D}) = \frac{1}{8}\begin{pmatrix} 6 & -2 \\ 1 & 1 \end{pmatrix}\begin{pmatrix} -2 & 2 \\ -1 & -3 \end{pmatrix}$	M1	Pre multiply *their* **I – D** with *their* $\mathbf{C}^{-1}$
	$= \frac{1}{8}\begin{pmatrix} -10 & 18 \\ -3 & -1 \end{pmatrix}$ isw	A1	
5 **(a)**	$2^{3(q-1)} \times 2^{2p+1} = 2^{14}$	B1	Correct powers of 2 allow unsimplified isw
	$3^{2(p-4)} \times 3^{q} = 3^{4}$	B1	Correct powers of 3 allow unsimplified isw
	Solve $3q + 2p = 16$ $q + 2p = 12$	M1	Attempt to solve *their* linear equations by eliminating one variable
	$p = 5, \quad q = 2$	A1	Both correct
(b)	$(3x-2)(x+1)$	M1	LHS oe isw
	$= 50$	A1	50 from correct processing of $2 - \lg 2$
	$3x^2 + x - 52 = 0 \rightarrow (3x+13)(x-4)$	M1	Solution of *their* three term quadratic Roots must be obtained from correct quadratic
	$x = 4$	A1	
	$x = -\frac{13}{3}$ discarded	A1	

6 (i)	$a=3, \quad b=2, \quad c=4$	B1B1B1	
(ii)	$\frac{dy}{dx}=8\cos 4x$ isw	M1 A1FT	$\pm k\cos cx$ and no other term in x $\quad c\neq 1$ $bc\times\cos cx$ and no other term
(iii)	$x=\frac{\pi}{2}\rightarrow\frac{dy}{dx}=8\cos 2\pi=8$	DM1	Find *their* correct numerical $\frac{dy}{dx}$
	Eqn: $\frac{y-3}{x-\frac{\pi}{2}}=-\frac{1}{8}$ $\quad\left(\rightarrow y=-\frac{1}{8}x+3.20\right)$	M1 A1	Find equation with *their* numerical normal gradient ie $\frac{-1}{\frac{dy}{dx}}$ and point $\left(\frac{\pi}{2},\ 3\right)$ All correct isw
7 (i)	$\frac{h}{8}=\frac{6-r}{6}\rightarrow h=\frac{4}{3}(6-r)$	M1 A1	Uses correct ratio. Cannot be implied
(ii)	$V=\pi r^2h=\pi r^2\times\frac{4}{3}(6-r)$ $=8\pi r^2-\frac{4}{3}\pi r^3$	B1	**AG** all steps must be seen Penalise missing brackets at any point in working
(iii)	$\frac{dV}{dr}=16\pi r-4\pi r^2$	M1 A1	Differentiate at least one power reduced by one
	$\frac{dV}{dr}=0\rightarrow r=4$	M1 A1	Attempt to solve – must get $r=\ldots$ Correct value of r. Ignore $r=0$
	$V=\frac{128}{3}\pi \quad (=42.7\pi)$	A1	Correct value of V. Condone 134.
	$\frac{d^2V}{dr^2}=16\pi-8\pi r<0$ when $r=4\rightarrow$ max	B1	$\frac{d^2V}{dr^2}$ must be correct and some indication of a negative value seen plus maximum stated

8 **(i)**	Gradient $AB = \frac{8-2}{9+3}$ $\left(= \frac{1}{2}\right)$ isw	B1	
	Equation AB and $x = 0 \rightarrow \frac{y-2}{0+3} = \frac{1}{2}$ $\left(\rightarrow y = \frac{1}{2}x + 3.5\right)$	M1	Find equation with *their* gradient and set $x = 0$
	$\rightarrow y = 3.5$	A1	
(ii)	D is (3, 5)	B1	
(iii)	Gradient perpendicular = –2	M1	Use of $m_1 \times m_2 = -1$ on gradient used for *their* line in **(i)**
	Equation perpendicular $\frac{y-5}{x-3} = -2$ $\rightarrow (y = -2x + 11)$	A1	
(iv)	E is (0, 11)	A1FT	
(v)	Area of $ABE = \frac{1}{2}\begin{vmatrix} -3 & 9 & 0 & -3 \\ 2 & 8 & 11 & 2 \end{vmatrix}$	M1	For area of ABE or ECD. $\frac{1}{2}$ and *their* correct 8 elements must be seen.
	$= \frac{1}{2}\lvert -24 + 99 - 18 + 33 \rvert = 45$	A1	45 condone from E (0, –4)
	Area of $EDC = \frac{1}{2}\begin{vmatrix} 3 & 0 & 0 & 3 \\ 5 & 3.5 & 11 & 5 \end{vmatrix}$		
	$= \frac{1}{2}\lvert -10.5 + 33 \rvert = 11.25$	A1	11.25 condone from E(0, –4)

9 **(i)**	$\tan 2x = -\frac{5}{4}$ $(2x = 128.7,\ 308.7)$	M1	For obtaining and using $\tan 2x = \pm\frac{5}{4}$ or $\pm\frac{4}{5}$ resulting in $2x =$
	$x = 64.3$ awrt	A1	$\tan x = \ldots$ gets M0
	154.3 awrt	A1FT	*their* $64.3° + 90°$
(ii)	$\text{cosec}^2 y + 3\text{cosec} y - 4 = 0$ or $4\sin^2 y - 3\sin y - 1 = 0$ $(\text{cosec} y + 4)(\text{cosec} y - 1) = 0$ or $(4\sin y + 1)(\sin y - 1) = 0$	B1	In any form as a three term quadratic.
	$\sin y = -\frac{1}{4}$ or $\sin y = 1$	M1	Solve three term quadratic in $\text{cosec}\, y$ or $\sin y$
	$y = 194.5,\ 345.5,\ 90$	A1A1A1	Answers must be obtained from the correct quadratic
(iii)	$z + \frac{\pi}{4} = \pi - \frac{\pi}{3}$ or	B1	Accept 2.09, 2.10, $\pi - 1.05$, $\pi - 1.04$ on RHS. Could be implied by final answer
	$z + \frac{\pi}{4} = \pi + \frac{\pi}{3}$	B1	Accept 4.19, 4.18, $\pi + 1.05$, $\pi + 1.04$ on RHS. Could be implied by final answer
	$z = \frac{5\pi}{12},\ \frac{13\pi}{12}$	B1B1	Answers must be correct multiples of π.
10 **(i)**	$s = \frac{1}{2}e^{2t} + 3e^{-2t} - t + (c)$	M1	Integrate : coefficient of $\frac{1}{2}$ or 3 seen with no change in powers of e. Ignore $-t$
	$t = 0,\ s = 0 \rightarrow c = -3.5$ $\left(s = \frac{1}{2}e^{2t} + 3e^{-2t} - t - 3.5\right)$	A1 A1	All correct and simplified
(ii)	$v = 0 \rightarrow u^2 - u - 6 = 0$ oe	M1	Obtain three term quadratic in u or e^{2t} Condone sign errors.
	$(u-3)(u+2) = 0$	DM1	Solve three term quadratic
	$\rightarrow u = 3 \rightarrow t = \frac{1}{2}\ln 3$ or 0.549	A1	Accept 0.55 No second answer
(iii)	$t = \frac{1}{2}\ln 3 \rightarrow a = 2e^{2t} + 12e^{-2t}$	B1	Correct differentiation
	$= 6 + 4 = 10$	B1	Allow awrt 10.0 or 9.99. No second answer.

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2015 series

0606 ADDITIONAL MATHEMATICS

0606/22 Paper 2, maximum raw mark 80

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1 (i)	$f(-2) = -32 - 16 + 30 + 18 = 0$	B1	All four evaluated terms must be seen. Allow if correct long division used
(ii)	$f(x) = (x+2)(4x^2 - 12x + 9)$	M1 A1	Coefficients 4 and 9 Coefficient –12
	$= (x+2)(2x-3)(2x-3)$	A1	All three factors together
	$f(x) = 0 \rightarrow x = -2,\ 1.5$ nfww	A1	Allow 1.5 mentioned just once
2 (i)	$(2-3x)^6 = 64 - 576x + 2160x^2$ isw	B1B1B1	
(ii)	$2160 - 2 \times 576 = 1008$	M1 A1	*their* final 2160 + 2 × *their* final –576
3 (i)	$\overrightarrow{AB} = \begin{pmatrix} -15 \\ 8 \end{pmatrix}$	B1	Allow $\overrightarrow{BA}$ May be implied by later work.
	$\lvert AB \rvert = \sqrt{15^2 + 8^2} \quad (=17)$ Speed $= 17 \times 3 = 51$ km/hr	M1 A1	Use of Pythagoras on *their AB* Must be exact
(ii)	$\overrightarrow{BC} = \begin{pmatrix} 16 \\ -30 \end{pmatrix}$	B1	Allow $\overrightarrow{CB}$
	$\lvert BC \rvert = \sqrt{16^2 + 30^2} \quad (=34)$	M1	Use of Pythagoras on *their BC*
	Time taken $= \frac{34}{51} \times 60 = 40$ mins (or $\frac{2}{3}$ hrs)	A1	Allow answers which round to 40 to 2sf. Accept 0.66 or 0.67 hrs. Mark final answer.

4 **(a)**	$2\mathbf{BA} = 2\begin{pmatrix} 1 & -2 & 4 \\ -2 & 3 & 0 \end{pmatrix}\begin{pmatrix} 2 & -1 \\ 3 & 5 \\ 7 & 4 \end{pmatrix}$ $= 2\begin{pmatrix} 24 & 5 \\ 5 & 17 \end{pmatrix} = \begin{pmatrix} 48 & 10 \\ 10 & 34 \end{pmatrix}$	B3,2,1,0	–1 each error in 2 × 2 result. Failure to multiply by 2 is one error
(b) **(i)**	$\mathbf{C}^{-1} = \frac{1}{8}\begin{pmatrix} 6 & -2 \\ 1 & 1 \end{pmatrix}$ isw	B1 B1	$\frac{1}{8}$ Matrix
(ii)	$\mathbf{I} - \mathbf{D} = \begin{pmatrix} -2 & 2 \\ -1 & -3 \end{pmatrix}$	B1	
	$\mathbf{X} = \mathbf{C}^{-1}(\mathbf{I} - \mathbf{D}) = \frac{1}{8}\begin{pmatrix} 6 & -2 \\ 1 & 1 \end{pmatrix}\begin{pmatrix} -2 & 2 \\ -1 & -3 \end{pmatrix}$	M1	Pre multiply *their* **I – D** with *their* $\mathbf{C}^{-1}$
	$= \frac{1}{8}\begin{pmatrix} -10 & 18 \\ -3 & -1 \end{pmatrix}$ isw	A1	
5 **(a)**	$2^{3(q-1)} \times 2^{2p+1} = 2^{14}$	B1	Correct powers of 2 allow unsimplified isw
	$3^{2(p-4)} \times 3^{q} = 3^{4}$	B1	Correct powers of 3 allow unsimplified isw
	Solve $3q + 2p = 16$ $q + 2p = 12$	M1	Attempt to solve *their* linear equations by eliminating one variable
	$p = 5, \quad q = 2$	A1	Both correct
(b)	$(3x-2)(x+1)$ $= 50$	M1 A1	LHS oe isw 50 from correct processing of $2 - \lg 2$
	$3x^2 + x - 52 = 0 \rightarrow (3x+13)(x-4)$	M1	Solution of *their* three term quadratic Roots must be obtained from correct quadratic
	$x = 4$ $x = -\frac{13}{3}$ discarded	A1 A1	

6 (i)	$a=3,\quad b=2,\quad c=4$	B1B1B1	
(ii)	$\frac{\mathrm{d}y}{\mathrm{d}x}=8\cos 4x$ isw	M1 A1FT	$\pm k\cos cx$ and no other term in x $\quad c\neq 1$ $bc\times\cos cx$ and no other term
(iii)	$x=\frac{\pi}{2}\rightarrow\frac{\mathrm{d}y}{\mathrm{d}x}=8\cos 2\pi=8$	DM1	Find *their* correct numerical $\frac{\mathrm{d}y}{\mathrm{d}x}$
	Eqn: $\frac{y-3}{x-\frac{\pi}{2}}=-\frac{1}{8}$ $\quad\left(\rightarrow y=-\frac{1}{8}x+3.20\right)$	M1 A1	Find equation with *their* numerical normal gradient ie $\frac{-1}{\frac{\mathrm{d}y}{\mathrm{d}x}}$ and point $\left(\frac{\pi}{2},\ 3\right)$ All correct isw
7 (i)	$\frac{h}{8}=\frac{6-r}{6}\rightarrow h=\frac{4}{3}(6-r)$	M1 A1	Uses correct ratio. Cannot be implied
(ii)	$V=\pi r^2h=\pi r^2\times\frac{4}{3}(6-r)$ $=8\pi r^2-\frac{4}{3}\pi r^3$	B1	**AG** all steps must be seen Penalise missing brackets at any point in working
(iii)	$\frac{\mathrm{d}V}{\mathrm{d}r}=16\pi r-4\pi r^2$	M1 A1	Differentiate at least one power reduced by one
	$\frac{\mathrm{d}V}{\mathrm{d}r}=0\rightarrow r=4$	M1 A1	Attempt to solve – must get $r=\ldots$ Correct value of r. Ignore $r=0$
	$V=\frac{128}{3}\pi\quad(=42.7\pi)$	A1	Correct value of V. Condone 134.
	$\frac{\mathrm{d}^2V}{\mathrm{d}r^2}=16\pi-8\pi r<0$ when $r=4\rightarrow$ max	B1	$\frac{\mathrm{d}^2V}{\mathrm{d}r^2}$ must be correct and some indication of a negative value seen plus maximum stated

8 **(i)**	Gradient $AB = \frac{8-2}{9+3}$ $\left(= \frac{1}{2}\right)$ isw	B1	
	Equation AB and $x = 0 \rightarrow \frac{y-2}{0+3} = \frac{1}{2}$ $\left(\rightarrow y = \frac{1}{2}x + 3.5\right)$	M1	Find equation with *their* gradient and set $x = 0$
	$\rightarrow y = 3.5$	A1	
(ii)	D is (3, 5)	B1	
(iii)	Gradient perpendicular = –2	M1	Use of $m_1 \times m_2 = -1$ on gradient used for *their* line in **(i)**
	Equation perpendicular $\frac{y-5}{x-3} = -2$ $\rightarrow (y = -2x + 11)$	A1	
(iv)	E is (0, 11)	A1FT	
(v)	Area of $ABE = \frac{1}{2}\begin{vmatrix} -3 & 9 & 0 & -3 \\ 2 & 8 & 11 & 2 \end{vmatrix}$	M1	For area of ABE or ECD. $\frac{1}{2}$ and *their* correct 8 elements must be seen.
	$= \frac{1}{2}\left\| -24 + 99 - 18 + 33 \right\| = 45$	A1	45 condone from E (0, –4)
	Area of $EDC = \frac{1}{2}\begin{vmatrix} 3 & 0 & 0 & 3 \\ 5 & 3.5 & 11 & 5 \end{vmatrix}$		
	$= \frac{1}{2}\left\| -10.5 + 33 \right\| = 11.25$	A1	11.25 condone from E(0, –4)

9 (i)	$\tan 2x = -\frac{5}{4}$ $(2x = 128.7,\ 308.7)$	M1	For obtaining and using $\tan 2x = \pm\frac{5}{4}$ or $\pm\frac{4}{5}$ resulting in $2x =$
	$x = 64.3$ awrt	A1	$\tan x = \ldots$ gets M0
	154.3 awrt	A1FT	*their* $64.3° + 90°$
(ii)	$\text{cosec}^2 y + 3\text{cosec} y - 4 = 0$ or $4\sin^2 y - 3\sin y - 1 = 0$ $(\text{cosec} y + 4)(\text{cosec} y - 1) = 0$ or $(4\sin y + 1)(\sin y - 1) = 0$	B1	In any form as a three term quadratic.
	$\sin y = -\frac{1}{4}$ or $\sin y = 1$	M1	Solve three term quadratic in $\text{cosec}\, y$ or $\sin y$
	$y = 194.5,\ 345.5,\ 90$	A1A1A1	Answers must be obtained from the correct quadratic
(iii)	$z + \frac{\pi}{4} = \pi - \frac{\pi}{3}$ or	B1	Accept 2.09, 2.10, $\pi - 1.05$, $\pi - 1.04$ on RHS. Could be implied by final answer
	$z + \frac{\pi}{4} = \pi + \frac{\pi}{3}$	B1	Accept 4.19, 4.18, $\pi + 1.05$, $\pi + 1.04$ on RHS. Could be implied by final answer
	$z = \frac{5\pi}{12},\ \frac{13\pi}{12}$	B1B1	Answers must be correct multiples of π.
10 (i)	$s = \frac{1}{2}e^{2t} + 3e^{-2t} - t + (c)$	M1	Integrate : coefficient of $\frac{1}{2}$ or 3 seen with no change in powers of e. Ignore $-t$
	$t = 0,\ s = 0 \to c = -3.5$ $\left(s = \frac{1}{2}e^{2t} + 3e^{-2t} - t - 3.5\right)$	A1 A1	All correct and simplified
(ii)	$v = 0 \to u^2 - u - 6 = 0$ oe	M1	Obtain three term quadratic in u or e^{2t} Condone sign errors.
	$(u-3)(u+2) = 0$	DM1	Solve three term quadratic
	$\to u = 3 \to t = \frac{1}{2}\ln 3$ or 0.549	A1	Accept 0.55 No second answer
(iii)	$t = \frac{1}{2}\ln 3 \to a = 2e^{2t} + 12e^{-2t}$	B1	Correct differentiation
	$= 6 + 4 = 10$	B1	Allow awrt 10.0 or 9.99. No second answer.

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2015 series

0606 ADDITIONAL MATHEMATICS

0606/23 Paper 2 , maximum raw mark 80

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soi	seen or implied
www	without wrong working

1	$y = x^3 + 3x^2 - 5x - 7$		
	$\frac{dy}{dx} = 3x^2 + 6x - 5$	M1 A1	Differentiate
	$x = 2 \rightarrow \frac{dy}{dx} = 19$	A1FT	on *their* $\frac{dy}{dx}$
	$y = 3$	B1	
	eqn of tangent: $\frac{y-3}{x-2} = 19 \quad \rightarrow \quad (y = 19x - 35)$	A1FT	
2	$2x + k + 2 = 2x^2 + (k+2)x + 8$	M1	eliminate *y* or *x*
	$2x^2 + kx + 6 - k \quad (=0)$	A1	correct quadratic
	$b^2 - 4ac = k^2 - 4 \times 2(6-k)$	M1	use discriminant
	$k^2 + 8k - 48 \quad (>0)$		
	$(k+12)(k-4) \quad (>0)$	DM1 A1	attempt to solve 3 term quadratic $k = -12$ and $k = 4$
	$k < -12$ or $k > 4$	A1	
3 (a)	$\frac{dy}{dx} = \frac{(2-x^2)3x^2 - x^3(-2x)}{(2-x^2)^2} = \left(\frac{6x^2 - x^4}{(2-x^2)^2}\right)$	M1 A2,1,0	For quotient rule (or product rule on correct *y*)
(b)	$\frac{dy}{dx} = x \times \frac{1}{2}(4x+6)^{-0.5} \times 4 + (4x+6)^{0.5}$	M1 A1	product rule
	$= \frac{6(x+1)}{(4x+6)^{0.5}} \quad \rightarrow \quad k = 6$	A1	
4	$x(4 - \sqrt{3}) = 13$	M1 A1	eliminate *y* or *x* simplified
	$x = \frac{13(4+\sqrt{3})}{(4-\sqrt{3})(4+\sqrt{3})}$	M1	rationalisation
	$= 4 + \sqrt{3}$	A1	
	$y = 1 - 2\sqrt{3}$	A1	

5	$(x-3)(x-3)(x-1)=0$ $x^3-7x^2+15x-9=0$ $a=-7$ $b=15$ $c=-9$	M1 A1 A1 A1	 **AG** for *c*
6	$\log_x 2=\frac{\log_2 2}{\log_2 x}$ $2\log_2 x=\log_2 x^2$ $3=\log_2 8$ $8x^2-29x+15\ \ (=0)$ $\rightarrow(8x-5)(x-3)\ \ (=0)$ $x=\frac{5}{8}$ or $x=3$	B1 B1 B1 M1 A1	 obtain quadratic and attempt to solve
7 (i)	$a=-\frac{20}{(t+2)^3}$ $t=3 \rightarrow a=-0.16\text{ m/s}^2$	M1 A1 A1FT	$k(t+2)^{-3}$ oe $k=-20$
(ii)	$\frac{10}{(t+2)^2}$ is never zero.	B1	
(iii)	$s=-\frac{10}{t+2}+5$	M1 A1 A1	integrate $\frac{k}{t+2}$ $k=-10$ +5
(iv)	$s=\left[-\frac{10}{t+2}\right]_3^8=-1+2$ $=1$	M1 A1	insert limits and subtract

8 **(i)**	$\sec^2 x + \text{cosec}^2 x = \dfrac{1}{\cos^2 x} + \dfrac{1}{\sin^2 x}$	B1	
	$= \dfrac{\sin^2 x + \cos^2 x}{\sin^2 x \cos^2 x}$	B1	add fractions
	$= \dfrac{1}{\sin^2 x \cos^2 x}$	B1	use of $\sin^2 x + \cos^2 x = 1$
	$= \sec^2 x \text{cosec}^2 x$	B1	fully correct solution
(ii)	$\dfrac{1}{\cos^2 x \sin^2 x} = 4\dfrac{\sin^2 x}{\cos^2 x}$	M1	
	$\rightarrow \quad 4\sin^2 x = 1$	A1	correct simplified equation
	$\sin x = \pm\dfrac{1}{\sqrt{2}}$		
	$x = 135^\circ, 225^\circ$	A1, A1	
9 **(i)**	$f(x) = 3x^2 + 12x + 2 = 3(x+2)^2 - 10$		
	$a = 3$	B1	
	$b = 2$	B1	
	$c = -10$	B1	
(ii)	minimum $f(x) = -10$	B1FT	
	at $x = -2$	B1FT	
(iii)	$f\left(\dfrac{1}{y}\right) = 0 \quad \rightarrow \quad \left(\dfrac{1}{y}\right) = (\pm)\sqrt{\dfrac{10}{3}} - 2$	M1	obtain explicit expression for $\dfrac{1}{y}$ or y
	$y = -5.74, \quad -0.26$	A1, A1	

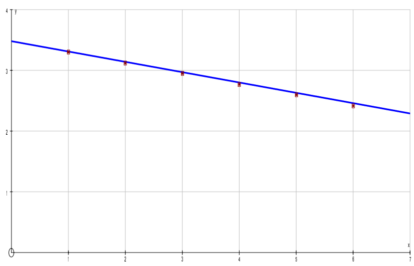
10 (i)	$\frac{d}{dx}(e^{2-x^2}) = -2xe^{2-x^2}$	B1	$k = -2$
(ii)	$-\frac{3e^{2-x^2}}{2} + c$	M1 A1FT	De^{2-x^2} $D = \frac{-3}{2}$ or $\frac{3}{k}$
(iii)	$\left[-\frac{3e^{2-x^2}}{2}\right]_1^{\sqrt{2}} = -\frac{3}{2} + \frac{3}{2}e$ 2.58	M1 A1	insert limits on *their* (ii) and subtract
(iv)	$y = 3xe^{2-x^2}$ $\frac{dy}{dx} = 3x(-2xe^{2-x^2}) + 3e^{2-x^2}$ $\frac{dy}{dx} = 0 \rightarrow \quad x = \pm\frac{1}{\sqrt{2}} = \pm 0.707$ $y = \pm\frac{3}{\sqrt{2}}e^{1.5} = \pm 9.51$	M1 A1 A1 A1	product rule both x or a pair both y
11 (i)	$\log N = \log A - t \log b$	B1	
(ii)	(table below) 	M1 M1 A1	find logs of N plot $\log N$ or $\ln N$ against t or $-t$ straight line passing through five points
(iii)	gradient $= -\log b = \frac{2.415 - 3.3}{5} \rightarrow b = 1.5$ intercept $= \log A = 3.47 \rightarrow A = 2950$	DM1 DM1 A1	set gradient = $-\log b$ and solve set intercept = $\log A$ and solve both values correct
(iv)	$t = 10 \rightarrow N = \frac{2950}{1.5^{10}} = 51$	B1	
(v)	$N = 10 \rightarrow 1.5^t = 295 \rightarrow t = \frac{\log 295}{\log 1.5}$ $= 14$ years	M1 A1	substitute $N = 10$, *their* A, b into given or transformed equation

