Cambridge International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2024**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the October/November 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions 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.

Mathematics-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, non-integer 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 or sign 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 A or B 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	$\dfrac{\sin\theta}{\cos\theta}+\dfrac{\cos\theta}{\sin\theta}$	**M1**	
	$\dfrac{\sin^2\theta+\cos^2\theta}{\cos\theta\sin\theta}$	**A1**	
	$\dfrac{1}{\cos\theta\sin\theta}$ oe **and** completion to given answer $\sec\theta\operatorname{cosec}\theta$	**A1**	
	Alternative		
	$\left[\tan\theta+\dfrac{1}{\tan\theta}=\right]=\dfrac{\tan^2+1}{\tan\theta}$	**(M1)**	
	$\dfrac{\sec^2\theta}{\tan\theta}$	**(A1)**	
	$\dfrac{\sec^2\theta\cos\theta}{\sin\theta}$ oe **and** completion to given answer $\sec\theta\operatorname{cosec}\theta$	**(A1)**	
2(a)	$\left[\dfrac{dy}{dx}=\right]$ $\tan^2 x$ nfww	**B2**	**B1** for $\sec^2 x - 1$
2(b)	$[\tan x - x]_0^{\frac{\pi}{4}}$	**M1**	
	$1-\dfrac{\pi}{4}$ or exact equivalent	**A1**	
3(a)	$\left(8^{\frac{1}{x}}\right)^2-8^{\frac{1}{x}}-2\ [=0]$ oe or $\left(2^{\frac{3}{x}}\right)^2-2^{\frac{3}{x}}-2\ [=0]$ oe	**B1**	
	$(8^{\frac{1}{x}}-2)(8^{\frac{1}{x}}+1)=0$ oe or $(2^{\frac{3}{x}}-2)(2^{\frac{3}{x}}+1)=0$ oe	**M1**	**FT** *their* 3-term quadratic in $8^{\frac{1}{x}}$ oe
	$8^{\frac{1}{x}}=2\ \left[8^{\frac{1}{x}}=-1\right]$ or $2^{\frac{3}{x}}=2\ \left[2^{\frac{3}{x}}=-1\right]$ oe	**A1**	
	$x = 3$ nfww	**A1**	

Question	Answer	Marks	Partial Marks
3(b)	$a^2 - 2\sqrt{3}a + 3$ [$= b + (3 - b)\sqrt{3}$]	**B1**	
	Equates coefficients to form two equations	**M1**	**FT** *their*($a^2 - 2\sqrt{3}a + 3$) $= b + (3 - b)\sqrt{3}$ providing of equivalent difficulty
	$a^2 + 3 = b$ and $-2a = 3 - b$ oe	**DM1**	**FT** *their*($a^2 - 2\sqrt{3}a + 3$) $= b + (3 - b)\sqrt{3}$
	$a^2 - 2a$ [= 0] or $b^2 - 10b + 21$ [= 0]	**DM1**	
	$a = 2, 0$ or $b = 3$ or 7	**A1**	
	$a = 2, b = 7$ **and** $a = 0, b = 3$	**A1**	
4	$\mathbf{b} - \mathbf{a} = \dfrac{p}{p+q}(\mathbf{c} - \mathbf{a})$ oe AND Correct completion to given answer $\mathbf{b} = \dfrac{q\mathbf{a} + p\,\mathbf{c}}{q + p}$	**5**	**B4** for $\mathbf{b} - \mathbf{a} = \dfrac{p}{p+q}(\mathbf{c} - \mathbf{a})$ OR **B1** for $\overrightarrow{AB} = \dfrac{p}{p+q}\overrightarrow{AC}$ soi **B1** for $\overrightarrow{AB} = \mathbf{b} - \mathbf{a}$ soi **B1** for $\overrightarrow{AC} = \mathbf{c} - \mathbf{a}$ soi
	Alternative 1		
	$q(\mathbf{b} - \mathbf{a}) = p(\mathbf{c} - \mathbf{b})$ oe AND Correct completion to given answer $\mathbf{b} = \dfrac{q\mathbf{a} + p\,\mathbf{c}}{q + p}$	**(5)**	**B4** for $q(\mathbf{b} - \mathbf{a}) = p(\mathbf{c} - \mathbf{b})$ OR **B1** for $q\overrightarrow{AB} = p\overrightarrow{BC}$ soi **B1** for $\overrightarrow{AB} = \mathbf{b} - \mathbf{a}$ soi **B1** for $\overrightarrow{BC} = \mathbf{c} - \mathbf{b}$ soi
	Alternative 2		
	$\mathbf{b} = \mathbf{a} + \dfrac{p}{p+q}(\mathbf{c} - \mathbf{a})$ oe or $\mathbf{b} = \mathbf{c} + \dfrac{q}{p+q}(\mathbf{a} - \mathbf{c})$ oe AND Correct completion to given answer $\mathbf{b} = \dfrac{q\mathbf{a} + p\,\mathbf{c}}{q + p}$	**(5)**	**B4** for $\mathbf{b} = \mathbf{a} + \dfrac{p}{p+q}(\mathbf{c} - \mathbf{a})$ oe or $\mathbf{b} = \mathbf{c} + \dfrac{q}{p+q}(\mathbf{a} - \mathbf{c})$ oe OR **B1** for $\overrightarrow{OB} = \overrightarrow{OA} + \overrightarrow{AB}$ or $\overrightarrow{OB} = \overrightarrow{OC} + \overrightarrow{CB}$ soi **B1** for $\overrightarrow{AB} = \dfrac{p}{p+q}\overrightarrow{AC}$ or $\overrightarrow{CB} = \dfrac{q}{p+q}\overrightarrow{CA}$ soi **B1** for $\overrightarrow{AC} = \mathbf{c} - \mathbf{a}$ **or** $\overrightarrow{CA} = \mathbf{a} - \mathbf{c}$ soi

Question	Answer	Marks	Partial Marks
5	$\log_a\left(\frac{5(p+1)p}{p+2}\right) = \log_a 12$ oe, nfww or $\frac{5(p+1)p}{p+2} = 12$ oe, nfww	**M2**	**M1** for correct use of one log law in a correct equation e.g. $\log_a(p+1)+\log_a p-\log_a(p+2)$ $+\log_a 5=\log_a 12$ or $\log_a p(p+1)-\log_a(p+2)$ $=\log_a 12-\log_a 5$ or $\log_a \frac{p+1}{p+2}+\frac{1}{\log_p a}$ $+\log_a 5=\log_a 12$
	$5p^2 - 7p - 24 = 0$	**A1**	
	$(5p + 8)(p - 3) = 0$ or formula	**DM1**	**FT** *their* 3-term quadratic
	$p = 3$ and no other solution nfww	**A1**	
6(a)	OA: $2\sqrt{3}$ or $\sqrt{12}$ soi	**B1**	
	Correct method to find angle AOE e.g. $2\tan(\ldots) = \frac{3}{\sqrt{3}}$ oe or $36 = 12 + 12 - 2(12)\cos AOE$ oe or $\pi - 2\tan^{-1}\frac{\sqrt{3}}{3}$ oe	**M1**	
	Angle AOE: $\frac{2\pi}{3}$ soi, isw	**A1**	
	Arc AFE: *their* $2\sqrt{3}$ × *their* $\frac{2\pi}{3}$ soi or $\frac{4\sqrt{3}}{3}\pi$	**M1**	**FT** *their* $\frac{2\pi}{3}$ and *their* $2\sqrt{3}$
	Perimeter: $10 + 2\sqrt{3} + \frac{4\sqrt{3}}{3}\pi$ or exact equivalent, cao	**A1**	

Question	Answer	Marks	Partial Marks
6(b)	Sum of three correct areas $4\pi + 12 + 3\sqrt{3}$ cao	3	**M2 FT** *their* $\frac{2\pi}{3}$ and *their* $2\sqrt{3}$ for sector AOE: $\frac{1}{2} \times (their\ 2\sqrt{3})^2 \times their \frac{2\pi}{3}$ oe or 4π **and** $\frac{1}{2}\times 6 \times 4$ or $2\times\frac{1}{2}\times 3\times\sqrt{3}$ oe or **M1 FT** *their* $\frac{2\pi}{3}$ and *their* $2\sqrt{3}$ for sector AOE: $\frac{1}{2} \times (their\ 2\sqrt{3})^2 \times their \frac{2\pi}{3}$ oe or 4π
7	Attempts product rule	M1	
	$\frac{dy}{dx}$ = $2\cos x - 2x\sin x$ oe	A1	
	When $x = \pi$, $\frac{dy}{dx} = -2$	DM1	**FT** *their* $\left.\frac{dy}{dx}\right\|_{x=\pi}$
	Gradient of normal: $\frac{1}{2}$	M1	**FT** $\dfrac{-1}{their \left.\frac{dy}{dx}\right\|_{x=\pi}}$
	$y + 2\pi = \frac{1}{2}(x - \pi)$ oe	A1	**FT** *their* normal gradient
	$(5\pi, 0)$ or $(0, -\frac{5}{2}\pi)$ oe, soi	A1	
	Area of triangle POQ: $\frac{25}{4}\pi^2$ nfww	A1	
8(a)	$3t^2 + 2t - 1$	B1	
	$(3t - 1)(t + 1)$	M1	**FT** *their* 3-term quadratic in $t = 0$ soi
	$t = \frac{1}{3}$ and no other solutions	A1	
8(b)	At $t = 0$, $x = 8$ and $v = -1$	B2	**B1** for $t = 0$, $x = 8$ or $t = 0$, $v = -1$
	Conclusion: Since x is positive and v is negative [the particle is moving towards O.]	B1	

Question	Answer	Marks	Partial Marks
8(c)	$t = \frac{1}{3}$ $x = \frac{211}{27}$ or 7.814[814…] rot to 4 or more sf	**B1**	
	Distance $t = 0$ to $t = \frac{1}{3}$: $8 - \frac{211}{27}$ or $\frac{5}{27}$ or 0.1851[85…] rot to 4 or more sf **and** Distance $t = \frac{1}{3}$ to $t = 2$: $18 - \frac{211}{27}$ or $\frac{275}{27}$ or 10.18[51…] rot to 4 or more sf	**M2**	**M1** for distance $t = 0$ to $t = \frac{1}{3}$: $8 - \frac{211}{27}$ or $\frac{5}{27}$ or 0.1851[85…] rot to 4 or more sf or $t = \frac{1}{3}$ to $t = 2$: $18 - \frac{211}{27}$ or $\frac{275}{27}$ or 10.18[51…] rot to 4 or more sf
	Total: 10.4 or 10.37[037…] rot to 4 or more sf	**A1**	
9(a)(i)	$c = 12$	**B1**	
9(a)(ii)	$\frac{dy}{dx} = 2x - 8 = 0$ or $x^2 - 8x + c = (x-4)^2 - 16 + c$	**M1**	
	$3 = -16 + c$ or $3 = 4^2 - 8\times4 + c$	**DM1**	
	$c = 19$	**A1**	
9(b)	$c > 16$	**B2**	**B1** for c * 16 where * is = or an incorrect inequality sign
10(a)	${}^7C_3 \times {}^8C_3 + {}^7C_4 \times {}^8C_2$	**M2**	**M1** for ${}^7C_3 \times {}^8C_3$ or ${}^7C_4 \times {}^8C_2$
	2940	**A1**	
10(b)	${}^6P_4 \times 3 \times 5$ oe	**M2**	**M1** for ${}^6P_4[\times 1]$ or ${}^6P_4 \times 3$ or ${}^6P_4 \times 5$ oe
	5400	**A1**	
11(a)(i)	Valid explanation e.g. The line $x = k$, where $-10 \leqslant k \leqslant 10$ cuts the curve in one point only	**B1**	
11(a)(ii)	$\dfrac{\frac{x}{x-1}}{\frac{x}{x-1} - 1}$	**M1**	
	Correct simplification to x	**A1**	

Question	Answer	Marks	Partial Marks
11(a)(iii)	Valid explanation e.g. f and f^{-1} are the same or f is self-inverse oe	**B1**	
11(a)(iv)	Valid explanation e.g. The curve is symmetrical about line $y = x$	**B1**	
11(b)	$1 < g \leqslant 2$	**B1**	
11(c)	$x \neq -\frac{1}{3}$	**B1**	
12(a)	$d_A = 3$ and $d_B = -3$	**B2**	**B1** for $d_A = 3$ or $d_B = -3$
	$a_n = 1 + (n-1)\times 3$ oe, isw or $a_n = 3n - 2$	**B1**	
	$b_n = 298 + (n-1)\times(-3)$ oe, isw or $b_n = -3n + 301$	**B1**	
	Solves $3n - 2 - (-3n + 301) = 45$ oe to find a value of n	**M1**	**FT** *their* $a_n - (-3n + 301)$ or $3n - 2$ – *their* b_n
	$n = 58$	**A1**	
12(b)	$3m - 2 * 2(-3m + 301)$ oe where * is = or any inequality sign	**M1**	**FT** *their* a_n and *their* b_n from part **(a)**
	$m * 67.1[11…]$ where * is = or any inequality sign	**A1**	
	68	**A1**	

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- marks are not deducted for omissions
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Mathematics-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, non-integer 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 or sign 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 A or B 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.

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

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

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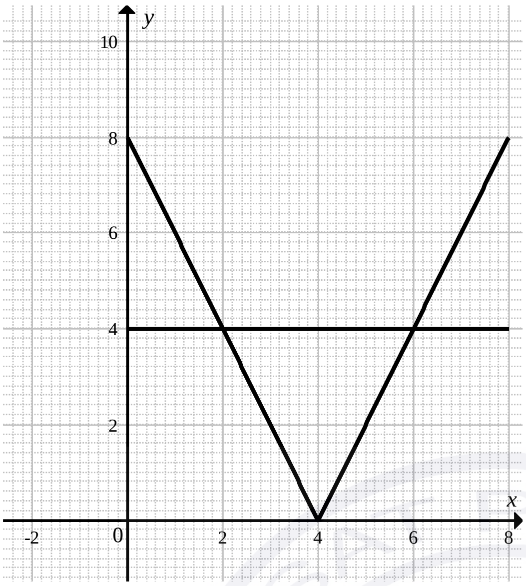
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial marks
1	Correct elimination of one unknown e.g. $\left(\frac{3}{2}\right)^4 \times \frac{1}{x} = \frac{27}{16}$ or $\left(\frac{3}{2}x\right)^4 \times \frac{1}{x^5} = \frac{27}{16}$ or $\frac{y^4}{\left(\frac{2y}{3}\right)^5} = \frac{27}{16}$ or $16\left(\frac{81}{16}x^4\right) = 27x^5$ or $16y^4 = 27\left(\frac{32}{243}y^5\right)$ oe	**M1**	
	$x = 3$ and $y = \frac{9}{2}$ oe and no other solutions	**A2**	**A1** for $x = 3$ or $y = \frac{9}{2}$ oe
2(a)	$\frac{\mathrm{d}}{\mathrm{d}x}\sqrt{1+2x} = (1+2x)^{-\frac{1}{2}}$ or $\frac{1}{2}\times(1+2x)^{-\frac{1}{2}}\times 2$ oe	**B2**	**B1** for $k(1+2x)^{-\frac{1}{2}}$ where k is a positive constant, $k \neq 1$
	$x \times their\left(\frac{1}{2}(1+2x)^{-\frac{1}{2}} \times 2\right) + [1](1+2x)^{\frac{1}{2}}$ oe, isw	**B1**	**FT** *their* $\frac{\mathrm{d}}{\mathrm{d}x}\sqrt{1+2x}$
	Alternative		
	$\frac{1}{2}\left(x^2+2x^3\right)^{-\frac{1}{2}} \times \left(2x+6x^2\right)$ or $\frac{1}{2}\left(x^2(1+2x)\right)^{-\frac{1}{2}} \times \left(2x^2+2x(1+2x)\right)$	**(B3)**	**B2** for $\frac{1}{2}\left(x^2+2x^3\right)^{-\frac{1}{2}} \times \left(ax+bx^2\right)$ or $\frac{1}{2}\left(x^2(1+2x)\right)^{-\frac{1}{2}} \times \left(ax+bx^2\right)$ where a and b are constants or **B1** for $k\left(x^2+2x^3\right)^{-\frac{1}{2}}$ or $k\left(x^2(1+2x)\right)^{-\frac{1}{2}}$ where k is a positive constant, soi
2(b)	Uses *their* $4(1+2(4))^{-\frac{1}{2}} + (1+2(4))^{\frac{1}{2}}$ in an attempt at a small changes relationship	**M1**	**FT** $x = 4$ substituted into *their* derivative
	$\frac{0.06}{\delta x} = their\left(4(1+2(4))^{-\frac{1}{2}} + (1+2(4))^{\frac{1}{2}}\right)$ oe	**M1**	**dep** previous **M1** **FT** *their* $\frac{13}{3}$
	0.0138 or 0.01384[6…] or $\frac{9}{650}$ oe nfww	**A1**	

Question	Answer	Marks	Partial marks
2(c)	$\dfrac{x}{\sqrt{1+2x}}+\sqrt{1+2x}=0$ oe and solves as far as $x=$ ….	**M1**	**FT** a derivative of the form $\dfrac{ax}{\sqrt{1+2x}}+b\sqrt{1+2x}$ or $\dfrac{a}{\sqrt{1+2x}}+b\sqrt{1+2x}$ or $\dfrac{ax+b}{\sqrt{1+2x}}$ oe
	$x=-\dfrac{1}{3}$ oe	**A1**	
3(a)	$8a-12-6+b=0$ oe and $-a-3+3+b=0$ oe and $a=2$, $b=2$	**B3**	**B1** for $8a-12-6+b=0$ oe **B1** for $-a-3+3+b=0$ oe
3(b)	$[2x^3-3x^2-3x+2=]$ $(x-2)$, $(x+1)$, $(2x-1)$ or (x^2-x-2), $(2x-1)$ **and** $x=2$, $\frac{1}{2}$, -1 OR $[2x^3-3x^2-3x+2=]$ $(x+1)$, $(2x^2-5x+2)$ or $(x-2)$, $(2x^2+x-1)$ **and** correct factorisation or method of solution of the quadratic **and** $x=2$, $\frac{1}{2}$, -1 OR $2-1+x=-\left(\dfrac{-3}{2}\right)$ or $2-1+x=\dfrac{3}{2}$ or for $2\times-1\times x=\dfrac{-2}{2}$ or $2\times-1\times x=-1$ **and** $x=2$, $\frac{1}{2}$, -1	**B2**	**B1** for $[2x^3-3x^2-3x+2=]$ $(x-2)$ and $(x+1)$ seen or (x^2-x-2) seen or $(x+1)$, $(2x^2-5x+2)$ or $(x-2)$, $(2x^2+x-1)$ **B1** for $2-1+x=-\left(\dfrac{-3}{2}\right)$ or $\dfrac{3}{2}$ or for $2\times-1\times x=\dfrac{-2}{2}$ or -1

Question	Answer	Marks	Partial marks
4	Correct intersecting graphs 	**3**	$y = \|2x - 8\|$: **M1** for an attempt to draw the sections from (0, 8) to (2, 4) and (6, 4) to (8, 8) with at least one side accurate or for $\vee$ shape with vertex at (4, 0) **A1** for correct graph **B1** for $y = 4$ drawn
	critical values: 2, 6	**M1**	**dep** on 3 marks awarded for intersecting graphs
	$x < 2$, $x > 6$ mark final answer	**A1**	
5(a)	Correctly derives correct equation free of logarithms e.g. $x^9 = 16^{18}$ or $x = 16^2$ oe or $x^9 = 2^{72}$ or $x = 2^8$ oe or $x^{\frac{9}{4}} = 2^{18}$ oe	**M3**	**M2** for correctly changing to consistent bases **<u>and</u>** correct use of one other log law or correct use of $\log_a a = 1$ in a correct equation e.g. $\dfrac{\log_{16} x^2}{\frac{1}{4}} + \log_{16} x = 18$ oe or $\log_2 x^2 + \dfrac{\log_2 x}{4} = 18$ oe or $\dfrac{\log_x x^2}{\log_x 2} + \dfrac{\log_x x}{4\log_x 2} = 18$ or **M1** for correctly changing to consistent bases or correct use of one other log law or correct use of $\log_a a = 1$ in a correct equation
	$x = 256$ nfww	**A1**	

Question	Answer	Marks	Partial marks
5(b)	$e^{4x+2} - 3e^{2x+1} - 10 \; [= 0]$ or $\left(e^{2x+1}\right)^2 - 3e^{2x+1} - 10 \; [= 0]$	**B1**	
	Solves or factorises *their* 3-term quadratic in e^{2x+1}	**M1**	**FT** *their* 3-term quadratic in e^{2x+1}
	$e^{2x+1} = 5$ nfww	**A1**	
	$x = \dfrac{-1+\ln 5}{2}$ oe, isw or 0.305 or 0.3047[18…] isw	**A1**	and no other solution
	Alternative		
	$e\left(e^{2x}\right)^2 - 3e^{2x} - 10e^{-1} \, [= 0]$ oe or $e^2\left(e^{2x}\right)^2 - 3e\left(e^{2x}\right) - 10 \, [= 0]$ oe or $e^2\left(e^{x}\right)^4 - 3e\left(e^{x}\right)^2 - 10 \, [= 0]$ oe	**(B1)**	
	Solves or factorises *their* 3-term quadratic in e^{2x} oe	**(M1)**	**FT** *their* 3-term quadratic in e^{2x}
	$e^{2x} = \dfrac{5}{e}$ or 1.839[…] or $e^x = \sqrt{\dfrac{5}{e}}$ or 1.356[…] nfww	**(A1)**	
	$x = \dfrac{1}{2}\ln\dfrac{5}{e}$ oe, isw or 0.305 or 0.3047[18…] isw	**(A1)**	and no other solution
6	$\dfrac{5-\sqrt{3}}{\left(\sqrt{6}+\sqrt{2}\right)^2}$ soi	**B1**	
	$\left(\sqrt{6}+\sqrt{2}\right)^2 = 6+2+2\sqrt{12}$ or $8+2\sqrt{12}$	**B1**	
	$\dfrac{5-\sqrt{3}}{8+4\sqrt{3}} \times \dfrac{8-4\sqrt{3}}{8-4\sqrt{3}}$ or $\dfrac{5-\sqrt{3}}{4\left(2+\sqrt{3}\right)} \times \dfrac{2-\sqrt{3}}{2-\sqrt{3}}$ oe	**M1**	**FT** $\dfrac{a\left(5-\sqrt{3}\right)}{b+c\sqrt{d}}$ where *a*, *b*, and *c* are non-zero constants and *d* is an integer
	$\dfrac{40-20\sqrt{3}-8\sqrt{3}+12}{8^2-(4\sqrt{3})^2}$ or $\dfrac{40-20\sqrt{3}-8\sqrt{3}+12}{64-48}$ or $\dfrac{10-5\sqrt{3}-2\sqrt{3}+3}{4(2^2-(\sqrt{3})^2)}$ or $\dfrac{10-5\sqrt{3}-2\sqrt{3}+3}{4}$	**A1**	
	$\dfrac{13}{4}-\dfrac{7}{4}\sqrt{3}$ oe, nfww	**A1**	**dep** on all previous marks awarded

Question	Answer	Marks	Partial marks
7(a)(i)	252	**B1**	
7(a)(ii)	56	**B2**	**B1** for ${}^8C_3$ or $\frac{8!}{5! \times 3!}$ oe
7(a)(iii)	140	**B2**	**B1** for ${}^8C_4 \times 2$ oe or ${}^{10}C_5 - {}^8C_5 - {}^8C_3$ oe
7(b)	483 840	**B3**	**B2** for 8! × 6 [× 2] or 241 920 oe or **B1** for 8! or 40 320 or 8! × 2 or 80 640
8	$\text{cosec}^2 2\theta + 3\text{cosec}\, 2\theta - 10$ [= 0] or $10\sin^2 2\theta - 3\sin 2\theta - 1$ [= 0]	**B2**	**B1** for correctly writing the equation in terms of one trigonometric function e.g. $\text{cosec}^2 2\theta - 1 + 3\,\text{cosec}\, 2\theta = 9$ or $\frac{1-\sin^2 2\theta}{\sin^2 2\theta} + \frac{3}{\sin 2\theta} = 9$
	Solves or factorises *their* 3-term quadratic in $\text{cosec}2\theta$ or $\sin 2\theta$ e.g. $(\text{cosec}\, 2\theta - 2)(\text{cosec}\, 2\theta + 5)$ [= 0] or $(2\sin 2\theta - 1)(5\sin 2\theta + 1)$ [= 0]	**M1**	**FT** *their* 3-term quadratic in $\text{cosec}2\theta$ or $\sin 2\theta$
	[$\sin 2\theta = \frac{1}{2}$ $\sin 2\theta = -\frac{1}{5}$ $\theta =$] 15 75 −5.8 or –5.76 to –5.77 −84.2 or –84.23 to –84.232 and no other angles in range; nfww	**A3**	**A2** for any 2 correct, ignoring extras in range; nfww or **A1** for one correct angle or one correct double angle; nfww

Question	Answer	Marks	Partial marks
9(a)	Horizontal line, $v = 6$ for $0 \leqslant t \leqslant 5$	**B1**	
	Horizontal line, $v = -3$ for $5 \leqslant t \leqslant 15$	**B2**	**B1** for horizontal line for $5 \leqslant t \leqslant 15$ with $v = k$ where $k < 0$ or $v = 3$ for $5 \leqslant t \leqslant 15$ or $v = -3$ for $t > 5$ and at least $7 \leqslant t \leqslant 13$ If **0** scored, award: **SC2** for Horizontal line, $v = -6$ for $0 \leqslant t \leqslant 5$ **and** Horizontal line, $v = 3$ for $5 \leqslant t \leqslant 15$ **OR SC1** for Horizontal line, $v = -6$ for $0 \leqslant t \leqslant 5$ **and** Horizontal line for $5 \leqslant t \leqslant 15$ with $v = k$ where $k > 0$
9(b)	Single line with positive gradient passing through (0, –8), (10, 0) and (20, 8)	**B3**	**B2** for a single line with positive gradient • passing through a point indicated as (0, –8) or (20, 8) **and** the point (10, 0) • or passing through points indicated as (0, –8) and (20, 8) which does not pass through (10, 0) or **B1** for a single line with positive gradient • passing through a point indicated as (0, –8) or (20, 8) to or through any point on the t-axis • or passing through (10, 0) but with both endpoints incorrect or unlabelled If 0 scored, award **SC1** for a single line with negative gradient passing through (0, 8), (10, 0) and (20, –8)

Question	Answer	Marks	Partial marks
10(a)	Maximum point at (2, 1) oe, nfww and h = 5 nfww	**B4**	**B3** for maximum point at (2, 1) oe or **B2** for maximum point when x = 2 or **B1** for a correct method which could be used to find the maximum point $\left[x\left(1-\frac{x}{4}\right)=0 \text{ when } x=0 \text{ and}\right]$ x = 4 or [differentiating and equating to 0:] $1-\frac{2x}{4}=0$ or [completing the square to find:] $1-\frac{1}{4}(x-2)^2$ If 0 scored, **SC1** for h = 5 with incorrect or no method shown
10(b)	$x^2 - 4x - 16$ [= 0] oe or $-\frac{1}{4}(x-2)^2=-4-1$ oe	**B1**	**FT** *their* attempt to complete the square, if already seen and of the form $a+b(x+c)^2$ where a, b and c are constants and b is negative
	Solves *their* 3-term quadratic using the formula or completing the square	**M1**	**FT** *their* rearrangement of $-4=x-\frac{x^2}{4}$ oe
	$x=2+2\sqrt{5}$ oe	**A1**	
10(c)	First derivative $1-\frac{x}{2}$ and substitution of *their* $2+2\sqrt{5}$ or 6.47	**M1**	**FT** *their* attempt to differentiate $x-\frac{x^2}{4}$, if already seen, and *their* $2+2\sqrt{5}$
	$1-2\times\frac{2+2\sqrt{5}}{4}$ or $-\sqrt{5}$ or awrt –2.24 soi	**A1**	**dep** on correct derivative and correct x-coordinate of A
	Correct method to find the angle e.g. $-\tan^{-1}\left(1-2\times\frac{2+2\sqrt{5}}{4}\right)$ soi or $\tan^{-1}\sqrt{5}$ or $-\tan^{-1}\left(-\sqrt{5}\right)$ soi	**M1**	**dep** on previous **M1 A1**
	Degrees: awrt 65.9 or Radians: awrt 1.15	**A1**	
11(a)	$x=5$ $y=5\sqrt{3}$	**B2**	**B1** for either component correct

Question	Answer	Marks	Partial marks
11(b)	$\left[\begin{pmatrix}0\\0\end{pmatrix}+\right] \quad t\begin{pmatrix}5\\5\sqrt{3}\end{pmatrix}$ oe, isw	**B1**	**FT** *their* $\begin{pmatrix}5\\5\sqrt{3}\end{pmatrix}$, which must be a vector with at least one non-zero component
11(c)	$\begin{pmatrix}2\sqrt{3}\\9\end{pmatrix}+t\begin{pmatrix}\frac{5}{3}\\0\end{pmatrix}$ oe, isw	**B2**	**B1** for x component $2\sqrt{3}+\frac{5}{3}t$ seen or y component 9 seen or $\begin{pmatrix}2\sqrt{3}\\9\end{pmatrix}+t\begin{pmatrix}\frac{5}{3}\\0\end{pmatrix}$ with at most one error but must include t
11(d)	$5t\sqrt{3}=9$ or $5t=2\sqrt{3}+\frac{5}{3}t$	**M1**	**FT** *their* position vector of A and *their* position vector of B providing • both are in terms of t and • at least one is of form $\begin{pmatrix}a\\b\end{pmatrix}+t\begin{pmatrix}c\\d\end{pmatrix}$ where a, b, c and d are constants
	$\left(5\sqrt{3}\right)t=9$ and $5t=2\sqrt{3}+\frac{5}{3}t$ oe	**A1**	
	Shows the exact times to be the same e.g. $t=\frac{9}{5\sqrt{3}}=\frac{3\sqrt{3}}{5}$ oe **<u>and</u>** $\frac{10}{3}t=2\sqrt{3}\rightarrow t=\frac{3\sqrt{3}}{5}$ or $t=\frac{6\sqrt{3}}{10}\rightarrow t=\frac{3\sqrt{3}}{5}$ or $\frac{5}{3}t=\sqrt{3}\rightarrow t=\frac{3\sqrt{3}}{5}$ oe OR Finds a correct value for t, as above, and shows this satisfies the other equation OR Finds a correct value for t, as above, and shows both particles are at $\begin{pmatrix}\frac{9}{\sqrt{3}}\\9\end{pmatrix}$ oe at this time	**A2**	**A1** for $t=\frac{9}{5\sqrt{3}}$ **and** $t=\frac{2\sqrt{3}}{\frac{10}{3}}$ oe

Question	Answer	Marks	Partial marks
12	Correct use of $x^2h = 5$ to find an expression that can be used to eliminate h	M2	**M1** for $x^2h = 5$ soi
	Surface area: $x^2 + 4x\left(\frac{5}{x^2}\right)$ oe	B1	
	Derivative of the surface area: $2x - 20x^{-2}$ oe	B1	**FT** *their* surface area of form $ax^2 + \frac{b}{x}$
	Equates *their* $2x - 20x^{-2}$ to 0 and solves to find a value of x	M1	**FT** *their* derivative of form $ax + \frac{b}{x^2}$ oe
	$x = 2.15$ or $2.154[\ldots]$ $h = 1.08$ or $1.077[\ldots]$ nfww	A1	**dep** on all previous marks awarded
	Alternative		
	Correct use of $x^2h = 5$ to find an expression that can be used to eliminate x	(M2)	**M1** for $x^2h = 5$ soi
	Surface area: $\left(\sqrt{\frac{5}{h}}\right)^2 + 4h \times \sqrt{\frac{5}{h}}$ oe	(B1)	
	Derivative of the surface area: $4\sqrt{5} \times \frac{1}{2}h^{-\frac{1}{2}} - \frac{5}{h^2}$ oe	(B1)	**FT** *their* surface area of form $\frac{a}{h} + b\sqrt{h}$
	Equates *their* $4\sqrt{5} \times \frac{1}{2}h^{-\frac{1}{2}} - \frac{5}{h^2}$ to 0 and solves to find a value of h	(M1)	**FT** *their* derivative of form $\frac{a}{\sqrt{h}} + \frac{b}{h^2}$ oe
	$h = 1.08$ or $1.077[\ldots]$ $x = 2.15$ or $2.154[\ldots]$ nfww	(A1)	**dep** on all previous marks awarded

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **October/November 2024**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the October/November 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions 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.

Mathematics-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, non-integer 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 or sign 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 A or B 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	−0.8, 0.55, 2.25	**B1**	
	$x < -0.8$ $0.55 < x < 2.25$	**B2**	**B1** for either inequality correct
2(a)	$5 - (x + 2)^2$	**B2**	**B1** for $-(x + 2)^2$ or $(x + 2)^2$ or $a = 5$ and $b = 2$
2(b)	$f \leqslant 5$ or $f(x) \leqslant 5$	**B1**	**FT** *their* 5
2(c)	−2	**B1**	**FT** − *their* 2
2(d)	Complete method to find inverse function: Swaps the variables and rearranges or rearranges and swaps the variables at some point in their solution	**M1**	For **M1 FT** *their* part (a) provided it is in the form $a-\left(x+b\right)^2$
	$[g^{-1}(x) =] -2 + \sqrt{5-x}$ or $\left[g^{-1}\left(x\right)=\right]\dfrac{-4+\sqrt{4^2-4[1](x-1)}}{2}$ or $\left[g^{-1}\left(x\right)=\right]\dfrac{-(-4)-\sqrt{(-4)^2-4(-1)(1-x)}}{-2}$ oe, isw	**A2**	**A1** for $[g^{-1}(x) =] -2 \pm \sqrt{5-x}$ or $[g^{-1}(x) =] = \dfrac{-4\pm\sqrt{4^2-4[1](x-1)}}{2(1)}$ or $[g^{-1}(x) =] = \dfrac{-(-4)\pm\sqrt{4^2-4(-1)(1-x)}}{2(-1)}$
	[Domain:] $x \leqslant 5$	**B1**	**FT** *their* part (b) provided it is in form $f(x) \leqslant a$ where a is a constant
	[Range:] $g^{-1} \geqslant$ *their* −2	**B1**	**FT** *their* value of k in part (c)
3(a)	$4\tan^2\theta - \sec^2\theta$	**M1**	e.g. $4\dfrac{\sin^2\theta}{\cos^2\theta}-\dfrac{1}{\cos^2\theta}$
	Justified completion to given answer e.g. $4\tan^2\theta - (1 + \tan^2\theta)$ $= 3\tan^2\theta - 1$ or $3\tan^2\theta - (\sec^2\theta - \tan^2\theta)$ $= 3\tan^2\theta - 1$	**A1**	e.g. $4\dfrac{\sin^2\theta}{\cos^2\theta}-\dfrac{\sin^2\theta+\cos^2\theta}{\cos^2\theta}$ $= 4\tan^2\theta - \tan^2\theta - 1$ $= 3\tan^2\theta - 1$
3(b)	$\tan\theta = [\pm]\sqrt{\dfrac{2}{3}}$ oe	**M2**	**M1** for $\tan^2\theta = \dfrac{2}{3}$ oe
	$[\theta =]$ 39.2 or 39.23 to 39.232 $[\theta =]$ 140.8 or 140.76 to 140.77 and no extras in range	**A2**	**A1** for either one correct, ignoring extras

Question	Answer	Marks	Partial marks
4(a)	Correct statement for area e.g. $\frac{1}{2}r^2\alpha = 9$ or $\frac{1}{2}rs = 9$	**B1**	
	Finds an equation that can be used to eliminate α or s e.g. $\alpha = \frac{18}{r^2}$ or $r\alpha = \frac{18}{r}$ or $s = \frac{18}{r}$	**M1**	
	Correct substitution and completion to given answer e.g. $P = 2r + r \times \frac{18}{r^2} = 2r + \frac{18}{r}$	**A1**	
4(b)	Correct derivative: $2 - \frac{18}{r^2}$ oe isw	**B1**	
	$2 - \frac{18}{r^2} = 0$ and solves for r	**M1**	**FT** *their* $\frac{dP}{dr} = 0$ providing of the form $2 + \frac{n}{r^k}$ where n and k are non-zero integers
	$r = 3$ only soi	**A1**	
	$P = 12$ only soi	**A1**	
	[2nd derivative =] $\frac{36}{r^3}$ oe **and** which is positive for $r = 3$ →minimum **or** as $r > 0$ [2nd derivative =] > 0 →minimum **or** [2nd derivative =] $\frac{36}{3^3}$ oe →minimum OR correctly finds the values of the first derivative at $3 \pm h$ where h is small → minimum	**A1**	**dep** on $r = 3$ and no other value

Question	Answer	Marks	Partial marks
5	[When $x = 3$] $y = \frac{2}{3}$ soi	**B1**	
	Correct derivative: $\dfrac{x \times \frac{1}{2}(x+1)^{-\frac{1}{2}} - \sqrt{x+1}}{x^2}$ or $-x^{-2}(x+1)^{\frac{1}{2}} + x^{-1} \times \frac{1}{2}(x+1)^{-\frac{1}{2}}$	**M2**	**M1** for an attempt to differentiate using the quotient rule oe
	Gradient of tangent: $\dfrac{3 \times \frac{1}{2}(4)^{-\frac{1}{2}} - \sqrt{4}}{3^2}$	**M1**	**dep** on attempt at a derivative which includes $(x+1)^{-\frac{1}{2}}$
	$-\frac{5}{36}$ isw	**A1**	**dep** on having a **correct derivative**
	$y = -\frac{5}{36}x + \frac{13}{12}$ oe or $y - \frac{2}{3} = \left(-\frac{5}{36}\right)(x-3)$ oe soi	**A1**	**FT** *their* non-zero $\frac{2}{3}$ and *their* non- zero $-\frac{5}{36}$
	$A(15, -1)$	**B2**	**B2 dep** on all previous marks awarded **B1 dep** for $x = 15$ or $y = -1$
6(a)	$\frac{2}{3}(3x+2)^{\frac{1}{2}}(+c)$ oe	2	**B1** for $k(3x+2)^{\frac{1}{2}}$ oe, soi where k is a constant and $k \neq 0$
6(b)	$-\frac{e^{1-2a}}{2} + \frac{1}{2}$ oe, isw	3	**B2** for $-\frac{1}{2}e^{(1-2x)}$ oe or **B1** for $ke^{(1-2x)}$ or $ke^{(1-2a)}$ where k is a constant, $k \neq 0$
7(a)	$x = \sqrt[3]{\frac{28}{56}}$ oe, nfww, isw	3	**B2** for $28x^{10}$ and $56x^{13}$ OR $[x^8](28x^2)$ and $[x^8](56x^5)$ or **B1** for $28x^{10}$ or $56x^{13}$ OR $[x^8](28x^2)$ or $[x^8](56x^5)$
7(b)(i)	$n = 10$	2	**B1** for the correct term in any form e.g. ${}^nC_5 x^{n-5}\left(\frac{2}{x}\right)^5$ or for $n - 5 = 5$ oe, soi
7(b)(ii)	8064	2	**B1** for ${}^{10}C_5 \times 2^5$ oe e.g. 252×32

Question	Answer	Marks	Partial marks
8(a)	$[x =]\ \frac{\pi}{24}, \frac{5\pi}{24}$ and no extras in range	**2**	**B1** for $[x =]\ \frac{\pi}{24}$ or $\frac{5\pi}{24}$ ignoring extras or for $4x = \frac{\pi}{6}$ **and** $\frac{5\pi}{6}$ soi
8(b)	Correct and complete plan soi e.g. $\int_{their\frac{\pi}{24}}^{their\frac{5\pi}{24}}\left(\sin(4x)-\frac{1}{2}\right)dx$ or $2\int_{their\frac{\pi}{24}}^{\frac{\pi}{8}}\left(\sin(4x)-\frac{1}{2}\right)dx$	**M1**	**FT** *their* limits in radians from part (a) or $\int_{their\frac{\pi}{24}}^{their\frac{5\pi}{24}}\sin 4x\,dx-\frac{1}{2}\left(their\frac{5\pi}{24}-their\frac{\pi}{24}\right)$
	Integrates sin $4x$: $-\frac{1}{4}\cos 4x$	**B2**	**B1** for $k\cos 4x$ where $k < 0$ or $k = \frac{1}{4}$
	Substitutes exact limits in correct order: $-\frac{1}{4}\cos 4\left(\frac{5\pi}{24}\right)-\left[-\frac{1}{4}\cos 4\left(\frac{\pi}{24}\right)\right]$ oe soi	**M1**	**FT** *their* exact limits and *their* $-\frac{1}{4}\cos 4x$ providing at least **B1** awarded
	$\frac{\sqrt{3}}{4}-\frac{\pi}{12}$ or exact equivalent	**A1**	
9	$\frac{18+12\sqrt{10}}{2+\sqrt{10}}$	**B1**	
	$\frac{their18+(their12)\sqrt{10}}{2+\sqrt{10}}\times\frac{2-\sqrt{10}}{2-\sqrt{10}}$	**M1**	**FT** $\frac{a+b\sqrt{10}}{2+\sqrt{10}}$ where a and b are integers
	$\frac{36–18\sqrt{10}+24\sqrt{10}–120}{–6}$	**A1**	
	$14-\sqrt{10}$ nfww	**A1**	**dep** on all previous marks awarded
	Alternative		
	$\frac{16+11\sqrt{10}}{2+\sqrt{10}}\times\frac{2-\sqrt{10}}{2-\sqrt{10}}$ [+1]	**(M1)**	
	$\frac{32-16\sqrt{10}+22\sqrt{20}-110}{–6}$ [+1]	**(A1)**	
	$\frac{-78+6\sqrt{10}\ [-6]}{–6}$ oe	**(A1)**	e.g. $13-\sqrt{10}$ [+1]
	$14-\sqrt{10}$ nfww	**(A1)**	**dep** on all previous marks awarded

Question	Answer	Marks	Partial marks
10(a)	$1.1^n * 3$	**B2**	where * is any inequality sign or = **B1** for $\frac{10\left(1.1^n - 1\right)}{1.1 - 1} * 200$ or $\frac{10\left(1 - 1.1^n\right)}{1 - 1.1} * 200$ or for $r = 1.1$ soi
	$n\log 1.1 * \log 3$ oe or $\log_{1.1} 3$ [* n]	**M1**	**FT** $1.1^n * their 3$ providing **B1** has been awarded for a correct sum to n terms **and** (*their* 3) > 0
	[n =]12	**A1**	**dep** on all previous marks awarded
10(b)	$r = 2$ only nfww	**B4**	**B3** for a correct equation or equations which can be solved directly for r e.g. $[d =]\frac{[a](r-1)}{2} = \frac{[a]r(r-1)}{4}$ or $[d =]\frac{[a](r-1)}{2} = \frac{[a](r^2-1)}{6}$ or $[a](r^2 - 3r + 2)$ [= 0] oe or $\frac{2(r+1)(r-1)}{(r-1)} = 6$ or $r = \frac{4d}{2d}$ or $[r =]\frac{a+2d}{a}$ or $[r =]\frac{a+6d}{a+2d}$ **and** $a = 2d$ or **B2** for a correct equation or equations which need to be rearranged to find r e.g. $[d =]\frac{ar-a}{2} = \frac{ar^2-ar}{4}$ or $[d =]\frac{ar-a}{2} = \frac{ar^2-a}{6}$ or $[a =]\frac{6[d]}{r^2-1} = \frac{2[d]}{r-1}$ or $a(r-1) = 2d$ and $ar(r-1) = 4d$ or **either** $[r =]\frac{a+2d}{a}$ or $[r =]\frac{a+6d}{a+2d}$ **and** $4d^2 - 2ad$ [= 0] or **B1** for $ar = a + 2d$ oe and **B1** for $ar^2 = a + 6d$ oe

Question	Answer	Marks	Partial marks
11(a)(i)	12	**2**	**B1** for $3! \times 2!$ or ${}^2P_2 \times {}^3P_3$ oe
11(a)(ii)	72	**2**	**B1** for $5! - 4! \times 2!$ oe or $6 \times 2! \times 3!$ oe
11(b)	4200	**2**	**B1** for ${}^{10}C_3 \times {}^7C_3 \left[\times {}^4C_4\right]$ oe or ${}^{10}C_4 \times {}^6C_3 \left[\times {}^3C_3\right]$ oe
12(a)	Correct derivative: $-\sin t - \cos t$	**M1**	
	$-\dfrac{1+\sqrt{3}}{2}$ oe or -1.37 or –1.366[02…] rot to 3 or more dp	**A1**	Mark **final answer**
12(b)	$[v = 0 \Rightarrow] \cos t - \sin t = 0$ $t = \dfrac{\pi}{4}$	**B2**	**B1** for $\cos t - \sin t = 0$
	Correct integral: $\sin t + \cos t\ (+ c)$	**M1**	
	$0 = \sin 0 + \cos 0 + c$	**M1**	**FT** *their* attempt to integrate
	$s = \sin t + \cos t - 1$	**A1**	
	$\sqrt{2} - 1$ oe, isw or 0.414[21…]	**A1**	**dep** on all previous marks awarded
	Alternative		
	$[v = 0 \Rightarrow] \cos t - \sin t = 0$ $\rightarrow t = \dfrac{\pi}{4}$	**(B2)**	**B1** for $\cos t - \sin t = 0$
	Correct integral: $\sin t + \cos t$	**(M1)**	
	with limits $t = \dfrac{\pi}{4}$ and $t = 0$	**(A1)**	Must be in radians
	Substitutes limits into correct integral	**(M1)**	**FT** *their* $t = \dfrac{\pi}{4}$ from attempt at solving $v = 0$
	$\sqrt{2} - 1$ oe, isw or 0.414[21…]	**(A1)**	**dep** on all previous marks awarded
12(c)	$-s - 1$ oe isw	**B1**	

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2024**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions 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.