Table for 11 (ii):

t	1	2	3	4	5	6
$\log N$	3.30	3.11	2.95	2.77	2.60	2.41
$\ln N$	7.60	7.17	6.79	6.38	5.98	5.56

12	$v_p = \begin{pmatrix} 250\cos 20^\circ \\ 250\sin 20^\circ \end{pmatrix}$, $v_r = \begin{pmatrix} V\cos 30^\circ \\ V\sin 30^\circ \end{pmatrix}$, $v_w = \begin{pmatrix} 0 \\ w \end{pmatrix}$	B1	
	$v_r = v_p + v_w$ $\begin{pmatrix} V\cos 30^\circ \\ V\sin 30^\circ \end{pmatrix} = \begin{pmatrix} 250\cos 20^\circ \\ 250\sin 20^\circ \end{pmatrix} + \begin{pmatrix} 0 \\ w \end{pmatrix}$		
	$V = \dfrac{250\cos 20^\circ}{\cos 30^\circ}$	M1	equate x components and solve
	$= 271\text{km/hr}$	A1	
	$w = V\sin 30^\circ - 250\sin 20^\circ$	M1	equate y components and solve
	$= 50.1\text{km/hr}$	A1	
	OR triangle with sides 250 V w opposite angles 60° 110° 10°	B1	
	sine rule: $\dfrac{w}{\sin 10^\circ} = \dfrac{250}{\sin 60^\circ}$	M1	apply to correct triangle and solve
	$w = 50.1\text{km/hr}$	A1	
	$\dfrac{V}{\sin 110^\circ} = \dfrac{250}{\sin 60^\circ}$	M1	apply to correct triangle and solve
	$V = 271\text{km/hr}$	A1	

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MARK SCHEME for the May/June 2015 series

0606 ADDITIONAL MATHEMATICS

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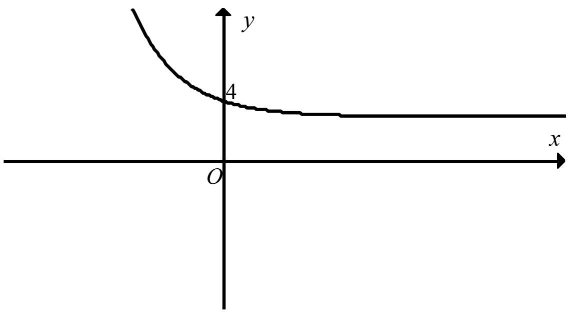
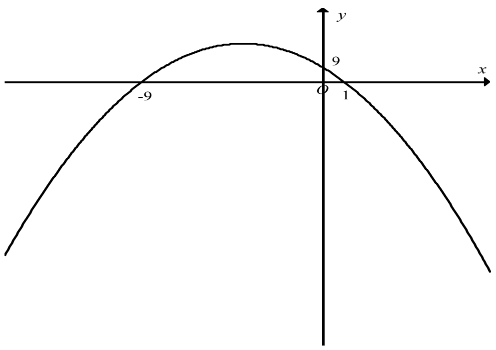
1	(a)	$\frac{\log_3 x}{\log_3 27}$	M1	Can use other interim bases if all correct but M1 when in base 3 only
		$\frac{\log_3 x}{3}$ isw	A1	NOT $\log_3 x \div 3$
	(b)	$\log_a 15 - \log_a 3 = \log_a 5$ soi	M1	
		$\log_a 5^3$ or $\log_a a$	M1	
		$\log_a y = \log_a 125a \Rightarrow y = 125a$	A1	
2	(a)	$[\mathrm{f}(x) =] 2x - 4$ and $[\mathrm{f}(x) =] -2x + 4$	B1,B1	Condone $y =$….
	(b)		B1 B1 B1	correct shape; y intercept marked or seen nearby; intent to tend to $y = 3$ (i.e. not tending to or cutting x-axis)
3	(a)	$\mathbf{A} = \frac{1}{4}\left[\begin{pmatrix} 51 & -8 & 19 \\ 31 & 2 & 65 \end{pmatrix} - \begin{pmatrix} 20 & 0 & -5 \\ 15 & -10 & 25 \end{pmatrix}\right]$	M1	
		$\mathbf{A} = \begin{pmatrix} 8 & -2 & 6 \\ 4 & 3 & 10 \end{pmatrix}$	A1	Integer values
	(b) (i)	The (total) value of the stock in **each** of the 3 shops	B1	Must have "each" oe
	(ii)	The **total** value of the stock in all 3 shops	B1	Must have "total" oe

4 **(i)**	$\frac{PT}{8} = \tan\left(\frac{3\pi}{8}\right)$ oe	M1	$\frac{PT}{\sin\frac{3\pi}{8}} = \frac{8}{\sin\frac{\pi}{8}}$
	$PT = 19.3$	A1	awrt 19.3
(ii)	$\frac{1}{2} \times 8^2 \times \frac{3\pi}{4}$ oe (75.4)	M1	or $\frac{1}{2} \times 8^2 \times \frac{3\pi}{8}$
	$8\tan\left(\frac{3\pi}{8}\right) \times 8 -$ *their* sector oe (=154.5-'75.4')	M1	$8 \times$ *their PT* $-$ *their* sector
	79.1	A1	awrt 79.1
(iii)	$8\left(\frac{3\pi}{4}\right)$ oe (18.8)	M1	
	$\left[6\pi + 16\tan\left(\frac{3\pi}{8}\right)\right] = 57.5$	A1	Accept 57.4 to 57.5
5 **(a)**	Permutation because the order matters oe	B1	
(b) (i)	${}^6C_4 + {}^5C_4 + {}^7C_4$ 55	M1 A1	3 correct terms added
(ii)	${}^2C_1 \times {}^6C_1 \times {}^5C_1 \times {}^7C_1$ 420	M1 A1	4 correct terms multiplied
(iii)	${}^6C_3 \times {}^2C_1$ or ${}^2C_2 \times {}^5C_1 \times {}^6C_1$ summation 70	M1 M1 A1	for either correct product adding two correct products If 0 scored, then SC1for 1,1,1,0 and 0,0,2,1 seen
6 **(i)**	$2t^2 - 14t + 12 = 0$ $(t-1)(t-6)$ oe $(t =)\ 1$	M1 A1	Can use formula, etc. If $t = 1$ with no working, then M1A1
(ii)	$\int(2t^2 - 14t + 12)\,dt$	M1	
	$(s =)\ \frac{2t^3}{3} - \frac{14t^2}{2} + 12t$	A2,1,0	-1 for each error or for $+c$ left in or limits introduced
(iii)	$(a =)\frac{dv}{dt}$ $(4t - 14)$	M1	
	$[4(3) - 14 =]\ -2$ cao	A1	

7 **(a)**	$\overrightarrow{AB} = 15\mathbf{b} - 5\mathbf{a} = 5(3\mathbf{b} - \mathbf{a})$ or $\overrightarrow{BC} = 24\mathbf{b} - 3\mathbf{a} - 15\mathbf{b} = 3(3\mathbf{b} - \mathbf{a})$ or $\overrightarrow{AC} = 24\mathbf{b} - 3\mathbf{a} - 5\mathbf{a} = 8(3\mathbf{b} - \mathbf{a})$	B1 B1	Any correct simplified vector Any second simplified vector
	Comment: e.g. the vectors are scalar multiples of each other AND they have a common point (A, B or C as appropriate)	B1dep	Dep on both B marks being awarded.
(b) **(i)**	$2\mathbf{i} + 11\mathbf{j}$ soi $\Rightarrow \sqrt{2^2 + 11^2}$	B1	
	$\sqrt{125}$ or $5\sqrt{5}$ or 11.2 (3 s.f.) or better)	B1fT	ft *their* $2\mathbf{i} + 11\mathbf{j}$ (not $\overrightarrow{OP}$ or $\overrightarrow{OQ}$)
(ii)	$\frac{1}{5\sqrt{5}}(2\mathbf{i} + 11\mathbf{j})$ isw	B1fT	ft *their* answers from **(i)**
(iii)	$\frac{\mathbf{i} - 4\mathbf{j} + 3\mathbf{i} + 7\mathbf{j}}{2}$ or $\mathbf{i} - 4\mathbf{j} + \frac{2\mathbf{i} + 11\mathbf{j}}{2}$ or $3\mathbf{i} + 7\mathbf{j} - \frac{2\mathbf{i} + 11\mathbf{j}}{2}$	M1	
	$2\mathbf{i} + 1.5\mathbf{j}$	A1	
8 **(a)** **(i)**	$k\mathrm{e}^{4x+3}$ $(+c)$ oe $k = \frac{1}{4}$ oe	M1 A1	any constant, non-zero k
(ii)	$\frac{1}{4}\left(\mathrm{e}^{4(3)+3} - \mathrm{e}^{4(2.5)+3}\right)$ or better	DM1	ft *their* integral attempt
	706 650.99… = 707 000 to 3 sf or better	A1	Accept $\frac{1}{4}\left(\mathrm{e}^{15} - \mathrm{e}^{13}\right)$
(b) **(i)**	$k\sin\left(\frac{x}{3}\right)$ $(+ c)$ $k = 3$	M1 A1	any constant, non-zero k
(ii)	$3\sin\left(\frac{\pi}{6} \times \frac{1}{3}\right) - 3\sin(0)$	DM1	Dep on *their* integral attempt in sin; condone omission of lower limit
	0.520 944… = 0.521 to 3 sf or better	A1	Accept $3\sin\left(\frac{\pi}{18}\right)$
(c)	$\int\left(x^{-2} + 2 + x^2\right)\mathrm{d}x = \frac{x^{-1}}{-1} + 2x + \frac{x^3}{3}$ $+ c$	B1 M1 A1 B1	Expands – accept unsimplified integration of *their* 3 term expansion Fully correct $+c$

9 (a)	$(4x-1)(x+5)$ [$\leqslant 0$]	M1	Solves quadratic
	critical values $\frac{1}{4}$ and –5 soi	A1	
	$-5 \leqslant x \leqslant \frac{1}{4}$	A1	Accept: $\left[-5, \frac{1}{4}\right]$; $-5 \le x$ AND $x \le 0.25$
(b) (i)	$(x+4)^2 - 25$ or $a = 4$ and $b = -25$	B1, B1	
(ii)	(Greatest value =) 25 $x = -4$	B1ft B1ft	Must be clear
(iii)		B1 B1	Correct shape with maximum in second quadrant and crossing positive and negative axes correctly All 3 intercepts correctly shown on graph
10 (i)	$\ln y = \ln(Ab^x) \Rightarrow \ln y = \ln A + \ln b^x$ $\Rightarrow \ln y = \ln A + x \ln b$	M1 A1	
(ii)	$\ln A = 11.4 \Rightarrow A = e^{their\ 11.4}$	M1	condone misread of scale for M1 (11.2 only)
	$A = 90\,000$ cao $\ln b = -1$ $b = 0.4$ cao	A1 M1 A1	 Allow awrt –1
(iii)	$x = 2.5 \Rightarrow \ln y = 9$ $y = e^9$ or 8000 to 1 sf	M1 A1	 Allow awrt 8100
11 (i)	$7 - x, x, 6 - x$ oe	B1	
	their attempt at $7 - x + x + 6 - x + 16 = 25$ oe	M1	
	$x = 4$	A1	Condone $x = 4$ for all 3 marks
(ii)	$23 - y, y, 9 - y$ oe	B1	or $\text{n}(A \cup C) = 48 - 16 = 32$
	48 = 30 + 25 + 15 – 7 – 6 – (*their* 4 + y) + *their* 4 oe soi	M1	or 32 = 30 + 15 – (*their* 4 + y) or 48 = (23 – y) + 3 + 16 + y + 4 + 2 + (9 – y)
	$y = 9$	A1	Condone $y = 9$ for all 3 marks
(iii)	n(C) = 15 and $y + \text{n}(B \cap C) = 9 + 6 = 15$ [and so $A' \cap B' \cap C = \varnothing$].	B1	or equivalent deduction

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the May/June 2015 series

0606 ADDITIONAL MATHEMATICS

0606/22 Paper 2, 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.

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Cambridge is publishing the mark schemes for the May/June 2015 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

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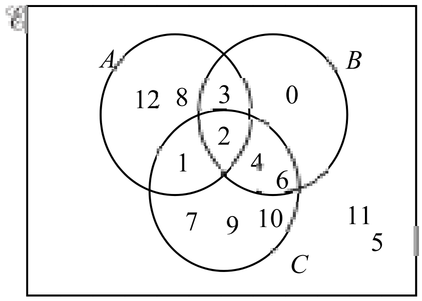
Abbreviations

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

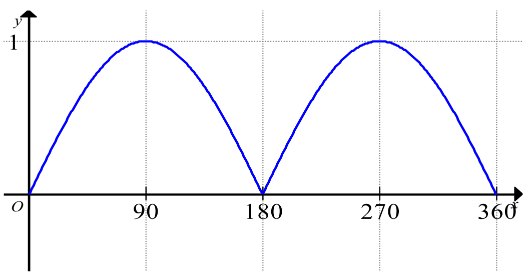
1 **(i)**		B3,2,1,0	2 correctly placed in Venn diagram; 1, 3, 4, 6 correctly placed; 12, 8, 0, 7, 9, 10 correctly placed; 11, 5 correctly placed
(ii)	3	B1ft	correct or correct ft *their* (i), provided non-zero
(iii)	{4, 6}	B1ft	correct or correct ft *their* (i), provided not the empty set
2 **(i)**	$[\mathbf{P} =]\begin{pmatrix} 60 & 70 & 58 \\ 50 & 52 & 34 \end{pmatrix}$ and $[\mathbf{Q} =]\ (120 \quad 300)$	B2	or $[\mathbf{P} =]\begin{pmatrix} 50 & 52 & 34 \\ 60 & 70 & 58 \end{pmatrix}$ and $[\mathbf{Q} =]\ (300 \quad 120)$ or B1 if one error may be written as an unevaluated product; B0 if choice of **P** and **Q** offered
(ii)	$(22\,200 \quad 24\,000 \quad 17\,160)$	B2	must have brackets and must not have commas; must be a 1 by 3 matrix; must be from correct product; working may be seen in **(i)** or B1 for any two elements correct
(iii)	The **total** (amount of revenue) **from all** (three) flights. oe	B1	do not accept, e.g. The total amount from **each** flight; must be a comment not just a figure; must not contain a contradiction

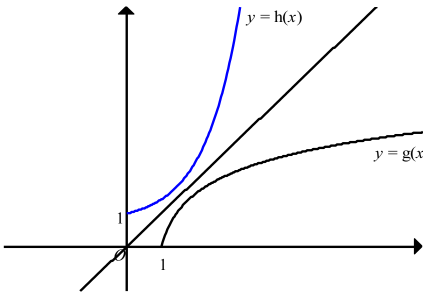
3 (i)	$\frac{(36+15\sqrt{5})}{(6+3\sqrt{5})} \times \frac{(6-3\sqrt{5})}{(6-3\sqrt{5})}$ oe	M1	or $\frac{(12+5\sqrt{5})}{(2+\sqrt{5})} \times \frac{(2-\sqrt{5})}{2-\sqrt{5}}$ oe
	$\frac{216+90\sqrt{5}-108\sqrt{5}-225}{-9}$	DM1	or $\frac{24+10\sqrt{5}-12\sqrt{5}-25}{-1}$ or $-(24+10\sqrt{5})-12\sqrt{5}-25$
	$1+2\sqrt{5}$ cao	A1	allow a = 1 and b = 2
	Alternative method: $36+15\sqrt{5}=(6a+15b)+(3a+6b)\sqrt{5}$	M1	
	$6a + 15b = 36$ $3a + 6b = 15$	DM1	
	$a = 1$ and $b = 2$	A1	or $1+2\sqrt{5}$
(ii)	$\left[AC^2 = (6+3\sqrt{5})^2 + their(1+2\sqrt{5})^2\right]$ $= 36+36\sqrt{5}+45+their(1+4\sqrt{5}+20)$	M1	correct or correct ft expansions, using Pythagoras with $(6+3\sqrt{5})$ and *their BC*
	$102+40\sqrt{5}$ cao	A1	ignore attempts to square root after correct answer seen
4 (i)	$\cos(x)=\frac{2}{3}$ oe soi	M1	**Alternatively** $\sin(y)=\frac{2}{3}$ oe soi
	48.189…° or 131.810…° or 0.8410… rad or 2.3(00…) rad oe isw with reference axis indicated by comment, e.g. “to the bank” or “upstream”, etc. or clearly marked on a diagram	A1	41.810…° or 0.7297 ... or 0.73(0) rad oe isw with reference axis indicated by comment, e.g. “to the perpendicular with the bank”, etc. or clearly marked on a diagram If M0 then SC1 for an unsupported answer of 138.189…° or 2.4118… rad or 318.189...° or 5.5534... rad with reference axis indicated by comment, e.g. “on a bearing of” or “from North” or clearly marked on a diagram

(ii)	Speed $=\sqrt{9-4}\left(=\sqrt{5}\right)$ or $3\sin 48.2$ or $2\tan 48.2$ or $3\cos 41.8$ or $\dfrac{2}{\tan 41.8}$ or $\sqrt{2^2+3^2-2\times2\times3\cos 48.2}$ oe or 2.236(0…) rot to 4 or more figs or 2.24 [m/s] soi	B1	Or Distance $=\dfrac{80}{\sin 48.2}=107.(33\ldots)$ oe soi
	time $=\dfrac{80}{\textit{their}\ \sqrt{5}}$ oe	M1	time $=\dfrac{\textit{their}\ 107.33\ldots}{3}$
	35.66 to 35.8 (seconds) oe	A1	ignore subsequent rounding or attempted conversion to, e.g. minutes but A0 if answer spoiled by continuation of method if no working, so B0 M0, then allow B3 for an answer 35.66 to 35.8 oe
5	Substitution of either $4-x$ or $4-y$ into equation of curve and brackets expanded	M1	condone one sign error or slip in either equation of curve or expansion of brackets; condone omission of $=0$, BUT $4-x$ or $4-y$ must be correct
	$12x^2-52x+48$ [= 0] or $12y^2-44y+32$ [= 0] oe	A1	
	Solve their 3-term quadratic	M1	dep on a valid substitution attempt
	$x=\dfrac{4}{3}$ and 3 isw	A1	or $x=\dfrac{4}{3}$ $y=\dfrac{8}{3}$ not from wrong working
	$y=\dfrac{8}{3}$ and 1 isw	A1	or $x=3$ $y=1$ not from wrong working if no working, allow full marks for fully correct answer only.
6 (a)	$(x-2)\log 6=\log\left(\dfrac{1}{4}\right)$ oe or $\log_6\left(\dfrac{1}{4}\right)=x-2$ oe	M1	or $x\log 6=\log\left(\dfrac{36}{4}\right)$ oe or $x\log 6-\log 36=\log 1-\log 4$ oe
	1.23 or 1.226(29…) rot to 4 or more figures isw	A1	correct answer or 1.22 implies M1

(b)	**Method 1** $\log\left(\frac{8\times 2y^2\times 16y}{64y}\right)=\log 4^2$ oe $y = 2$	B3 B1	or B2 if at most one error or omitted step or B1 if at most two errors or omitted steps not from wrong working
	Method 2 $\log 2 + 2\log y + 3\log 2 + 4\log 2 + \log y - 6\log 2 - \log y = 4\log 2$ $y = 2$	B3,2,1,0 B1	LHS terms $\log 2y^2 = \log 2 + 2\log y$; $\log 8 = 3\log 2$; $\log 16y = 4\log 2 + \log y$; $-\log 64y = -6\log 2 - \log y$; RHS term $2\log 4 = 4\log 2$ not from wrong working
7	$\frac{n(n-1)(n-2)(n-3)(2^4)}{4\times 3\times 2\times 1}=10\frac{n(n-1)(2^2)}{2\times 1}$ or better $n^2 - 5n - 24$ [= 0] oe $(n + 3)(n - 8)$ [= 0] $n = 8$ only	M3 A1 M1 A1	condone omitting the factor of n and/or $n - 1$; must have dealt with factorials M2 if one slip/omission or M1 if two slips/omissions or B1 for $\frac{n(n-1)}{2}(2)^2[x^2]$ seen and B1 for $\frac{n(n-1)(n-2)(n-3)}{24}(2)^4[x^4]$ seen equivalent must be 3-terms, e.g. $n^2 - 5n = 24$ or any valid method of solution for their 3-term quadratic A0 if –3 also given as a final solution, i.e. not discarded If zero scored, allow SC1 for $n = 8$ unsupported or without correct method

8	**Method 1** (Separate areas subtracted)		
	$[x_B = x_C =]$ 7 soi	B1	
	$\left[\int(x^2-6x+10)\,dx=\right]\ \frac{x^3}{3}-\frac{6x^2}{2}+10x$	M2	or M1 for at least one term correct
	Correct or correct ft substitution of limits 0 and *their* 7 into *their* $\left[\frac{x^3}{3}-\frac{6x^2}{2}+10x\right]$	DM1	dep on at least M1 being earned; evidence of substitution must be seen in *their* integral which must be at least two terms; condone omission of lower limit;
	$\frac{1}{2}(10+17)\times 7$ oe or $\int_0^7(x+10)\,dx=\left[\frac{x^2}{2}+10x\right]_0^7=\frac{(7)^2}{2}+10(7)$ oe	B2	or M1 for $\frac{1}{2}$(*their* 10 + *their* 17) × *their* 7 oe or B1 for $\int(x+10)dx=\frac{x^2}{2}+10x$
	their $\left(\frac{189}{2}-\frac{112}{3}\right)$	M1	dep on a genuine attempt to integrate the equation of the curve; must be *their* area trapezium/under the line – *their* attempt at area under curve
	$\frac{343}{6}$ or $57\frac{1}{6}$ or 57.2 to 3 sf or 57.16(6...) rot to 4 figs isw	A1	from full and correct working with no omitted steps
	Method 2 (Subtracting and using integration once)		
	$[x_B = x_c =]$ 7 soi	B1	
	$\int(-x^2+7x)dx$	B1	condone omission of dx
	$\left[-\frac{x^3}{3}+\frac{7x^2}{2}\right]$ oe or $\left[\frac{x^3}{3}-\frac{7x^2}{2}\right]$ oe	M3	or M2 for $\int(px^2+qx)dx=\frac{px^3}{3}+\frac{qx^2}{2}$ oe either with $p = \pm1$ or $q = \pm7$ or M1 for $\int(px^2+qx)dx=\frac{px^3}{3}+\frac{qx^2}{2}$ with non-zero constants p and q, with $p \neq \pm1$ and $q \neq \pm7$
	Correct or correct ft substitution of limits 0 and *their* 7 into *their* $\left[-\frac{x^3}{3}+\frac{7x^2}{2}\right]$	M2	dep on a valid integration attempt; evidence of substitution must be seen; condone omission of lower limit;
	$\frac{343}{6}$ or $57\frac{1}{6}$ or 57.2 to 3 sf or 57.16(6...) rot to 4 figs isw	A1	from full and correct working with no omitted steps