Mathematics-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, non-integer 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 or sign 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 A or B 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.

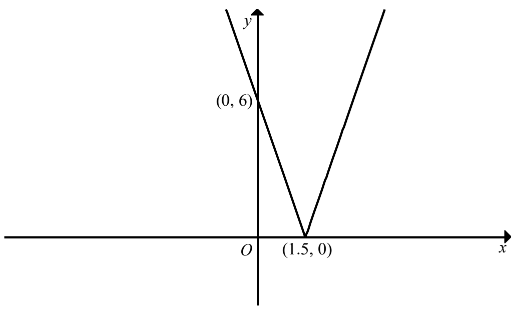
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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(a)	Fully correct graph with intercepts marked  	**B2**	**B1** for a graph of correct shape with vertex on x-axis

Question	Answer	Marks	Partial Marks
1(b)	$4x - 6 = 2x$ and $4x - 6 = -2x$ oe	**M1**	
	$x = 3$ $x = 1$	**A2**	**A1** for either correct
	Alternative method		
	$12x^2 - 48x + 36 = 0$ oe	**(B1)**	
	Factorises or solves	**(M1)**	
	$x = 1, x = 3$	**(A1)**	
2(a)	$5 - 2(x - 1)^2$	**B3**	Mark final expression **B2** for $-2(x - 1)^2$ or **B1** for $(x - 1)^2$ or $b = -2$, $c = -1$ and **B1** for $5 + b(x + c)^2$ oe with numerical values of b and c or $a = 5$
2(b)	f $\le$ *their* 5	**B1**	**STRICT FT** of *their* 5 from **(a)**
3	$5x^2 - 20x + 26$ [= 0]	**M1**	Condone one slip in expansion of brackets or collection of terms
	Correctly finds $b^2 - 4ac$ for *their* $5x^2 - 20x + 26$ [= 0] e.g. $(-20)^2 - 4(5)(26)$	**M1**	**FT** *their* $5x^2 - 20x + 26 = 0$ providing the discriminant is negative for *their* equation
	$400 - 520 < 0$ or -120	**A1**	
	Alternative method		
	$5x^2 - 20x + 26$ [= 0]	**(M1)**	Condone one slip in expansion of brackets or collection of terms
	Completes the square $5(x - 2)^2 + 6$ and states the correct minimum point (2, 6)	**(M1)**	**FT** *their* $5x^2 - 20x + 26 = 0$ providing the minimum point has positive y-coordinate
	Correct conclusion e.g. Minimum point at $y = 6$ therefore does not intersect x-axis oe	**(A1)**	

Question	Answer	Marks	Partial Marks
4(a)	$4(y-3)^2 = 36-9$ or $4y^2 - 24y + 9 [= 0]$	M1	
	$y = 3 \pm \sqrt{\frac{27}{4}}$ or exact equivalent, soi	A1	
	$3+\sqrt{\frac{27}{4}} - \left(3 - \sqrt{\frac{27}{4}}\right)$ oe	M1	**FT** *their* $a \pm \sqrt{b}$ providing b is not a square number
	$\sqrt{27}$ or $3\sqrt{3}$ or exact equivalent, nfww	A1	
4(b)	Eliminates one unknown and simplifies terms: $2x^2 + 83 = x^2 - 20x$ oe, soi	M1	
	$x^2 + 20x + 83 = 0$	A1	
	Applies quadratic formula or completes the square: $x = \frac{-20 \pm \sqrt{20^2 - 4[1](83)}}{2}$	M1	**FT** *their* 3-term quadratic
	$x = -10 \pm \sqrt{17}$	A1	
	$y = \frac{1}{-10 \pm \sqrt{17}} \times \frac{-10 \mp \sqrt{17}}{-10 \mp \sqrt{17}}$	M1	**FT** *their* $x = a \pm \sqrt{b}$ providing previous **M1** awarded
	$x = -10 \pm \sqrt{17}$, $y = -\frac{10}{83} \mp \frac{\sqrt{17}}{83}$	A1	**dep** on all marks previously awarded
5(a)(i)	30 240	2	**M1** for $3 \times 7! \times 2$ or ${}^3P_1 \times {}^7P_7 \times {}^2P_1$ oe
5(a)(ii)	17 280	2	**M1** for $4! \times 6!$ oe or ${}^4P_4 \times {}^6P_5$ oe
5(b)(i)	35	2	**M1** for ${}^7C_4$ or $1 + 4 + 18 + 12$
5(b)(ii)	51	2	**M1** for ${}^3C_2 \times {}^6C_2 + {}^3C_3 \times {}^6C_1$ oe or $18 + 4 + 3 + 2 + 24$

Question	Answer	Marks	Partial Marks
6	$\frac{\mathrm{d}}{\mathrm{d}x}(\sin^2 x) = 2\sin x \cos x$ soi	**B1**	
	$\cos x \times their(2\sin x \cos x) +$ $(their - \sin x) \times \sin^2 x$	**M1**	**FT** *their* $\frac{\mathrm{d}}{\mathrm{d}x}(\sin^2 x)$
	$\cos x \times their(2\sin x \cos x) + (-\sin x) \times \sin^2 x$ isw	**A1**	**FT** *their* $\frac{\mathrm{d}}{\mathrm{d}x}(\sin^2 x)$
	$\frac{\delta y}{h} = their(2\sin 3\cos^2 3 - \sin^3 3)$ or better	**M1**	**FT** *their* derivative
	$0.274h$ or $0.2738[08...]h$ where the coefficient of h is rot to 4 or more sf	**A1**	**dep** on correct derivative seen
7	$\frac{\mathrm{d}y}{\mathrm{d}x} = 2mx + \frac{1}{2}$	**B1**	
	$\frac{\mathrm{d}^2 y}{\mathrm{d}x^2} = 2m$	**B1**	
	$m = \frac{1}{4}$ and $n = -\frac{5}{4}$ and no other values	**2**	**M1** for $3(2m) = \left(2mx + \frac{1}{2}\right)^2 - \left(mx^2 + \frac{x}{2} + n\right)$ soi

Question	Answer	Marks	Partial Marks
8(a)	$S_{30} = \frac{30}{2}\{2a + 29d\} = -1065$	**B1**	
	$S_{50} - S_{30} =$ $\frac{50}{2}\{2a+49d\} - \left(\frac{30}{2}\{2a+29d\}\right) = -2210$ or $S_{50} = \frac{50}{2}\{2a+49d\} = -2210 - 1065$	**B1**	
	Solves *their* linear equations in a and d as far as $a = ..$ or $d = …$ Some correct pairs are e.g. $150a + 2175d = –5325$ $150a + 3675d = –9825$ or $30a + 435d = –1065$ $50a + 1225d = –3275$ or $2a + 49d = –131$ $2a + 29d = –71$	**M1**	**dep** on an attempt to form *their* equations using at least one sum formula
	$a = 8$, $d = –3$	**A2**	**A1** for each
8(b)	$4 + 4r + 4r^2 = 7$ or $\frac{4(1-r^3)}{1-r} = 7$ oe	**B1**	
	$4r^2 + 4r - 3[=0]$ oe	**B1**	
	Solves or factorises *their* 3-term quadratic oe e.g. $(2r – 1)(2r + 3)$ [= 0]	**M1**	
	$r = 0.5$, $–1.5$	**A1**	
	$\left[\frac{4}{1-0.5} = \right]$ 8 only, nfww	**A1**	
9(a)	Valid explanation: Range of g is g > 0 oe	**B1**	
9(b)	$\frac{1}{\left(\frac{3x^2}{4x-1}\right)^2}$	**M1**	
	$\frac{(4x-1)^2}{9x^4}$ or simplified equivalent, isw	**A1**	

Question	Answer	Marks	Partial Marks
9(c)	$3x^2 - 4xy + y[=0]$ or $3y^2 - 4xy + x[=0]$	**B1**	
	$[x=]\dfrac{-(-4y)\pm\sqrt{(-4y)^2-4(3)(y)}}{2(3)}$ oe or $[y=]\dfrac{-(-4x)\pm\sqrt{(-4x)^2-4(3)(x)}}{2(3)}$ oe	**M1**	**FT** *their* expression providing it has at most one sign error
	Justifies the negative square root	**B1**	
	$\mathrm{f}^{-1}(x)=\dfrac{2x-\sqrt{x(4x-3)}}{3}$	**A1**	
10(a)	$\tan^2 x + 2\tan x\sec x + \sec^2 x$ or $\left(\dfrac{\sin x}{\cos x}+\dfrac{1}{\cos x}\right)^2$	**M1**	
	$\dfrac{\sin^2 x}{\cos^2 x}+2\times\dfrac{\sin x}{\cos x}\times\dfrac{1}{\cos x}+\dfrac{1}{\cos^2 x}$ or factorises $\dfrac{1}{\cos^2 x}(\sin x+1)^2$ oe	**A1**	
	$\dfrac{(1+\sin x)^2}{1-\sin^2 x}$	**A1**	
	$\dfrac{(1+\sin x)(1+\sin x)}{(1-\sin x)(1+\sin x)}=\dfrac{1+\sin x}{1-\sin x}$ or $\dfrac{(1+\sin x)^2}{(1-\sin x)(1+\sin x)}=\dfrac{1+\sin x}{1-\sin x}$	**A1**	must be fully justified
10(b)	$7\sin 3\theta = 5$	**B1**	
	One correct value for 3θ soi e.g. 45.58… 134.4… 405.5… 494.4…	**M1**	
	15.2 or 15.19 to 15.195 44.8 or 44.80 to 44.81 135.2 or 135.19 to 135.195 164.8 or 164.80 to 164.81	**A2**	with no extras in range **A1** for any 2 correct, ignoring extras

Question	Answer	Marks	Partial Marks
11	$P = 2\left(\frac{\pi x}{4}\right) + x + 2\left(\frac{400}{x} - \frac{x}{2}\right)$ oe	**B2**	**B1** for rectangle length = $\frac{400}{x}$ soi
	Correct first derivative $\frac{\pi}{2} - \frac{800}{x^2}$	**B1**	**FT** *their P* providing it is of the form $\frac{a}{x} + bx$ oe with a an integer and b a constant
	Equates *their* $\frac{\mathrm{d}P}{\mathrm{d}x}$ to 0 and solves for x	**M1**	**FT** provided one term of *their* derivative is correct
	$x = \frac{40}{\sqrt{\pi}}$ or 22.6 or 22.56[75...]	**A1**	
	$P = \frac{\pi}{2}\left(\frac{40}{\sqrt{\pi}}\right) + \frac{800}{\frac{40}{\sqrt{\pi}}}$	**M1**	**FT** *their* value of x provided it is greater than 0
	P = 70.9 or 70.89[81...]	**A1**	
12(a)	$\overrightarrow{OP} = \frac{4}{7}\mathbf{b} + \lambda\left(\mathbf{c} - \frac{4}{7}\mathbf{b}\right)$ and $\overrightarrow{OP} = \mathbf{b} + \mu\left(\frac{4}{7}\mathbf{c} - \mathbf{b}\right)$	**B3**	**B2** for $\overrightarrow{OP} = \frac{4}{7}\mathbf{b} + \lambda\left(\mathbf{c} - \frac{4}{7}\mathbf{b}\right)$ or $\overrightarrow{OP} = \mathbf{b} + \mu\left(\frac{4}{7}\mathbf{c} - \mathbf{b}\right)$ oe or **B1** for $\overrightarrow{OP} = \left(\mathit{their}\,\frac{4}{7}\right)\mathbf{b} + \lambda\left(\mathbf{c} - \left(\mathit{their}\,\frac{4}{7}\right)\mathbf{b}\right)$ or $\overrightarrow{OP} = \mathbf{b} + \mu\left(\left(\mathit{their}\,\frac{4}{7}\right)\mathbf{c} - \mathbf{b}\right)$ or
	Equates components e.g.: $\left(\mathit{their}\,\frac{4}{7}\right)(1-\lambda) = (1-\mu)$ or $\lambda = \mathit{their}\,\frac{4}{7}\mu$	**M1**	**FT** providing at least **B1** awarded and two expressions for $\overrightarrow{OP}$ in terms of **b**, **c**, λ and μ found
	$\frac{4}{7}(1-\lambda) = (1-\mu)$ $\lambda = \frac{4}{7}\mu$ oe	**A1**	
	$\lambda = \frac{4}{11}$ and $\mu = \frac{7}{11}$ oe and conclusion $AP : AC = 4 : 11$ therefore $AP : PC = 4 : 7$ $BP : BD = 7 : 11$ therefore $DP : PB = 4 : 7$ oe	**A2**	**A1** for $\lambda = \frac{4}{11}$ or $\mu = \frac{7}{11}$ oe

Question	Answer	Marks	Partial Marks
12(b)	$\overrightarrow{OP} = \frac{4}{11}(\mathbf{b}+\mathbf{c})$ or $\overrightarrow{OP} = \frac{4}{11}\mathbf{b} + \frac{4}{11}\mathbf{c}$ and $\overrightarrow{OP}$ and $\overrightarrow{OQ}$ are scalar multiples of each other and have a point in common oe	2	**M1** for $\overrightarrow{OP} = \frac{4}{11}(\mathbf{b}+\mathbf{c})$ or $\overrightarrow{OP} = \frac{4}{11}\mathbf{b} + \frac{4}{11}\mathbf{c}$

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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **May/June 2024**

MARK SCHEME

Maximum Mark: 80

Published

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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.

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GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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Mathematics-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, non-integer answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.

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MARK SCHEME NOTES

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

Types of mark

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

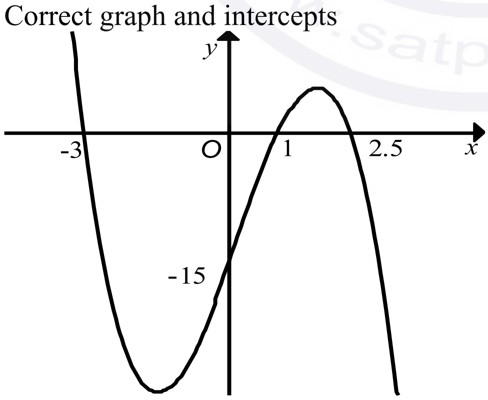
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

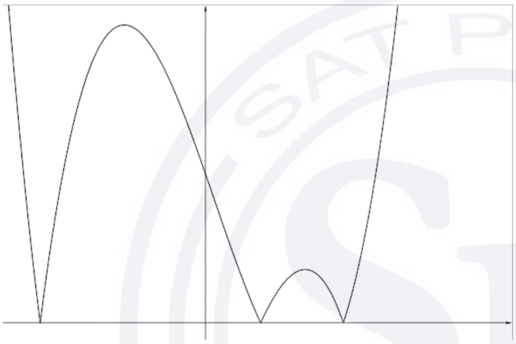
B Mark for a correct result or statement independent of Method marks.

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

Abbreviations

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

Question	Answer	Marks	Partial Marks
1(a)	Correct graph and intercepts 	**B3**	**B1** for correct shape; the ends must extend above and below the *x*-axis **B1** for correct roots indicated; must have attempted a cubic shape **B1** for correct *y*-intercept indicated; must have attempted a cubic shape

Question	Answer	Marks	Partial Marks
1(b)(i)	$-3 \leqslant x \leqslant 1$, $x \geqslant 2.5$ mark final answer	**B2**	**FT** *their* **(a)** providing it is an equivalent cubic shape and has 3 stated or indicated roots for **B2, B1** or **SC1** **B1** for one correct inequality out of two If 0 scored then **SC1** for $-3 < x < 1$, $x > 2.5$ or $-3 < x \leqslant 1$, $x > 2.5$ or $-3 \leqslant x < 1$, $x > 2.5$
1(b)(ii)	Graph of correct shape, with cusps, positive y-intercept and x-intercepts which match **(a)** 	**B1**	**FT** *their* **(a)** providing it is an equivalent cubic shape
2(a)	$\left[4\sin\frac{x}{4}\right]_{\frac{\pi}{3}}^{\frac{\pi}{2}}$	**B2**	**B1** for $k\sin\frac{x}{4}$ where $k > 0$ or $k = -4$
	$4\sin\frac{\pi}{8} - 4\sin\frac{\pi}{12}$	**M1**	**FT** provided at least **B1** awarded
	0.495 or 0.4954[57…] rot to 4 or more sf	**A1**	**dep** on all previous marks awarded
2(b)	$\frac{1}{4}\ln(4x-3) - \frac{x^{-2}}{2} (+c)$ oe, isw or $\frac{1}{4}\ln(x-0.75) - \frac{x^{-2}}{2} (+c)$ oe, isw	**B3**	**B2** for $\frac{1}{4}\ln(4x-3)$ or $\frac{1}{4}\ln(x-0.75)$ or **B1** for $\frac{1}{4}\ln 4x - 3$ or $\frac{1}{4}\ln x - 0.75$ or $k\ln(4x-3)$ or $k\ln(x-0.75)$ where $k \neq \frac{1}{4}$ and **B1** for $\frac{x^{-2}}{-2}$ oe

Question	Answer	Marks	Partial Marks
3(a)	$7x^2+9x+5[=0]$ or $-7x^2-9x-5[=0]$	**B2**	**B1** for two terms correct in $7x^2+9x+5=0$ or at most one term incorrect in $12x^2+11x+2=5x^2+2x-3$ oe
	$9^2-4(7)(5)$ or $(-9)^2-4(-7)(-5)$ oe	**M1**	**FT** *their* 3-term quadratic
	–59 and no real roots or 81 – 140 < 0 and no real roots oe	**A1**	
3(b)	$\left(\sqrt[3]{x}\right)^2+4\sqrt[3]{x}-12=0$ oe soi or $y=\sqrt[3]{x}$ and $y^2+4y-12=0$ oe soi	**B1**	
	Factorises or solves *their* 3-term quadratic in $\sqrt[3]{x}$	**M1**	**FT** *their* 3-term quadratic in $\sqrt[3]{x}$ or a stated substituted unknown
	$x=8 \quad x=-216$	**A2**	**A1** for $\sqrt[3]{x}=2 \quad \sqrt[3]{x}=-6$
4(a)	33	**B1**	
4(b)(i)	$6\left(\frac{1}{2}\right)^3+\left(\frac{1}{2}\right)^2-12\left(\frac{1}{2}\right)+5=0$ oe or $6\left(\frac{1}{8}\right)+\frac{1}{4}-\frac{12}{2}+5=0$ oe or $\frac{3}{4}+\frac{1}{4}-6+5=0$ oe	**B1**	
4(b)(ii)	Finds the quadratic factor $3x^2+2x-5$	**M2**	**M1** for any two terms correct in $3x^2+2x-5$
	$(2x-1)(3x+5)(x-1)$ oe	**A1**	If 0 scored then **SC2** for justifying $x-1$ as a factor and writing down $(2x-1)(3x+5)(x-1)$ without any incorrect work seen
4(b)(iii)	$[\sin\theta=0.5]$ $\theta=30$ nfww $[\sin\theta=1]$ $\theta=90$ nfww and no value of θ from $3\sin\theta+5=0$	**B2**	**B1** for $\sin\theta=0.5$ or $\theta=30$ or **B1** for $\sin\theta=1$ nfww or $\theta=90$ nfww