9 **(i)**	$10 = 2m + 4$ soi	M1	or $[m =]\frac{10-4}{2-0}$ oe soi
	$m = 3$	A1	
(ii)	1	B1	
(iii)	$\frac{10-y_R}{2--1} = 1$ oe soi	M1	or $y = x + 8$ oe
	$(-1, 7)$ or $x = -1$ and $y = 7$	A1	if $y = 7$ only stated, provided that $x = -1$ is soi in working allow both marks if M0 then B1 for $y = 7$ only with no working
(iv)	Use of $m_1 m_2 = -1$ with *their* m from **(i)**	M1	may be implied by perpendicular gradient seen in equation
	$y - 10 = \left(their -\frac{1}{3}\right)(x-2)$	A1	or $\left(their -\frac{1}{3}\right)x + c$ and $10 = \left(their -\frac{1}{3}\right)2 + c$
	$3y + x = 32$ isw	A1	allow for correct equation with integer coefficients in any simplified form
(v)	$\left(\frac{1}{2},\ their\frac{11}{2}\right)$ oe isw	B1,B1ft	ft *their* y_Q or M1 for $\left(\frac{2-1}{2}, \frac{10+1}{2}\right)$ seen
(vi)	4.5 oe cao	B2	not from wrong working or M1 for any correct method with correct coordinates
10 **(a)**		B2,1,0	correct sinusoidal/reflected sinusoidal shape, all above x-axis with intent to have all maximum points of equal height; 2 maximum points of intended equal height only over 0 to 360; all max points clearly at $y = 1$; cusp at 180

(b)(i)	$[\text{hg}(x) =] \dfrac{e^{\ln(4x-3)}+3}{4}$	M1	**Alternative method** $y = \ln(4x-3)$ and change of subject to x oe,
	fully correct **and** completion to $[\text{hg}(x) =]\ x$	A1	fully correct and comment that $\text{h}(x) = \text{g}^{-1}(x)$ oe
(ii)		B2,1,0	correct shape; 1 marked on the y-axis or (0, 1) stated close by; curve with positive gradient in first quadrant only
(iii)	$x \geqslant 0$ or $[0, \infty)$	B1	not domain ≥ 0
(iv)	$y \geqslant 1$ or $[1, \infty)$	B1	or $\text{h}(x) \geqslant 1$, $\text{h} \geqslant 1$ etc.
11 (i)	$\dfrac{8-h}{8}$ or $8 : 8 - h$ soi	M1	or $\dfrac{8}{8-h}$ or $8 - h : 8$ soi
	$\dfrac{8-h}{8} \times 4$ oe	A1	or $4 \div \dfrac{8}{8-h}$ oe
	$h\left(\dfrac{8-h}{8} \times 4\right)^2$ oe	M1	h must be in the numerator of the expression for this mark;
	expand and simplify to $\dfrac{h^3}{4} - 4h^2 + 16h$ **AG**	A1	
(ii)	$\dfrac{3}{4}h^2 - 8h + 16$ oe	B1	
	their $\left(\dfrac{3}{4}h^2 - 8h + 16\right) = 0$ and attempt to solve	M1	must be a 3-term quadratic; must be an attempt at a derivative
	$\dfrac{8}{3}$ oe only	A2	or A1 for $h = \dfrac{8}{3}$ and 8 allow 2.67 or 2.66(6...) rot to 4 or more figs for $\dfrac{8}{3}$

12 **(i)**	$-120 + 104 + 22 - 6 = 0$ or correct unsimplified form, e.g. $15(-2)^3 + 26(-2)^2 - 11(-2) - 6 = 0$ or $15(-8) + 26(4) - 11(-2) - 6 = 0$	B1	or correct synthetic division $\begin{array}{r\|rrrr} -2 & 15 & 26 & -11 & -6 \\ & & -30 & 8 & 6 \\ \hline & 15 & -4 & -3 & 0 \end{array}$
(ii)	Substituting $x = 3$ into $15x^3 + 26x^2 - 11x - 6$	M1	or correct synthetic division $\begin{array}{r\|rrrr} 3 & 15 & 26 & -11 & -6 \\ & & 45 & 213 & 606 \\ \hline & 15 & 71 & 202 & 600 \end{array}$
	600	A1	correct answer implies M1; must be explicitly identified as answer if using synthetic/long division methods by e.g. circling
(iii)	$(x - 1)(15x^3 + 26x^2 - 11x - 6)$ soi	B1	by inspection or division; may be implied by e.g. $(ax + b)(15x^3 + 26x^2 - 11x - 6)$ and $a = 1$, $b = -1$ seen in later work comparing coefficients
	Multiply out $(x \pm 1)(15x^3 + 26x^2 - 11x - 6)$ and compare coefficients of x^3 or x to quartic	M1	or multiply out, e.g. $(ax + b)(15x^3 + 26x^2 - 11x - 6)$ and compare coefficients of x^3 or x to quartic
	$p = 11$ $q = 5$	A1 A1	correct p or q implies M1; correct p and q www implies B1 M1

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the May/June 2015 series

0606 ADDITIONAL MATHEMATICS

0606/23 Paper 2 (Paper 2), maximum raw mark 80

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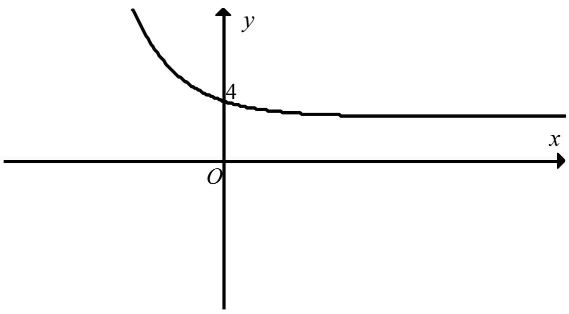
International Examinations

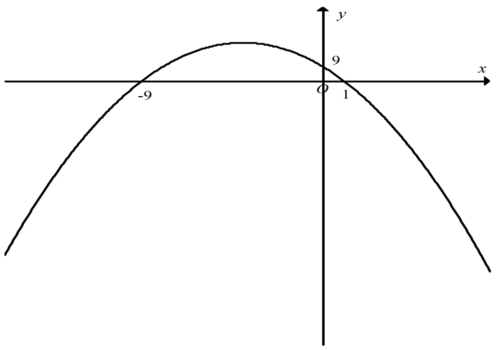
Abbreviations

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 (a)	$\dfrac{\log_3 x}{\log_3 27}$	M1	Can use other interim bases if all correct but M1 when in base 3 only
	$\dfrac{\log_3 x}{3}$ isw	A1	NOT $\log_3 x \div 3$
(b)	$\log_a 15 - \log_a 3 = \log_a 5$ soi	M1	
	$\log_a 5^3$ or $\log_a a$	M1	
	$\log_a y = \log_a 125a \Rightarrow y = 125a$	A1	
2 (a)	$[\mathrm{f}(x) =] 2x - 4$ and $[\mathrm{f}(x) =] -2x + 4$	B1,B1	Condone $y =$….
(b)		B1 B1 B1	correct shape; y intercept marked or seen nearby; intent to tend to $y = 3$ (i.e. not tending to or cutting x-axis)
3 (a)	$\mathbf{A} = \dfrac{1}{4}\left[\begin{pmatrix} 51 & -8 & 19 \\ 31 & 2 & 65 \end{pmatrix} - \begin{pmatrix} 20 & 0 & -5 \\ 15 & -10 & 25 \end{pmatrix}\right]$	M1	
	$\mathbf{A} = \begin{pmatrix} 8 & -2 & 6 \\ 4 & 3 & 10 \end{pmatrix}$	A1	Integer values
(b) (i)	The (total) value of the stock in **each** of the 3 shops	B1	Must have "each" oe
(ii)	The **total** value of the stock in all 3 shops	B1	Must have "total" oe

4 (i)	$\frac{PT}{8} = \tan\left(\frac{3\pi}{8}\right)$ oe	M1	$\frac{PT}{\sin\frac{3\pi}{8}} = \frac{8}{\sin\frac{\pi}{8}}$
	$PT = 19.3$	A1	awrt 19.3
(ii)	$\frac{1}{2}\times 8^2 \times \frac{3\pi}{4}$ oe (75.4)	M1	or $\frac{1}{2}\times 8^2 \times \frac{3\pi}{8}$
	$8\tan\left(\frac{3\pi}{8}\right)\times 8 -$ *their* sector oe (=154.5-'75.4')	M1	$8\times$ *their PT* – *their* sector
	79.1	A1	awrt 79.1
(iii)	$8\left(\frac{3\pi}{4}\right)$ oe (18.8)	M1	
	$\left[6\pi + 16\tan\left(\frac{3\pi}{8}\right)\right] = 57.5$	A1	Accept 57.4 to 57.5
5 (a)	Permutation because the order matters oe	B1	
(b) (i)	${}^6C_4 + {}^5C_4 + {}^7C_4$ 55	M1 A1	3 correct terms added
(ii)	${}^2C_1 \times {}^6C_1 \times {}^5C_1 \times {}^7C_1$ 420	M1 A1	4 correct terms multiplied
(iii)	${}^6C_3 \times {}^2C_1$ or ${}^2C_2 \times {}^5C_1 \times {}^6C_1$ summation 70	M1 M1 A1	for either correct product adding two correct products If 0 scored, then SC1for 1,1,1,0 and 0,0,2,1 seen
6 (i)	$2t^2 - 14t + 12 = 0$ $(t-1)(t-6)$ oe	M1	Can use formula, etc.
	$(t=)\ 1$	A1	If $t = 1$ with no working, then M1A1
(ii)	$\int(2t^2 - 14t + 12)\,\mathrm{d}t$	M1	
	$(s=)\ \frac{2t^3}{3} - \frac{14t^2}{2} + 12t$	A2,1,0	–1 for each error or for $+c$ left in or limits introduced
(iii)	$(a=)\frac{\mathrm{d}v}{\mathrm{d}t}$ $(4t-14)$	M1	
	[4(3) – 14 =] –2 cao	A1	

7 **(a)**	$\overrightarrow{AB} = 15\mathbf{b} - 5\mathbf{a} = 5(3\mathbf{b} - \mathbf{a})$ or $\overrightarrow{BC} = 24\mathbf{b} - 3\mathbf{a} - 15\mathbf{b} = 3(3\mathbf{b} - \mathbf{a})$ or $\overrightarrow{AC} = 24\mathbf{b} - 3\mathbf{a} - 5\mathbf{a} = 8(3\mathbf{b} - \mathbf{a})$	B1 B1	Any correct simplified vector Any second simplified vector
	Comment: e.g. the vectors are scalar multiples of each other AND they have a common point (*A*, *B* or *C* as appropriate)	B1dep	Dep on both B marks being awarded.
(b) **(i)**	$2\mathbf{i} + 11\mathbf{j}$ soi $\Rightarrow \sqrt{2^2 + 11^2}$	B1	
	$\sqrt{125}$ or $5\sqrt{5}$ or 11.2 (3 s.f.) or better)	B1fT	ft *their* $2\mathbf{i} + 11\mathbf{j}$ (not $\overrightarrow{OP}$ or $\overrightarrow{OQ}$)
(ii)	$\frac{1}{5\sqrt{5}}(2\mathbf{i} + 11\mathbf{j})$ isw	B1fT	ft *their* answers from **(i)**
(iii)	$\frac{\mathbf{i}-4\mathbf{j}+3\mathbf{i}+7\mathbf{j}}{2}$ or $\mathbf{i}-4\mathbf{j}+\frac{2\mathbf{i}+11\mathbf{j}}{2}$ or $3\mathbf{i}+7\mathbf{j}-\frac{2\mathbf{i}+11\mathbf{j}}{2}$	M1	
	$2\mathbf{i}+1.5\mathbf{j}$	A1	
8 **(a)** **(i)**	ke^{4x+3} $(+c)$ oe	M1	any constant, non-zero k
	$k = \frac{1}{4}$ oe	A1	
(ii)	$\frac{1}{4}\left(e^{4(3)+3} - e^{4(2.5)+3}\right)$ or better	DM1	ft *their* integral attempt
	706 650.99… = 707 000 to 3 sf or better	A1	Accept $\frac{1}{4}\left(e^{15} - e^{13}\right)$
(b) **(i)**	$k\sin\left(\frac{x}{3}\right)$ $(+ c)$ $k = 3$	M1 A1	any constant, non-zero k
(ii)	$3\sin\left(\frac{\pi}{6}\times\frac{1}{3}\right) - 3\sin(0)$	DM1	Dep on *their* integral attempt in sin; condone omission of lower limit
	0.520 944… = 0.521 to 3 sf or better	A1	Accept $3\sin\left(\frac{\pi}{18}\right)$
(c)	$\int\left(x^{-2}+2+x^2\right)dx = \frac{x^{-1}}{-1}+2x+\frac{x^3}{3}$	B1 M1 A1	Expands – accept unsimplified integration of *their* 3 term expansion Fully correct
	$+ c$	B1	$+c$

9 (a)	$(4x-1)(x+5)\ [\leqslant 0]$ critical values $\frac{1}{4}$ and –5 soi $-5 \leqslant x \leqslant \frac{1}{4}$	M1 A1 A1	Solves quadratic Accept: $\left[-5, \frac{1}{4}\right]$; $-5 \le x$ AND $x \le 0.25$
(b) (i)	$(x+4)^2 - 25$ or $a = 4$ and $b = -25$	B1, B1	
(ii)	(Greatest value =) 25 $x = -4$	B1ft B1ft	Must be clear
(iii)		B1 B1	Correct shape with maximum in second quadrant and crossing positive and negative axes correctly All 3 intercepts correctly shown on graph
10 (i)	$\ln y = \ln(Ab^x) \Rightarrow \ln y = \ln A + \ln b^x$ $\Rightarrow \ln y = \ln A + x \ln b$	M1 A1	
(ii)	$\ln A = 11.4 \Rightarrow A = e^{their\ 11.4}$ $A = 90\,000$ cao $\ln b = -1$ $b = 0.4$ cao	M1 A1 M1 A1	condone misread of scale for M1 (11.2 only) Allow awrt –1
(iii)	$x = 2.5 \Rightarrow \ln y = 9$ $y = e^9$ or 8000 to 1 sf	M1 A1	 Allow awrt 8100
11 (i)	$7 - x, x, 6 - x$ oe *their* attempt at $7 - x + x + 6 - x + 16 = 25$ oe $x = 4$	B1 M1 A1	 Condone $x = 4$ for all 3 marks
(ii)	$23 - y, y, 9 - y$ oe $48 = 30 + 25 + 15 - 7 - 6 - (their\ 4 + y) + their\ 4$ oe soi $y = 9$	B1 M1 A1	or $n(A \cup C) = 48 - 16 = 32$ or $32 = 30 + 15 - (their\ 4 + y)$ or $48 = (23 - y) + 3 + 16 + y + 4 + 2 + (9 - y)$ Condone $y = 9$ for all 3 marks
(iii)	$n(C) = 15$ and $y + n(B \cap C) = 9 + 6 = 15$ [and so $A' \cap B' \cap C = \varnothing$].	B1	or equivalent deduction

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the March 2015 series

0606 ADDITIONAL MATHEMATICS

0606/22 Paper 2 (Paper 22), 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.

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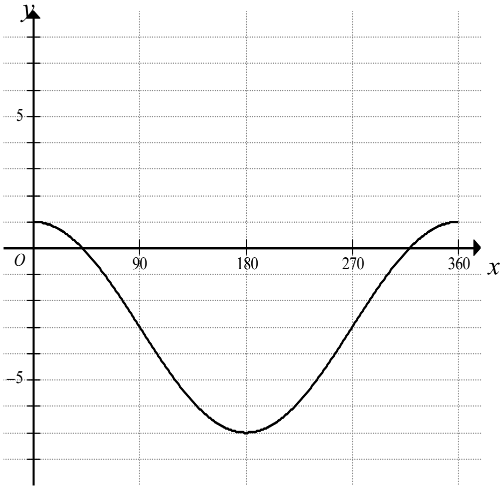
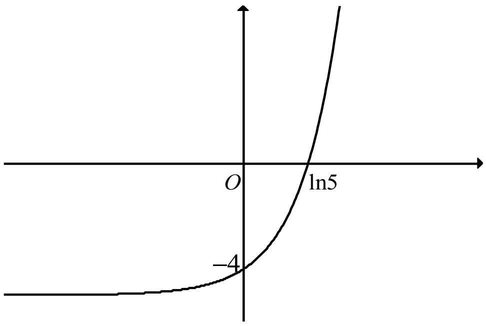
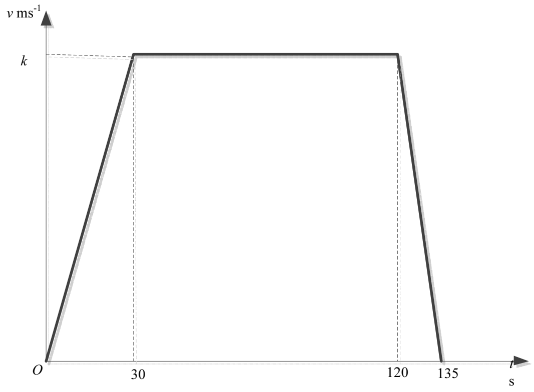
1 (i)	4	**B1**	
(ii)	360	**B1**	or 2π
(iii)		**B2**	Correct symmetrical shape; one cycle; both maximums at 1 and minimum at –7
2 (a) (i)	$\left({}^9C_3 =\right)$ 84	**B1**	
(ii)	$\left({}^9P_5 =\right)$ 15120	**B1**	
(b)	$\frac{2}{6} \times 6!$ or $5! + 5!$ oe 240	**M1** **A1**	or clear indication of method
3	Eliminate x or y $3x^2 + 2x - 8 = 0$ or $12y^2 - 44y + 32 = 0$ oe	**M1** **A1**	
	Factorise 3 term quadratic oe	**M1**	correct method
	$x = \frac{4}{3}$ and –2	**A1**	
	$y = \frac{8}{3}$ and 1	**A1**	Or allow **A1 A1** for each (x, y) pair If second **M0** then **SC1** for **one** (x, y) pair found by inspection i.e. with no method or with no incorrect method shown

4 **(i)**	$\sin x\left(their\left(-\sin x\right)\right)+\cos x\left(their\cos x\right)$	**M1**	clearly applies correct form of product rule
	$-\sin^2 x+\cos^2 x$ oe	**A1**	If **M1 A0 A0** then allow **SC1** for
	$1-2\sin^2 x$ oe	**A1**	$\sin^2 x-\cos^2 x=2\sin^2 x-1$
(ii)	$\int\left(1-2\sin^2 x\right)\mathrm{d}x=\sin x\cos x\left(+c\right)$	**M1**	**or** $\int\sin^2 x\mathrm{d}x=\frac{1}{-2}\left(\int\left(-2\sin^2 x+1\right)\mathrm{d}x-\int 1\mathrm{d}x\right)$ oe
	$-2\int\sin^2 x\mathrm{d}x=\sin x\cos x-\int 1\mathrm{d}x$	**M1**	$\int\sin^2 x\mathrm{d}x=\frac{1}{-2}\sin x\cos x-\frac{1}{-2}\int 1\mathrm{d}x$
	$\frac{x}{2}-\frac{1}{2}\sin x\cos x$ [+ c] oe isw	**A1**	
5 **(i)**	6**i** + 2**j** – (–2**i** + 17**j**) = 8**i** – 15**j**	**B1**	
(ii)	$\sqrt{their 8^2+their\left(-15\right)^2}$	**M1**	
	$\frac{their\left(8\mathbf{i}-15\mathbf{j}\right)}{their 17}$	**A1ft**	**ft** *their* $\overrightarrow{AB}$
(iii)	–2**i** + 17**j** + m(6**i** + 2**j**) leading to		
	17 + 2m = 0	**M1**	
	m = –8.5 oe	**M1**	
	–53**i**	**A1**	If **M0**, allow **SC1** for 6m – 2 = 0 leading to $\frac{53}{3}$**j**
6 **(i)**	15π = 20θ	**M1**	
	$\theta=\frac{3}{4}\pi$ or exact equivalent form isw	**A1**	
(ii)	Sector plus triangle approach:		Semicircle less segment approach:
	Area sector $=\frac{1}{2}\times 20^2\times\left(their\frac{3}{4}\pi\right)$ soi	**B1**	Area sector $=\frac{1}{2}\times 20^2\times\left(their\frac{1}{4}\pi\right)$ soi
	Area triangle $=\frac{1}{2}\times 20^2\times\sin\left(their\frac{1}{4}\pi\right)$ soi	**B1**	
	their sector area + *their* triangle area	**M1**	$\frac{\pi\left(20\right)^2}{2}$ – (*their* area sector – *their* area triangle) soi
	613 or 612.6(60254…) rot to 4 sig figs	**A1**	

7 **(i)**	$\mathbf{A}^2 = \begin{pmatrix} -14 & 45 \\ -27 & 85 \end{pmatrix}$ seen	**M1**	condone one error
	$\begin{pmatrix} -11 & 50 \\ -23 & 95 \end{pmatrix}$	**A1**	
(ii)	10	**B1**	
(iii)	$\dfrac{1}{their10}$ or $\begin{pmatrix} 10 & -5 \\ -4 & 3 \end{pmatrix}$ oe, seen	**B1**	
	$\dfrac{1}{10}\begin{pmatrix} 10 & -5 \\ -4 & 3 \end{pmatrix}$ oe isw	**B1**	
(iv)	$\mathbf{X} = \mathbf{B}^{-1}\mathbf{A}$ soi	**M1**	
	$\begin{pmatrix} 0.5 & 0 \\ -0.5 & 1 \end{pmatrix}$ oe	**A1ft**	**ft** *their* $\mathbf{B}^{-1}$
8 **(i)**	(4, 2)	**B1**	allow unsimplified
	$m_{AB} = \dfrac{3}{2} \Rightarrow m_{Perp} = -\dfrac{2}{3}$	**M1**	allow arithmetic slips provided method is correct
	$y - 2 = -\dfrac{2}{3}(x - 4)$ oe	**M1**	**ft** *their* mid-point and perpendicular gradient
	$2x + 3y = 14$	**A1**	allow any correct equivalent form with integer *a*, *b*, *c*
(ii)	m_{AB} used $y + 2 = their\ m_{AB}(x - 10)$	**M1** **A1ft**	
(iii)	$(10-6)^2 + (5-(-2))^2$ oe	**M1**	any valid method
	$\sqrt{65}$ or 8.0622577… rot to 3 or more sf	**A1**	
(iv)	$AC^2 = (2-10)^2 + (-1-(-2))^2$ and $AC^2 = BC^2 = 65$ **or** showing *C* lies on the perpendicular bisector of *AB* **or** showing line from *C* to (4, 2) is perpendicular to *AB*	**B1**	any valid method

9 **(i)**	$k(2x+1)^{-3}$ $-8(2x+1)^{-3}\times 2$ oe $+\ 2$ *their* $\frac{dy}{dx}=0$ and solves $x=\frac{1}{2},\ \ y=2$	**M1** **A1** **B1** **M1** **A1**	
(ii)	$y=4\times\frac{1}{2}=2$	**B1**	or equivalent correct method
(iii)	$\int\left(\frac{4}{(2x+1)^2}+2x\right)dx$ $4\times\frac{(2x+1)^{-1}}{-2}+\frac{2x^2}{2}$ or better $\left[\textit{their}\left(4\times\frac{(2x+1)^{-1}}{-2}+\frac{2x^2}{2}\right)\right]_0^{\textit{their}\,0.5}$ Substitution of correct limits seen, leading to $1\frac{1}{4}$ Shaded area = *their* $1\frac{1}{4}$ – *their* $\frac{1}{2}$ $\frac{3}{4}$	**M1** **A1** **M1** **A1** **M1** **A1**	**Alternative method:** **M1** for $\int\left(\frac{4}{(2x+1)^2}+2x-4x\right)dx$ **A1** for $4\times\frac{(2x+1)^{-1}}{-2}+\frac{2x^2}{2}-2x^2$ or better **M1** for $\left[\textit{their}\left(4\times\frac{(2x+1)^{-1}}{-2}-\frac{2x^2}{2}\right)\right]_0^{\textit{their}\,0.5}$ **M1** for subst of *their* limits into *their* genuine attempt at an integral **A1** for subst of correct limits into correct expression **A1** for for $\frac{3}{4}$