Question	Answer	Marks	Partial Marks
5	$\frac{dy}{dx} = 10e^{2x-1}\ [+0]$ oe	M2	**M1** for $\frac{dy}{dx} = ke^{2x-1}$, $k \neq 10$ or **SCM1** for $\frac{dy}{dx} = 10e^{2x-1} + c$ where c is algebraic or numerical
	$\left.\frac{dy}{dx}\right\|_{x=1} = 10e$ and $y = 6e$	A1	**FT** *their* $\frac{dy}{dx}$ provided **M1** or **SCM1** awarded and a value is found
	$y - 6e = 10e(x-1)$ oe or $y = 10ex + c$ and $6e = 10e + c$	M1	**FT** *their* $\left.\frac{dy}{dx}\right\|_{x=1}$ and *their* y
	$y = 10ex - 4e$ isw	A1	
	[x-coordinate of P =] 0.4 oe, isw	A1	**dep** on correct equation of tangent with exact values
6(a)	Convincing correct statement from which the answer can be easily determined e.g. $\sin^3 x\left(\frac{1}{\sin x} \times \frac{\sin x}{\cos x}\right)$ oe or $\sin^2 x\left(\sin x \times \frac{1}{\sin x} \times \frac{1}{\cot x}\right)$ oe or $\sin^3 x\left(\frac{1}{\sin x} \div \frac{\cos x}{\sin x}\right) = \sin^3 x\left(\frac{1}{\cos x}\right)$ oe or $\sin^3 x\left(\frac{1}{\sin x} \div \frac{1}{\tan x}\right) = \sin^3 x\left(\frac{1}{\sin x} \times \tan x\right)$ oe	2	**M1** for either $\operatorname{cosec} x$ correctly written as $\frac{1}{\sin x}$ oe seen in a correct expression or for $\cot x$ correctly written as $\frac{\cos x}{\sin x}$ or $\frac{1}{\tan x}$ oe seen in a correct expression e.g. $\sin^3 x(\operatorname{cosec} x \times \tan x)$ or $\sin^3 x\left(\operatorname{cosec} x \div \frac{\cos x}{\sin x}\right)$ or $\sin^3 x\left(\frac{1}{\sin x} \div \frac{\cos x}{\sin x}\right)$ or $\sin^3 x\left(\frac{1}{\sin x} \div \frac{1}{\tan x}\right)$
	Correct completion to given answer: $\sin^2 x \tan x$	A1	

Question	Answer	Marks	Partial Marks
6(b)	Factorises: $\tan x\left(\cos^2 x - \frac{1}{2}\right) = 0$ oe or $\tan x\left(\frac{1}{2} - \sin^2 x\right) = 0$ oe or correctly rewrites and then factorises: $\sin x\left(\cos^2 x - \frac{1}{2}\right) = 0$ oe or $\sin x\left(\frac{1}{2} - \sin^2 x\right) = 0$ oe or $\tan x\left(1 - \tan^2 x\right) = 0$ oe	**M1**	Note: division by tan$x$ is **M0** Note: division by sin$x$ is **M0**
	[tan$x$ = 0 or sin$x$ = 0] [x =] 0	**A1**	
	cos$x$ = [±]$\sqrt{\frac{1}{2}}$ oe or sin$x$ = [±]$\sqrt{\frac{1}{2}}$ oe or tan x = [±]1	**M1**	nfww
	[x =] $\pm\frac{\pi}{4}$ or ± 0.785 or ± 0.7853 to ± 0.7854, $\pm\frac{3\pi}{4}$ or ± 2.36 or ± 2.356 to ± 2.3562	**A2**	with no extras in range; nfww **A1** for any two out of four correct, ignoring extras
7(a)	282 240	**2**	**M1** for 9! – 2! × 8! oe
7(b)	120	**2**	**M1** for 5! or $^5P_5$ oe
8(a)	Points plotted at <table><tr><td>x</td><td>15</td><td>30</td><td>45</td><td>60</td><td>75</td></tr><tr><td>ln$y$</td><td>2.3</td><td>2.5 or 2.6</td><td>3.1</td><td>3.5 or 3.6</td><td>3.9</td></tr></table> soi and single, ruled, straight line of best fit drawn	**B2**	**B1** for at least 4 correctly plotted points

Question	Answer	Marks	Partial Marks
8(b)	$\ln y = 0.03x + 1.8$	**2**	**M1** for m = awrt 0.02 to awrt 0.03 or c = awrt 1.7 to awrt 2.0 or for the straight line form in terms of $\ln A$ and k: $\ln y = \ln A + kx$[lne]
	$A = 6$ or $A = 7$ and $k = 0.03$ or $k = 0.02$	**B3**	Must have been found using linear points **or** linear equation **B2** for $A = 6$ or $A = 7$ or A in range: awrt 6 or awrt 7 or **B1 FT** for $\ln A = their\ 1.8$ or $A = e^{their 1.8}$ and **B1 FT** for $k = 0.03$ or 0.02 or k in range: awrt 0.02 or awrt 0.03 **Maximum of 2 marks if one or both values not rounded to 1 sf** If **B0** scored, award **SC1** for $A = 6$ or $A = 7$ and **SC1** for $k = 0.03$ or $k = 0.02$ found not using transformed data

Question	Answer	Marks	Partial Marks
8(c)	A value of x in range $33 \leqslant x \leqslant 37.5$ nfww, isw	**2**	**M1** for $\ln y = 2.8$ or 2.83[32...] OR A value of x in range $29.5 \leqslant x < 33$ or $37.5 < x \leqslant 45$ nfww OR **M1 STRICT FT** for $x = \dfrac{\ln 17 - \textit{their} \ln A}{\textit{their } k}$ **STRICT FT** *their* stated ln$A$ and *their* stated k or *their* stated linear equation in **(b)** OR $x = \dfrac{1}{\textit{their } k}\ln\left(\dfrac{17}{\textit{their} A}\right)$ **STRICT FT** *their* stated A and *their* stated k or *their* stated exponential equation in **(b)**

Question	Answer	Marks	Partial Marks
9	$A(2, 0)$ or $x = 2$ [$x = 6$]	**2**	**M1** for factorising or solving $32x - 4x^2 - 48 = 0$
	Finds equation CD/ x-coordinate of C or D or maximum point : $x = 4$	**2**	**M1** for $\frac{2+6}{2}$ or $32 - 8x = 0$
	$D(4, 8)$ or [equation AB is $y =$] $4x - 8$	**2**	**M1** for $y = \frac{2}{3} \times 12$ or $m_{AB} = \frac{12-0}{5-2}$ soi
	$\left[\frac{32}{2}x^2 - \frac{4}{3}x^3 - 48x\right]_2^4$ or $\left[\frac{28}{2}x^2 - \frac{4}{3}x^3 - 40x\right]_2^4$	**B1**	**must be seen**
	Correct plan **including** correct substitution of upper and lower limits at some point e.g. $\left[16x^2 - \frac{4}{3}x^3 - 48x\right]_2^{their4} - \frac{1}{2} \times (their4 - 2) \times their8$ or $\left[16x^2 - \frac{4}{3}x^3 - 48x\right]_2^{their4} - \left[2x^2 - 8x\right]_2^{their4}$ or $\left[14x^2 - \frac{4}{3}x^3 - 40x\right]_2^{their4}$	**M1**	**dep** on attempt to integrate **FT** *their* 4 and *their* 8 if needed or **FT** *their* 4 and *their* $4x - 8$ of the form $mx + c$ if needed or **FT** *their* 4 and $(32 - their4)x - 4x^2 + (-48 - their(-8))$ providing clear evidence of the derivation of this has been seen
	$\frac{40}{3}$ isw or 13.3[33….] **nfww**	**A1**	**dep on all previous marks awarded**
10(a)	Valid explanation using f: f is one-one oe	**B1**	
10(b)	Complete method to find inverse function: Swaps the variables and rearranges or rearranges and swaps the variables	**M1**	Condone one sign or arithmetic error but must have the correct order of operations
	$\left[f^{-1}(x) =\right] -\sqrt{\ln x - 3}$ isw or $\left[f^{-1}(x) =\right] -\sqrt{\ln \frac{x}{e^3}}$ oe isw	**A2**	**A1** for $\left[f^{-1}(x) =\right]$ $[\pm]\sqrt{\ln x - 3}$ or $\left[f^{-1}(x) =\right]$ $[\pm]\sqrt{\ln \frac{x}{e^3}}$ oe
	Domain f^{-1}: $x > e^3$	**B1**	
	Range f^{-1}: $f^{-1} < 0$	**B1**	

Question	Answer	Marks	Partial Marks
10(c)	$g(x) = f^{-1}(e^{2x})$ soi or $g(x) = -\sqrt{\ln e^{2x} - 3}$	**M1**	**FT** *their* expression for f^{-1}
	$-\sqrt{2x-3}$	**A1**	If 0 scored, allow **SCB1** for $-\sqrt{2x-3}$ found from solving $(g(x))^2 + 3 = 2x$ and using existence of composite functions to deduce that the square root must be negative
11	$2^n + n \times 2^{n-1} \times \frac{x}{2} + \frac{n(n-1)}{2[!]} \times 2^{n-2} \times \left(\frac{x}{2}\right)^2$ soi	**B1**	implied by three correct equations or e.g. $2^n + {}^nC_1 \times 2^{n-1} \times \frac{x}{2} + {}^nC_2 \times 2^{n-2} \times \left(\frac{x}{2}\right)^2$ **and** sight of ${}^nC_1 = n$ **and** ${}^nC_2 = \frac{n(n-1)}{2[!]}$ clearly in the working
	Forms three correct equations e.g. $b = 2^n$ $ab = n(2^{n-2})$ or $ab = n\frac{(2^{n-1})}{2}$ $\frac{9}{8}ab = n(n-1)(2^{n-5})$ or $\frac{9}{8}ab = \frac{n(n-1)}{2}\frac{(2^{n-2})}{2^2}$ OR finds e.g. $a = \frac{n}{4}$ and $\frac{9}{8}a = \frac{n(n-1)}{32}$ OR finds e.g. $ab = n \times \frac{b}{2} \times \frac{1}{2}$ and $\frac{9}{8}ab = \frac{n(n-1)}{2} \times \frac{b}{4} \times \frac{1}{4}$	**B3**	**B2** for any two of three correct equations or **B1** for any one of three correct equations **OR B2 for** $a = \frac{n}{4}$ or $\frac{9}{8}a = \frac{n(n-1)}{32}$ oe or $ab = n \times \frac{b}{2} \times \frac{1}{2}$ or $\frac{9}{8}ab = \frac{n(n-1)}{2} \times \frac{b}{4} \times \frac{1}{4}$ oe
	Finds a correct equation in n soi e.g. $n^2 - 10n = 0$ or $n - 1 = 9$ or $10n = n^2$ or $\frac{n}{4} = \frac{n(n-1)}{36}$ OR Finds a correct equation in a soi e.g. $16a^2 - 40a = 0$	**B1**	
	$n = 10$ $a = \frac{5}{2}$ oe $b = 1024$	**B3**	**B1** for each

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **May/June 2024**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions 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.

Mathematics-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, non-integer 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 or sign 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 A or B 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.

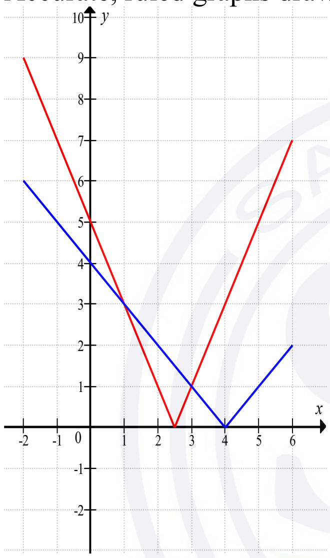
B Mark for a correct result or statement independent of Method marks.

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	$y-5=-2(x-3)$ oe	**3**	**M1** for midpoint $\left(\frac{5+1}{2},\frac{6+4}{2}\right)$ or $(3,5)$ **M1** for $m_\perp=\frac{-1}{\frac{1}{2}}$ oe or -2
	$\frac{121}{4}$ or 30.25 oe cao	**2**	**B1 FT** for *x*-intercept (5.5, 0) and *y*-intercept (0, 11) soi; **FT** *their* perpendicular bisector providing **M1 M1** awarded

Question	Answer	Marks	Partial Marks
2	Uses $b^2 - 4ac$ correctly: $(2k-1)^2 - 4(k)(k+1)$ [*0 where * is any inequality sign or =]	**M1**	
	Simplifies to $-8k + 1$[*0]	**A1**	
	Critical Value: $k = \frac{1}{8}$ soi	**M1**	**FT** *their* $ak + b$ where a and b are constants
	$k > \frac{1}{8}$ mark final answer	**A1**	
3(a)	Accurate, ruled graphs drawn 	**4**	**M1** for $y = \lvert 4 - x \rvert$: $\vee$ shape with vertex at (4, 0) **A1** Correct graph with y-intercept at (0, 4) **M1** for $y = \lvert 2x - 5 \rvert$: $\vee$ shape with vertex at (2.5, 0) **A1** Correct graph with y-intercept at (0, 5)
3(b)	$x \le 1$, $x \ge 3$ final answer	**2**	**FT** *their* **(a)** providing at least **M1** awarded and a pair of V-shaped graphs attempted **B1** for exactly two correct critical values or **B1 FT** for exactly two correct FT critical values soi, **FT** *their* **(a)** providing at least **M1** awarded and a pair of V-shaped graphs attempted
4(a)	$\frac{105}{8}$ isw or 13.125 oe	**2**	**B1** for ${}^{10}C_4 (x^2)^6 \left(-\frac{1}{2x^3}\right)^4$ oe

Question	Answer	Marks	Partial Marks
4(b)(i)	$1+4(2\sqrt{2})+6(2\sqrt{2})^2+4(2\sqrt{2})^3+(2\sqrt{2})^4$ soi or $1+4(-2\sqrt{2})+6(-2\sqrt{2})^2+4(-2\sqrt{2})^3$ $+(-2\sqrt{2})^4$ soi	M1	
	$1+8\sqrt{2}+48+64\sqrt{2}+64$ or $1-8\sqrt{2}+48-64\sqrt{2}+64$	A1	
	Correct difference stated or clearly implied $1+8\sqrt{2}+48+64\sqrt{2}+64-$ $(1-8\sqrt{2}+48-64\sqrt{2}+64)$	M1	**dep** on sight of correct expansions with numerical coefficients
	$144\sqrt{2}$ nfww	A1	
4(b)(ii)	$\frac{(their\ k)\sqrt{2}}{1+\sqrt{2}}\times\frac{1-\sqrt{2}}{1-\sqrt{2}}=$ $\frac{(their\ k)\sqrt{2}-2their\ k}{-1}$ oe simplified to $2(their\ k)-(their\ k)\sqrt{2}$ mark final answer	2	**STRICT FT** of *their* integer value of *k* **B1 STRICT FT** of *their* integer value of *k* for $\frac{their\ k\sqrt{2}}{1+\sqrt{2}}\times\frac{1-\sqrt{2}}{1-\sqrt{2}}$
5(a)(i)	$\sec^2 x+2\tan^2 x$ oe and correct completion to $3\tan^2 x+1$ nfww	2	**M1** for use of a relationship to form a convincing correct statement from which the answer can be easily determined e.g. $\sec^2 x+\frac{2\sin^2 x}{\cos^2 x}$ or $\frac{1}{\cos^2 x}+2\tan^2 x$
5(a)(ii)	$\tan x=[\pm]1$ soi	M1	**FT** $\tan x=[\pm]\sqrt{\frac{4-their1}{their3}}$ providing $\frac{4-their1}{their3}>0$
	$[x=]\frac{\pi}{4},-\frac{\pi}{4}$ or $\pm0.785[39\ldots]$ nfww and no other solutions	A2	**A1** for each, ignoring extra solutions

Question	Answer	Marks	Partial Marks
5(a)(iii)	$\mathrm{f}'(x) = 6\tan x\sec^2 x$ oe	**M2**	**FT** $2(\mathit{their}3)\tan x\sec^2 x$ **M1** for $\mathrm{f}'(x) = k\tan x\sec^2 x$ where $k \neq 2\mathit{their}\ 3$
	$\left[\mathrm{f}'\left(\frac{\pi}{4}\right)=\right]$ 12; $\left[\mathrm{f}'\left(-\frac{\pi}{4}\right)=\right]$ – 12 nfww	**A2**	**A1** for each nfww
5(b)	Correct use of $\sin^2\theta + \cos^2\theta = 1$ to form a 3-term quadratic in $\sin\theta$ in solvable form $50\sin^2\theta + 5\sin\theta - 3\,[=0]$ oe	**M1**	Condone one sign or arithmetic error in rearrangement
	Solves or factorises *their* 3-term quadratic in $\sin\theta$ e.g. $(10\sin\theta + 3)(5\sin\theta - 1)$ [= 0]	**M1**	**FT** *their* 3-term quadratic in $\sin\theta$
	$\sin\theta = -0.3$ $\sin\theta = 0.2$ soi	**A1**	
	11.5 or 11.53[69...] 168.5 or 168.46[30...] 197.5 or 197.45[76...] 342.5 or 342.54[23...]	**A2**	with no extras in range **A1** for any two correct angles, ignoring extras
6(a)	$(2x + 1)(x - 3)(x + 1)$ nfww	**M1**	
	Correct method leading to $x = -\frac{1}{2}$, $x = 3$, $x = -1$	**A1**	
6(b)(i)	$[\mathrm{p}'(x) =]\,3x^2 + 2ax + b\,[=0]$	**B1**	
	$3\left(\frac{4}{3}\right)^2 + 2a\left(\frac{4}{3}\right) + b = 0$	**B1**	OR forms the product $(3x - 4)(x - 2) = 0$
	$3(2)^2 + 2a(2) + b = 0$	**B1**	OR multiplies out to find $3x^2 - 10x + 8 = 0$
	Solves to find the value of one unknown	**M1**	**FT** *their* linear equations in a and b oe OR compares coefficients to state a value of a or b
	$a = -5$, $b = 8$	**A1**	
	[p(1)=] $1 + a + b + c = -5$ oe, soi	**M1**	
	[$1 - 5 + 8 + c = -5$] $c = -9$	**A1**	

Question	Answer	Marks	Partial Marks
6(b)(ii)	$[p''(x)=]\ 6x+2(\textit{their } a)$ soi	**M1**	**FT** *their a*
	6(2) – 10 = 2 > 0 [therefore minimum]	**A1**	
7(a)	$\frac{1}{2}\times 9^2\times\theta-\frac{1}{2}\times 5^2\times\theta=4\pi$ oe, soi	**M2**	**M1** for $\frac{1}{2}\times 9^2\times\theta$ or $\frac{1}{2}\times 5^2\times\theta$ oe, soi
	$\theta=\frac{\pi}{7}$ oe or 0.449 or 0.4487 to 0.4488	**A1**	
7(b)	[Arc AD =] $\frac{5\pi}{7}$	**2**	**M1** for [Arc AD =] $5\times \textit{their}\frac{\pi}{7}$ **FT** any stated value of θ from **(a)**
	[AC =] 4.991[27...] rot to 4 or more sf	**2**	**M1** for $[AC^2=]\ 9^2+5^2-2(9)(5)\cos\left(\textit{their}\frac{\pi}{7}\right)$ **FT** *their* θ providing $0<\theta<\frac{\pi}{2}$
	11.2 or 11.23[526...] rot to 4 or more sf	**A1**	
8	$\int\cos\left(4x-\frac{\pi}{4}\right)\mathrm{d}x=\frac{1}{4}\sin\left(4x-\frac{\pi}{4}\right)(+c)$	**B2**	**B1** for $k\sin\left(4x-\frac{\pi}{4}\right)$ where $k>0$ or $k=-\frac{1}{4}$
	$\frac{3}{4}=\frac{1}{4}\sin\left(4\left(\frac{3\pi}{16}\right)-\frac{\pi}{4}\right)+c$	**M1**	**FT** *their k* providing **B1** awarded
	$-\frac{1}{16}\cos\left(4x-\frac{\pi}{4}\right)+\frac{1}{2}x\quad(+A)$	**2**	**M1 FT** for $m\cos\left(4x-\frac{\pi}{4}\right)+\left(\textit{their}\frac{1}{2}\right)x\quad(+A)$ **FT** $\textit{their } k\sin\left(4x-\frac{\pi}{4}\right)+\textit{their } c$ providing at least **B1 M1** awarded
	$y=-\frac{1}{16}\cos\left(4x-\frac{\pi}{4}\right)+\frac{1}{2}x+\frac{5\pi}{32}$ oe, cao	**2**	**M1 FT** for $\frac{\pi}{4}=-\frac{1}{16}\cos\left(\frac{3\pi}{4}-\frac{\pi}{4}\right)+\frac{1}{2}\left(\frac{3\pi}{16}\right)+A$ **FT** $(\textit{their } m)\cos\left(4x-\frac{\pi}{4}\right)+\left(\textit{their}\frac{1}{2}\right)x+A$ providing previous **M1** awarded

Question	Answer	Marks	Partial Marks
9	$\frac{dy}{dx} = -(3x-1)^{-2} \times 3$	**M2**	**M1** for $\frac{dy}{dx} = -k(3x-1)^{-2}$ where $k > 0$
	[When $x = 1$] $\frac{dy}{dx} = -\frac{3}{4}$ and $y = \frac{9}{2}$	**A1**	**FT** *their* $\frac{dy}{dx}$ providing **M1** has been awarded
	Equation of tangent: $y - \frac{9}{2} = -\frac{3}{4}(x-1)$ oe isw	**M1**	**FT** the value of *their* $\frac{dy}{dx}$ at $x = 1$ and *their* y
	$B(7, 0)$ oe	**A1**	
	Area of triangle: $\frac{1}{2} \times \frac{9}{2} \times ((\mathit{their}\,7) - 1)$ or $\frac{27}{2}$ nfww or $-\frac{3}{8}(49) + \frac{21}{4}(7) - \left(-\frac{3}{8} + \frac{21}{4}\right)$	**M1**	**FT** *their* 7 and *their* $-0.75x + 5.25$ of the form $mx + c$ if needed
	[Area under curve = F(x) =] $\left[4x + \frac{1}{3}\ln(3x-1)\right]_1^9$ oe	**B2**	**B1** for $\int \frac{1}{3x-1}\,dx = k\ln(3x-1)$ or $\frac{1}{3}\ln 3x - 1$
	Correct and actioned plan e.g. F(9) – F(1) – *their* $\frac{27}{2}$	**M1**	**dep** on at least previous **B1** and correct plan or correct **FT** area of triangle oe
	$18\frac{1}{2} + \frac{1}{3}\ln 13$ or 19.4 or 19.35[49...]	**A1**	
10	$\overrightarrow{OP} = \lambda(\mathbf{a} + \mathbf{c})$ oe	**B1**	
	$\overrightarrow{OP} = \mathbf{a} + \mu\left(-\mathbf{a} + \frac{2}{5}\mathbf{c}\right)$ oe	**B2**	**B1** for $\overrightarrow{OP} = \mathbf{a} + \mu\left(-\mathbf{a} + \left(\mathit{their}\,\frac{2}{5}\right)\mathbf{c}\right)$
	Equates components at least once: $\lambda = 1 - \mu$ or $\lambda = \frac{2}{5}\mu$	**M1**	**FT** providing at least **B1** awarded
	Equates components: $\lambda = 1 - \mu$ and $\lambda = \frac{2}{5}\mu$	**A1**	
	$\mu = \frac{5}{7}$ $\lambda = \frac{2}{7}$ and $DP : PA = 2 : 5 = OP : PB$ oe	**A2**	**A1** for $\mu = \frac{5}{7}$ or $\lambda = \frac{2}{7}$

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **February/March 2024**

MARK SCHEME

Maximum Mark: 80

Published

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3 Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.

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5 Where a candidate has misread a number or sign 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 A or B 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(a)	$8 - 4x = 10$ oe soi and $8 - 4x = -10$ oe soi OR $16x^2 - 64x - 36[=0]$ oe	**M1**	
	$x = -\frac{1}{2}$, $x = \frac{9}{2}$	**A2**	mark final answer **A1** for $x = -\frac{1}{2}$ or $x = \frac{9}{2}$
1(b)	$-30x^2 + 105x - 75\ [*0]$ oe where * is any inequality sign or =	**M1**	condone one sign or arithmetic error
	Critical values 2.5 and 1	**2**	**M1** for factorises or solves a 3-term quadratic to find critical values
	$x < 1$ $x > 2.5$	**A1**	mark final answer

Question	Answer	Marks	Partial Marks
2	$\frac{a+b\sqrt{5}}{1+7\sqrt{5}}=\frac{20}{4+2\sqrt{5}}$ or $\frac{20(1+7\sqrt{5})}{4+2\sqrt{5}}$ oe, soi	**B1**	
	$[20\times]\frac{1+7\sqrt{5}}{4+2\sqrt{5}}\times\frac{4-2\sqrt{5}}{4-2\sqrt{5}}$ or $[10\times]\frac{1+7\sqrt{5}}{2+\sqrt{5}}\times\frac{2-\sqrt{5}}{2-\sqrt{5}}$ oe	**M1**	condone one slip providing it is not in the rationalisation factor
	$\frac{20(28\sqrt{5}-70+4-2\sqrt{5})}{16-20}$ or $\frac{10(14\sqrt{5}-35+2-\sqrt{5})}{4-5}$ oe	**A1**	
	a = 330 and b = –130 oe, nfww	**A1**	
	Alternative method		
	$\frac{a+b\sqrt{5}}{1+7\sqrt{5}}=\frac{20}{4+2\sqrt{5}}$ oe, soi	**(B1)**	
	Cross multiplies and multiplies out: $20+140\sqrt{5}=4a+4b\sqrt{5}+2a\sqrt{5}+10b$	**(M1)**	condone one sign or arithmetic error
	Correct pair of simultaneous equations $4a + 10b = 20$ oe $2a + 4b = 140$ oe and solves for a = 330 or b = –130	**(A1)**	
	a = 330 and b = –130 oe, nfww	**(A1)**	
3(a)	$\frac{3}{4}\mathbf{a}+\frac{1}{4}\mathbf{b}$ or equivalent simplified expression	**B2**	**B1** for $\mathbf{a}+\frac{1}{4}(\mathbf{b}-\mathbf{a})$ or $\mathbf{b}+\frac{3}{4}(\mathbf{a}-\mathbf{b})$ oe or for $3(\overrightarrow{OP}-\mathbf{a})=\mathbf{b}-\overrightarrow{OP}$ oe

Question	Answer	Marks	Partial Marks
3(b)	$\mathbf{q} = \begin{pmatrix} 24 \\ -12 \end{pmatrix}$ oe	2	**M1** for $12\sqrt{5} \times \dfrac{1}{\sqrt{6^2 + (-3)^2}} \begin{pmatrix} 6 \\ -3 \end{pmatrix}$ oe, soi
	$\mathbf{r} = \begin{pmatrix} -15 \\ 15 \end{pmatrix}$ oe	2	**M1** for $15\sqrt{2} \times \dfrac{1}{\sqrt{(-5)^2 + 5^2}} \begin{pmatrix} -5 \\ 5 \end{pmatrix}$ oe, soi If M0 M0, then **SC1** for the unit direction vectors $\dfrac{1}{\sqrt{45}} \begin{pmatrix} 6 \\ -3 \end{pmatrix}$ or better and $\dfrac{1}{\sqrt{50}} \begin{pmatrix} -5 \\ 5 \end{pmatrix}$ or better
	$\lvert \mathbf{q} + \mathbf{r} \rvert = \left\lvert \begin{pmatrix} 9 \\ 3 \end{pmatrix} \right\rvert = \sqrt{9^2 + 3^2}$	M1	**FT** *their* (**q** + **r**) providing at least M1 previously awarded
	[unit vector in direction **q** + **r** =] $\dfrac{1}{\sqrt{90}} \begin{pmatrix} 9 \\ 3 \end{pmatrix}$ oe, isw	A1	
4(a)(i)	$\dfrac{dy}{dx} = 6\sin x \cos x - \sin x$ oe, isw	B2	**B1** for an attempt to differentiate both terms with one term correct
	$3\sin^2 x + \cos x + \dfrac{\cos x}{\sin x}(6\sin x \cos x - \sin x)$	M1	**FT** *their* $\dfrac{dy}{dx}$ of the form $k\sin x \cos x \pm \sin x$
	Correct simplified step e.g. $3\sin^2 x + \cos x + 6\cos^2 x - \cos x$ or $3\sin^2 x + 6\cos^2 x$ or $3 + 3\cos^2 x$ leading to $3(1+\cos^2 x)$ nfww	A1	
4(a)(ii)	$\cos^2 x = \dfrac{1}{3}$	M1	**FT** *their* k providing $0 < k \le 4$
	$\cos x = [\pm]\sqrt{\dfrac{1}{3}}$ oe	M1	**dep** on previous **M1; FT** *their* k
	±0.955 or ±0.9553[1…] rot to 4 or more sf ±2.19 or ±2.186[2…] rot to 4 or more sf	A2	and no other angles in range **A1** for any two correct angles, ignoring extras

Question	Answer	Marks	Partial Marks
4(b)(i)	$\left(1-\frac{1}{2}x^{-\frac{1}{2}}\right)\sec^2\left(x-\sqrt{x}\right)$ oe, isw	2	**M1** for $f(x)\sec^2\left(x-\sqrt{x}\right)$
4(b)(ii)	Correctly writes $\left(1-\frac{1}{2}x^{-\frac{1}{2}}\right)\sec^2\left(x-\sqrt{x}\right)=$ $\frac{2\sqrt{x}-1}{2\sqrt{x}}\sec^2(x-\sqrt{x})$ or $\frac{2\sqrt{x}-1}{2\sqrt{x}\cos^2(x-\sqrt{x})}$ **and** states an answer $k\tan\left(x-\sqrt{x}\right)$ or states $\frac{1}{2}\int\frac{2\sqrt{x}-1}{\sqrt{x}\cos^2(x-\sqrt{x})}\,dx=\tan(x-\sqrt{x})$	M1	where k is a non-zero constant; dependent on **part (b)(i)**
	$2\tan\left(x-\sqrt{x}\right)+c$ nfww	A1	
5	Correct quotient rule: $\frac{dy}{dx}=\frac{(\ln 3x)[1]-x\left(\frac{1}{3x}\times 3\right)}{(\ln 3x)^2}$ oe OR correct product rule using $y=x(\ln 3x)^{-1}$: $\frac{dy}{dx}=x\left(-(\ln 3x)^{-2}\times\frac{3}{3x}\right)+[1](\ln 3x)^{-1}$	2	**M1** for $\frac{dy}{dx}=\frac{(\ln 3x)[1]-x\times their\left(\frac{1}{3x}\times 3\right)}{(\ln 3x)^2}$ OR for $\frac{dy}{dx}=x\times their\left(-(\ln 3x)^{-2}\times\frac{3}{3x}\right)$ $+[1](\ln 3x)^{-1}$
	$\frac{\delta y}{h}=\frac{\ln 3-1}{(\ln 3)^2}$ oe, soi	M1	**FT** *their* $\left.\frac{dy}{dx}\right\|_{x=1}$ providing quotient rule or appropriate product rule attempted
	$\delta y=\frac{\ln 3-1}{(\ln 3)^2}h$ or $\delta y=0.0817h$ nfww	A1	must have evidence of correct derivative
6	$\left[-\frac{1}{4}e^{2-4x}\right]_{-0.25}^{0.5}$ oe	B2	**B1** for ke^{2-4x}, $k\neq -4$
	Correct use of correct limits: $-\frac{1}{4}e^0-\left(-\frac{1}{4}e^3\right)$ oe	M1	**FT** *their* $-\frac{1}{4}e^{2-4x}$ providing **B1** awarded
	$-\frac{1}{4}+\frac{1}{4}e^3$ or exact equivalent, isw	A1	

Question	Answer	Marks	Partial Marks
7(a)	Correctly eliminates x or y e.g. $4x^2 - 3\left(\frac{2}{x}\right)^2 + x\left(\frac{2}{x}\right) = 24$ oe or $4\left(\frac{2}{y}\right)^2 - 3y^2 + y\left(\frac{2}{y}\right) = 24$ oe	**M1**	
	Rearranges to a 3-term quadratic in x^2 or y^2 soi e.g. $4x^4 - 22x^2 - 12[=0]$ or $2x^4 - 11x^2 - 6[=0]$ or $3y^4 + 22y^2 - 16[=0]$ oe	**A1**	
	Factorises or solves *their* 3-term quadratic in x^2 or y^2 soi e.g. $(2x^2 + 1)(x^2 - 6)$ or $(3y^2 - 2)(y^2 + 8)$	**M1**	
	$x^2 = 6$ oe, nfww or $y^2 = \frac{2}{3}$ nfww	**A1**	
	$\left(\pm\sqrt{6}, \pm\frac{2}{\sqrt{6}}\right)$ or $\left(\pm\sqrt{6}, \pm\sqrt{\frac{2}{3}}\right)$ oe, nfww	**A1**	and no other values; **dep** on at least the first M1 A1
7(b)	$\sqrt{(x_P - x_Q)^2 + (y_P - y_Q)^2}$ oe, soi	**M1**	**FT** providing *their* x_P, x_Q and *their* y_P, y_Q are non-zero
	$\frac{4}{3}\sqrt{15}$	**A1**	
8(a)	Points plotted at $\begin{array}{\|c\|c\|c\|c\|c\|c\|} \hline x & 1 & 3 & 5 & 10 & 12 \\ \hline \lg y & 1.6 & 2.2 & 2.8 & 4.3 & 4.9 \\ \hline \end{array}$ soi and ruled, single straight line of best fit	**B2**	**B1** for at least 4 correctly plotted points
8(b)	$\lg y = \lg A + x\lg b$ soi	**B1**	
	$\lg A =$ *their* 1.3 soi	**M1**	**dep** on using linear points
	$\lg b =$ *their* $\frac{4.9 - 1.6}{12 - 1}$ oe or $\lg b = 0.3$ oe soi	**M1**	**dep** on using linear points
	$A = 10^{1.3}$ isw and $b = 10^{\frac{3}{10}}$ isw	**A2**	**A1** for $A = 10^{1.3}$ isw or $b = 10^{\frac{3}{10}}$ isw
	$A = 20$ and $b = 2$ nfww	**A1**	If zero scored, award **SC1** for $A = 20$ and **SC1** for $b = 2$ found without using the graph in any way

Question	Answer	Marks	Partial Marks
8(c)	lg1500 = 3.2 or 3.17[60…]	**M1**	
	OR $x = \log_{their\,b}\left(\frac{1500}{their A}\right)$		**FT** *their A* and *b*
	OR $x = \frac{\lg 1500 - their \lg A}{their \lg b}$		**FT** *their* lg*A* and lg*b*
	awrt 6.2 to awrt 6.4 isw	**A1**	
9(a)	$[A=]\frac{1}{2}x^2 \times 0.5 + \frac{1}{2}(x+2)^2 \times 2 + \frac{1}{2}y^2[\times 1]$ soi	**B1**	
	$[P\ =\ ]$ $x + 0.5x + 2 + 2(x+2) + (x+2-y) + y + y$	**M1**	Attempts to form an expression in *x* and *y* for the perimeter using arc lengths and lengths of lines
	Equates *P* to 24 and rearranges: $y = 16 - \frac{9}{2}x$	**A1**	
	$A = \frac{5}{4}x^2 + 4x + 4 + 128 - 72x + \frac{81}{8}x^2$ oe leading to given answer $A = \frac{91}{8}x^2 - 68x + 132$	**A1**	
9(b)	$\frac{dA}{dx} = \frac{91}{4}x - 68$	**M1**	
	Solves $\frac{dA}{dx} = 0$ for *x*	**M1**	**FT** *their* $\frac{dA}{dx}$ providing at least one term is correct
	$x = \frac{272}{91}$ or $2\frac{90}{91}$ or 2.99 or 2.989[01…] rot to 4 or more sf	**A1**	
	$A = \frac{91}{8}\left(\frac{272}{91}\right)^2 - 68\left(\frac{272}{91}\right) + 132$	**M1**	**FT** *their x*
	$A = \frac{2764}{91}$ or $30\frac{34}{91}$ or 30.4 or 30.37[36…] rot to 4 or more sf	**A1**	

Question	Answer	Marks	Partial Marks
10(a)	$a^n = b^4$ and $na^{n-1}\left(\frac{1}{a}\right) = 48b^3$ oe	**M1**	
	Eliminates b from one equation using the other equation e.g. $\frac{a^{n-2}}{a^{\frac{3}{4}n}} = \frac{48}{n}$	**M1**	**dep** previous **M1**
	Simplifies a terms e.g. $a^{\frac{n}{4}-2} = \frac{48}{n}$ or $a^{\frac{3n}{4}-6} = \left(\frac{48}{n}\right)^3$	**A1**	
	Uses an appropriate power and completes to the given form e.g. $\left(a^{\frac{n}{4}-2}\right)^2 = \left(\frac{48}{n}\right)^2$ or $\left(a^{\frac{3n}{4}-6}\right)^{\frac{2}{3}} = \left(\frac{48}{n}\right)^{3\times\frac{2}{3}}$ $\rightarrow$ $a^{\frac{n}{2}-4} = \left(\frac{48}{n}\right)^2$	**A1**	
10(b)	Correct equation in a, b, n $\frac{n(n-1)}{2}\times a^{n-2}\times\frac{1}{a^2} = 1056b^2$ oe, soi	**M1**	
	Correct equation in a, n $\frac{n(n-1)}{2}\times a^{n-2}\times\frac{1}{a^2} = 1056a^{\frac{n}{2}}$ oe	**A1**	
	$\left[\frac{n(n-1)}{2}\times a^{\frac{n}{2}-4} = 1056 \text{ oe} \rightarrow\right]$ Correct equation in n only $\frac{n(n-1)}{2}\times\left(\frac{48}{n}\right)^2 = 1056$ oe	**A1**	
	$n^2 - 12n = 0$ or $n - 12 = 0$ oe	**A1**	
	$n = 12$ only	**A1**	
	$a = 4$ only and $b = 64$ only	**A1**	

Question	Answer	Marks	Partial Marks
11	$\frac{dS}{dt} = \frac{dS}{dr} \times \frac{dr}{dt}$ or $\frac{dS}{dr} = 6$ soi	B1	
	$S = 2\pi r(4r)$ or $8\pi r^2$	B1	
	$16\pi r = 6$	M1	**FT** *their* $S = k\pi r^2$ with k a positive integer to give $2k\pi r = 6$
	$r = \frac{6}{16\pi}$ oe, isw	A1	
	$S = \frac{9}{8\pi}$ oe, isw	A1	

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2023**

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

Question	Answer	Marks	Partial marks
1(a)	$-3(x+2)^2+31$	**B4**	**B2** for $-3(x+2)^2$ or **B1** for $(x+2)^2$ or $a = -3$ and $b = 2$ **B2** for $c = 31$ or **B1** for $-4 \times -3 + 19$ soi
1(b)	Maximum value 31 when $x = -2$	**B2**	**Strict FT** *their c* from part **(a)** and **–***their b* from part **(a)** **B1** for either without contradiction
1(c)	$-3\left(\sqrt{u}+2\right)^2 = -31$ oe	**M1**	**FT** an expression of correct form from part **(a)**
	Rearranges as far as $\sqrt{u} = -2 \pm \sqrt{\frac{31}{3}}$	**A1**	
	1.48 cao or 1.475[13…] rot to 3 or more dp or $\frac{43-4\sqrt{93}}{3}$ isw	**A1**	
2	Correct method to eliminate *y:* $5x-3(1-x)=2$ oe or adds $3x + 3\ln y = 3$ $5x - 3\ln y = 2$ to obtain $3x + 5x = 3 + 2$ or better	**M1**	
	$x = \frac{5}{8}$ oe	**A1**	
	$\ln y = \frac{3}{8}$ oe	**M1**	
	$y = e^{\frac{3}{8}}$ oe or 1.45	**A1**	

Question	Answer	Marks	Partial marks
2	**Alternative method**		
	Correct method to eliminate x: $5(1 - \ln y) - 3\ln y = 2$ oe or subtracts $5x - 3\ln y = 2$ from $5x + 5\ln y = 5$ to obtain $5\ln y - (-3\ln y) = 5 - 2$ or better	**(M1)**	
	$\ln y = \frac{3}{8}$ oe	**(M1)**	
	$y = e^{\frac{3}{8}}$ oe or 1.45	**(A1)**	
	$x = \frac{5}{8}$ oe	**(A1)**	
3(a)	$2x^2 + 5x - \frac{1}{2}\ln(2x+3) + c$ oe	**B3**	**B2** for $2x^2 + 5x - \frac{1}{2}\ln(2x+3)$ or $2x^2 + 5x - \frac{1}{2}\ln 2x + 3 + c$ or $2x^2 + 5x + k\ln(2x+3) + c$ with $k \neq 0$ or **B1** for $2x^2 + 5x + \ldots + c$ or $\ldots - \frac{1}{2}\ln 2x + 3$ or $\ldots + k\ln(2x+3)$ with $k \neq 0$
3(b)	Substitutes limits and subtracts in correct order	**M1**	**FT** *their* part (a) providing it includes a term $k\ln(2x+3)$ with $k \neq 0$
	$\left[18 + 15 - \frac{1}{2}\ln 9\right] - \left[2 + 5 - \frac{1}{2}\ln 5\right]$	**A1**	
	$26 - \frac{1}{2}\ln\frac{9}{5}$ or $26 + \frac{1}{2}\ln\frac{5}{9}$ oe	**A1**	

Question	Answer	Marks	Partial marks
4	$(2+ax)^5 = 2^5 + 5\times 2^4 ax + 10\times 2^3 a^2x^2 + ...$	**B1**	
	$(2+ax)^5(1+bx) =$ $32 + 80ax + 80a^2x^2 + 32bx + 80abx^2...$	**M1**	
	$80a + 32b = 112$ oe, isw	**A1**	
	$80a^2 + 80ab = -240$ oe, isw	**A1**	
	$3a^2 - 7a - 6 = 0$ oe	**M1**	
	$(3a + 2)(a - 3) = 0$	**M1**	
	$a = 3$ and $b = -4$ and no other values	**A1**	
5	$[m_{\text{tangent}} =] -2px^{-3} + 5$ oe	**B1**	
	[When $x = 1$, m_{normal} =] $\dfrac{-1}{-2p+5}$ or gradient of tangent = 1 nfww	**B1**	**FT** $\dfrac{-1}{\textit{their} \left.\dfrac{dy}{dx}\right\|_{x=1}}$ if appropriate
	$\dfrac{-1}{\textit{their}(-2p+5)} = -1$ oe or *their*$(-2p + 5) = 1$	**M1**	**FT** $\dfrac{-1}{\textit{their} \left.\dfrac{dy}{dx}\right\|_{x=1}}$ or *their* $\left.\dfrac{dy}{dx}\right\|_{x=1}$ and *their* evaluation of $\dfrac{-1}{-1}$
	$p = 2$ nfww	**A1**	
	[When $x = 1$] *their* $5 = -1 + q$ or $y = -x + 6$	**M1**	**FT** y = (*their* p) + 3 providing at least 2 of the first 3 marks awarded
	$q = 6$ nfww	**A1**	
6	$ax^2 - 5x + 2 = 2ax + x - 10$	**M1**	
	$ax^2 - (2a+6)x + 12[=0]$ oe	**A1**	
	Correct use of $b^2 - 4ac$ [*0]: $(-(2a + 6))^2 - 4(a)(12)$ [*0] oe	**M1**	where * is any inequality sign or =; **FT** *their* 3-term quadratic in x and a
	$4a^2 - 24a + 36$ [*0]	**A1**	
	Factorises or solves *their* 3-term quadratic in a	**M1**	**FT** *their* 3-term quadratic in a
	$a = 3$	**A1**	