10 (a)(i)		B3	**B1** correct shape **B1** through (0, –4) **B1** through (ln5, 0)
(ii)	$k \leqslant -5$	B1	
(b)	$\frac{1}{2}\log_a 2 + 3\log_a 2 - \log_a 2$ or $\log_a\left(2^{\frac{1}{2}} \times 2^3 \times 2^{-1}\right)$ oe	M1	condone one error
	$2\frac{1}{2}\log_a 2$ oe	A1	
(c)	$\log_9 4x = \frac{\log_3 4x}{\log_3 9}$ **or** $\log_3 x = \frac{\log_9 x}{\log_9 3}$	B1	soi
	$\log_3 x - \frac{\log_3 4x}{2} = 1$ **or** $\frac{\log_9 x}{\frac{1}{2}} - \log_9 4x = 1$	M1	
	$\log_3 \frac{x}{(4x)^{\frac{1}{2}}} = \log_3 3$ **or** $\log_9 \frac{x^2}{4x} = \log_9 9$ oe	M1	
	$x = 36$	A1	

11 (a)(i)		B2	Horizontal line of correct length; deceleration correctly drawn; key times soi on horizontal axis
(ii)	$450 = \frac{1}{2} \times 30 \times k$	M1	
	$k = 30$	A1	
	$a = \frac{their30}{30}$	M1	
	$a = 1$ [ms^{-2}]	A1	
(b)	$v = \int a\mathrm{d}t = \int (3t^2 + 6)\mathrm{d}t$	M1	
	$(v =)\ t^3 + 6t + 5$	A2	**A1** for two terms correct
	When $t = 3$, $v = 3^3 + 6(3) + 5$	M1	
	50 [ms^{-1}]	A1	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2014 series

0606 ADDITIONAL MATHEMATICS

0606/21 Paper 2, maximum raw mark 80

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Cambridge is publishing the mark schemes for the October/November 2014 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

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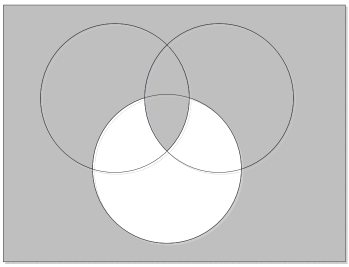
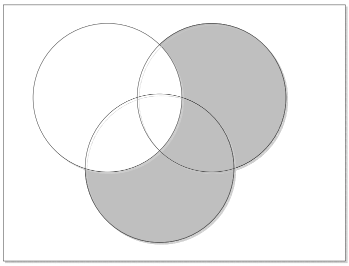
International Examinations

1 **(a)**		**B1**	
		**B1**	
(b)	No.in H only $=50-x$; No in F only $=60-x$ Sum: $50-x+60-x+x+30-2x=98$ $x=14$	**B1** **M1** **A1**	Both written or on diagram Add at least 3 terms each with x involved and equate to 98 soi
2	$9x^2+2x-1<(x+1)^2$ $8x^2<2$ oe isw $-\frac{1}{2}<x<\frac{1}{2}$	**M1** **A1** **A1**	Expand and collect terms
3	$\log_2(x+3)=\log_2 y+2 \quad \rightarrow \quad x+3=4y$ $\log_2(x+y)=3 \quad \rightarrow \quad x+y=8$ $x+3=4(8-x)$ $5x=29 \quad \rightarrow \quad x=5.8,$ oe $y=2.2$ oe	**B1** **B1** **M1** **A1** **A1**	 Eliminate y or x from two linear three term equations

4 **(i)**	$\mathrm{f}(37)=3$ or $\mathrm{gf}(x)=\dfrac{\sqrt{x-1}-3-2}{2\left(\sqrt{x-1}-3\right)-3}$	**B1**	
	$\mathrm{gf}(37)=\dfrac{3-2}{6-3}=\dfrac{1}{3}$	**B1**	
(ii)	$y=\sqrt{x-1}-3 \rightarrow (y+3)^2=x-1$	**M1**	Rearrange and square in any order
	$(x+3)^2+1=\mathrm{f}^{-1}(x)$ oe isw	**A1**	Interchange x and y and complete
(iii)	$y=\dfrac{x-2}{2x-3}$		
	$2xy-3y=x-2 \rightarrow 2xy-x=3y-2$	**M1**	Multiply and collect like terms
	$\dfrac{3x-2}{2x-1}=\mathrm{g}^{-1}(x)$ oe	**A1**	Interchange and complete Mark final answer
5 **(i)**	$B=900$	**B1**	
(ii)	$B = 500 + 400e^2 = 3455$ or 3456 or 3460	**B1**	3455.6 scores **B0**
(iii)	$\left(\dfrac{\mathrm{d}B}{\mathrm{d}t}=\right)80\mathrm{e}^{0.2t}$	**B1**	
	$t=10 \rightarrow \dfrac{\mathrm{d}B}{\mathrm{d}t}=80\mathrm{e}^2=591\,(/\text{day})$	**B1**	awrt
(iv)	$10000=500+400\mathrm{e}^{0.2t} \rightarrow \mathrm{e}^{0.2t}=(23.75)$	**M1**	$\mathrm{e}^{0.2t}=k$
	$0.2t=\ln 23.75$	**DM1**	take logs: $0.2t = \ln k$
	$t=15.8\,(\text{days})$	**A1**	awrt

6	(i)	$(x+2)^2 + x^2 = 10$ $x^2 + 2x - 3 = 0 \quad \to \quad (x+3)(x-1) = 0$ Points (1, 3), (–3, –1) isw or elimination of x leads to $y^2 - 2y - 3 = 0$, then as above	B1 M1 A1 A1	 3 term quadratic with attempt to solve both x or a pair both y or second pair
	(ii)	$m^2x^2 + 10mx + 25 + x^2 = 10$ $(m^2+1)x^2 + 10mx + 15 = 0$ $b^2 - 4ac = (0) \quad \to \quad 100m^2 - 60(m^2+1) = 0$ $m = \pm\sqrt{\frac{3}{2}}$ oe isw Alternative solution: $\frac{dy}{dx} = \frac{-x}{\sqrt{10-x^2}}$ or $\frac{dy}{dx} = -\frac{x}{y}$ Result: $y^2 = x^2 + 5y$ after inserted in $y = mx + 5$ Attempt to solve with $x^2 + y^2 = 10$ $y = 2, x = \pm\sqrt{6}$ $m = \pm\frac{3}{\sqrt{6}}$ oe	B1 M1 A1 A1 B1 M1 A1 A1	 attempt to use discriminant on three term quadratic. Allow unsimplified cao ± is required allow unsimplified Eliminate x or y both
7	(i)	$v = 2\cos t + 1$	B1	mark final answer
	(ii)	$2\cos t + 1 = 0$ $t = \frac{2\pi}{3}$ or 2.09	M1 A1	equate their v to zero (must be a differential) and attempt to solve to find an **angle** awrt
	(iii)	$t = \frac{2\pi}{3} \quad \to \quad x = 2\sin\left(\frac{2\pi}{3}\right) + \frac{2\pi}{3} = 3.83\,\text{m}$ $a = -2\sin t$ $t = \frac{2\pi}{3} a = -\sqrt{3} = -\frac{1.73}{4}\text{ms}^{-2}$	B1 B1ft DB1ft	awrt ft *their* v (2nd differential) ft using *their* **angle** t in correct a awrt
8	(i)	$\frac{dy}{dx} = \frac{(2+x^2)\times 2x - x^2 \times 2x}{(2+x^2)^2} = \frac{4x}{(2+x^2)^2}$ $k = 4$	M1 A1 A1	apply quotient or product rule unsimplified k=4 does not need to be specifically identified
	(ii)	$\int \frac{x}{(2+x^2)^2} dx = \frac{1}{4} \times \frac{x^2}{2+x^2} + (c)$ isw	B1 B1	$\frac{1}{\textit{their } k} \times$ original function

9	$\left(a+3\sqrt{5}\right)^2 = a^2 + 3\sqrt{5}a + 3\sqrt{5}a + 45$ oe	**B1**	anywhere
	Equate: $a^2 + a + 45 = 51$ and $6a - b = 0$	**B1** **B1**	
	$(a+3)(a-2) = 0$	**M1**	Attempt to solve three term quadratic with integer coefficients obtained by equating coeffs
	$a = -3, 2$ $b = -18, 12$	**A1** **A1**	Both *a*s correct or one correct pair Both *b*s correct
10 (i)	$\sec x \operatorname{cosec} x = \dfrac{1}{\cos x \sin x}$	**B1**	anywhere
	$\cot x = \dfrac{\cos x}{\sin x}$	**B1**	anywhere
	LHS = $\dfrac{1-\cos^2 x}{\cos x \sin x}$ oe	**B1ft**	correct addition of *their* terms
	$= \dfrac{\sin^2 x}{\cos x \sin x} = \tan x$ AG	**B1**	use of identity and cancel
(ii)	$3\cot x - \cot x = \tan x \rightarrow 2\cot x = \tan x$	**M1**	equate and collect like terms, allow sign errors
	$\tan^2 x = 2$ oe x = 54.7, 125.3, 234.7, 305.3	**A1** **A1** **A1**	 2 values only 2 more values. awrt
11 (i)	Area of sector = $\dfrac{1}{2} \times x^2 \times 0.8 \left(= 0.4x^2 \text{ cm}^2\right)$	**B1**	anywhere
	$SR = 5\sin 0.8 \,(= 3.59)$ or $OR = 5\cos 0.8 \,(= 3.48)$	**B1**	*SR* may be seen in stated $\dfrac{1}{2}ab\sin C$
	Area of triangle = $\dfrac{1}{2} 5\cos 0.8 \times 5\sin 0.8 = 6.247\,\text{cm}^2$	**M1** **A1**	insert correct terms into correct area formulae
	$0.08x^2 = 6.247$ $x = 8.837\,\text{cm}$ AG	**A1**	
(ii)	$SQ = 8.84 - 5 \,(= 3.84\,\text{cm})$ $PR = 8.84 - 5\cos 0.8 \,(= 5.35 \text{ or } 5.36\,\text{cm})$	**B1**	two lengths from *SQ, PR, PQ* awrt
	$PQ = 8.84 \times 0.8 \,(= 7.07\,\text{cm})$	**B1**	third length awrt
	Perimeter = 19.84 to 19.86 cm or rounded to 19.8 or 19.9	**B1**	sum
(iii)	Area $PQSR = 4 \times 6.247$	**M1**	
	$= 25\,\text{cm}^2$	**A1**	24.95 to 25

12 (i)	$f(2)=3(2^3)-14(2^2)+32=0$ Or complete long division	**B1**	
(ii)	$f(x)=(x-2)(3x^2-8x-16)$ $f(x)=(x-2)(x-4)(3x+4)$	**M1** **A1** **M1** **A1**	$3x^2$ and 16 $8x$ and correct signs Factorise three term quadratic
(iii)	$x = 2, 4$	**B1**	
(iv)	$\int 3x-14+\frac{32}{x^2}\,dx = 1.5x^2-14x-\frac{32}{x}(+c)$ Area = $\left[1.5x^2-14x-\frac{32}{x}\right]_2^4$ = (–) 2	**B1** **B1** **M1** **A1**	first 2 terms third term correct unsimplified Limits of 2 and 4 and subtract

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2014 series

0606 ADDITIONAL MATHEMATICS

0606/22 Paper 2, maximum raw mark 80

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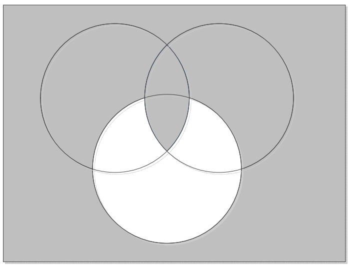
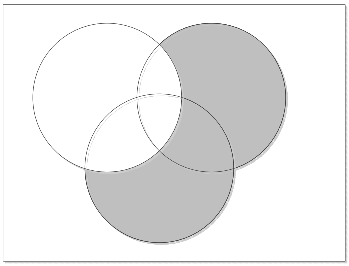
International Examinations

1 (a)		**B1**	
		**B1**	
(b)	No.in H only $= 50 - x$; No in F only $= 60 - x$	**B1**	Both written or on diagram
	Sum: $50 - x + 60 - x + x + 30 - 2x = 98$	**M1**	Add at least 3 terms each with x involved and equate to 98 soi
	$x = 14$	**A1**	
2	$9x^2 + 2x - 1 < (x+1)^2$	**M1**	Expand and collect terms
	$8x^2 < 2$ oe isw	**A1**	
	$-\frac{1}{2} < x < \frac{1}{2}$	**A1**	
3	$\log_2(x+3) = \log_2 y + 2 \rightarrow x + 3 = 4y$	**B1**	
	$\log_2(x+y) = 3 \rightarrow x + y = 8$	**B1**	
	$x + 3 = 4(8 - x)$	**M1**	Eliminate y or x from two linear three term equations
	$5x = 29 \rightarrow x = 5.8$, oe	**A1**	
	$y = 2.2$ oe	**A1**	

4 (i)	$f(37)=3$ or $gf(x)=\dfrac{\sqrt{x-1}-3-2}{2\left(\sqrt{x-1}-3\right)-3}$	**B1**	
	$gf(37)=\dfrac{3-2}{6-3}=\dfrac{1}{3}$	**B1**	
(ii)	$y=\sqrt{x-1}-3 \rightarrow (y+3)^2=x-1$	**M1**	Rearrange and square in any order
	$(x+3)^2+1=f^{-1}(x)$ oe isw	**A1**	Interchange x and y and complete
(iii)	$y=\dfrac{x-2}{2x-3}$		
	$2xy-3y=x-2 \rightarrow 2xy-x=3y-2$	**M1**	Multiply and collect like terms
	$\dfrac{3x-2}{2x-1}=g^{-1}(x)$ oe	**A1**	Interchange and complete Mark final answer
5 (i)	$B=900$	**B1**	
(ii)	$B = 500 + 400e^2 = 3455$ or 3456 or 3460	**B1**	3455.6 scores **B0**
(iii)	$\left(\dfrac{dB}{dt}=\right)80e^{0.2t}$	**B1**	
	$t=10 \rightarrow \dfrac{dB}{dt}=80e^2=591\,(/\text{day})$	**B1**	awrt
(iv)	$10000=500+400e^{0.2t} \rightarrow e^{0.2t}=(23.75)$	**M1**	$e^{0.2t}=k$
	$0.2t=\ln 23.75$	**DM1**	take logs: $0.2t = \ln k$
	$t=15.8\,(\text{days})$	**A1**	awrt

6 (i)	$(x+2)^2 + x^2 = 10$	**B1**	
	$x^2+2x-3=0 \;\rightarrow\; (x+3)(x-1)=0$	**M1**	3 term quadratic with attempt to solve
	Points (1, 3), (–3, –1) isw	**A1** **A1**	both x or a pair both y or second pair
	or elimination of x leads to $y^2 - 2y - 3 = 0$, then as above		
(ii)	$m^2x^2 + 10mx + 25 + x^2 = 10$	**B1**	
	$(m^2+1)x^2 + 10mx + 15 = 0$		
	$b^2 - 4ac = (0) \;\rightarrow\; 100m^2 - 60(m^2+1) = 0$	**M1** **A1**	attempt to use discriminant on three term quadratic. Allow unsimplified
	$m = \pm\sqrt{\frac{3}{2}}$ oe isw	**A1**	cao ± is required
	Alternative solution: $\frac{dy}{dx} = \frac{-x}{\sqrt{10-x^2}}$ or $\frac{dy}{dx} = -\frac{x}{y}$	**B1**	allow unsimplified
	Result: $y^2 = x^2 + 5y$ after inserted in $y = mx + 5$		
	Attempt to solve with $x^2 + y^2 = 10$	**M1**	Eliminate x or y
	$y = 2, x = \pm\sqrt{6}$	**A1**	both
	$m = \pm\frac{3}{\sqrt{6}}$ oe	**A1**	
7 (i)	$v = 2\cos t + 1$	**B1**	mark final answer
(ii)	$2\cos t + 1 = 0$	**M1**	equate their v to zero (must be a differential) and attempt to solve to find an **angle**
	$t = \frac{2\pi}{3}$ or 2.09	**A1**	awrt
(iii)	$t = \frac{2\pi}{3} \;\rightarrow\; x = 2\sin\left(\frac{2\pi}{3}\right) + \frac{2\pi}{3} = 3.83\,\text{m}$	**B1**	awrt
	$a = -2\sin t$	**B1ft**	ft *their* v (2nd differential)
	$t = \frac{2\pi}{3}\; a = -\sqrt{3} = -\frac{1.73}{4}\,\text{ms}^{-2}$	**DB1ft**	ft using *their* **angle** t in correct a awrt
8 (i)	$\frac{dy}{dx} = \frac{(2+x^2)\times 2x - x^2 \times 2x}{(2+x^2)^2} = \frac{4x}{(2+x^2)^2}$	**M1** **A1**	apply quotient or product rule unsimplified
	$k = 4$	**A1**	k=4 does not need to be specifically identified
(ii)	$\int \frac{x}{(2+x^2)^2}\,dx = \frac{1}{4} \times \frac{x^2}{2+x^2} + (c)$ isw	**B1** **B1**	$\frac{1}{\textit{their } k} \times$ original function

9	$\left(a+3\sqrt{5}\right)^2 = a^2 + 3\sqrt{5}a + 3\sqrt{5}a + 45$ oe	**B1**	anywhere
	Equate: $a^2 + a + 45 = 51$ and $6a - b = 0$	**B1** **B1**	
	$(a+3)(a-2)=0$	**M1**	Attempt to solve three term quadratic with integer coefficients obtained by equating coeffs
	$a = -3, 2$ $b = -18, 12$	**A1** **A1**	Both *a*s correct or one correct pair Both *b*s correct
10 (i)	sec*x*cosec*x* = $\dfrac{1}{\cos x \sin x}$	**B1**	anywhere
	$\cot x = \dfrac{\cos x}{\sin x}$	**B1**	anywhere
	LHS = $\dfrac{1-\cos^2 x}{\cos x \sin x}$ oe	**B1ft**	correct addition of *their* terms
	$= \dfrac{\sin^2 x}{\cos x \sin x} = \tan x$ AG	**B1**	use of identity and cancel
(ii)	$3\cot x - \cot x = \tan x \rightarrow 2\cot x = \tan x$	**M1**	equate and collect like terms, allow sign errors
	$\tan^2 x = 2$ oe x = 54.7, 125.3, 234.7, 305.3	**A1** **A1** **A1**	 2 values only 2 more values. awrt
11 (i)	Area of sector = $\dfrac{1}{2} \times x^2 \times 0.8 \left(= 0.4x^2 \text{ cm}^2\right)$	**B1**	anywhere
	$SR = 5\sin 0.8 \,(= 3.59)$ or $OR = 5\cos 0.8 \,(= 3.48)$	**B1**	*SR* may be seen in stated $\dfrac{1}{2}ab\sin C$
	Area of triangle = $\dfrac{1}{2}5\cos 0.8 \times 5\sin 0.8 = 6.247\,\text{cm}^2$ $0.08x^2 = 6.247$ $x = 8.837\,\text{cm}$ AG	**M1** **A1** **A1**	insert correct terms into correct area formulae
(ii)	$SQ = 8.84 - 5 \,(= 3.84\,\text{cm})$ $PR = 8.84 - 5\cos 0.8 \,(= 5.35 \text{ or } 5.36\,\text{cm})$ $PQ = 8.84 \times 0.8 \,(= 7.07\,\text{cm})$ Perimeter = 19.84 to 19.86 cm or rounded to 19.8 or 19.9	 **B1** **B1** **B1**	 two lengths from *SQ, PR, PQ* awrt third length awrt sum
(iii)	Area $PQSR = 4 \times 6.247$ $= 25\,\text{cm}^2$	**M1** **A1**	 24.95 to 25

12 (i)	$f(2)=3(2^3)-14(2^2)+32=0$ Or complete long division	B1	
(ii)	$f(x)=(x-2)(3x^2-8x-16)$ $f(x)=(x-2)(x-4)(3x+4)$	M1 A1 M1 A1	$3x^2$ and 16 $8x$ and correct signs Factorise three term quadratic
(iii)	$x=2, 4$	B1	
(iv)	$\int 3x-14+\frac{32}{x^2}\,dx=1.5x^2-14x-\frac{32}{x}(+c)$ Area = $\left[1.5x^2-14x-\frac{32}{x}\right]_2^4$ = (–) 2	B1 B1 M1 A1	first 2 terms third term correct unsimplified Limits of 2 and 4 and subtract

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the October/November 2014 series

0606 ADDITIONAL MATHEMATICS

0606/23 Paper 2, maximum raw mark 80

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1 (i)	$f(2)=0 \rightarrow 3(2)^3+8(2)^2-33(2)+p=0$	**M1**	
	correct working to $p = 10$ AG	**A1**	
	method for quadratic factor	**M1**	
	$f(x)=(x-2)(3x^2+14x-5)$	**A1**	
(ii)	$f(x)=(x-2)(3x-1)(x+5)$	**M1**	factorise or solve quadratic factor = 0
	$f(x)=0 \rightarrow x=2, -5, \frac{1}{3}$	**A1**	
2 (i)	${}^{12}C_4=495$	**B1**	
(ii)	${}^7C_2 \times {}^5C_2 = 21\times10$	**M1**	
	$=210$	**A1**	
(iii)	not K and B = ${}^6C_2\times{}^4C_1=15\times4=60$	**B1**	
	K and not B = ${}^6C_1\times{}^4C_2=6\times6=36$	**B1**	
	$60+36$	**M1**	
	96	**A1**	
	OR		
	K and B = ${}^6C_1\times{}^4C_1=6\times4=24$	**B1**	
	not K and not B = ${}^6C_2\times{}^4C_2=15\times6=90$	**B1**	
	$210-90-24$	**M1**	
	96	**A1**	
3 (i)	C is (1, 6)	**B1**	
	D is $(1, 6)+(12, 9)$	**M1**	
	= (13, 15)	**A1ft**	
(ii)	gradient of $CD = \frac{15-6}{13-1}\left(=\frac{3}{4}\right)$	**B1ft**	
	gradient of $AB = \frac{10-2}{-2-4}\left(=\frac{8}{-6}=\frac{-4}{3}\right)$	**B1**	
	$\frac{3}{4}\times\frac{-4}{3}=-1$ lines are perpendicular	**B1**	correct completion www
(iii)	area = $\frac{1}{2}\times AB\times CD=\frac{1}{2}\times10\times15$	**M1**	good attempt at two relevant lengths for $\frac{1}{2}$ base × height method
	=75	**A1**	
	or array method		

4 (i)	$2000 = 1000e^{a+b} \quad \rightarrow \quad a+b = \ln 2$	**B1**	
(ii)	$3297 = 1000e^{2a-b} \quad \rightarrow \quad 2a+b$ $= \ln 3.297$ oe	**M1** **A1**	substitution of 2, 3297 and rearrange
(iii)	Solve for one value $a = 0.5$ and $b = 0.193$ or 0.19	**M1** **A1**	
(iv)	$n = 10 \quad P = 1000e^{5.193}$ $= \$180\,000.$	**M1** **A1**	
5 (i)	$\overrightarrow{OX} = \mu(a+b)$	**B1**	
(ii)	$\overrightarrow{RP} = b - 3a$ or $\overrightarrow{RX} = \lambda(b-3a)$ oe $\overrightarrow{OX} = 3a + \lambda(b-3a)$	**B1** **B1**	
(iii)	$\overrightarrow{OX} = \overrightarrow{OX}$ and equate both coefficients $\mu = 3 - 3\lambda \qquad \mu = \lambda$ $\mu = \lambda = 0.75$ $\dfrac{RX}{XP} = 3$ or 3:1	 **M1** **A1** **A1ft**	 $\dfrac{\lambda}{1-\lambda}$
6 (i)	$m = 4$ equation of line is $\dfrac{\ln y - 39}{3^x - 9} = \dfrac{39-19}{9-4}$ $\ln y = 4(3^x) + 3$	**B1** **M1** **A1ft**	 forms equation of line ft only on their gradient
(ii)	$x = 0.5 \quad \rightarrow \quad \ln y = 4\sqrt{3} + 3 = 9.928$ $y = 20\,500$	**M1** **A1**	correct expression for ln$y$
(iii)	Substitutes y and rearrange for 3^x Solve $3^x = 1.150$ $x = 0.127$	**M1** **M1** **A1**	