Question	Answer	Marks	Partial marks
6	**Alternative method**		
	$a = \frac{3}{x-1}$ oe or $x = \frac{a+3}{a}$	**(2)**	**M1** for $2ax - 5$
	$\left(\frac{6}{x-1}+1\right)x - 10 = \left(\frac{3}{x-1}\right)x^2 - 5x + 2$ oe or $(2a+1)\left(\frac{a+3}{a}\right) - 10 = a\left(\frac{a+3}{a}\right)^2 - 5\left(\frac{a+3}{a}\right) + 2$ oe	**(M1)**	**FT** *their a* of the form $\frac{k}{bx+c}$ where k, b, c are non-zero constants or *their x* of the form $\frac{da+e}{fa}$ where d, e, f are non-zero constants
	$3x^2 - 12x + 12$ [= 0] oe or $a^2 - 6a + 9\,[= 0]$	**(A1)**	
	Solves *their* 3-term quadratic in x as far as $x = \ldots$ or factorises or solves *their* 3-term quadratic in a	**(M1)**	
	$a = 3$	**(A1)**	
7(a)	$20\cos 2t + 12\sin 2t$	**2**	**B1** for $20\cos 2t$ or $12\sin 2t$
7(b)	12	**B1**	
7(c)	$\tan 2t = their\left(-\frac{20}{12}\right)$ oe	**M1**	**FT** $a\cos 2t + b\sin 2t$ where a and b are non-zero integers
	$t = 1.06$ or 1.055[60…] rot to 3 or more dp	**A2**	**A1** for $2t = -1.030$[3…] or $2t = 2.111$[2…]
7(d)	$s = -5\cos 2t - 3\sin 2t$ $(+\ c)$	**B2**	**B1** for $-5\cos 2t$ or $-3\sin 2t$
	$-5\cos\pi - 3\sin\pi - (-5\cos\frac{\pi}{2} - 3\sin\frac{\pi}{2})$ or $s = -5\cos 2t - 3\sin 2t + 5$ and $s_{\frac{\pi}{2}} - s_{\frac{\pi}{4}} = 10 - 2$	**M1**	**FT** providing at least **B1** previously awarded
	8	**A1**	

Question	Answer	Marks	Partial marks
8	$\left(2-\sqrt{10}\right)\left(2+\sqrt{10}\right)=-6$	**B1**	
	$x=\dfrac{-1\pm\sqrt{1^{[2]}-4(2-\sqrt{10})(2+\sqrt{10})}}{2\left(2-\sqrt{10}\right)}$	**M1**	
	$x=\dfrac{-1\pm\sqrt{1-4(-6)}}{2\left(2-\sqrt{10}\right)}$	**A1**	
	$\dfrac{-6}{2\left(2-\sqrt{10}\right)}$ oe , $\dfrac{4}{2\left(2-\sqrt{10}\right)}$ oe	**A1**	
	$\dfrac{-6}{2\left(2-\sqrt{10}\right)}\times\dfrac{\left(2+\sqrt{10}\right)}{\left(2+\sqrt{10}\right)}$ or $\dfrac{4}{2\left(2-\sqrt{10}\right)}\times\dfrac{\left(2+\sqrt{10}\right)}{\left(2+\sqrt{10}\right)}$	**M1**	**FT** $\dfrac{k}{2\left(2-\sqrt{10}\right)}$ where k is a non-zero constant
	$\dfrac{-6(2+\sqrt{10})}{2(-6)}$ oe = $1+\dfrac{1}{2}\sqrt{10}$	**A1**	Must have sufficient detail shown
	$\dfrac{4(2+\sqrt{10})}{2(-6)}$ oe = $-\dfrac{2}{3}-\dfrac{1}{3}\sqrt{10}$	**A1**	Must have sufficient detail shown
9(a)	$2(e^x+1)^2-1$ [= 8]	**M1**	
	$e^x = -1+\sqrt{\dfrac{9}{2}}$ oe	**A1**	
	$x=\ln\left(\dfrac{3}{\sqrt{2}}-1\right)$ isw or 0.115 or 0.1145[06…] rot to 4 or more dp	**A1**	
9(b)	f is not one-one, hence f^{-1} does not exist oe	**B1**	
	$g^{-1}(x)=\ln(x-1)$	**2**	**M1** for $x=\ln(y-1)$ and a swop of variables at some point or $y=\ln(x+1)$ or $e^x=y-1$ and $y=\ln x-1$
	$x>1$	**B1**	

Question	Answer	Marks	Partial marks
10(a)	$OA = \sqrt{6^2 + 8^2}$ oe or 10	**B1**	
	[Angle *AOB* =] 0.9272[95…] rot to 4 or more dp or [Angle *OAB* =] 0.6435[01…] rot to 4 or more dp	**M1**	
	[Angle *COB* =] 2.214[297…] rot to 3 or more dp	**A1**	
	[Arc *CB* =] 6(*their* 2.214)	**M1**	**FT** *their COB*
	[Perimeter =] 8 + (*their* 10 + 6) + 6(*their* 2.214)	**M1**	**FT** *their* arc *CB* and *OA*
	37.3 or 37.28[578…] rot to 2 or more dp	**A1**	
10(b)	$\frac{1}{2}\times 8\times 6+\frac{1}{2}\times 6^2\times 2.214$ oe, soi	**M2**	**FT** *their* 2.21 **M1** for $\frac{1}{2}\times 6^2\times 2.214$ soi
	63.9 or 63.85[735…] rot to 2 or more dp	**A1**	
11(a)	$\dfrac{1}{\frac{1}{\cos x}-\frac{1}{\sin x}}+\dfrac{1}{\frac{1}{\cos x}+\frac{1}{\sin x}}$	**M1**	
	Simplifies denominator $\dfrac{1}{\frac{\sin x-\cos x}{\sin x\cos x}}+\dfrac{1}{\frac{\sin x+\cos x}{\sin x\cos x}}$	**A1**	
	Writes as two simple algebraic fractions: $\dfrac{\sin x\cos x}{\sin x-\cos x}+\dfrac{\sin x\cos x}{\sin x+\cos x}$	**A1**	OR writes as a single simple algebraic fraction: $\dfrac{\sin x\cos x(\sin x+\cos x)+\sin x\cos x(\sin x-\cos x)}{(\sin x-\cos x)(\sin x+\cos x)}$
	Combines and simplifies: $\dfrac{2\sin^2 x\cos x}{\sin^2 x-\cos^2 x}$	**A1**	
	Correct simplification to given answer e.g. $\dfrac{2\cancel{\sin^2} x\cos x}{\cancel{\sin^2} x-\frac{\cos^2 x}{\sin^2 x}}=\dfrac{2\cos x}{1-\cot^2 x}$ or $\dfrac{\cancel{\sin^2} x(2\cos x)}{\cancel{\sin^2} x(1-\cot^2 x)}$ $\left[=\dfrac{2\cos x}{1-\cot^2 x}\right]$	**A1**	All steps correct nd fully justified

Question	Answer	Marks	Partial marks
11(a)	**Alternative method**		
	Common denominator: $\dfrac{\sec x + \operatorname{cosec} x + \sec x - \operatorname{cosec} x}{(\sec x - \operatorname{cosec} x)(\sec x + \operatorname{cosec} x)}$	**(M1)**	
	Simplifies: $\dfrac{2\sec x}{\sec^2 x - \operatorname{cosec}^2 x}$	**(A1)**	
	Rewrites in terms of sin$x$ and cos$x$: $\dfrac{\frac{2}{\cos x}}{\frac{1}{\cos^2 x} - \frac{1}{\sin^2 x}}$	**(A1)**	OR multiplies numerator and denominator by $\cos^2 x$: $\dfrac{2\sec x}{\sec^2 x - \operatorname{cosec}^2 x} \times \dfrac{\cos^2 x}{\cos^2 x}$
	$\dfrac{\frac{2}{\cos x}}{\frac{1}{\cos^2 x} - \frac{1}{\sin^2 x}} \times \dfrac{\cos^2 x}{\cos^2 x}$	**(A1)**	
	Correct simplification to given answer e.g. $\dfrac{\frac{2\cos \cancel{2} x}{\cancel{\cos x}}}{\frac{\cos^2 x}{\cos^2 x} - \frac{\cos^2 x}{\sin^2 x}} = \dfrac{2\cos x}{1 - \cot^2 x}$	**(A1)**	
11(b)	$\tan\left(y + \dfrac{\pi}{4}\right) = [\pm]\dfrac{1}{\sqrt{3}}$	**B1**	
	$\left[y + \dfrac{\pi}{4} =\right]\ \dfrac{\pi}{6}$, or $-\dfrac{\pi}{6}$, or $-\dfrac{5\pi}{6}$, or $-\dfrac{7\pi}{6}$ oe	**M1**	
	$[y =] -\dfrac{\pi}{12},\ -\dfrac{5\pi}{12},\ -\dfrac{13\pi}{12},\ -\dfrac{17\pi}{12}$ oe	**A2**	No extras within range **A1** for two correct, ignoring extras

Cambridge Assessment International Education

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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **October/November 2023**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the October/November 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

Generic Marking Principles

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

Mathematics-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, non-integer 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 or sign 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 A or B mark for the misread.

6 Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

Abbreviations

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

Question	Answer	Marks	Guidance
1(a)	$y=-\frac{1}{2}x+25$ isw	3	**M1** for $m=\frac{29-23}{-8-4}$ oe or $-\frac{1}{2}$ and **M1 FT** for $\frac{y-23}{x-4}=their\left(-\frac{1}{2}\right)$ oe or $y=$ *their* $\left(-\frac{1}{2}\right)$ $x+c$ and $23=-\frac{1}{2}\times 4+c$ oe **OR** **M1** for solving $23=4m+c$ $29=-8m+c$ for $m=-\frac{1}{2}$ or $c=25$ and **M1 FT** for correctly using *their m* or *their c* to find c or m
	Solves *their* linear equation simultaneously with $y = 2x + 5$ to find x or y	M1	**FT** *their* $y=-\frac{1}{2}x+25$ oe
	(8, 21)	A1	
1(b)	$\sqrt{8^2+21^2}$ oe	M1	**FT** *their* (8, 21)
	$\sqrt{505}$ isw or 22.5 or 22.47[22…] rot to 2 or more dp	A1	
2	$x^2+2kx=-2x-6k-1$	M1	
	$x^2+(2k+2)x+6k+1[=0]$	A1	
	Correctly uses b^2-4ac [*0] for *their* equation $(2k+2)^2-4(6k+1)$ [*0]	M1	where * is any inequality sign or =; **FT** *their* 3-term quadratic in x and k
	$4k^2-16k$ [*0] nfww	A1	
	$k=4$	A1	**dep** on all previous marks awarded

Question	Answer	Marks	Guidance
2	**Alternative method**		
	$2x + 2k$	**(M1)**	
	$k = -x - 1$ or $x = -k - 1$ oe	**(A1)**	
	$-2(-k - 1) - 6k - 1 = (-k - 1)^2 + 2k(-k - 1)$ oe or $-2x - 6(-1 - x) - 1 = x(x + 2(-1 - x))$ oe	**(M1)**	**FT** *their k* of the form $ax + b$ where a and b are non-zero constants or *their x* of the form $ck + d$ where c and d are non-zero constants
	$k^2 - 4k$ [= 0] or $x^2 + 6x + 5$ [= 0] and $x = -5$ [$x = -1$] nfww	**(A1)**	
	$k = 4$	**(A1)**	**dep** on all previous marks awarded
3	$\dfrac{16+9\sqrt{3}}{(2+\sqrt{3})^2}$	**B1**	
	$\dfrac{\left(16+9\sqrt{3}\right)\left(7-4\sqrt{3}\right)}{\left(7+4\sqrt{3}\right)\left(7-4\sqrt{3}\right)}$ or $\dfrac{16+9\sqrt{3}}{7+4\sqrt{3}} \times \dfrac{7-4\sqrt{3}}{7-4\sqrt{3}}$	**M1**	**FT** $\dfrac{c\left(16+9\sqrt{3}\right)}{a+b\sqrt{3}}$ where a, b and c are non-zero constants
	$112-64\sqrt{3}+63\sqrt{3}-108$ or $\dfrac{-112+64\sqrt{3}-63\sqrt{3}+108}{-1}$	**A1**	
	$4-\sqrt{3}$ or $-\sqrt{3}+4$ cao, nfww	**A1**	
	Alternative method		
	$\dfrac{16+9\sqrt{3}}{(2+\sqrt{3})^2}$	**(B1)**	
	$\dfrac{\left(16+9\sqrt{3}\right)\left(2-\sqrt{3}\right)^2}{\left(2+\sqrt{3}\right)^2\left(2-\sqrt{3}\right)^2}$ or $\dfrac{16+9\sqrt{3}}{\left(2+\sqrt{3}\right)^2} \times \dfrac{\left(2-\sqrt{3}\right)^2}{\left(2-\sqrt{3}\right)^2}$	**(M1)**	
	$112-64\sqrt{3}+63\sqrt{3}-108$ or $64-32\sqrt{3}-32\sqrt{3}+48+$ $36\sqrt{3}-54-54+27\sqrt{3}$	**(A1)**	
	$4-\sqrt{3}$ or $-\sqrt{3}+4$ cao, nfww	**(A1)**	

Question	Answer	Marks	Guidance
4(a)	$\dfrac{e^{2x+2}}{e^{\frac{x}{2}}}=10$ oe, soi	**B1**	
	$e^{1.5x+2}=10$ oe	**M1**	**FT** $\dfrac{e^{2x+k}}{e^{\frac{x}{2}}}=10$ oe or $\dfrac{e^{kx+2}}{e^{\frac{x}{2}}}=10$ oe where k is an integer and $k>0$ or $\dfrac{e^{2x+2}}{e^{\frac{x}{n}}}=10$ oe where n is an integer and $n>1$ or $n=-2$
	$1.5x+2=\ln 10$ oe	**M1**	**FT** an expression of, or equivalent to, the form $e^{ax+b}=10$ oe where a and b are non-zero constants
	$x=\dfrac{2}{3}(\ln 10-2)$ oe, isw or 0.202 or 0.2017[23…] rot to 4 or more dp isw	**A1**	
4(b)	$\dfrac{y^2}{4y-9}=9^{\frac{1}{2}}$ nfww or $\log_9\dfrac{y^2}{4y-9}=\log_9 9^{\frac{1}{2}}$ oe	**M2**	**M1** for at least one correct log law used in a correct equation e.g. $\log_9 y^2-\log_9(4y-9)=\dfrac{1}{2}$ or $\log_9\dfrac{y^2}{4y-9}=\dfrac{1}{2}$ or $2\log_9 y-\log_9(4y-9)=\dfrac{1}{2}\log_9 9$
	$y^2-12y+27\,[=0]$ nfww	**A1**	
	$(y-3)(y-9)=0$	**DM1**	**dep** on at least **M1** previously awarded
	$y=3$, $y=9$ nfww	**A1**	
5(a)	Correct first derivative: $3x^2-14x+12$	**M2**	**M1** for two terms of $x^3-7x^2+12x-5$ differentiated correctly
	[At $x=1$] gradient of tangent: 1	**A1**	
	$y-1=their(-1)(x-1)$ oe or $y=-x+c$ **and** $1=-1+c$ soi	**M1**	**FT** $\dfrac{-1}{their\left.\dfrac{dy}{dx}\right\|_{x=1}}$
	$y-1=-1(x-1)$ or $y=-x+2$ oe, isw	**A1**	

Question	Answer	Marks	Guidance
5(b)	$x^3 - 7x^2 + 12x - 5 = their(-x+2)$	**B1**	**FT** *their* $y = ax + b$ where a is a non-zero constant
	Uses the correct linear factor $x - 1$ and the correct cubic $x^3 - 7x^2 + 13x - 7[=0]$ to find a quadratic factor with at least two terms correct	**M1**	
	$x^2 - 6x + 7$	**A1**	
	Correct use of formula or completing the square on *their* 3-term quadratic, e.g., $x = \frac{-(-6) \pm \sqrt{(-6)^2 - 4[1](7)}}{2[1]}$ or $x = \frac{6 \pm \sqrt{36 - 4[1](7)}}{2}$	**M1**	**FT** *their* 3-term quadratic providing it is from an attempt at finding a quadratic factor and the discriminant is not negative
	$x = 3 \pm \sqrt{2}$	**A1**	
6	$\left[\frac{(x+2)^2}{x} =\right]$ $x + 4 + \frac{4}{x}$ soi	**B2**	**B1** for two terms correct or for $\frac{x^2 + 4x + 4}{x}$
	$\left[\frac{x^2}{2} + 4x + 4\ln x\right]_2^3$	**B2**	**B1** for $\left[\frac{x^2}{2} + ... + 4\ln x\right]_2^3$ or $[... + 4x + 4\ln x]_2^3$ or $\left[\frac{x^2}{2} + 4x + k\ln x\right]_2^3$ with $k \neq 0$
	$\left[\frac{9}{2} + 12 + 4\ln 3\right] - \left[\frac{4}{2} + 8 + 4\ln 2\right]$	**M1**	**dep** on at least previous **B1** for integration
	$6.5 + 4\ln\left(\frac{3}{2}\right)$ or exact equivalent	**A1**	
7(a)	Velocity: $3e^{2t} - 4e^{-2t} - 1$ isw	**B2**	**B1** for $3e^{2t}$ or $-4e^{-2t}$
	Acceleration: $6e^{2t} + 8e^{-2t}$ isw	**B1**	**FT** $me^{2t} + ne^{-2t} + k$ where m, n and k are constants

Question	Answer	Marks	Guidance
7(b)	$3e^{4t} - e^{2t} - 4 = 0$ or $3\left(e^{2t}\right)^2 - e^{2t} - 4 = 0$	**B1**	
	$\left(3e^{2t} - 4\right)\left(e^{2t} + 1\right) = 0$	**M1**	**FT** *their* 3-term quadratic in e^{2t} oe
	$e^{2t} = \frac{4}{3}$ nfww	**A1**	
	$\frac{1}{2}\ln\frac{4}{3}$ oe, isw or 0.144 or 0.1438[41…] rot to 4 or more dp and no other solutions	**A1**	
7(c)	$6 \times e^{2\left(\frac{1}{2}\ln\frac{4}{3}\right)} + 8 \times e^{-2\left(\frac{1}{2}\ln\frac{4}{3}\right)}$	**M1**	**FT** $pe^{2t} + qe^{-2t}$ where p and q are non-zero constants and *their* **positive** $\frac{1}{2}\ln\frac{4}{3}$ from part (b)
	14 nfww	**A1**	
8(a)	Derivative of sin2x: $2\cos 2x$ soi	**B1**	
	Product rule: $x \times$ 2cos2x + [1]sin 2x isw	**B1**	**FT** *their* 2cos2x
8(b)	$y = \frac{\pi}{4}$ soi, isw	**B1**	
	gradient of tangent: 1 soi	**B1**	**dep** on correct derivative
	$y = x$ or $y - x = 0$ or $x - y = 0$	**B1**	**dep** on correct derivative
8(c)	$\left[x\sin 2x + \frac{1}{2}\cos 2x\right]_0^{\frac{\pi}{6}}$ nfww	**M3**	**M2** for $x\sin 2x + k\cos 2x$ where $k > 0$ or $k = -\frac{1}{2}$; nfww or **M1** for $\int 2x\cos 2x\,dx = x\sin 2x - \int \sin 2x\,dx$ or $\frac{-\cos 2x}{2} + \int 2x\cos 2x\,dx = x\sin 2x$
	$\frac{\pi}{6}\sin\frac{\pi}{3} + \frac{1}{2}\cos\frac{\pi}{3} - \frac{1}{2}\cos 0$	**A1**	
	$\frac{\pi\sqrt{3}}{12} - \frac{1}{4}$ or $\frac{\pi\sqrt{3} - 3}{12}$	**A1**	

Question	Answer	Marks	Guidance
9(a)	Correct pair of simplified linear equations in a and d with terms collected, e.g., $3a+3d=-36$ isw or $a+d=-12$ isw $3a+30d=72$ isw or $a+10d=24$ isw	B3	**B2** for one correct simplified equation or **B1** for $a+a+d+a+2d=-36$ or $\frac{3}{2}\{2a+(3-1)d\}=-36$ or $a+9d+a+10d+a+11d=72$ or $\frac{12}{2}\{2a+(12-1)d\}-\frac{9}{2}\{2a+(9-1)d\}=72$ or $12a+66d-9a-36d=72$ or $\frac{3}{2}\{2(a+9d)+(3-1)d\}=72$
	Solves two linear equations for d or a e.g. $27d=108 \to d=\dots$ or $9d=36 \to d=\dots$ or $a+10(-12-a)=24 \to a=\dots$ $27a=-432 \to a=\dots$	M1	**FT** *their* linear equations in a and d providing at least **B1** earned and the equations have a solution
	$d=4$ and $a=-16$ nfww	A1	
9(b)	$1.2^n * 101$	B3	where * is any inequality sign or =; **B2** for $\frac{[1](1.2^n-1)}{(1.2-1)} * 500$ or **B1** for $r=1.2$ soi
	$n\log 1.2 * \log 101$ or $\log_{1.2} 101$ soi	M1	**FT** $1.2^n *$ *their* 101 providing **B2** has been awarded and (*their* 101) > 0
	$n=26$	A1	**dep** on all previous marks awarded