7 (i)	$x = \frac{2}{y} + 1 \quad \rightarrow \quad y = \frac{2}{x-1}$	**M1**	any valid method
	$f^{-1}(x) = \frac{2}{x-1}$	**A1**	
(ii)	$gf(x) = \left(\frac{2}{x} + 1\right)^2 + 2$	**B2/1/0**	–1 each error
(iii)	$fg(x) = \frac{2}{x^2 + 2} + 1$	**B2/1/0**	–1 each error
(iv)	$ff(x) = \frac{2}{\frac{2}{x} + 1} + 1 = \frac{2x}{x+2} + 1$	**M1**	correct starting expression
	$= \frac{3x+2}{x+2}$	**A1**	correct algebra to given answer
	$\frac{3x+2}{x+2} = x \quad \rightarrow \quad x^2 - x - 2 = 0$	**M1**	form and solve 3 term quadratic
	$(x-2)(x+1) = 0$ $x = 2$ only	**A1**	
8 (i)	$v = C + K\sin 2t \qquad C \neq 0$ $v = 5 + 6\sin 2t$ $a = 12\cos 2t$	**M1** **A1** **A1ft**	
(ii)	$a = 0 \quad \rightarrow \quad \cos 2t = 0$ and solve	**M1**	set $a = 0$ and solve for t
	$t = \frac{\pi}{4}$ or 0.785 or 0.79	**A1**	
	$v = 5 + 6\sin\frac{\pi}{2} = 11$	**A1ft**	ft only on K
(iii)	$v = 2 \quad \rightarrow \quad \sin 2t = -\frac{1}{2}$ and solve	**M1**	set $v = 2$ and solve for t
	$t = \frac{7\pi}{12}$ or $1.83 - 1.84$	**A1**	
	$a = 12\cos\frac{7\pi}{6} = -6\sqrt{3}$ or -10.4	**A1**	

9 (i)	$\frac{dy}{dx} = 4 - \frac{1}{(x-2)^2}$	**B1**	
	$\frac{dy}{dx} = 0 \rightarrow (x-2)^2 = \frac{1}{4}$ $(4x^2 - 16x + 15 = 0)$	**M1**	solve 3 term quadratic from $\frac{dy}{dx} = 0$
	$x = 2.5$ or 1.5	**A1**	x values or 1 pair
	$y = 12$ or 4	**A1**	y values or 1 pair
	$\frac{d^2y}{dx^2} = 2(x-2)^{-3}$	**M1**	use $\frac{d^2y}{dx^2}$ with solution from $\frac{dy}{dx} = 0$
	$x = 2.5 \rightarrow \frac{d^2y}{dx^2} > 0 \rightarrow$ minimum $x = 1.5 \rightarrow \frac{d^2y}{dx^2} < 0 \rightarrow$ maximum	**A1**	both identified www
(ii)	$x = 3 \rightarrow \frac{dy}{dx} = 3$	**B1**	
	Use $m_1 m_2 = -1$ for gradient normal from gradient tangent	**M1**	must use numerical values
	Eqn of normal : $\frac{y-13}{x-3} = -\frac{1}{3}$	**A1ft**	
	Intersection of norm and curve $14 - \frac{x}{3} = 4x + \frac{1}{x-2}$	**M1**	equation and attempt to simplify
	$13x^2 - 68x + 87 = 0$	**DM1**	attempt to solve 3 term quadratic
	$x = \frac{29}{13}$ or 2.23	**A1**	
10 (i)	$\text{LHS} = \frac{1+\cos x + 1 - \cos x}{(1-\cos x)(1+\cos x)}$	**B1**	correct fraction
	$= \frac{2}{1-\cos^2 x}$	**B1**	correct evaluation
	$= \frac{2}{\sin^2 x} = \text{RHS}$	**B1**	use of $1-\cos^2 x = \sin^2 x$ and completion of fully correct proof
(ii)	$2\text{cosec}^2 x = 8$	**M1**	identity used
	$\sin^2 x = \frac{1}{4}$	**A1**	
	$\sin x = \pm\frac{1}{2}$	**A1**	
	$x = 30°, 150°, 210°, 330°$	**A1**	

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International General Certificate of Secondary Education

MARK SCHEME for the May/June 2014 series

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0606/21 Paper 2, maximum raw mark 80

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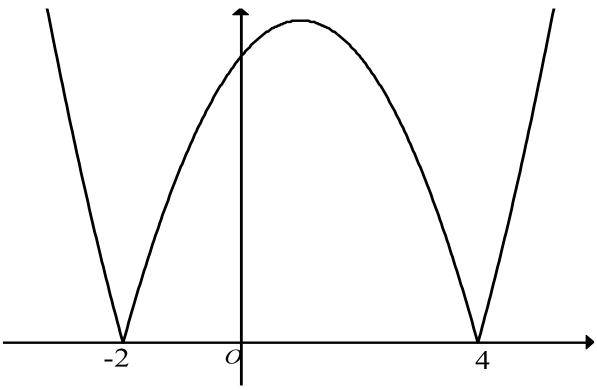
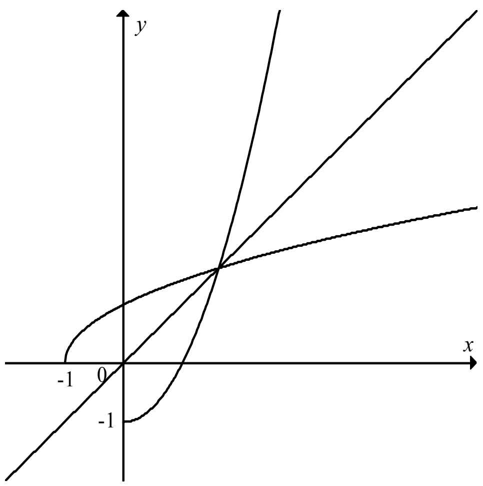
1	$x^2 + x\,[>0]$ critical values 0 and –1 soi $-1 < x < 0$	**M1** **A1** **A1**	expands and rearranges condone space, comma, "and" but not "or" Mark final answer.
2	$\frac{6}{(1+\sqrt{3})^2}$ or $6 = (a+b\sqrt{3})(1+\sqrt{3})^2$	**M1**	for dealing with the negative index (condone treating 6 as have negative index at this stage)
	$\frac{6}{4+2\sqrt{3}}$ or $6 = (a+b\sqrt{3})(4+2\sqrt{3})$	**M1**	for squaring
	$\frac{6}{4+2\sqrt{3}} \times \frac{4-2\sqrt{3}}{4-2\sqrt{3}}$ AND attempting to multiply out	**M1**	for rationalising or for obtaining a pair of simultaneous equations $4a + 6b = 6$ and $2a + 4b = 0$
	$6 - 3\sqrt{3}$ isw	**A1**	
3 (i)		**B1** **B1**	correct shape *x* intercepts marked or implied by tick marks, for example or seen nearby; condone *y* intercept omitted
(ii)	*x* = 1 (only) soi *y* = ± 9 (only) $0 < k < 9$	**B1** **B1** **B1**	can be implied by second **B1** or $k = \pm 9, +9$ or –9 or both; must be strict inequality in *k*; condone space, comma, "and", "or"
4	Attempt to find f(4) or f(1) or division to a remainder	**M1**	condone one error
	128 + 16*a* + 4*b* + 12 = 0 or better (16*a* + 4*b* = –140)	**A1**	
	2 + *a* + *b* + 12 = –12 or better (*a* + *b* = –26)	**A1**	
	Solves linear equations in *a* and *b*	**M1**	
	a = –3, *b* = –23	**A1**	both

5 (i)	$2\left(x-\frac{1}{4}\right)^2+\frac{47}{8}$ (5.875) isw	**B3,2,1,0**	one mark for each of p, q, r correct; allow correct equivalent values. If **B0**, then **SC2** for $2\left(x-\frac{1}{4}\right)+\frac{47}{8}$, or **SC1** for correct values but incorrect format
(ii)	$\frac{47}{8}$ is min value when $x=\frac{1}{4}$	**B1ft + B1ft**	strict **ft** *their* $\frac{47}{8}$ and *their* $\frac{1}{4}$; each value must be correctly attributed; condone $y=\frac{47}{8}$ for **B1**, or $\left(\frac{1}{4},\frac{47}{8}\right)$ for **B1B1**
6 (a)	${}^8C_3\times3^3\times(\pm2)^5$ or $3^8\left[{}^8C_3\left(\pm\frac{2}{3}\right)^5\right]$	**M1**	condone ${}^8C_5, -2x^5$
	–48384	**A1**	can be in expansion
(b) (i)	$1 + 12x + 60x^2$	**B2,1,0**	ignore additional terms. If **B0**, allow **M1** for 3 correct unsimplified terms
(ii)	Coefficient of x correct or correct **ft** $(12+a)$ soi Coefficient of x^2 correct or correct **ft** $(60+12a)$ soi	**B1ft** **B1ft**	**ft** *their* $1+12x+60x^2$ **ft** *their* $1+12x+60x^2$
	$1.5\times$ *their* $(12+a)=$ *their* $(60+12a)$ -4	**M1** **A1**	no x or x^2
7 (i)	$-\frac{1}{x^2}+\frac{1}{x^{1/2}}$	**B1 + B1**	or equivalent with negative indices
(ii)	$\frac{2}{x^3}-\frac{1}{2x^{3/2}}$	**B1ft + B1ft**	or equivalent with negative indices. Strict **ft**
(iii)	Attempting to solve *their* $\frac{dy}{dx}=0$	**M1**	must achieve $x =$… (allow slips)
	$x=1$ $y=3$	**A1**	**SC2** for (1, 3) stated, nfww
	Substitute *their* $x = 1$ into *their* $\frac{d^2y}{dx^2}$; or examines $\frac{dy}{dx}$ or y on both sides of *their* $x = 1$	**M1**	for using *their* value from $\frac{dy}{dx}=0$
	Complete and correct determination of nature. If correct, minimum.	**A1**	must be from correct work

8 **(i)**	$2r + r\theta = 30$ giving $\theta = \frac{30-2r}{r}$	**M1**	correct arc formula + (2)r rearranged
	Substitute *their* expression for θ into $A = \frac{1}{2}r^2\theta$	**M1**	
	Correct simplification to $A = 15r - r^2$ AG	**A1**	
(ii)	$15 - 2r = 0$ $r = 7.5$ 56.25	**M1** **A1** **A1**	*their* $\frac{\mathrm{d}A}{\mathrm{d}r} = 0$ 56.3 is **A0** unless 56.25 seen; if **M0**, then **SC2** for A = 56.25 with no working; or **SC1** for r = 7.5 with no working
9 **(i)**	(3, 5)	**B1B1**	column vector **B0B1**
(ii)	$m_{BD}\left(= \frac{6-4}{1-5}\right) = -\frac{1}{2}$	**M1**	can be implied by second M1
	$m_{AC}\left(= -1 \div -\frac{1}{2}\right)$ seen or used	**M1**	
	$y - 5 = 2(x-3)$ or $y = 2x + c$, $c = -1$ or better	**A1**	
(iii)	$p = 1$ $q = 7$ [A(1, 1) C(4, 7)] Method for finding area numerically	**M1** **M1**	could be in **(ii)** e.g. $24 - \left(\frac{1}{2}\times 1\times 3 + \frac{1}{2}\times 1\times 3 + \frac{1}{2}\times 4\right)$ or shoelace method
	15	**A1**	**SC2** for 15 with no working
10 **(i)**	$-2\sin 2x$ and $\frac{1}{3}\cos\left(\frac{x}{3}\right)$	**B1+B1**	each trig function correctly differentiated
	Attempt at product rule	**M1**	
	$\frac{1}{3}\cos 2x\cos\left(\frac{x}{3}\right) - 2\sin 2x\sin\left(\frac{x}{3}\right)$ isw	**A1ft**	**ft** $k_1 \sin 2x$ and $k_2 \cos\left(\frac{x}{3}\right)$ provided k_1, k_2 are non-zero
(ii)	$\sec^2 x$ and $\frac{1}{x}$	**B1 + B1**	
	Attempt at quotient rule (with given quotient)	**M1**	or rearrangement to correct product and attempt at product rule
	$\frac{(\sec^2 x)(1+\ln x) - \frac{1}{x}(\tan x)}{(1+\ln x)^2}$ isw	**A1**	penalise poor bracketing if not recovered

11 (a)	$2^{x^2-5x} = 2^{-6}$	M1	Or $\left(x^2-5x\right)\ln 2 = \ln\left(\frac{1}{64}\right) = -6\ln 2$
	$x^2 - 5x + 6 = 0$	M1	*their* "6"
	Correct method of solution of their 3 term quadratic	M1	
	$x = 2$ or $x = 3$	A1	
(b)	Correct change of base to $\frac{\log_a 4}{\log_a 2a}$	B1	base a only at this stage but can recover at end
	$\frac{\log_a 4}{\log_a 2 + \log_a a}$	M1	for $\log 2a = \log 2 + \log a$
	$\log_a a = 1$ used soi	M1	
	simplification to $\log_a 4$	A1	

12 (i)	f(3) $\frac{6}{4}$ oe	**M1** **A1**	or $\text{fg}(x)=\frac{2\sqrt{(x+1)}}{\sqrt{(x+1)}+1}$
(ii)	$\frac{2\left(\frac{2x}{x+1}\right)}{\frac{2x}{x+1}+1}$	**M1**	allow omission of 2(…..) in numerator or (…..) + 1 in denominator, but not both.
	A correct and valid step in simplification	**dM1**	e.g. multiplying numerator and denominator by $x+1$, , or simplifying $\frac{2x}{x+1}+1$ to $\frac{2x+x+1}{x+1}$
	Correctly simplified to $\frac{4x}{3x+1}$	**A1**	
(iii)	Putting $y=\text{g}(x)$, changing subject to x and swopping x and y or vice versa	**M1**	condone $x=y^2-1$; reasonable attempt at correct method
	$\text{g}^{-1}(x)=x^2-1$	**A1**	condone $y=$….. , $\text{f}^{-1}=$……
	(Domain) $x>0$ (Range) $\text{g}^{-1}(x)>-1$	**B1** **B1**	 condone $y>-1$ $\text{f}^{-1}>-1$
(iv)		**B1 + B1** **B1**	correct graphs; –1 need not be labelled but could be implied by 'one square' idea of reflection or symmetry in line $y=x$ must be stated.

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the May/June 2014 series

0606 ADDITIONAL MATHEMATICS

0606/22 Paper 2, maximum raw mark 80

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1	rationalise the denominator to get $\frac{(2+\sqrt{5})^2(\sqrt{5}+1)}{5-1}$ or better	**M1**	or squaring to get $\frac{(4+4\sqrt{5}+5)}{\sqrt{5}-1}$ or better
	squaring to get $\frac{(4+4\sqrt{5}+5)(\sqrt{5}+1)}{their4}$ or better	**M1**	or rationalising the denominator to get $\frac{their(9+4\sqrt{5})(\sqrt{5}+1)}{5-1}$ or better
	$\frac{29}{4}+\frac{13}{4}\sqrt{5}$ oe isw	**A1 + A1**	correct simplification Allow $\frac{29+13\sqrt{5}}{4}$ etc.
2	Correctly eliminate y	**M1**	$-kx+2=2x^2-9x+4$ oe
	$2x^2+(k-9)x+2[=0]$ oe	**A1**	allow even if x terms not collected; condone … $= y$ provided later work implies it should be 0
	Use b^2-4ac oe	**M1**	must be applied to a 3 term quadratic expression containing k as a coefficient; condone < 0 etc.
	Reach $their(k-9=\pm 4)$ or solves $their(k^2-18k+65)=0$	**M1**	condone $9-k=\pm 4$; condone an inequality at this stage
	$k = 5$ and 13 cao	**A1**	mark final answer, do not isw; **A0** if inequalities for final answers

3 **(i)**	$3(-1)^3 - 14(-1)^2 - 7(-1) + d = 0$ with completion to $d = 10$	**B1**	at least $-3 - 14 + 7 + d = 0$, $d = 10$; N.B. = 0 must be seen or implied by … = d or … = $-d$, may be seen in following step. or convincingly showing $3(-1)^3 - 14(-1)^2 - 7(-1) + 10 = 0$; at least $-3 - 14 + 7 + 10 = 0$ or correct synthetic division at least as far as $\begin{array}{r\|rrrr} -1 & 3 & -14 & -7 & 10 \\ & & -3 & 17 & -10 \\ \hline & 3 & -17 & 10 & \end{array}$
(ii)	$3x^2 - 17x + 10$ isw or $a = 3$, $b = -17$, $c = 10$ isw	**B2, 1, 0**	–1 each error; must be seen or referenced in **(ii)** even if found in **(i)** or **(iii)**
(iii)	$(x+1)(x-5)(3x-2)$	**M1**	for factorising quadratic **ft** correct; condone omission of $(x+1)$ or for **ft** correct use of formula or **ft** correct completing the square
	$-1, 5, \frac{2}{3}$	**A1**	If **M0** then **SC1** for all three roots stated without working or verified/found by trials

4 **(i)**	$12\left(x-\frac{1}{4}\right)^2+\frac{17}{4}$ isw	**B3, 2, 1,0**	one mark for each of p, q, r correct in a correctly formatted expression; allow correct equivalent values; If **B0** then **SC2** for $12\left(x-\frac{1}{4}\right)+\frac{17}{4}$ or **SC1** for correct 3 values seen in incorrect format e.g. $12\left(x-\frac{1}{4}x\right)+\frac{17}{4}$ or $12\left(x^2-\frac{1}{4}\right)+\frac{17}{4}$ or for a correct completed square form of the original expression in a different but correct format. e.g. $3\left(2x-\frac{1}{2}\right)^2+\frac{17}{4}$
(ii)	*their* $\frac{4}{17}$ or *their* 0.235	**B1ft**	strict **ft** ; *their* $\frac{4}{17}$ must be a proper fraction or decimal rounded to 3sig figs or more or truncated to 4 figs or more
	their $x=\frac{1}{4}$ oe	**B1ft**	strict **ft** ; x must be correctly attributed
5 **(i)**	$1-20x+160x^2$	**B2, 1, 0**	-1 each error if **B0** then **M1** for 3 correct terms seen; may be unsimplified e.g. $1,\ 5(-4x),\ \frac{5\times4}{2}(-4x)^2$
(ii)	$a+(their\ -20)=-23$ soi	**M1**	condone sign errors only; must be *their* -20 from **(i)**
	$a=-3$	**A1**	validly obtained
	$b+(their\ -20)a+(their160)=222$ soi	**M1**	condone sign errors only ; must be *their* -20 and *their*160 from **(i)** and *their* a if used
	$b=2$	**A1**	validly obtained

6 (a) (i)	1	**B1**	
(ii)	$x = -1$ or -2	**B1 + B1**	as final answers
(b)	$\dfrac{\log_3 5}{\log_3 a}$ seen or implied	**B1***	may be implied by $2\log_3 15 - \log_3 5$
	$2\log_3 15 = \log_3 15^2$ seen or implied	**B1**	
	$\log_3 15^2 - \log_3 5 = \log_3\left(\dfrac{15^2}{5}\right)$	**B1dep***	not from wrong working
	$\log_3 45$ cao	**B1**	must be 45 not e.g. $\dfrac{225}{5}$; with no wrong working seen
7 (i)	$x^4\left(3e^{3x}\right) + 4x^3e^{3x}$ isw	**B1 + B1**	each term of the **sum** correct; must be a sum of two terms
(ii)	$\dfrac{1}{2+\cos x} \times (-\sin x)$ isw	**B2**	or **B1** for $\dfrac{1}{2+\cos x} \times (k \pm \sin x)$ and k a constant
(iii)	$\dfrac{\mathrm{d}}{\mathrm{d}x}(\sin x) = \cos x$ soi	**B1**	
	$\dfrac{\mathrm{d}}{\mathrm{d}x}\left(1+\sqrt{x}\right) = \dfrac{1}{2}x^{-\frac{1}{2}}$ soi	**B1**	
	$\dfrac{\left(1+\sqrt{x}\right)\textit{their}\cos x - \left(\textit{their}\,\dfrac{1}{2}x^{-\frac{1}{2}}\right)\sin x}{\left(1+\sqrt{x}\right)^2}$ isw	**B1ft**	for correct form of quotient rule **ft** their $\cos x$ and their $\dfrac{1}{2}x^{-\frac{1}{2}}$; allow correct use of product and chain rules to obtain $\sin x\left(-\left(1+\sqrt{x}\right)^{-2} \times \dfrac{1}{2}x^{\frac{1}{2}}\right) +$ $\cos x\left(1+\sqrt{x}\right)^{-1}$ oe

8	Substitution of either $x - 5$ or $y + 5$ into equation of curve and brackets expanded	M1	condone one sign error in either equation of curve or expansion of brackets; condone omission of = 0, BUT $x - 5$ or $y + 5$ must be correct
	$2x^2 - 8x - 10[= 0]$ or $2y^2 + 12y[= 0]$ obtained	A1	
	Solving their quadratic	M1	dep on a valid substitution attempt
	$(-1, -6)$ oe and $(5, 0)$ oe isw	A1*+A1*	or **A1** for correct pair of x coordinates or correct pair of y coordinates
	$\sqrt{72}$ or $6\sqrt{2}$ cao isw	B1dep*	
9 (i)	$[y =]\dfrac{(2x+1)^{\frac{3}{2}}}{2 \times \frac{3}{2}}(+c)$ oe	B2	or **B1** for $(2x+1)^{\frac{1}{2}+1}$
	$10 = \frac{2}{6}(2(4)+1)^{\frac{3}{2}} + c$ oe	M1	for valid attempt to find c; condone slips e.g. omission of power or sign error
	$y = \dfrac{(2x+1)^{\frac{3}{2}}}{2 \times \frac{3}{2}} + c$ seen and $c = 1$ or $y = \dfrac{(2x+1)^{\frac{3}{2}}}{2 \times \frac{3}{2}} + 1$ isw	A1	must have $y = ….$; condone $f(x) = ...$
(ii)	$\int\left(\frac{1}{3}(2x+1)^{\frac{3}{2}} + 1\right)dx = \frac{1}{15}(2x+1)^{\frac{5}{2}} + x(+\mathit{const})$	B1 + B1	**B1** for $(2x+1)^{\frac{3}{2}+1}$, **B1** for $\frac{1}{15}(2x+1)^{\frac{5}{2}}$
		B1ft	**B1 ft** *their c* from **(i)** provided $c \neq 0$
	$\left[\frac{1}{15}(2x+1)^{\frac{5}{2}} + x\right]_0^{1.5} =$ $\left[\frac{1}{15}(2(1.5)+1)^{\frac{5}{2}} + (1.5)\right] - \left[\frac{1}{15}(2(0)+1)^{\frac{5}{2}} + 0\right]$	M1	for a genuine attempt to find F(1.5) – F(0) in an attempt to integrate *their y*; if their F(0) is 0 must see at least their F(1.5)– 0; condone + c as long as their c is **not** numerical.
	$\frac{107}{30}$ oe isw	A1	if decimal 3.57 or more accurate e.g. 3.566

10 (i)	Taking logs of both sides	**M1**	any base; must be an explicitly correct statement
	$\log y = \log A + x \log b$	**A1**	correct form; any base; no recovery from incorrect method steps
(ii)	b: awrt 3 to one sf isw or awrt 4 to one sf isw	**B2**	or **M1** for $b = e^{\textit{their}\text{ gradient}}$ soi; their gradient must be correctly evaluated as rise/run
	A: awrt 0.5 to one sf	**B2**	or **B1** for $A = e^{-0.6}$ or **SC1** for $A = e^{-0.3} = 0.7$ (giving an awrt 0.7)
(iii)	Evidence of graph used at ln y = 5.4 soi	**M1**	or $\frac{220}{\textit{their}0.5} = (\textit{their}4)^x$ or 5.39…= *their*(1.4)x + *their* –0.6 or $\ln(220) = x\ln(\textit{their}4) + \ln(\textit{their}0.5)$
	awrt 4.4 to two sf	**A1**	

11 (i)	$f(x) > 3$ or $[f(x) \in](3, \infty)$	**B1**	condone $y > 3$
(ii)	$x + 1 = 2^y$ $f^{-1}(x) = \log_2(x+1)$	**M1** **A1**	or $y + 1 = 2^x$ mark final answer or $\log_2(y+1) = x$ and $f^{-1}(x) = \log_2(x+1)$ or for $f^{-1}(x) = \dfrac{\log(x+1)}{\log 2}$ (any base for this form)
	Domain $x > 3$	**B1ft**	**ft** their **range** of f provided mathematically valid inequality or interval
	Range $f^{-1}(x) > 2$	**B1**	condone $f(x) > 2$ or $y > 2$
(iii)	$2^x(2^x - 1)$ oe isw	**B1**	e.g. $(2^x - 1)^2 + (2x - 1)$ or $2^{2x} - 2 \times 2^x + 1 + 2^x - 1$
	$2^x(2^x - 1) = 0$ **leading to** $2^x = 0$, impossible oe	**B1**	or $2^x = 0$ which is outside domain of gf
	$2^x = 1 \Rightarrow x = 0$	**M1**	or $2^x(2^x - 1) = 2^{2x} - 2^x = 0$ $[2^{2x} = 2^x] \Rightarrow x = 0$
	0 is not in the domain (and so $gf(x) = 0$ has no solutions)	**A1**	

12 (i)	$\frac{dy}{dx} = 3x^2 - 18x + 24$	**B1**	
	Solving their $3x^2 - 18x + 24 \geqslant 0$ by factorising or quadratic formula or completing the square	**M1**	attempt at differentiation resulting in quadratic expression with two terms correct; allow = or $\leqslant$ or < or > or $\geqslant$ 0 omitted here.
	Critical values 2 and 4	**A1**	
	$x \leqslant 2, x \geqslant 4$	**A1**	**A0** if spurious attempt to combine; mark final answer
(ii)	Evaluating their $\frac{dy}{dx}$ at $x = 3$	**M1**	
	Use of $m_1 m_2 = -1$ to get $m_{normal} = -\frac{1}{their(-3)}$	**M1**	must be explicit statement of gradient of normal ; may be seen in equation
	$y = 18$ soi	**B1**	
	$y - their18 = \left(their\frac{1}{3}\right)(x-3)$ or $y = their\frac{1}{3}x + c$ and $c = their17$ isw	**A1ft**	**ft** *their m* provided a genuine attempt at m_{normal} ; no **ft** if $m = their\ m_{\text{tangent}}$
	$P(0, 17)$ cao	**B1**	

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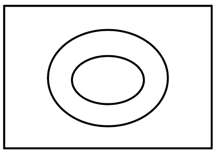
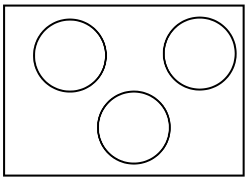
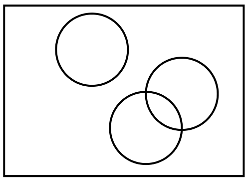
1 **(i)**	$500 = \frac{1}{2}r^2(1.6)$	**M1**	
	25 only	**A1**	± 25 is **A0**
(ii)	*their* 25 + *their* 25 + *their* 25 × 1.6 or better	**M1**	*their* 25 must be positive
	90	**A1**	
2	$\log_x 3 = \frac{1}{\log_3 x}$ oe soi	**B1**	may be implied by $\log_x 3 = \frac{1}{u}$ oe
	$u^2 - 4u - 12 = 0$ oe	**M1**	condone sign errors
	solve their 3 term quadratic in u	**M1**	
	Solve $\log_3 x = 6$ or $\log_3 x = -2$ oe	**M1**	
	729 and $\frac{1}{9}$	**A1**	
3 **(i)**	$\begin{pmatrix} 3 & 1 & 4 \\ 1 & 3 & 0 \end{pmatrix}$ and $\begin{pmatrix} 5 \\ 3 \\ 1 \end{pmatrix}$	**B1**	
	or $\begin{pmatrix} 5 & 3 & 1 \end{pmatrix}$ and $\begin{pmatrix} 3 & 1 \\ 1 & 4 \\ 4 & 0 \end{pmatrix}$		
	Multiplication of compatible matrices	**M1**	Must be correct shape from candidates product
	$\begin{pmatrix} 22 \\ 17 \end{pmatrix}$ or $\begin{pmatrix} 22 & 17 \end{pmatrix}$ as appropriate	**A1**	
(ii)	$\begin{pmatrix} 1 & 1 \end{pmatrix}$ with $\begin{pmatrix} 22 \\ 17 \end{pmatrix}$ or $\begin{pmatrix} 22 & 17 \end{pmatrix}$ with $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$	**B1**	

4 (a) (i)		**B1**	
(ii)	 or 	**B1**	any Venn diagram showing three circles which do not all overlap
(b) (i)	$50 \notin C$	**B1**	
(ii)	$64 \in S \cap C$	**B1ft**	**ft** only on use of $\not\subset$ and $\subset$ instead of $\notin$ and $\in$
(iii)	$n(S') = 90$	**B1**	
5 (i)	$\left(2\sqrt{2}+4\right)^2 = 8 + 16\sqrt{2} + 16$	**B1**	
	Correct completion	**B1**	
(ii)	Use $\dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$	**M1**	$\left(= \dfrac{\left(2\sqrt{2}+4\right)}{2\left(2\sqrt{2}+3\right)}\right)$
	Multiply top and bottom by $2\sqrt{2} - 3$	**M1**	
	$2 - \sqrt{2}$	**A1**	Or $4\sqrt{2} - 6$
6	Eliminate x or y	**M1**	
	Rearrange to quadratic in x or y	**M1**	
	$x^2 - 27x + 72 = 0$ or $y^2 + 9y - 90 = 0$	**A1**	
	Factorise or solve 3 term quadratic	**M1**	
	$x = 3$, $x = 24$ or $y = 6$, $y = -15$	**A1**	
	$y = 6$, $y = -15$ or $x = 3$, $x = 24$	**B1**	

7 **(a)**	$\dfrac{\dfrac{\sin\theta}{\cos\theta}+\dfrac{\cos\theta}{\sin\theta}}{\dfrac{1}{\cos\theta}+\dfrac{1}{\sin\theta}}$	**B1**	
	Clears the fractions in the numerator and denominator using common denominator	**M1**	
	$\dfrac{\sin^2\theta+\cos^2\theta}{\sin\theta+\cos\theta}$ and completion	**A1**	
(b)	evidence of 13	**B1**	
	$\sin x=\dfrac{5}{13}$	**B1**	
	$\cos x=-\dfrac{12}{13}$	**B1ft**	**ft** on *their* 13
8 **(i)**	Attempt to find b^2-4ac	**M1**	may be in formula or attempt to complete square
	Completely correct argument	**A1**	
(ii)	$m = 6(4) - 8(2) + 3$	**M1**	
	$y - 10 = 11(x - 2)$ or $y = 11x - 12$	**A1**	
(iii)	Integrate to $2x^3 - 4x^2 + 3x(+c)$	**B2,1,0**	
	$10 = 2(2)^3 - 4(2)^2 + 3(2) + c$	**M1**	dep on c being a genuine constant of integration
	$y = 2x^3 - 4x^2 + 3x + 4$ soi	**A1**	

9 (i)	(0, 7)	**B1**	
	$m_{AB} = 2$	**B1**	
	perpendicular gradient $= -\frac{1}{2}$	**M1**	
	$y = -\frac{1}{2}x + 7$	**A1**	
(ii)	$m_{AB} = -1$	**B1**	
	$y = -x + 13$	**B1**	
	Solve their $y = -x + 13$ and $y = -\frac{1}{2}x + 7$	**M1**	
	$D(12,1)$	**A1**	
	Complete method for area	**M1**	
	84	**A1**	
10 (i)	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\sqrt{x^2+21}\right) = \frac{x}{\sqrt{x^2+21}}$	**B1**	Alt method using product rule $\frac{\mathrm{d}}{\mathrm{d}x}\frac{1}{\left(\sqrt{x^2+21}\right)} = \frac{-x}{\left(\sqrt{x^2+21}\right)^3}$ is B1
	Use of quotient rule	**M1**	then **M1 A1** as in quotient
	$\dfrac{2\sqrt{(x^2+21)} - 2x \times \frac{x}{\sqrt{(x^2+21)}}}{(x^2+21)}$	**A1**	
	Multiply each term by $\sqrt{(x^2+21)}$	**M1**	
	$\dfrac{2(x^2+21) - 2x^2}{(x^2+21)^{\frac{3}{2}}}$ leading to $k = 42$	**A1**	
(ii)	$\frac{6}{k} \times \frac{2x}{\sqrt{x^2+21}}$	**M1**	k must be a constant
	Use limits in $C \times \frac{2x}{\sqrt{x^2+21}}$	**M1**	
	$\frac{8}{55}$ or 0.145	**A1**	

11 (i)	$\overrightarrow{OM} = \mathbf{a}$	**B1**	
	$\overrightarrow{MB} = 5\mathbf{b} - \mathbf{a}$	**B1**	
(ii)	$\overrightarrow{ON} = 3b$	**B1**	
	$\overrightarrow{AP} = \lambda(3\mathbf{b} - 2\mathbf{a})$	**B1**	
(iii)	$\overrightarrow{MP} = \overrightarrow{MA} + \overrightarrow{AP}$ $\mathbf{a} + \lambda(3\mathbf{b} - 2\mathbf{a})$	**M1** **A1**	
(iv)	Put $\overrightarrow{MP} = \mu\overrightarrow{MB}$	**M1**	
	Equate components	**M1**	
	Solve simultaneous equations	**M1**	
	$\lambda = \frac{5}{7}$	**A1**	
12 (i)	$3 < \mathrm{f} < 7$	**B1,B1**	If **B0** then **SC1** for $3 < \mathrm{f} < 7$
(ii)	f(12) = 5	**B1**	$\mathrm{f}^2(x)\ \sqrt{\left(\sqrt{(x-3)}+2-3\right)}+2$ earns **B1**
	(f(5) =) $2 + \sqrt{2}$	**B1**	
(iii)	Clear indication of method $\mathrm{f}^{-1}(x) = (x-2)^2 + 3$	**M1** **A1**	condone $y = (x-2)^2 + 3$
(iv)	$\mathrm{gf}(x) = \dfrac{120}{\sqrt{(x-3)}+2}$	**B1**	
	Attempt to solve *their* gf $(x) = 20$	**M1**	
	$x = 19$	**A1**	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the October/November 2013 series

0606 ADDITIONAL MATHEMATICS

0606/21 Paper 2, maximum raw mark 80

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CAMBRIDGE
International Examinations

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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.

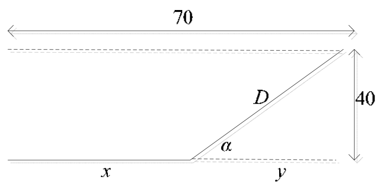
- When a part of a question has two or more "method" steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an 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.

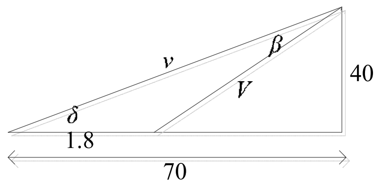
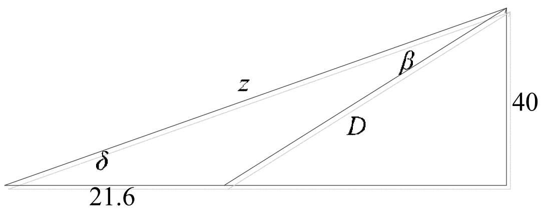
- The symbol √ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

- 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		$(x+6)(x-1)$ Critical values –6 and 1 $-6 < x < 1$	**M1** **A1** **A1** **[3]**	Attempt to solve a three term quadratic Allow $x > -6$ **AND** $x < 1$ but not **OR** or a comma. Mark final answer.
2		$\left(4\sqrt{5}-2\right)^2 = 80 - 16\sqrt{5} + 4$ Multiply top and bottom by $\sqrt{5+1}$ $17\sqrt{5+1}$ **OR** $\left(4\sqrt{5}-2\right)^2 = 80 - 16\sqrt{5+4}$ $\left(\sqrt{5}-1\right)\left(p\sqrt{5}+q\right) = 5p - q + \sqrt{5(q-p)}$ Leading to $5p - q = 84, q - p = -16$ $p = 17 \quad q = 1$	**M1** **M1** **A1 A1** **[4]** **M1** **M1** **A1 A1**	Attempt to expand, allow one error, must be in the form $a + b\sqrt{5}$. Must be attempt to expand top and bottom. Allow A1 for $\frac{68\sqrt{5}+4}{c}$ Must get to a pair of simultaneous equations for this mark
3	**(i)**	$\frac{dy}{dk} = k\left(\frac{1}{4}x - 5\right)^7$ $k = 2$	**M1** **A1** **[2]**	
	(ii)	Use $\partial y = \frac{dy}{dx} \times \partial x$ with $x = 12$ and $\partial x = p$ –256p	**M1** **A1**√ **[2]**	√ on k needs both M marks √ only for –128kp and must be evaluated
4	**(i)**	10	**B1** **[1]**	
	(ii)	–5	**B1** **[1]**	Not $\log_p 1 - 5$
	(iii)	$\log_p XY = \log_p X + \log_p Y = 7$ $\frac{1}{7}$	**B1** **B1**√ **[2]**	Or $\log_{XY} p = \frac{1}{\log_p XY}$ Do not allow just $\log_p X + \log_p Y = 7$ √ on $\frac{1}{\log_p XY}$

5	$x-4y=5$ oe $2x+2y=5$ oe Solve their linear simultaneous equations $x=3$ or $y=-0.5$ **OR** from log $0.602x-2.408y=3.01$ $0.954x+0.954y=2.386$ **OR** from ln $1.386x-5.545y=6.931$ $2.197x+2.197y=5.493$ Final M1A1A1√ follows as before	**B1** **B1** **M1** **A1,A1√** **[5]** **B1** **B1** **B1** **B1**	 Each in two variables and not quadratic as far as $x = \ldots$ or $y = \ldots$
6 (a) (i)	–8 or 20 $-160(x^3)$ isw	**B1** **B1** **[2]**	± 40 implies $\pm 2\times 20$ or +160 hence B1 OK if seen in expansion
(ii)	$60(x^2)$ (i) $+\frac{1}{2}$ (their 60) $-130(x^3)$	**B1** **M1** **A1** **[3]**	Can be implied
(b)	$16x^2+32x+24+\frac{8}{x}+\frac{1}{x^2}$ oe	**B3,2,1,0** **[3]**	Terms must be evaluated (allow $24x^0$) B2 for 4 terms correct. B1 for 2 or 3 terms correct. ISW once expansion is seen.
7 (i)	$l=\frac{3500}{x^2}$ $L=3\times 4x+2x+2l$ Substitute for l and correctly reach $L=14x+\frac{7000}{x^2}$	**B1** **B1** **DB1ag** **[3]**	allow $lx^2=3500$ RHS 3 terms e.g. $12x+2x+2\left(\frac{3500}{x^2}\right)$ or better Dependent on both previous B marks
(ii)	$\frac{\mathrm{d}L}{\mathrm{d}x}=14-\frac{14000}{x^3}$ Equate $\frac{\mathrm{d}L}{\mathrm{d}x}$ to 0 and solve $x=10$ $L=210$ $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\frac{42000}{x^4}$ and minimum stated	**M1A1** **DM1** **A1** **B1** **[5]**	M1 either power reduced by one A1 both terms correct Must get $x^n=$ Both values Or use of gradient either side of turning point.

8	**(i)**	x^2	**B1** **[1]**	Implied by axes or values in a table. May be seen in (ii)
	(ii)	Plot $\frac{y}{x}$ against x^2 with linear scales		Must be linear scales
		x^2: 4, 16, 36, 64	**B1**	At least 3 correct points plotted and no incorrect points
		$\frac{y}{x}$: 4.8, 9.6, 17.5, 29	**B1** **[2]**	Line must be ruled and through at least 2 correct points
	(iii)	Finds gradient (0.4) $a = 0.4 \pm 0.02$ $b = 3.2 \pm 0.4$	**M1** **A1** **B1** **[3]**	Condone use of correct values from table/graph to find gradient and /or equation. Values read from graph must be correct.
	(iv)	Read $\frac{y}{x} = 12.5$	**M1**	Obtaining $(x^2) = 22$ to 24 from graph
		or substitute in formula		As far as x^2 = +ve constant
		4.8	**A1** **[2]**	4.7 to 4.9 ignore –4.8 or 0
9		Method A	**M1**	
		Takes components	**A1**	
		$12v\sin\alpha = 40$	**A1**	
		$12(v\cos\alpha + 1.8) = 70$	**M1A1**	
		$12v\cos\alpha = 48.4$	**DM1**	
		Solve for v or α	**A1**	
		$\alpha = 39.6$	**A1**	Allow 0.691 radians
		$v = 5.23$	**[8]**	
		Method B 		
		$x = 1.8 \times 12 = 21.6$	**B1**	
		$y = 70 - 21.6 = 48.4$	**B1**	
		$D^2 = 40^2 + 48.4^2 (= 3942.56)$	**M1**	
		$D = 62.8$	**A1**	
		$V = \frac{D}{12}$	**DM1**	
		$V = 5.23$	**A1**	5.23 or better
		$\tan\alpha = \frac{40}{48.4}$	**M1**	
		$\alpha = 39.6°$	**A1** **[8]**	Allow 0.691 radians

Method C 		
$z=\sqrt{40^2+70^2}\,(=80.6)$	B1	
$v=\dfrac{\sqrt{40^2+70^2}}{12}\,(=6.72)$	B1	
$\tan\delta=\dfrac{4}{7}\rightarrow(\delta=29.74)$ oe	B1	Or $\tan(90-\delta)=\dfrac{7}{4}$
$V^2=1.8^2+6.72^2-2\times1.8\times6.72\cos29.74$	M1	
$V=5.23$	A1	
$\dfrac{\sin\beta}{1}.8=\dfrac{\sin29.74}{5}.23$	M1	
$\beta=9.8(3)$ or $9.8(2)$	A1	Allow 0.172 radians
$\alpha=29.74+\beta=39.6$	A1 **[8]**	Allow 0.691 radians
Method D 		
$z=\sqrt{40^2+70^2}\,(=80.6)$	B1	
$x=1.8\times12=21.6$	B1	
$\tan\delta=\dfrac{4}{7}\rightarrow(\delta=29.74)$ oe	B1	
$D^2=21.6^2+80.6^2-2.21.6.80.6\cos29.74$	M1	
$V=(62.8/12)=5.23$	A1	This method has extra steps so note at this point the M mark is for an equation in *D* but the A mark is for a value of *V*.
$\dfrac{\sin\beta}{21}.6=\dfrac{\sin29.74}{62}.8$	M1	
$\beta=9.8(3)$ or $9.8(2)$	A1	Allow 0.172 radians
$\alpha=29.74+\beta=39.6$	A1 **[8]**	Allow 0.691 radians

10	(i)	$AB^2 = 12^2 + 12^2 - 2\times12\times12\times\cos1.4$ 15.4 to 15.5 $\theta = 2\pi - 1.4 (= 4.88)$ Use $s = r\theta (= 58.6)$ 74.1	**M1** **A1** **B1** **M1** **A1** **[5]**	$AB = 2\times12\sin0.7$ May be implied May be implied 12×4.9 or better oe
	(ii)	(Sector) $\frac{1}{2}\times12^2\times(2\pi-1.4)(=352)$ or $\pi\times12^2 - \frac{1}{2}\times12^2\times1.4$ (Triangle) $=\frac{1}{2}\times12\times12\times\sin1.4 (= 70.9 \text{ or } 71)$ Area of **major** sector + Area of triangle 422 or 423	**M1** **M1** **M1** **A1** **[4]**	May be implied . May be implied
11	(i)	$\frac{dy}{dx} = \frac{1}{3}e^{\frac{1}{3}x}$ $m = \frac{1}{3}e^3$ $y - e^3 = \frac{1}{3}e^3(x-9)$ At Q $y = 0$, $x = 6$	**B1** **M1** **DM1** **A1** **[4]**	 For insertion of $x = 9$ into their $\frac{dy}{dx}$. 6.7 or better if correct. Using their evaluated m to find eqn $y = 6.7x - 40.2$ or better if correct. Accept value that rounds to 6.0 to 2sf
	(ii)	Area triangle $1.5e^3$ or 30.1 $\int e^{\frac{1}{3}x}dx = 3e^{\frac{1}{3}x}$ oe Uses limits of 0 and 9 in integrated function. $3e^3 - 3$ or 57.3 Area under curve subtract area of triangle $1.5e^3 - 3$ or 27.1	**B1** **B1** **M1** **A1** **M1** **A1** **[6]**	 $\pm$ must see both values inserted if incorrect answer Condone 27.2 if obtained from 57.3 – 30.1.

12	**(a)**	$\text{cosec}x = \frac{1}{\sin x}$ inserted into equation	**B1**	
		$\tan x = -\frac{2}{7}$	**DB1**	
		164.1	**B1**	One correct value.
		344.1	**B1**√	√ on $180 + (164.1)$ Must come from $\tan x =$ Condone164 and 344
			[4]	Deduct 1 mark for extras in range
	(b)	$(2y - 1) = 0.79..$or 2.34…	**B1**	Allow 0.8 , 2.3 or 45.6°
		Find y using radians	**M1**	Add 1 then divide by 2 on a correct angle
		0.898 (or 0.9 or 0.90)	**A1**	One correct value
		1.67, 4.04 and 4.81(45)	**A1**	Another correct value
			A1	Final two values
			[5]	Deduct 1 mark for extras in range

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the October/November 2013 series

0606 ADDITIONAL MATHEMATICS

0606/22 Paper 2, maximum raw mark 80

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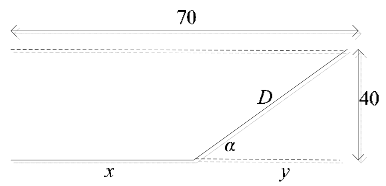
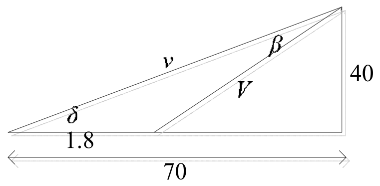
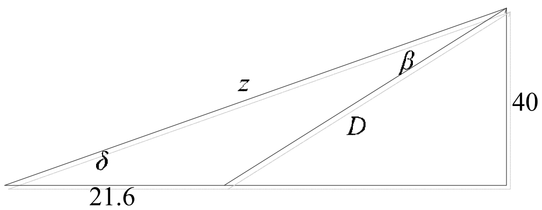
  B2, 1, 0 means that the candidate can earn anything from 0 to 2.