Question	Answer	Marks	Guidance
10(a)	Writes cot$x$ and tan$x$ in terms of sin$x$ and cos$x$: $\dfrac{\sin x}{1-\dfrac{\cos x}{\sin x}}+\dfrac{\cos x}{1-\dfrac{\sin x}{\cos x}}$	**M1**	OR $\dfrac{\sin x\left(1-\dfrac{\sin x}{\cos x}\right)+\cos x\left(1-\dfrac{\cos x}{\sin x}\right)}{\left(1-\dfrac{\cos x}{\sin x}\right)\left(1-\dfrac{\sin x}{\cos x}\right)}$
	Simplifies denominator: $\dfrac{\sin x}{\dfrac{\sin x-\cos x}{\sin x}}+\dfrac{\cos x}{\dfrac{\cos x-\sin x}{\cos x}}$	**A1**	OR $\dfrac{\sin x\left(\dfrac{\cos x-\sin x}{\cos x}\right)+\cos x\left(\dfrac{\sin x-\cos x}{\sin x}\right)}{\left(\dfrac{\sin x-\cos x}{\sin x}\right)\left(\dfrac{\cos x-\sin x}{\cos x}\right)}$
	Writes as two simple algebraic fractions: $\dfrac{\sin^2 x}{\sin x-\cos x}+\dfrac{\cos^2 x}{\cos x-\sin x}$	**A1**	OR writes as a single simple algebraic fraction: $\dfrac{\sin^2 x(\cos x-\sin x)+\cos^2 x(\sin x-\cos x)}{(\sin x-\cos x)(\cos x-\sin x)}$
	Writes as a difference with a common denominator: $\dfrac{\sin^2 x}{\sin x-\cos x}-\dfrac{\cos^2 x}{\sin x-\cos x}$	**A1**	OR $\dfrac{\sin^2 x(\cos x-\sin x)-\cos^2 x(\cos x-\sin x)}{(\sin x-\cos x)(\cos x-\sin x)}$
	Correct simplification to given answer, e.g., $\dfrac{(\sin x-\cos x)(\sin x+\cos x)}{(\sin x-\cos x)}=\sin x+\cos x$ or $\dfrac{\cancel{(\sin x-\cos x)}(\sin x+\cos x)}{\cancel{(\sin x-\cos x)}}[=\sin x+\cos x]$	**A1**	All steps correct and final step fully justified by factorising

Question	Answer	Marks	Guidance
10(b)	$10\cos^2 x + 3\cos x - 1 [= 0]$ or $\sec^2 x - 3\sec x - 10 [= 0]$	**B2**	**B1** for $\frac{9\cos x}{\sin x} + \frac{3}{\sin x} = \frac{\sin x}{\cos x}$ or better or $9 + \frac{3\tan x}{\sin x} = \tan^2 x$ or better OR **M1** for one sign error in $10\cos^2 x + 3\cos x - 1 [= 0]$ or $\sec^2 x - 3\sec x - 10 [= 0]$
	$(5\cos x - 1)(2\cos x + 1)[= 0]$ or $(\sec x - 5)(\sec x + 2)[= 0]$	**M1**	**FT** *their* 3-term quadratic in cos$x$ or sec$x$
	[cos$x$ = $\frac{1}{5}$ **and** cos$x$ = $-\frac{1}{2}$ OR sec$x$ = 5 **and** sec$x$ = –2 leading to] 78.5 or 78.46[30…] rot to 2 or more dp 281.5 or 281.53[69…] rot to 2 or more dp 120 240 and no extras in range $0 < x < 360$	**A2**	**A1** for any two correct angles [found using cos$x$ = $\frac{1}{5}$ **and** cos$x$ = $-\frac{1}{2}$ OR sec$x$ = 5 **and** sec$x$ = –2]; ignore extras

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **October/November 2023**

MARK SCHEME

Maximum Mark: 80

Published

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Mathematics-Specific Marking Principles

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2 Unless specified in the question, non-integer 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 or sign 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 A or B mark for the misread.

6 Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

Abbreviations

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

Question	Answer	Marks	Guidance
1(a)	3	**B2**	**B1** for g(0) = 0 or [fg(x) =] 2sin(e^{3x} – 1) + 3cos(e^{3x} – 1) soi
1(b)	$gg(x) = e^{3(e^{3x}-1)} - 1$ oe, isw	**B1**	
1(c)	$3y = \ln(x+1)$ or $3x = \ln(y+1)$ **and** swops the variables at some point	**M1**	condone one error
	$g^{-1}(x) = \frac{1}{3}\ln(x+1)$ soi	**A1**	
	[x =] 4	**A1**	
	Alternative method		
	$x = g(\frac{1}{3}\ln 5)$ soi	**(B1)**	
	$e^{3\left(\frac{1}{3}\ln 5\right)} - 1$ oe	**(M1)**	
	[x =] 4	**(A1)**	
2	Uses $b^2 - 4ac$ [*0] $k^2 - 4(4k - 15)$ [*0]	**M1**	where * is any inequality sign or =;
	$k^2 - 16k + 60$ [*0]	**A1**	
	$(k-6)(k-10)[*0]$	**DM1**	**FT** *their* 3-term quadratic; **dep** on previous **M1**
	$6 < k < 10$	**A1**	Mark final answer
	Alternative method		
	$2x + k$ [= 0]	**(M1)**	
	$-\frac{k^2}{4} + 4k - 15[*0]$ oe or $-x^2 - 8x - 15[*0]$ oe	**(A1)**	
	Solves or factorises $(k-6)(k-10)[*0]$ or $(x + 5)(x + 3)$ [*0] **and** $x = -5$, $x = -3$	**(DM1)**	**FT** *their* 3-term quadratic; **dep** on previous **M1**
	$6 < k < 10$	**(A1)**	Mark final answer

Question	Answer	Marks	Guidance
3(a)	Correctly eliminates $\log_2 x$ or $\log_2 y$	**M1**	A correct equation in $\log_2 x$ only or $\log_2 y$ only
	$x = 16$ or $y = 64$	**A2**	**A1** for $\log_2 x = 4$ or $\log_2 y = 6$
	$y = 64$ or $x = 16$	**A2**	**A1** for $\log_2 y = 6$ or $\log_2 x = 4$
	Alternative method		
	$x^3y^2 = 2^{24}$ **and** $\dfrac{x^5}{y^3} = 2^2$ oe	**(M1)**	
	$y = 64$ or $x = 16$	**(A2)**	**A1** for $y^{19} = 2^{114}$ oe or $x^{19} = 2^{76}$ oe
	$x = 16$ or $y = 64$	**(A2)**	**A1** for $x^3 \times 64^2 = 2^{24}$ oe or $\dfrac{x^5}{64^3} = 2^2$ oe OR $16^3 \times y^2 = 2^{24}$ oe or $\dfrac{16^5}{y^3} = 2^2$ oe
3(b)	$2^{t+4-(1-2t)} = 2^9$ or $2^{t+4} = 2^{9+1-2t}$ oe, soi OR $t + 4 - (1-2t) = \log_2 512$ oe, soi or $t + 4 - (1-2t) = \dfrac{\log_a 512}{\log_a 2}$ oe	**B2**	**B1** for $2^{t+4-(1-2t)} = 512$ or $\dfrac{2^{t+4}}{2^{1-2t}} = 2^9$ soi OR $(t+4)\log_a 2 - (1-2t)\log_a 2 = \log_a 512$
	$3t + 3 = 9$ or better	**M1**	
	$t = 2$	**A1**	

Question	Answer	Marks	Guidance
4	$\dfrac{(x-1)^2}{x^3}=\dfrac{1}{x}-2x^{-2}+x^{-3}$ soi	**B2**	**B1** for $\dfrac{x^2-2x+1}{x^3}$ or $\dfrac{1}{x}-\dfrac{2}{x^2}+\dfrac{1}{x^3}$ or for any two terms correct in $\dfrac{1}{x}-2x^{-2}+x^{-3}$
	$\left[\ln x+\dfrac{2}{x}-\dfrac{1}{2x^2}\right]_3^5$	**B2**	**B1** for $\left[\ln x+...-\dfrac{1}{2x^2}\right]_3^5$ or $\left[\ln x+\dfrac{2}{x}+...\right]_3^5$ or $\left[k\ln x+\dfrac{2}{x}-\dfrac{1}{2x^2}\right]_3^5$ with $k\neq 0$
	$\left[\ln 5+\dfrac{2}{5}-\dfrac{1}{50}\right]-\left[\ln 3+\dfrac{2}{3}-\dfrac{1}{18}\right]$	**M1**	**dep** on at least previous **B1** for integration
	$\ln\left(\dfrac{5}{3}\right)-\dfrac{52}{225}$	**A1**	
5(a)	Correct use of $\pi r^2h=1000$ to find an expression that can be used to eliminate h e.g. $h=\dfrac{1000}{\pi r^2}$ or $\pi rh=\dfrac{1000}{r}$	**M2**	**M1** for $\pi r^2h=1000$ soi
	Correct substitution and completion to given answer e.g. $2\pi r^2+2\pi r\times\dfrac{1000}{\pi r^2}=2\pi r^2+\dfrac{2000}{r}$	**A1**	

Question	Answer	Marks	Guidance
5(b)	Correct derivative: $4\pi r - \dfrac{2000}{r^2}$ oe, isw	B2	**B1** for one correct term
	$4\pi r - \dfrac{2000}{r^2} = 0$ and solves for r	M1	**FT** *their* derivative providing that at least one term is correct
	$r = \sqrt[3]{\dfrac{2000}{4\pi}}$ oe, isw or 5.42 or 5.419[26…] rot to 3 or more dp	A1	
	Second derivative $\dfrac{d^2S}{dr^2} = 4\pi + 4000r^{-3}$ **and** When $r = 5.42$, $\dfrac{d^2S}{dr^2} > 0$ oe [hence minimum] or $4\pi + 4000(5.42)^{-3} > 0$ oe [hence minimum] or $\dfrac{d^2S}{dr^2} = 12\pi$ or 37 to 38 [hence minimum] or as $r > 0$, $\dfrac{d^2S}{dr^2} > 0$ [hence minimum] OR correctly finds the values of the first derivative at 5.42 oe $\pm h$, where h is small [hence minimum]	A1	**Dep** on previous mark
6(a)	Velocity: $\dfrac{8t}{4t^2-5} - 1$	B2	**B1** for $\dfrac{f(t)}{4t^2-5} - 1$ or for $\dfrac{8t}{4t^2-5} + g(t)$
	Correct structure of quotient rule or equivalent product rule	M1	**FT** *their* v if possible; must be of equivalent difficulty
	Acceleration: $\dfrac{(4t^2-5)(8)-(8t)(8t)}{(4t^2-5)^2}$ oe, isw	A1	**FT** $\dfrac{8t}{4t^2-5} + k$ where k is a constant
6(b)	$4t^2 - 8t - 5 = 0$ oe	B1	
	$(2t+1)(2t-5) = 0$	M1	**FT** *their* 3-term quadratic in t
	$t = 2.5$ and no other values	A1	**dep** on correct quadratic seen
6(c)	$\dfrac{(4\times2.5^2-5)(8)-(8\times2.5)(8\times2.5)}{(4\times2.5^2-5)^2}$ oe, soi	M1	Substitutes a value of $t > 2$ in an expression for a which has at least one term with a factor of $\dfrac{1}{(4t^2-5)^2}$ or $\dfrac{1}{16t^4-40t^2+25}$
	$a = -\dfrac{3}{5}$ oe only	A1	

Question	Answer	Marks	Guidance
7(a)	$\dfrac{BC}{\sin 60} = \dfrac{\sqrt{2}}{\sin 45}$ oe	M1	
	$BC = \sqrt{3}$ oe	A1	
	$\dfrac{1}{2} \times \sqrt{2} \times \sqrt{3} \times \sin 75 = \dfrac{3+\sqrt{3}}{4}$ OR height $= \left(\dfrac{3+\sqrt{3}}{4}\right) \times \dfrac{2}{\sqrt{3}}$ oe	M1	**FT** *their BC* providing it has not been found using the given result for sin75
	$\sin 75 = \dfrac{2(3+\sqrt{3})}{4\sqrt{6}}$ oe OR $\sin 75 = \dfrac{\left(\dfrac{3+\sqrt{3}}{4}\right) \times \dfrac{2}{\sqrt{3}}}{\sqrt{2}}$ oe $\left[= \dfrac{\dfrac{1+\sqrt{3}}{2}}{\sqrt{2}} = \dfrac{1+\sqrt{3}}{2\sqrt{2}}\right]$	A1	**dep** on all previous marks being awarded Isolates sin 75 correctly or deals with surds on LHS of correct equation e.g. $\dfrac{1}{2} \times 6 \times \sin 75 = \left(\dfrac{3+\sqrt{3}}{4}\right) \times \sqrt{6}$
	correct completion to given answer $\dfrac{\sqrt{6}+\sqrt{2}}{4}$	A1	must be convincing with an intermediate step if needed
	Alternative methods (finding *AC* first)		
	$\dfrac{1}{2} \times \sqrt{2} \times AC \times \sin 60 = \dfrac{3+\sqrt{3}}{4}$ oe	(M1)	
	$AC = \dfrac{2}{\sqrt{2}} \times \dfrac{2}{\sqrt{3}} \times \dfrac{3+\sqrt{3}}{4}$ oe	(A1)	Isolates *AC* correctly
	$AC = \dfrac{\sqrt{2}+\sqrt{6}}{2}$	(A1)	Must be convinced no calculator is being used
	$\dfrac{\sin 75}{\dfrac{\sqrt{2}+\sqrt{6}}{2}} = \dfrac{\sin 45}{\sqrt{2}}$ oe	(M1)	**FT** *their AC* May simplify to $\sin 75 = \dfrac{AC}{2}$ before inserting *their AC*
	correct completion to given answer $\dfrac{\sqrt{6}+\sqrt{2}}{4}$	(A1)	**dep** on all previous marks being awarded must be convincing with an intermediate step if needed

Question	Answer	Marks	Guidance
7(b)	$\dfrac{AC}{\frac{\sqrt{6}+\sqrt{2}}{4}}=\dfrac{\sqrt{2}}{\frac{\sqrt{2}}{2}}$ or $\dfrac{AC}{\frac{\sqrt{6}+\sqrt{2}}{4}}=\dfrac{\sqrt{3}}{\frac{\sqrt{3}}{2}}$ or better	**M1**	
	$\dfrac{\sqrt{6}+\sqrt{2}}{2}$ nfww	**A1**	
8(a)	$\dfrac{\sin x}{\frac{\sin x}{\cos x}-1}-\dfrac{\cos x}{\frac{\sin x}{\cos x}+1}$	**M1**	OR $\dfrac{\sin x(\tan x+1)-\cos x(\tan x-1)}{(\tan x-1)(\tan x+1)}$
	$\dfrac{\sin x}{\frac{\sin x-\cos x}{\cos x}}-\dfrac{\cos x}{\frac{\sin x+\cos x}{\cos x}}$ OR $\dfrac{\sin x\left(\frac{\sin x}{\cos x}+1\right)-\cos x\left(\frac{\sin x}{\cos x}-1\right)}{\frac{\sin^2 x}{\cos^2 x}-1}$	**A1**	OR $\dfrac{\sin x\tan x+\sin x-\cos x\tan x+\cos x}{(\tan x-1)(\tan x+1)}$ OR $\dfrac{\sin x\left(\frac{\sin x}{\cos x}+1\right)-\cos x\left(\frac{\sin x}{\cos x}-1\right)}{\left(\frac{\sin x}{\cos x}-1\right)\left(\frac{\sin x}{\cos x}+1\right)}$
	$\dfrac{\sin x\cos x}{\sin x-\cos x}-\dfrac{\cos^2 x}{\sin x+\cos x}$ OR $\dfrac{\sin x\left(\frac{\sin x+\cos x}{\cos x}\right)-\cos x\left(\frac{\sin x-\cos x}{\cos x}\right)}{\frac{\sin^2 x-\cos^2 x}{\cos^2 x}}$	**A1**	OR $\dfrac{\frac{\sin^2 x}{\cos x}+\sin x-\sin x+\cos x}{\frac{\sin^2 x}{\cos^2 x}-1}$
	$\dfrac{\sin^2 x\cos x+\sin x\cos^2 x-\cos^2 x\sin x+\cos^3 x}{\sin^2 x+\cos x\sin x-\cos x\sin x-\cos^2 x}$ OR $\dfrac{\sin^2 x+\sin x\cos x-\cos x\sin x+\cos^2 x}{\cos x}\times\dfrac{\cos^2 x}{\sin^2 x-\cos^2 x}$	**A1**	OR $\dfrac{\frac{\sin^2 x+\cos^2 x}{\cos x}}{\frac{\sin^2 x-\cos^2 x}{\cos^2 x}}$ or $\dfrac{\frac{\sin^2 x+\cos^2 x}{\cos x}}{\frac{1-2\cos^2 x}{\cos^2 x}}$
	Fully correct justification of given answer e.g. $\dfrac{\cos x\left(\sin^2 x+\cos^2 x\right)}{\sin^2 x-\cos^2 x}=\dfrac{\cos x}{\sin^2 x-\cos^2 x}$ oe	**A1**	All steps correct and final step justified $\dfrac{1}{\cos x}\times\dfrac{\cos^2 x}{\sin^2 x-\cos^2 x}=\dfrac{\cos x}{\sin^2 x-\cos^2 x}$ oe
8(b)	$2\cos^2 x+\cos x-1[=0]$	**B2**	**B1** for $\cos x=1-\cos^2 x-\cos^2 x$ or better
	$(2\cos x-1)(\cos x+1)[=0]$	**M1**	**FT** *their* 3-term quadratic in cos$x$
	$[x=]\ 60°, 300°, 180°$ and no extras in range	**A2**	**A1** for any two correct , ignoring extras

Question	Answer	Marks	Guidance
9(a)	Derivative of e^{2x} : $2e^{2x}$ soi	B1	
	$x \times 2e^{2x} + e^{2x}$ isw	B1	**FT** *their* $2e^{2x}$
9(b)	$[\text{When } x = 1]\ y = e^2$	B1	
	$[\text{gradient tangent} =]\ \textit{their} \left.\frac{dy}{dx}\right\vert_{x=1}$	B1	**FT** *their* derivative which must include at least one term in e^{2x}
	Gradient of normal = $\frac{-1}{\textit{their}(3e^2)}$	B1	**FT** $\frac{-1}{\textit{their} \left.\frac{dy}{dx}\right\vert_{x=1}}$
	$y - e^2 = \frac{-1}{3e^2}(x - 1)$ oe, isw	B1	**dep** on 2 marks awarded in part (a) and all previous marks awarded in this part
9(c)	$\left[xe^{2x} - \frac{1}{2}e^{2x}\right]_0^2$	M3	**M2** for $xe^{2x} + ke^{2x}$ where $k < 0$ or $k = \frac{1}{2}$ or **M1** for $\int 2xe^{2x}dx = xe^{2x} - \int e^{2x}dx$
	$\left(2e^4 - \frac{1}{2}e^4\right) - \left(-\frac{1}{2}\right)$	A1	
	$1.5e^4 + 0.5$ or exact equivalent	A1	
10(a)	$a + 4d = 11$ oe	B1	
	$a + 6d = 3(a + d)$ oe	B1	
	Correctly eliminates one unknown and solves for a or d	M1	**FT** *their* linear equations in a and d providing **B1** earned.
	$d = 2,\ a = 3$	A1	

Question	Answer	Marks	Guidance
10(b)	$3+d=3r^2$	**B1**	
	$3+5d=3r^4$	**B1**	
	$3+5d=3\left(\frac{3+d}{3}\right)^2$ oe or $3+5\left(3r^2-3\right)=3r^4$ oe	**M1**	
	$d^2-9d[=0]$ or $3r^4-15r^2+12[=0]$	**A1**	
	d = 9 and r = 2 and no other values	**A2**	**A1** for d = 9 and no other value of d or for r = 2 and no other value of r

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **May/June 2023**

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Published

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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.

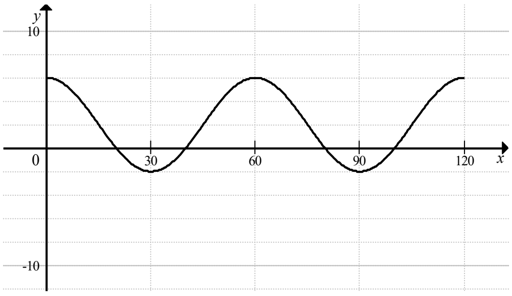
B Mark for a correct result or statement independent of Method marks.