1		$(x+6)(x-1)$ Critical values –6 and 1 $-6<x<1$	M1 A1 A1 [3]	Attempt to solve a three term quadratic Allow $x>-6$ **AND** $x<1$ but not **OR** or a comma. Mark final answer.
2		$\left(4\sqrt{5}-2\right)^2=80-16\sqrt{5}+4$ Multiply top and bottom by $\sqrt{5}+1$ $17\sqrt{5}+1$ **OR** $\left(4\sqrt{5}-2\right)^2=80-16\sqrt{5}+4$ $\left(\sqrt{5}-1\right)\left(p\sqrt{5}+q\right)=5p-q+\sqrt{5}(q-p)$ Leading to $5p-q=84, q-p=-16$ $p=17 \quad q=1$	M1 M1 A1 A1 [4] M1 M1 A1 A1	Attempt to expand, allow one error, must be in the form $a+b\sqrt{5}$. Must be attempt to expand top and bottom. Allow A1 for $\dfrac{68\sqrt{5}+4}{c}$ Must get to a pair of simultaneous equations for this mark
3	(i)	$\dfrac{\mathrm{d}y}{\mathrm{d}k}=k\left(\dfrac{1}{4}x-5\right)^7$ $k=2$	M1 A1 [2]	
	(ii)	Use $\partial y=\dfrac{\mathrm{d}y}{\mathrm{d}x}\times\partial x$ with $x=12$ and $\partial x=p$ $-256p$	M1 A1√ [2]	√ on k needs both M marks √ only for $-128kp$ and must be evaluated
4	(i)	10	B1 [1]	
	(ii)	–5	B1 [1]	Not $\log_p 1-5$
	(iii)	$\log_p XY=\log_p X+\log_p Y=7$ $\dfrac{1}{7}$	B1 B1√ [2]	Or $\log_{XY} p=\dfrac{1}{\log_p XY}$ Do not allow just $\log_p X+\log_p Y=7$ √ on $\dfrac{1}{\log_p XY}$

5	$x-4y=5$ oe $2x+2y=5$ oe Solve their linear simultaneous equations $x=3$ or $y=-0.5$ **OR** from log $0.602x-2.408y=3.01$ $0.954x+0.954y=2.386$ **OR** from ln $1.386x-5.545y=6.931$ $2.197x+2.197y=5.493$ Final M1A1A1√ follows as before	**B1** **B1** **M1** **A1,A1√** **[5]** **B1** **B1** **B1** **B1**	Each in two variables and not quadratic as far as $x=\ldots$ or $y=\ldots$
6 (a) (i)	–8 or 20 $-160(x^3)$ isw	**B1** **B1** **[2]**	± 40 implies $\pm 2\times 20$ or +160 hence B1 OK if seen in expansion
(ii)	$60(x^2)$ (i) $+\frac{1}{2}$ (their 60) $-130(x^3)$	**B1** **M1** **A1** **[3]**	Can be implied
(b)	$16x^2+32x+24+\frac{8}{x}+\frac{1}{x^2}$ oe	**B3,2,1,0** **[3]**	Terms must be evaluated (allow $24x^0$) B2 for 4 terms correct. B1 for 2 or 3 terms correct. ISW once expansion is seen.
7 (i)	$l=\frac{3500}{x^2}$ $L=3\times 4x+2x+2l$ Substitute for l and correctly reach $L=14x+\frac{7000}{x^2}$	**B1** **B1** **DB1ag** **[3]**	allow $lx^2=3500$ RHS 3 terms e.g. $12x+2x+2\left(\frac{3500}{x^2}\right)$ or better Dependent on both previous B marks
(ii)	$\frac{dL}{dx}=14-\frac{14000}{x^3}$ Equate $\frac{dL}{dx}$ to 0 and solve $x=10$ $L=210$ $\frac{d^2y}{dx^2}=\frac{42000}{x^4}$ and minimum stated	**M1A1** **DM1** **A1** **B1** **[5]**	M1 either power reduced by one A1 both terms correct Must get $x^n=$ Both values Or use of gradient either side of turning point.

8	(i)	x^2	B1 [1]	Implied by axes or values in a table. May be seen in (ii)
	(ii)	Plot $\frac{y}{x}$ against x^2 with linear scales		Must be linear scales
		x^2: 4, 16, 36, 64	B1	At least 3 correct points plotted and no incorrect points
		$\frac{y}{x}$: 4.8, 9.6, 17.5, 29	B1 [2]	Line must be ruled and through at least 2 correct points
	(iii)	Finds gradient (0.4) $a = 0.4 \pm 0.02$ $b = 3.2 \pm 0.4$	M1 A1 B1 [3]	Condone use of correct values from table/graph to find gradient and /or equation. Values read from graph must be correct.
	(iv)	Read $\frac{y}{x} = 12.5$	M1	Obtaining $(x^2) = 22 \text{ to } 24$ from graph
		or substitute in formula		As far as x^2 = +ve constant
		4.8	A1 [2]	4.7 to 4.9 ignore –4.8 or 0
9		Method A Takes components $12v\sin\alpha = 40$ $12(v\cos\alpha + 1.8) = 70$ $12v\cos\alpha = 48.4$ Solve for v or α $\alpha = 39.6$ $v = 5.23$	M1 A1 A1 M1A1 DM1 A1 A1 [8]	 Allow 0.691 radians
		Method B  $x = 1.8 \times 12 = 21.6$ $y = 70 - 21.6 = 48.4$ $D^2 = 40^2 + 48.4^2 (= 3942.56)$ $D = 62.8$ $V = \frac{D}{12}$ $V = 5.23$ $\tan\alpha = \frac{40}{48.4}$ $\alpha = 39.6°$	B1 B1 M1 A1 DM1 A1 M1 A1 [8]	 5.23 or better Allow 0.691 radians

Method C		
		
$z=\sqrt{40^2+70^2}\ (=80.6)$	**B1**	
$v=\frac{\sqrt{40^2+70^2}}{12}\ (=6.72)$	**B1**	
$\tan\delta=\frac{4}{7}\to(\delta=29.74)$ oe	**B1**	Or $\tan(90-\delta)=\frac{7}{4}$
$V^2=1.8^2+6.72^2-2\times1.8\times6.72\cos 29.74$	**M1**	
$V=5.23$	**A1**	
$\frac{\sin\beta}{1}.8=\frac{\sin 29.74}{5}.23$	**M1**	
$\beta=9.8(3)$ or $9.8(2)$	**A1**	Allow 0.172 radians
$\alpha=29.74+\beta=39.6$	**A1** **[8]**	Allow 0.691 radians
Method D		
		
$z=\sqrt{40^2+70^2}\ (=80.6)$	**B1**	
$x=1.8\times12=21.6$	**B1**	
$\tan\delta=\frac{4}{7}\to(\delta=29.74)$ oe	**B1**	
$D^2=21.6^2+80.6^2-2.21.6.80.6\cos 29.74$	**M1**	
$V=(62.8/12)=5.23$	**A1**	This method has extra steps so note at this point the M mark is for an equation in *D* but the A mark is for a value of *V*.
$\frac{\sin\beta}{21}.6=\frac{\sin 29.74}{62}.8$	**M1**	
$\beta=9.8(3)$ or $9.8(2)$	**A1**	Allow 0.172 radians
$\alpha=29.74+\beta=39.6$	**A1** **[8]**	Allow 0.691 radians

10	(i)	$AB^2 = 12^2 + 12^2 - 2\times12\times12\times\cos1.4$ 15.4 to 15.5 $\theta = 2\pi - 1.4(= 4.88)$ Use $s = r\theta(= 58.6)$ 74.1	M1 A1 B1 M1 A1 [5]	$AB = 2\times12\sin0.7$ May be implied May be implied 12×4.9 or better oe
	(ii)	(Sector) $\frac{1}{2}\times12^2\times(2\pi-1.4)(=352)$ or $\pi\times12^2 - \frac{1}{2}\times12^2\times1.4$ (Triangle) $= \frac{1}{2}\times12\times12\times\sin1.4(= 70.9 \text{ or } 71)$ Area of **major** sector + Area of triangle 422 or 423	M1 M1 M1 A1 [4]	May be implied . May be implied
11	(i)	$\frac{dy}{dx} = \frac{1}{3}e^{\frac{1}{3}x}$ $m = \frac{1}{3}e^3$ $y - e^3 = \frac{1}{3}e^3(x-9)$ At Q $y = 0, x = 6$	B1 M1 DM1 A1 [4]	 For insertion of x = 9 into their $\frac{dy}{dx}$. 6.7 or better if correct. Using their evaluated m to find eqn $y = 6.7x - 40.2$ or better if correct. Accept value that rounds to 6.0 to 2sf
	(ii)	Area triangle $1.5e^3$ or 30.1 $\int e^{\frac{1}{3}x}dx = 3e^{\frac{1}{3}x}$ oe Uses limits of 0 and 9 in integrated function. $3e^3 - 3$ or 57.3 Area under curve subtract area of triangle $1.5e^3 - 3$ or 27.1	B1 B1 M1 A1 M1 A1 [6]	 $\pm$ must see both values inserted if incorrect answer Condone 27.2 if obtained from 57.3 – 30.1.

12	(a)	$\text{cosec}x = \frac{1}{\sin x}$ inserted into equation	B1	
		$\tan x = -\frac{2}{7}$	DB1	
		164.1	B1	One correct value.
		344.1	B1√	√ on $180 + (164.1)$ Must come from $\tan x =$ Condone164 and 344
			[4]	Deduct 1 mark for extras in range
	(b)	$(2y - 1) = 0.79..\text{or } 2.34\ldots$	B1	Allow 0.8 , 2.3 or 45.6°
		Find y using radians	M1	Add 1 then divide by 2 on a correct angle
		0.898 (or 0.9 or 0.90)	A1	One correct value
		1.67, 4.04 and 4.81(45)	A1	Another correct value
			A1	Final two values
			[5]	Deduct 1 mark for extras in range

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the October/November 2013 series

0606 ADDITIONAL MATHEMATICS

0606/23 Paper 2, maximum raw mark 80

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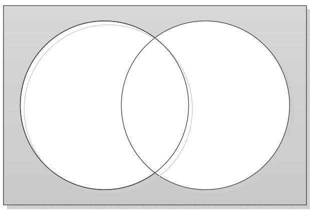
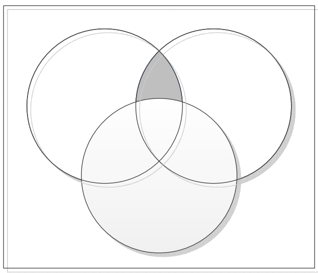
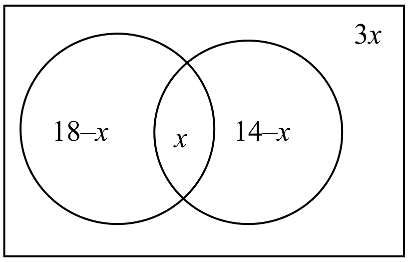
1	$\frac{dy}{dx} = 3x^2 - 12x - 36$	B2, 1, 0	Allow B1 if 2 terms correct
	Equate to 0 and solve 3 term quadratic	M1	
	$x = -2$ and $x = 6$	A1	Or one coordinate pair
	$y = 56$ and $y = -200$	A1 [5]	For two y values
2 (a) (i)	840	B1 [1]	
(ii)	480	B1 [1]	
(iii)	Calculates any case(s) correctly	B1	e.g. $1 \times 5 \times 4 \times 3 = 60$, $1 \times 5 \times 4 \times 4 = 80$
	Partitions all cases correctly	M1	
	140	A1 [3]	
3	Eliminate x or y	M1*	
	Obtain $kx^2 + 8x + k - 6$ (= 0)	A1	
	Use $b^2 - 4ac$*0	DM1	
	Obtain $-4k^2 + 24k + 64$*0 oe	A1	
	Solve 3 term quadratic ($k = 2, 8$)	M1	
	$k < -2$, $k > 8$	A1 [1]	
4 (a) (i)	$A = 3$, $B = 2$	B1, B1	
(ii)	$C = 4$	B1	
(b)	120 or $\frac{2\pi}{3}$	B1	
	5	B1	
5 (a) (i)		B1 [1]	
(ii)		B1 [1]	
(b)	$S \cap T'$ or $(S' \cup T)'$ oe	B1 [1]	Others will be seen but only accept completely correct set notation

(c)	 $18 - x + x + 14 - x + 3x = 40$ $x = 4$	B1 M1 A1 [3]	B1 for any two of x, $3x$, $18 - x$ or $14 - x$ in correct place (or implied by correct equation)
6 (a) (i)	Equate f(–3) to zero Equate f(2) to 65 $-54 + 9a - 3b + 21 = 0$ $(9a - 3b = 33)$ or $16 + 4a + 2b + 21 = 65$ $(4a + 2b = 28)$ Solve simultaneous equations $a = 5$, $b = 4$	M1 M1 A1 M1 A1 [5]	
(ii)	Calculate $f\left(-\frac{1}{2}\right) = -\frac{1}{4} + \frac{a}{4} - \frac{b}{2} + 21$ 20	M1 A1 [2]	Or use long division
7	Eliminate x or y Rearrange to quadratic in x or y correctly $x^2 - 10x + 16$ $(= 0)$ or $y^2 + 8y - 128$ $(= 0)$ oe Solve 3 term quadratic $x = 2$, $x = 8$ $y = 8$, $y = -16$ Correct method for at least one coordinate of C C (4, 0)	M1 M1 A1 M1 A1 A1 M1 A1 [8]	 Or one correct coordinate pair e.g. $x_c = \frac{1}{3}[2(2) + 1(8)]$, $\mathbf{OC} = \mathbf{OA} + \frac{1}{3}\mathbf{AB}$ oe

8 (a) (i)	$X(14, 12)$	B1	
	$m_{AX} = \frac{1}{3}$	B1	
	Use $m_1m_2 = -1$ for grad CD from grad AX	M1	
	CD is $y - 4 = -3(x - 10)$ or $y = -3x + 34$	A1√	√ on grad AX
	AX is $y - 6 = \frac{1}{3}(x + 4)$ or $3y - x = 22$	B1√	√ on grad AX
	Solve eqn for CD with eqn for AX $D(8, 10)$	M1 A1 [7]	
(ii)	Method for area 100	M1 A1 [2]	
9 (a) (i)	9	B1 [1]	
(ii)	$a = k\cos 2t$ $12\cos 2t$ -7.84	M1 A1 A1√ [3]	No other functions of t or constants √ on k **only** Must be negative (if correct) or say "deceleration"
(iii)	$t = \frac{7\pi}{12}$ or awrt 1.8	B1	
	$3t - 3\cos 2t$	B1, B1	
	Use limits of 0 and their $\left(\frac{7\pi}{12}\right)$ or finds c ($\neq 0$) and substitutes their $\left(\frac{7\pi}{12}\right)$	M1	Upper limit must be positive
	11.1 or $\frac{7\pi}{4} + \frac{3\sqrt{3}}{2} + 3$	A1 [5]	

10 (a) (i)	Radius is $\frac{h}{4}$	B1	
	Use $\frac{1}{3}\pi r^2 h$	M1	On water cone
	$\frac{1}{3}\pi\left(\frac{h}{4}\right)^2 \times h\left(=\frac{\pi h^3}{48}\right)$	A1**ag** [3]	
(ii)	$\frac{\mathrm{d}V}{\mathrm{d}h}=\frac{\pi h^2}{16}$	B1	
	Use $\frac{\mathrm{d}h}{\mathrm{d}t}=\frac{\mathrm{d}V}{\mathrm{d}t}\times\frac{\mathrm{d}h}{\mathrm{d}V}$		
	with $h = 50$, $\frac{\mathrm{d}V}{\mathrm{d}t}=20\pi$	M1	
	0.128	A1 [3]	
(iii)	$A=\frac{\pi h^2}{16}$ $\frac{\mathrm{d}A}{\mathrm{d}h}=\frac{\pi h}{8}$	B1 M1	
	Use $\frac{\mathrm{d}A}{\mathrm{d}t}=\frac{\mathrm{d}h}{\mathrm{d}t}\times\frac{\mathrm{d}A}{\mathrm{d}h}$ with substitution of $h = 50$, their 0.128	M1	
	0.8π or 2.51	A1 [3]	
11 (a) (i)	$(2\mathbf{i} + 4\mathbf{j})t$	B1	
	$(-21\mathbf{i} + 22\mathbf{j}) + (5\mathbf{i} + 3\mathbf{j})t$	B1 [2]	
(ii)	Subtract position vectors $((-21+3t)\mathbf{i}+(22-t)\mathbf{j})$	M1	Or use $t = 2$ to find position vectors of A, B $4\mathbf{i} + 8\mathbf{j}$, $-11\mathbf{i} + 28\mathbf{j}$
	Substitute $t = 2$ and use Pythagoras Correctly reach 25	M1 A1 [3]	Subtract position vectors and use Pythagoras
(iii)	$(-21+3t)^2+(22-t)^2=25^2$ oe	M1	Set expression for distance apart to 25
	$t^2 - 17t + 30$ (= 0)	A1	
	Solve 3 term quadratic	M1	Not essential to solve quadratic
	$t = 15$ (and 2)	A1	e.g. $t_1 + t_2 = 17$ and $t_1 = 2$
	13 hours	A1 [5]	

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1	$\dfrac{2+2\sin^2\theta}{\cos^2\theta}$	**B1**	For all methods look for: – correct simplified expression – correct use of Pythagoras – use of tan = $\dfrac{\sin}{\cos}$ – use of $\dfrac{1}{\cos}$ = sec
	$\dfrac{2}{\cos^2\theta}=2\sec\theta$	**B1**	
	$\dfrac{\sin^2\theta}{\cos^2\theta}=2\tan^2\theta$	**B1**	
	$2\sec^2\theta=2+2\tan^2\theta$ and completion	**B1**	Award first 3 then last B1 for final expression from fully correct method. Inconsistent no angle used then –1 (can recover). If start from RHS award similarly.
	Or $(\sec\theta+\tan\theta)^2+(\sec\theta-\tan\theta)^2$	**[B1, B1**	
	$2\sec^2\theta+2\tan^2\theta$	**B1**	
	$2(1+\tan^2\theta)+2\tan^2\theta$ and completion	**B1]**	
	Or $\dfrac{2+2\sin^2\theta}{\cos^2\theta}$	**[B1**	
	$\dfrac{2(\sin^2\theta+\cos^2\theta)+2\sin^2\theta}{\cos^2\theta}$	**B1**	
	$\dfrac{4\sin^2\theta}{\cos^2\theta}=4\tan^2\theta$	**B1**	
	$\dfrac{2\cos^2\theta}{\cos^2\theta}=2$ and completion	**B1]**	
2 (i)	3.2	**B1**	
(ii)	15	**B1**	
(iii)	uses area to find distance	**M1**	If split 2 or 3 correct formulae and must be attempting total area
	two of 40, 240 and 32	**A1**	
	312	**A1**	or **A2** for 312 from trapezium

3	$\frac{dy}{dx} = k\sin x\cos x$	**M1**	
	$k = -8$	**A1**	
	Attempt to find x when $y = 8$	**M1**	Must get to x = numerical value
	$x = \frac{\pi}{4}$ (0.785)	**A1**	45° = **A0** (but can still gain next 2 marks)
	Uses $\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}$	**M1**	Must use numerical value for x and 0.2 for $\frac{dx}{dt}$
	–0.8 (not rounded)	**A1**	(condone poor notation if correct terms multiplied)
4 (i)	Idea of modulus correct	**B1**	Two straight lines above and touching x-axis
	$\frac{1}{2}$ indicated on x-axis	**B1**	Must be a sketch
	2 indicated on y-axis	**B1**	Must be a sketch
(ii)	$\frac{2}{3}$ (0.667)	**B1**	0.67 is **B0**
	Solve $4x - 2 = -x$ or $(4x-2)^2 = x^2$	**M1**	As far as x = numerical value
	$\frac{2}{5}$	**A1**	SC: If drawn then **B1**, **B2** for exact answers only
5 (i)	$(QR = PS =) \frac{96 - 3x}{2}$	**B1**	Can be implied by next statement
	Area = $\left(\frac{96-3x}{2}\right) \times x$	**B1**	**AG**
(ii)	$\frac{dA}{dx} = \frac{96-6x}{2}$ or $48 - 3x$ o.e.	**B1**	
	Solving $\frac{dA}{dx} = \frac{96-6x}{2} = 0$	**M1**	As far as x = numerical value
	$x = 16$	**A1**	
	$A = 384$ and state maximum	**A1**	

6		Applies quotient rule correctly	**M1**	or product rule
		$\frac{(x-2)2x-(x^2+8)}{(x-2)^2}$	**A1**	$2x(x-2)^{-1}-(x^2+8)(x-2)^{-2}$
		$y = 12$	**B1**	
		Uses $m_1m_2 = -1$	**M1**	
		(Gradient normal = $\frac{1}{2}$)		
		Uses equation of line for **normal**	**M1**	If uses $y = mx + c$ must find c for **M1**
		$y-12=\frac{1}{2}(x-4)$ or $y=\frac{1}{2}x+10$	**A1**	
7	**(i)**	$64 + 192x + 240x^2 + 160x^3$ mark final answer	**B3, 2, 1, 0**	3 terms correct earn **B2**; 2 terms correct earn **B1** Can be earned in **(ii)**; **SC2** correct but unsimplified
	(ii)	Multiply out $(1 + 3x)(1 - x)$	**M1**	
		$1 + 2x - 3x^2$ o.e.	**A1**	
		$(1) \times (160) + (2) \times (240) + (-3) \times (192)$ o.e.	**M1**	3 terms
		64	**A1**	
		Or Multiply out $(1 - x)(64 + 192x + 240x^2 + 160x^3)$	**[M1**	May be other variations: for first **M1** find x^2 term or x^3 term
		$\dots 48x^2 - 80x^3\dots$o.e.	**A1**	
		Multiply by $1 + 3x$	**M1**	for second **M1** must produce all relevant terms
		64	**A1]**	
		Or $(1 + 3x)(64 + 192x + 240x^2 + 160x^3)$	**[M1**	
		$\dots 816x^2 + 880x^3\dots$o.e.	**A1**	
		Multiply by $1 - x$	**M1**	
		64	**A1]**	

8	Eliminates y (or x) and full attempt at expansion	**M1**	
	$4x^2 - 8x - 96 = 0$ or $y^2 + 12y - 64 = 0$	**A1**	
	Factorise 3 term relevant quadratic	**M1**	Or use correct formula
	$x = -4$ and 6 or $y = -16$ and 4	**A1**	
	$y = -16$ and 4 or $x = -4$ and 6	**A1√**	
	Uses Pythagoras for relevant points	**M1**	
	22.4 or $\sqrt{500}$ or $10\sqrt{5}$	**A1**	cao
9 (i)	Attempt to solve 3 term quadratic	**M1**	
	–3 and 8	**A1**	
	$-3 < x < 8$	**A1**	Condone $-3 < x$ AND $x < 8$
(ii)	$4 < x$ (< 12)	**B1**	
	$S \cup T = -3 < x < 12$	**B1**	
(iii)	$S \cap T = 4 < x < 8$ or $S' = -5 < x \leqslant -3$, $8 \leqslant x < 12$ and $T' = -5 < x \leqslant 4$	**B1**	Penalise confusion over $<$ and $\leqslant$ (or $>$ and $\geqslant$) once only
	$-5 < x \leqslant 4$	**B1√**	*their* 4
	$8 \leqslant x < 12$	**B1√**	*their* 8 (Ignore AND/OR etc.)

10 (i)	$\frac{\sin\alpha}{50} = \frac{\sin 58}{240}$	**M1 A1**	Use of sin rule/cosine rule/resolving with 50, 240 and 58/32/122/148. Must be correct for **A1**
	$\alpha = 10.2$	**A1**	
	Bearing (0)21.8 or (0)22	**A1√**	√ for $32 - \alpha$
(ii)	$V^2 = 240^2 + 50^2 - 2 \times 240 \times 50 \times \cos(122 - \alpha)$	**M1**	Correct use of sin rule/cosine rule/resolving
	$V = 263$ awt	**A1**	Can be in **(i)**
	$T = \frac{500}{V}$	**M1**	Only allow if V calculated from non right-angled triangle
	114 or 1 hour 54 mins	**A1**	Do not allow incorrect units
	Or $T = \frac{500\cos 32}{240\cos 21.8}$	**[M1**	Alternative for part **(ii)** only. Also can find distance for 240 (457) then 457/240
	500 cos 32	**B1**	
	240 cos 21.8	**B1**	
	114 or 1 hour 54 mins	**A1]**	
11 (i)	1	**B1**	Not a range for k, but condone $x = 1$ and $x \geqslant 1$
(ii)	$f \geqslant -5$	**B1**	Not x, but condone y
(iii)	Method of inverse	**M1**	Do not reward poor algebra but allow slips
	$1+\sqrt{x+5}$	**A1**	Must be f^{-1} = ...or y = ...
(iv)	f: Positive quadratic curve correct range and domain	**B1**	Must cross x-axis
	f^{-1}: Reflection of f in $y = x$	**B1√**	√*their* f(*x*) sketch. Condone slight inaccuracies unless clear contradiction.
(v)	Arrange $f(x) = x$ or $f^{-1}(x) = x$ to 3 term quadratic = 0	**M1**	
	4 only www	**A1**	Allow $x = 4$ with no working. Condone (4, 4). Do not allow final **A** mark if –1 also given in answer

12 (i)	$f(3) = (27 + 9 + 3a + b) = 0$ or $3a + b = -36$	**M1**	Equate f(3) to 0
	$f(-1) = (-1 + 1 - a + b) = 20$ or $-a + b = 20$	**M1**	Equate f(–1) to 20
	Solve equations	**M1**	
	$a = -14,\ b = 6$	**A1**	If uses $b = 6$ then **M0, A0** Need both values for **A1**
(ii)	Find quadratic factor	**M1**	If division, must be complete with first 2 terms correct If writes down, must be $(x^2 + kx - 2)$
	$x^2 - 4x - 2$	**A1**	
	Use quadratic formula or completing square on relevant 3 term quadratic	**M1**	If completing square, must reach $\left(x+\frac{k}{2}\right)^2 = 2 \pm \left(\frac{k}{2}\right)^2$
	$\frac{-4 \pm \sqrt{16+8}}{2}$ or better	**A1√**	
	$-2 \pm \sqrt{6}$ isw	**A1**	cao

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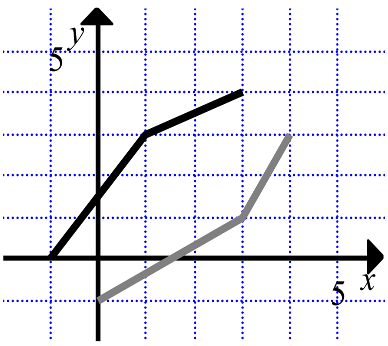
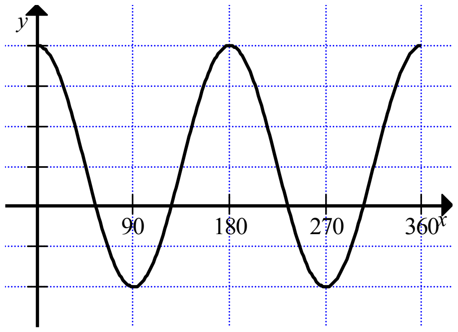
1	$m = \frac{18-3}{4-1}$ or 5 soi	M1	or $18 = 4m + c$ and $3 = m + c$ subtracting/substituting to solve for m or c, condone one error
	$Y - 3 =$ *their* $5(X - 1)$ or $Y - 18 =$ *their* $5(X - 4)$ or $3 =$ *their* $5 + c$ or $18 =$ *their* $5 \times 4 + c$	M1	or using *their m* or *their c* to find *their c* or *their m*, without further error
	$\sqrt{y} = (their\ m)\ x^2 + (their\ c)$ or $\sqrt{y} = (their\ m)\ (x^2 - 1) + 3$ or $\sqrt{y} = (their\ m)\ (x^2 - 4) + 18$	M1	their m and c must be validly obtained
	$y = (5x^2 - 2)^2$ or $y = (5(x^2 - 1) + 3)^2$ or $y = (5(x^2 - 4) + 18)^2$ cao, isw	A1	
2 (a)	$(p + 1) \ln 3 = \ln 0.7$	M1	or $p + 1 = \log_3 0.7$ or $p \ln 3 = \ln\left(\frac{0.7}{3}\right)$
	$p = \frac{\ln 0.7}{\ln 3} - 1$ or $p = \frac{\lg 0.7}{\lg 3} - 1$	M1	or $p = \log_3 0.7 - 1$ or $p \ln 3 = \ln\left(\frac{0.7}{3}\right) \div \ln 3$
	-1.32 cao	A1	allow **M2** for $p = \log_3\left(\frac{0.7}{3}\right)$ correct answer only scores **B3**
(b)	$2^{\frac{5}{2}} \times x^6 \times y^{-\frac{1}{2}}$ or $a = \frac{5}{2}$, $b = 6$, $c = -\frac{1}{2}$	B3	**B1** for each component
3 (a) (i)	A and E	B2	1 mark for each **B1** for 1 extra, **B0** if 2 or more extras
(ii)	C and D	B2	1 mark for each **B1** if 1 extra, **B0** if 2 or more extras
(b)		B2	(–1, 0), (1, 3), (3, 4) or **B1** for two points correct and joined or for three points correct but clearly not joined

4 **(i)**	$\overrightarrow{OC}=\overrightarrow{OA}+\overrightarrow{AC}$ or $\overrightarrow{OB}-\overrightarrow{OA}=3\left(\overrightarrow{OC}-\overrightarrow{OA}\right)$ soi	**B1**	or $3\overrightarrow{AC}=3(c_1-4)\mathbf{i}+3(c_2+21)\mathbf{j}$ o.e. soi
	$\pm(18\mathbf{i}-9\mathbf{j})$ o.e. or $\overrightarrow{OC}=\frac{2}{3}\overrightarrow{OA}+\frac{1}{3}\overrightarrow{OB}$	**B1**	
	$4\mathbf{i}-21\mathbf{j}+\frac{1}{3}\left(\textit{their}(18\mathbf{i}-9\mathbf{j})\right)$ o.e. or $\frac{2}{3}(4\mathbf{i}-21\mathbf{j})+\frac{1}{3}(22\mathbf{i}-30\mathbf{j})$	**M1**	or $3(c_1-4)=$ *their* 18 and $3(c_2+21)=$ *their* (-9)
	$10\mathbf{i}-24\mathbf{j}$ cao	**A1**	
(ii)	$\left\lvert\overrightarrow{OC}\right\rvert=\sqrt{\textit{their}10^2+\textit{their}(-24)^2}$ soi	**M1**	condone $\left\lvert\overrightarrow{OC}\right\rvert=\sqrt{\textit{their}10^2+\textit{their}(24)^2}$
	$\frac{1}{13}(5\mathbf{i}-12\mathbf{j})$ or $\frac{1}{26}(10\mathbf{i}-24\mathbf{j})$ isw	**A1 FT**	FT their $x\mathbf{i}+y\mathbf{j}$ o.e.
5	$AX=\sqrt{45}$	**B1**	may be implied by $3\sqrt{5}$
	$AX=3\sqrt{5}$	**B1**	may be seen later
	$\frac{1}{2}\left(4+\sqrt{5}+2+x\right)\times\textit{their}\ \sqrt{45}$ soi	**M1**	may be implied by e.g. summation of rectangle and two triangles
	$15(\sqrt{5}+2)=\frac{1}{2}\left(4+\sqrt{5}+2+x\right)\times\textit{their}\ \sqrt{45}$ or better	**M1**	
	Correctly divide *their* equation by *their* $\sqrt{5}$ or *their* $\sqrt{45}$ and rationalise denominator	**M1**	or correctly multiply both sides of *their* equation by *their* $\sqrt{5}$ or *their* $\sqrt{45}$ and obtain a rational coefficient of x soi
	completion to $4+3\sqrt{5}$ www	**A1**	answer only does not score

6	(i)	arc $AB = r\left(\frac{\pi}{3}\right)$	B1	
		chord $AB = r$ with justification and summation and completion to given answer	B1	$r\left(\frac{3+\pi}{3}\right)$
	(ii)	$r = 12.7$	B1	must be seen; accept awrt 12.7
		$\frac{1}{2} \times \textit{their } r^2 \times \left(\frac{\pi}{3} - \sin\left(\frac{\pi}{3}\right)\right)$	M3	may be implied for example 84.45…– 69.84… or **M1** for $\frac{1}{2} \times \textit{their } r^2 \times \frac{\pi}{3}$ or 84.45... **and** **M1** for $\frac{1}{2} \times \textit{their } r^2 \times \sin\frac{\pi}{3}$ o.e. or 69.84… **and** **M1** for Area Sector – Area triangle attempted
		awrt 14.6	A1	
7	(i)	$k(3-5x)^{11}$	M1	
		$5 \times 12(3-5x)^{11}$ or better, isw	A1	
	(ii)	$x^2(\textit{their} \cos x) + (\textit{their } 2x) \sin x$	M1	clearly applies correct form of product rule
		$x^2 \cos x + 2x \sin x$ isw	A1	
	(iii)	Quotient rule attempt:		Product rule attempt:
		$\frac{\mathrm{d}}{\mathrm{d}x}(\tan x) = \sec^2 x$	B1	$\frac{\mathrm{d}}{\mathrm{d}x}(\tan x) = \sec^2 x$
		$\frac{\mathrm{d}}{\mathrm{d}x}(1+\mathrm{e}^{2x}) = 2\mathrm{e}^{2x}$	B1	$\frac{\mathrm{d}}{\mathrm{d}x}(1+\mathrm{e}^{2x})^{-1} = -2\mathrm{e}^{2x}(1+\mathrm{e}^{2x})^{-2}$
		clearly applies correct form of quotient rule $\frac{(1+\mathrm{e}^{2x})(\textit{their } \sec^2 x) - (\textit{their } 2\mathrm{e}^{2x})\tan x}{(1+\mathrm{e}^{2x})^2}$	M1	$\tan x\,(\textit{their} - 2\mathrm{e}^{2x}(1+\mathrm{e}^{2x})^{-2}) + (1+\mathrm{e}^{2x})^{-1}(\textit{their } \sec^2 x)$
		$\frac{(1+\mathrm{e}^{2x})\sec^2 x - 2\mathrm{e}^{2x}\tan x}{(1+\mathrm{e}^{2x})^2}$ isw	A1	$\tan x\,(-2\mathrm{e}^{2x}(1+\mathrm{e}^{2x})^{-2}) + (1+\mathrm{e}^{2x})^{-1}(\sec^2 x)$

8	(i)	$y-2=\left(\frac{6-2}{2+6}\right)(x+6)$ o.e. soi	M1	or $y-6=\left(\frac{6-2}{2+6}\right)(x-2)$
		$y=\frac{1}{2}x+5$ isw	A1	
	(ii)	Use of $m_1m_2=-1$ $y-6=$ (*their* -2)$(x-2)$ or better, isw	M1 A1 FT	or $y=$ (*their* -2)$x+c$, $c=$ *their* 10, isw
	(iii)	$(x+6)^2+(y-2)^2=10^2$ o.e.	B1	or $(x-2)^2+(y-6)^2=(\sqrt{20})^2$ o.e. or $(\sqrt{80})^2+((x-2)^2+(y-6)^2)=10^2$
		Substitute $y=$ *their* $(-2x+10)$	M1*	or identifying one point by inspection from the length equation and testing it in the equation of *BC* or vice versa
		Solve their quadratic	M1 dep*	or identifying the second point by inspection from the length equation and testing it in the equation of *BC* or vice versa
		(0, 10) and (4, 2) o.e. only	A1	answer only does not score
9	(a)	$14=k+c$ and $6=\frac{k}{9}+c$ o.e.	M1	for two equations in *k* and *c*; may be unsimplified; condone one slip in one equation
		$c=5$ $k=9$	A1 A1	
	(b) (i)	79.2 or 79.158574 … rot to 4 or more sf	B1	
	(ii)	$e^{2x}+5e^x-24(=0)$ or $(e^x)^2+5e^x-24(=0)$ o.e. factorise *their* 3 term quadratic	M1 M1	condone one error, but must be three terms or correct/correct ft use of formula or completing the square
		$e^x=3$ $x=\ln 3$ or 1.1(0) or 1.0986122 … rot to 3 or more sf **as only answer from fully correct working**	A1 A1	ignore $e^x=-8$ do not allow final mark if value given from $e^x=-8$ if **M0M0** then **SC2** if $e^x=3$ is seen www and leads to $x=\ln 3$ or 1.1(0) or 1.0986122… rot to 3 or more sf

10 (a) (i)		**B1** **B1** **B1** **B1**	shape; cosine curve – ends must be approaching a turning point be centred on $y = 1$ clear intent to have min at –2 and max at 4 2 cycles
(ii)	3	**B1**	
(iii)	180	**B1**	
(b)	$\operatorname{cosec} x = \dfrac{1}{\sin x}$ soi	**B1**	or $1 + \tan^2 x = \dfrac{1}{\cos^2 x}$
	$\sin x = \sqrt{1-\cos^2 x}$ or $\sqrt{1-p^2}$	**B1**	or $\operatorname{cosec}^2 x = 1 + \dfrac{1}{1-p^2/p^2}$ soi
	$\dfrac{-1}{\sqrt{1-p^2}}$ o.e.	**B1**	or $-\sqrt{1+\dfrac{p^2}{1-p^2}}$ or better

<table>
<tr><td>11 (i)</td><td>$\frac{dy}{dx} = 3 - 3(x-4)^{-4}$ o.e. isw
$\frac{d^2y}{dx^2} = (\textit{their } 12)(x-4)^{\textit{their } (-5)}$ o.e.
$\frac{d^2y}{dx^2} = 12(x-4)^{-5}$ o.e. isw</td><td>B1 + B1
M1
A1</td><td>if M0 then SC1 for $12(x-4)^{-5}$ + one other term</td></tr>
<tr><td>(ii)</td><td>Verifies $\frac{dy}{dx} = 0$ when $x = 3$ and $x = 5$
or solves $3 - \frac{3}{(x-4)^4} = 0$ to obtain 3 and 5

Shows that $x = 3 \Rightarrow y = 8$ and $x = 5 \Rightarrow y = 16$</td><td>M1

A1</td><td>if M0 then SC1 for verifying or correctly solving to find one x coordinate and showing that it gives rise to the corresponding y coordinate</td></tr>
<tr><td>(iii)</td><td>$x = 5$ $\frac{d^2y}{dx^2}$ $(=12) > 0 \Rightarrow$ min or
$x = 3$ $\frac{d^2y}{dx^2}$ $(=-12) < 0 \Rightarrow$ max

Both correct cao</td><td>M1

A1</td><td>or, using first derivative e.g.
<table><tr><td>x</td><td>–</td><td>5</td><td>+</td></tr><tr><td>$\frac{dy}{dx}$</td><td>\</td><td>0</td><td>/</td></tr></table>min at $x = 5$
or
<table><tr><td>x</td><td>–</td><td>3</td><td>+</td></tr><tr><td>$\frac{dy}{dx}$</td><td>/</td><td>0</td><td>\</td></tr></table>max at $x = 3$</td></tr>
<tr><td>(iv)</td><td>$\frac{3x^2}{2} - \frac{(x-4)^{-2}}{2}(+c)$ o.e. isw</td><td>B1 + B1</td><td>may be unsimplified</td></tr>
<tr><td>(v)</td><td>their
$\left[\left(\frac{3(6)^2}{2} - \frac{1}{2(6-4)^2}\right) - \left(\frac{3(5)^2}{2} - \frac{1}{2(5-4)^2}\right)\right]$
16.875 to 3 or more sf or $\frac{135}{8}$ or $16\frac{7}{8}$ cao</td><td>M1

A1</td><td></td></tr>
</table>

CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the May/June 2013 series

0606 ADDITIONAL MATHEMATICS

0606/23 Paper 2, 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 May/June 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

CAMBRIDGE
International Examinations

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.

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.

1	$\dfrac{2+2\sin^2\theta}{\cos^2\theta}$	**B1**	For all methods look for:
	$\dfrac{2}{\cos^2\theta}=2\sec\theta$	**B1**	– correct simplified expression – correct use of Pythagoras – use of tan = $\dfrac{\sin}{\cos}$ – use of $\dfrac{1}{\cos}=\sec$
	$\dfrac{\sin^2\theta}{\cos^2\theta}=2\tan^2\theta$	**B1**	
	$2\sec^2\theta=2+2\tan^2\theta$ and completion	**B1**	Award first 3 then last B1 for final expression from fully correct method. Inconsistent no angle used then –1 (can recover). If start from RHS award similarly.
	Or $(\sec\theta+\tan\theta)^2+(\sec\theta-\tan\theta)^2$	**[B1, B1**	
	$2\sec^2\theta+2\tan^2\theta$	**B1**	
	$2(1+\tan^2\theta)+2\tan^2\theta$ and completion	**B1]**	
	Or $\dfrac{2+2\sin^2\theta}{\cos^2\theta}$	**[B1**	
	$\dfrac{2(\sin^2\theta+\cos^2\theta)+2\sin^2\theta}{\cos^2\theta}$	**B1**	
	$\dfrac{4\sin^2\theta}{\cos^2\theta}=4\tan^2\theta$	**B1**	
	$\dfrac{2\cos^2\theta}{\cos^2\theta}=2$ and completion	**B1]**	
2 (i)	3.2	**B1**	
(ii)	15	**B1**	
(iii)	uses area to find distance	**M1**	If split 2 or 3 correct formulae and must be attempting total area
	two of 40, 240 and 32	**A1**	
	312	**A1**	or **A2** for 312 from trapezium

3	$\frac{dy}{dx} = k\sin x\cos x$	**M1**	
	$k = -8$	**A1**	
	Attempt to find x when $y = 8$	**M1**	Must get to x = numerical value
	$x = \frac{\pi}{4}$ (0.785)	**A1**	45° = **A0** (but can still gain next 2 marks)
	Uses $\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}$	**M1**	Must use numerical value for x and 0.2 for $\frac{dx}{dt}$
	–0.8 (not rounded)	**A1**	(condone poor notation if correct terms multiplied)
4 (i)	Idea of modulus correct	**B1**	Two straight lines above and touching x-axis
	$\frac{1}{2}$ indicated on x-axis	**B1**	Must be a sketch
	2 indicated on y-axis	**B1**	Must be a sketch
(ii)	$\frac{2}{3}$ (0.667)	**B1**	0.67 is **B0**
	Solve $4x - 2 = -x$ or $(4x-2)^2 = x^2$	**M1**	As far as x = numerical value
	$\frac{2}{5}$	**A1**	SC: If drawn then **B1**, **B2** for exact answers only
5 (i)	$(QR = PS =) \frac{96 - 3x}{2}$	**B1**	Can be implied by next statement
	Area = $\left(\frac{96-3x}{2}\right) \times x$	**B1**	**AG**
(ii)	$\frac{dA}{dx} = \frac{96-6x}{2}$ or $48 - 3x$ o.e.	**B1**	
	Solving $\frac{dA}{dx} = \frac{96-6x}{2} = 0$	**M1**	As far as x = numerical value
	$x = 16$	**A1**	
	$A = 384$ and state maximum	**A1**	

6	Applies quotient rule correctly	**M1**	or product rule
	$\frac{(x-2)2x-(x^2+8)}{(x-2)^2}$	**A1**	$2x(x-2)^{-1}-(x^2+8)(x-2)^{-2}$
	$y = 12$	**B1**	
	Uses $m_1m_2 = -1$	**M1**	
	(Gradient normal = $\frac{1}{2}$)		
	Uses equation of line for **normal**	**M1**	If uses $y = mx + c$ must find c for **M1**
	$y-12=\frac{1}{2}(x-4)$ or $y=\frac{1}{2}x+10$	**A1**	
7 (i)	$64 + 192x + 240x^2 + 160x^3$ mark final answer	**B3, 2, 1, 0**	3 terms correct earn **B2**; 2 terms correct earn **B1** Can be earned in **(ii)**; **SC2** correct but unsimplified
(ii)	Multiply out $(1 + 3x)(1 - x)$	**M1**	
	$1 + 2x - 3x^2$ o.e.	**A1**	
	$(1) \times (160) + (2) \times (240) + (-3) \times (192)$ o.e.	**M1**	3 terms
	64	**A1**	
	Or Multiply out $(1 - x)(64 + 192x + 240x^2 + 160x^3)$	**[M1**	May be other variations: for first **M1** find x^2 term or x^3 term
	$...48x^2 - 80x^3...$o.e.	**A1**	
	Multiply by $1 + 3x$	**M1**	for second **M1** must produce all relevant terms
	64	**A1]**	
	Or $(1 + 3x)(64 + 192x + 240x^2 + 160x^3)$	**[M1**	
	$...816x^2 + 880x^3...$o.e.	**A1**	
	Multiply by $1 - x$	**M1**	
	64	**A1]**	

8	Eliminates y (or x) and full attempt at expansion	**M1**	
	$4x^2 - 8x - 96 = 0$ or $y^2 + 12y - 64 = 0$	**A1**	
	Factorise 3 term relevant quadratic	**M1**	Or use correct formula
	$x = -4$ and 6 or $y = -16$ and 4	**A1**	
	$y = -16$ and 4 or $x = -4$ and 6	**A1√**	
	Uses Pythagoras for relevant points	**M1**	
	22.4 or $\sqrt{500}$ or $10\sqrt{5}$	**A1**	cao
9 (i)	Attempt to solve 3 term quadratic	**M1**	
	–3 and 8	**A1**	
	–3 x 8	**A1**	Condone –3 x AND x 8
(ii)	4 x (12)	**B1**	
	$S \cup T$ = –3 x 12	**B1**	
(iii)	$S \cap T$ = 4 x 8 or S' = –5 x –3, 8 x 12 and T' = –5 x 4	**B1**	Penalise confusion over and (or and) once only
	–5 x 4	**B1√**	*their* 4
	8 x 12	**B1√**	*their* 8 (Ignore AND/OR etc.)

10 (i)	$\frac{\sin\alpha}{50} = \frac{\sin 58}{240}$	**M1 A1**	Use of sin rule/cosine rule/resolving with 50, 240 and 58/32/122/148. Must be correct for **A1**
	$\alpha = 10.2$	**A1**	
	Bearing (0)21.8 or (0)22	**A1√**	√ for $32 - \alpha$
(ii)	$V^2 = 240^2 + 50^2 - 2 \times 240 \times 50 \times \cos(122 - \alpha)$	**M1**	Correct use of sin rule/cosine rule/resolving
	$V = 263$ awt	**A1**	Can be in **(i)**
	$T = \frac{500}{V}$	**M1**	Only allow if V calculated from non right-angled triangle
	114 or 1 hour 54 mins	**A1**	Do not allow incorrect units
	Or $T = \frac{500\cos 32}{240\cos 21.8}$	**[M1**	Alternative for part **(ii)** only Also can find distance for 240 (457) then 457/240
	500 cos 32	**B1**	
	240 cos 21.8	**B1**	
	114 or 1 hour 54 mins	**A1]**	
11 (i)	1	**B1**	Not a range for k, but condone $x = 1$ and x 1
(ii)	f –5	**B1**	Not x, but condone y
(iii)	Method of inverse	**M1**	Do not reward poor algebra but allow slips
	$1+\sqrt{x+5}$	**A1**	Must be f^{-1} = ...or y = ...
(iv)	f: Positive quadratic curve correct range and domain	**B1**	Must cross x-axis
	f^{-1}: Reflection of f in $y = x$	**B1√**	√*their* f(*x*) sketch Condone slight inaccuracies unless clear contradiction.
(v)	Arrange $f(x) = x$ or $f^{-1}(x) = x$ to 3 term quadratic = 0	**M1**	
	4 only www	**A1**	Allow $x = 4$ with no working. Condone (4, 4). Do not allow final **A** mark if –1 also given in answer

12	**(i)**	$f(3) = (27 + 9 + 3a + b) = 0$ or $3a + b = -36$	**M1**	Equate f(3) to 0
		$f(-1) = (-1 + 1 - a + b) = 20$ or $-a + b = 20$	**M1**	Equate f(–1) to 20
		Solve equations	**M1**	
		$a = -14,\ b = 6$	**A1**	If uses $b = 6$ then **M0, A0** Need both values for **A1**
	(ii)	Find quadratic factor	**M1**	If division, must be complete with first 2 terms correct If writes down, must be $(x^2 + kx - 2)$
		$x^2 - 4x - 2$	**A1**	
		Use quadratic formula or completing square on relevant 3 term quadratic	**M1**	If completing square, must reach $\left(x+\frac{k}{2}\right)^2 = 2 \pm \left(\frac{k}{2}\right)^2$
		$\frac{-4 \pm \sqrt{16+8}}{2}$ or better	**A1√**	
		$-2 \pm \sqrt{6}$ isw	**A1**	cao