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

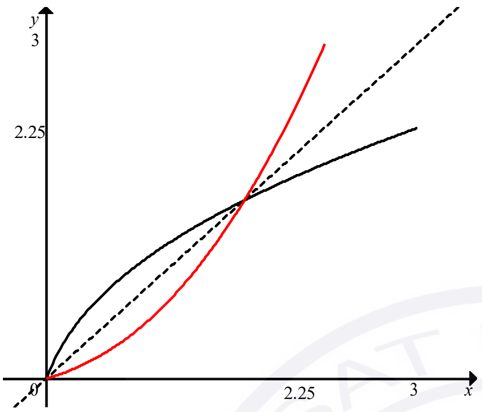
Question	Answer	Marks	Partial Marks
1	$\lg y = 2\sqrt{x}+3$ OR $\lg b = 2$ and $\lg A = 3$	**B2**	**B1** for $\lg y = \left(\frac{8-5}{2.5-1}\right)\sqrt{x}+c$ soi or $\lg y = m\sqrt{x}+3$ soi OR $\lg b = \frac{8-5}{2.5-1}$ or $\lg A = 3$ soi
	$y = 10^{2\sqrt{x}+3}$ or $\lg\frac{y}{10^3} = 2\sqrt{x}$ OR $b = 100$ and $A = 1000$	**M1**	**FT** *their m* and *c*
	$y = 10^3 \times 100^{\sqrt{x}}$ oe mark final answer	**A1**	

Question	Answer	Marks	Partial Marks
2(a)	Correct curve 	3	**B2** for correct cosine shape over 2 cycles with midline at $y = 2$ and consistent amplitude or **B1** for attempt at cosine shape over 2 cycles **with** consistent amplitude **B1** for a consistent amplitude of 2; must have attempted correct shape **Maximum of 2 marks if not fully correct**
2(b)	4	1	
2(c)	60°	1	
3(a)	$a = 2$, $b = 3$, $c = -2$	2	**B1** for any two correct
3(b)	$-3 \leqslant x \leqslant -0.5$ or $x \geqslant 1$	3	**B1** for the critical values –3, –0.5, 1 **B1** for $-3 \leqslant x \leqslant -0.5$ **B1** for $x \geqslant 1$
4(a)	$(2y-1)\log 5 = \log 6 + y\log 3$ oe or $2y\log 5 = \log 30 + y\log 3$ oe OR [rearranges $\frac{5^{2y}}{5} = 6 \times 3^y$ and collects powers to a single power in y] $\left(\frac{5^2}{3}\right)^y = 30$ oe	M1	
	Collects terms and factorises: $y(2\log 5 - \log 3) = \log 6 + \log 5$ oe or $y(2\log 5 - \log 3) = \log 30$ oe OR takes logs $y = \log_{\frac{25}{3}} 30$ oe or $y\log\left(\frac{5^2}{3}\right) = \log 30$ oe	M1	**FT** if of equivalent difficulty
	1.604	A1	cao

Question	Answer	Marks	Partial Marks
4(b)	$e^{4x} - 4e^{2x} + 3 = 0$ or $(e^{2x})^2 - 4e^{2x} + 3 = 0$ oe	M1	condone one error
	Factorises: $(e^{2x} - 1)(e^{2x} - 3)$ oe or solves $e^{4x} - 4e^{2x} + 3 = 0$ oe	M1	**FT** $a(e^{2x})^2 + be^{2x} + c\left[=0\right]$
	$e^{2x} = 1, \quad e^{2x} = 3$	A1	
	$x = 0$, $x = \frac{1}{2}\ln 3$ or exact equivalent	A1	
5	$\frac{dV}{dr} = 4\pi r^2$ **oe and** $\left.\frac{dV}{dr}\right\|_{r=6} = 144\pi$	B1	
	$\frac{dr}{dt} = \frac{dV}{dt} \times \frac{dr}{dV}$ **soi**	B1	Not if chain rule for $\frac{dt}{dr}$ unless answer is inverted
	$\frac{24}{\text{their } 144\pi}$	M1	*their* 144π must come from an attempt at differentiation
	0.0531 or 0.05305[16….] rot to 4 or more sig figs	A1	
6(a)	$3\begin{pmatrix} x-8 \\ y-5 \end{pmatrix} = 2\begin{pmatrix} x-4 \\ y-7 \end{pmatrix}$ oe OR $\overrightarrow{QR} = \begin{pmatrix} x-8 \\ y-5 \end{pmatrix}$ and $\overrightarrow{PR} = \begin{pmatrix} x-4 \\ y-7 \end{pmatrix}$ and $3x - 24 = 2x - 8$ and $3y - 15 = 2y - 14$	M1	
	$x = 16$	A1	**dep** on vector method
	$y = 1$	A1	**dep** on vector method

Question	Answer	Marks	Partial Marks
6(b)(i)	**a** = –2.5**i** $-\frac{5\sqrt{3}}{2}$**j** isw	**B1**	
	c = –5**i** + $5\sqrt{3}$ **j** isw	**B1**	
6(b)(ii)	**b** = (–5 + 2.5)**i** + $\left(5\sqrt{3}+2.5\sqrt{3}\right)$ **j** oe soi	**B1**	
	$r=\sqrt{(-2.5)^2+\left(7.5\sqrt{3}\right)^2}$	**M1**	**FT** *their* **b** of the form x**i** + y**j** providing neither component is zero
	[r =] 13.2 or 13.22875… rot to 4 or more sf	**A1**	**dep** on **B1**
	$\tan\alpha=\left(\frac{7.5\sqrt{3}}{2.5}\right)$ oe or awrt 79.1 or $\tan\beta=\left(\frac{2.5}{7.5\sqrt{3}}\right)$ oe or awrt 10.9	**M1**	**FT** *their* **b** of the form x**i** + y**j**
	349[.106…] rot to 3 or more sf	**A1**	**dep** on **B1**
	Alternative method		
	$[r^2=]10^2+5^2-2\times10\times5\times\cos120°$	**(M1)**	
	[r =] 13.2 or 13.22875… rot to 4 or more sf	**(A1)**	
	$\frac{\sin\theta}{10}=\frac{\sin their 120}{their 5\sqrt{7}}$ or $\frac{\sin\phi}{5}=\frac{\sin their 120}{their 5\sqrt{7}}$	**(M1)**	**FT** consistent use of *their* 120 and *their* r
	$[\theta=]$ awrt 40.9 or $[\phi=]$ awrt 19.1	**(A1)**	
	349[.106…] rot to 3 or more sf	**(A1)**	

Question	Answer	Marks	Partial Marks
7(a)	$\left[\frac{6x^2}{2}-\frac{x^3}{3}\right]_0^5$	**B1**	
	Area under line: $0.5\times5\times5$ oe	**B1**	
	Fully actioned correct plan: $3(25)-\frac{5^3}{3}-\left(3(0)-\frac{0^3}{3}\right)-0.5\times5\times5$ oe	**M1**	
	$\frac{125}{6}$ oe isw	**A1**	**dep** on all previous marks
	Alternative method		
	$\int_0^5(5x-x^2)\mathrm{d}x$	**(B1)**	
	$\left[\frac{5x^2}{2}-\frac{x^3}{3}\right]_0^5$	**(B1)**	
	Correct use of correct limits $2.5(25)-\frac{5^3}{3}-\left(2.5(0)-\frac{0^3}{3}\right)$	**(M1)**	
	$\frac{125}{6}$ oe isw	**(A1)**	**dep** on all previous marks
7(b)(i)	$\frac{(2x-6)^{-2}}{-2\times2}+\sin x\ (+c)$ oe, isw	**3**	**B1** for $\sin x$ **B2** for $\frac{(2x-6)^{-2}}{-2\times2}$ or **B1** for $\frac{(2x-6)^{-2}}{-2}$ soi
7(b)(ii)	$\frac{x^7}{2}+x^3+\frac{1}{2x}$ oe	**B1**	
	$\frac{x^8}{16}+\frac{x^4}{4}+\frac{1}{2}\ln x(+c)$ oe or $\frac{x^8}{16}+\frac{x^4}{4}+\frac{1}{2}\ln 2x(+c)$ oe	**B2**	**B1** for any two correct

Question	Answer	Marks	Partial Marks
8(a)(i)	[Domain f^{-1}] $0 \leqslant x \leqslant 2.25$ oe	**B2**	**B1** for either end correct or for 0 and 2.25 in an incorrect inequality
	[Range f^{-1}] $0 \leqslant f^{-1} \leqslant 3$	**B1**	
8(a)(ii)	$x = 1.6$ oe or $x = 0$	**2**	**B1** for each
8(a)(iii)		**2**	**B1** for attempt at correct graph of inverse function drawn over correct domain soi **B1** for correct shape with intersection in approximately correct location
8(b)(i)	For a complete method to find the inverse, including changing the subject and swapping the variables	**M1**	
	$\left[g^{-1}(x) =\right] \sqrt[3]{\dfrac{x^3 - 3}{8}}$ oe mark final answer	**A1**	
8(b)(ii)	$[\ k =]\ 0$	**1**	
8(b)(iii)	$\sqrt[3]{8e^{12x} + 3}$ mark final answer	**1**	

Question	Answer	Marks	Partial Marks
9(a)	$\frac{1}{2}\times 24^2\times\theta=432$	M1	
	$\theta=\frac{3}{2}$ rads soi	A1	
	$24\times$ *their* θ	M1	
	36 cao	A1	
	Alternative method		
	$s=r\theta$ soi and $\frac{1}{2}\times r\times s=432$	(B1)	
	$\frac{1}{2}\times 24\times s=432$	(M1)	
	$s=\frac{432\times 2}{24}$ oe	(M1)	
	[s =] 36	(A1)	
9(b)(i)	[OB =] $2y\cos\alpha$ oe	B1	
9(b)(ii)	$\frac{(their\ 2y\cos\alpha)\times y\sin\alpha}{2}$ $-\frac{1}{2}\times(their\ y\cos\alpha)^2\times\alpha$ oe	M2	**M1** for either area
	correct completion to $\frac{y^2}{2}\cos\alpha(2\sin\alpha-\alpha\cos\alpha)$	A1	

Question	Answer	Marks	Partial Marks
10	[Term independent of x:] $^9C_3 \times a^6 \times b^3$ or $84 \times a^6 \times b^3$	**B1**	
	$a^6b^3 = \frac{-145152}{84}$	**M1**	**dep** on **B1**
	$(a^2b)^3 = -1728$ leading to $a^2b = -12$ or $a^2b = \sqrt[3]{-1728} = -12$	**A1**	
	$^9C_1 \times a^8 \times b$ or $9 \times a^8 \times b$	**B1**	
	Correctly solves correct equations simultaneously $9 \times a^8 \times b = -6912$ and $a^2b = -12$ as far as $a^6 = \ldots$ or $b^3 = \ldots..$	**M1**	Must be solving correct equations
	$a = 2$, $b = -3$ and no other values nfww	**B2**	**B1** for each nfww **dep** on previous B1B1
11	Eliminates one variable $(k-3y)^2 + y^2 + 2y - 9 = 0$	**M1**	
	$10y^2 + (2-6k)y + (k^2-9) = 0$ soi	**A1**	
	Uses $b^2 - 4ac * 0$ with *their* 3-term quadratic: $(2-6k)^2 - 4(10)(k^2-9)\quad [*0]$	**M1**	* can be = or any inequality sign
	$-4k^2 - 24k + 364\quad [*0]$	**A1**	
	Factorises $-4k^2 - 24k + 364$ or solves *their* $-4k^2 - 24k + 364 = 0$	**M1**	
	$k = 7$ only	**A1**	
	Uses *their* k in $10y^2 + (2-6k)y + (k^2-9) = 0$ oe	**M1**	
	$y = 2$ only	**A1**	
	$x = 1$ only	**A1**	

Cambridge Assessment International Education

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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **May/June 2023**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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(a)	$3x^2 - 15x + 12$ [* 0] oe where * is any inequality sign or =	**B1**	
	Factorises or solves *their* 3-term quadratic	**M1**	**FT** *their* 3-term quadratic
	$x < 1$ or $x > 4$ mark final answer	**A1**	
1(b)(i)	$3(x-2)^2 + 4$	**3**	**B2** for $3(x-2)^2$ or **B1** for $(x-2)^2$ or $a = 3$, $b = -2$ and **B1** for $a(x+b)^2 + 4$ with numerical values of a and b or $c = 4$
1(b)(ii)	$y =$ *their* 4	**B1**	**STRICT FT** *their* 4 from part **(i)**

Question	Answer	Marks	Partial Marks
2(a)	$\frac{\mathrm{d}y}{\mathrm{d}x} = 64x - \frac{2x^{-3}}{8}$ oe, isw	**B2**	**B1** for $\frac{\mathrm{d}y}{\mathrm{d}x} = 64x + kx^{-3}$ or $\frac{\mathrm{d}y}{\mathrm{d}x} = kx - \frac{2x^{-3}}{8}$ where k is a non-zero constant or **SC1** for $\frac{\mathrm{d}y}{\mathrm{d}x} = 64x - \frac{2}{8}x^{-3} + c$
	their $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ and attempt to solve	**M1**	**FT** *their* derivative providing it has two terms and at least one term is a correct power of x
	(0.25, 4), (–0.25, 4) nfww, isw	**A2**	**A1** for either stationary point correct or for $x = \pm 0.25$ nfww or, if $\frac{\mathrm{d}y}{\mathrm{d}x} = 64x - 16x^{-3}$, then award **SC2** for $\left(\pm\frac{1}{\sqrt{2}}, \frac{65}{4}\right)$ oe or **SC1** for either of these stationary points or $x = \pm\frac{1}{\sqrt{2}}$ oe

Question	Answer	Marks	Partial Marks
2(b)	Correct second derivative: $\frac{d^2y}{dx^2} = 64 + \frac{3}{4}x^{-4}$ oe, isw	**M1**	**FT** *their* $\frac{dy}{dx} = mx + nx^{-3}$ where $m \neq 0$ and $n \neq 0$ seen in part (a)
	$64 + \frac{3}{4}\left(\frac{1}{4}\right)^{-4} = 256$ or $64 + \frac{3}{4}\left(\frac{1}{4}\right)^{-4} > 0$ or when $x = 0.25$ $\frac{d^2y}{dx^2} = 256$ or $\frac{d^2y}{dx^2} > 0$ oe **and** minimum [points] oe OR $64 + \frac{3}{4}\left(-\frac{1}{4}\right)^{-4} = 256$ or $64 + \frac{3}{4}\left(-\frac{1}{4}\right)^{-4} > 0$ or when $x = -0.25$ $\frac{d^2y}{dx^2} = 256$ or $\frac{d^2y}{dx^2} > 0$ oe **and** minimum [points] oe OR $\frac{d^2y}{dx^2} = 64 + \frac{3}{4x^4}$ and this is positive for any value of x **and** minimum [points]	**A2**	**dep** on $x = \pm 0.25$ nfww in part **(a)** **A1 dep** on $x = 0.25$ or $x = -0.25$ nfww in part (a) for correctly showing or stating $\frac{d^2y}{dx^2}\left[= 64 + \frac{3}{4x^4}\right]$ is positive
3(a)	$-12 - 69 + 27 + 54 = 0$	**B1**	

Question	Answer	Marks	Partial Marks
3(b)	$10x+7=-2x^3+3x^2+33x-5$ oe, soi	**M1**	
	Uses the correct factor $x + 3$ to find a quadratic factor of the polynomial from part (a) oe with at least 2 terms correct	**M1**	
	$-2x^2+9x-4$ or $2x^2-9x+4$	**A1**	
	Factorises or solves *their* 3-term quadratic factor = 0: $(2x-1)(-x+4)$ or $(-2x+1)(x-4)$ or $(2x-1)(x-4)$ oe	**DM1**	**dep** on previous **M1**
	$x=-3$, $x=0.5$, $x=4$ nfww	**A1**	**dep** on at least **M0 M1 A1 DM1** awarded
	$A(-3, -23)$, $B(0.5, 12)$, $C(4, 47)$ oe **and** correct method to show mid-point e.g.: $\left(\frac{-3+4}{2}, \frac{-23+47}{2}\right)=\left(\frac{1}{2}, 12\right)$ oe or $\left[\overrightarrow{AB}=\right]\begin{pmatrix}0.5\\12\end{pmatrix}-\begin{pmatrix}-3\\-23\end{pmatrix}=\begin{pmatrix}3.5\\35\end{pmatrix}$ and $\left[\overrightarrow{BC}=\right]\begin{pmatrix}4\\47\end{pmatrix}-\begin{pmatrix}0.5\\12\end{pmatrix}=\begin{pmatrix}3.5\\35\end{pmatrix}$ oe OR [x-coordinate mid-point] $\frac{-3+4}{2}=\frac{1}{2}$ oe **and** valid comment e.g. The points are collinear [so B is the mid-point of AC].	**B2**	**dep** on $x=-3$, $x=0.5$, $x=4$ nfww **B1 dep** on $x=-3$, $x=0.5$, $x=4$ nfww for $A(-3, -23)$, $B(0.5, 12)$, $C(4, 47)$ oe or [x-coordinate of the mid-point] $\frac{-3+4}{2}=\frac{1}{2}$ oe

Question	Answer	Marks	Partial Marks
4	$\frac{dy}{dx} = -\sec^2(1-x)$ oe	B2	**must be seen** **B1** for $\frac{dy}{dx} = k\sec^2(1-x)$ oe, $k \neq -1$ or **SC1** for $\frac{dy}{dx} = -\sec^2 1 - x$ or $\frac{dy}{dx} = -\sec^2(1-x) + c$
	Solves $3 = 2 + \tan(1-x)$ as far as $1 - x = \tan^{-1} 1$	M1	
	$1 - x = \frac{\pi}{4}$ isw or 0.7853[98…] $x = 1 - \frac{\pi}{4}$ isw or 0.2146[01…]	A1	
	Correct use of chain rule **and** correctly writes in terms of cosine or tangent: $\frac{their(-1)}{\cos^2\left(their\frac{\pi}{4}\right)} \times 0.04$ oe, soi or $their(-1)\left\{1 + \tan^2\left(their\frac{\pi}{4}\right)\right\} \times 0.04$ oe soi	M1	**dep** on at least **B1** and an attempt to solve $3 = 2 + \tan(1-x)$
	–0.08 oe, nfww	A1	**dep** on all previous marks awarded
5(a)	$\lg P = \lg A + T\lg b$ oe nfww **and** correct comparison with $y = mx + c$ soi	B2	Must be seen and not from wrong working **B1** for $\lg P = \lg A + T\lg b$ isw, nfww
5(b)	$A = 10^6$ oe isw and $b = 10^{\frac{3}{7}}$ oe isw	4	**B2** for $A = 10^6$ oe isw **or B1** correct method which could be used to find A e.g. $\lg A = 6$ or $12 = \frac{3}{7} \times 14 + \lg A$ **B2** for $b = 10^{\frac{3}{7}}$ oe isw or **B1** correct method which could be used to find b e.g. $\lg b = \frac{12-6}{14-0}$ oe or $12 = 14\lg b + 6$

Question	Answer	Marks	Partial Marks
5(c)	lg P_1 = 8 and lg P_2 = 9 soi leading to T_1 = 4.6 to 4.8 or T_2 = 6.8 to 7.2	**M1**	If graph not used then allow **M1** for substitution of *their A* and *their b* in the exponential equation as far as $\frac{10^8}{theirA} = (theirb)^T$ and $\frac{10^9}{theirA} = (theirb)^T$ OR substitution of *their A* and *their b* or *their* lg*A* and *their* lg *b* in the log equation $\lg 10^8 = their \lg A + T(their \lg b)$ or better and $\lg 10^9 = their \lg A + T(their \lg b)$ or better
	Difference of correct times: $T_2 - T_1$ where T_2 = 6.8 to 7.2 T_1 = 4.6 to 4.8	**M1**	
	Answer in range 2.2 to 2.4 nfww	**A1**	
	Alternative method		
	Change in $T = \frac{9-8}{\frac{3}{7}}$	**(M2)**	**M1** for lg10^8 = 8 and lg10^9 = 9 **and** $\frac{\text{Change in } \lg P}{\text{Change in } T} = \frac{3}{7}$
	Answer in range 2.2 to 2.4 nfww	**(A1)**	
6(a)(i)	$1 + \frac{5}{7}x + \frac{10}{49}x^2$	**B2**	**B1** for any two correct terms or for the three terms listed but not summed
6(a)(ii)	12	**B2**	**B1** for $7n + 5 = 89$ or $7\left(n + \frac{5}{7}\right) = 89$ oe or ${}^nC_1 = 12$
6(b)	${}^8C_4 \times k^4 \times (-2)^4$ $[\times x^4]$ oe or $1120k^4$ $[x^4]$ soi	**B1**	
	${}^8C_2 \times k^6 \times (-2)^2$ $[\times x^2]$ oe or $112k^6$ $[x^2]$ soi	**B1**	
	$\frac{1120k^4}{112k^6} = \frac{5}{8}$ or $\frac{70 \times 16 \times k^4}{28 \times 4 \times k^6} = \frac{5}{8}$ oe, soi	**M1**	**FT** providing at least **B1** awarded and correct terms attempted
	$k^2 = 16$ soi	**A1**	
	[For coefficient of x to be positive $k < 0$, therefore] $k = -4$	**A1**	

Question	Answer	Marks	Partial Marks
7(a)	$\dfrac{10(4x-2)^4}{\sqrt{3+(4x-2)^5}}$ or $\dfrac{10(4x-2)^4}{\left(3+(4x-2)^5\right)^{\frac{1}{2}}}$ isw	3	**B2** for correct unsimplified form e.g. $\dfrac{1}{2}\left(3+(4x-2)^5\right)^{-\frac{1}{2}}\times 5\left(4x-\ 2\right)^4\times 4$ or $10\left(3+(4x-2)^5\right)^{-\frac{1}{2}}\left(4x-\ 2\right)^4$ or **B1** for $5(4x-2)^4\times 4$ soi or $\dfrac{1}{2}\left(3+(4x-2)^5\right)^{-\frac{1}{2}}\times \mathrm{g}(x)$
7(b)	$\dfrac{\mathrm{d}y}{\mathrm{d}x}=\dfrac{5(3x+2)-3(5x)}{(3x+2)^2}$ oe isw or $\dfrac{\mathrm{d}y}{\mathrm{d}x}=5x\left(-\left(3x+2\right)^{-2}\times 3\right)+5\left(3x+2\right)^{-1}$ oe isw	B1	
	$[\,y=10]\ x=-0.8$	B1	
	$\dfrac{0.01}{\delta x}=\left(\mathit{their}\dfrac{\mathrm{d}y}{\mathrm{d}x}\bigg\vert_{x=-0.8}\right)$ oe	M1	**FT** *their x* providing *their x* ≠ 10 or 0.01and *their* genuine attempt at a derivative using product or quotient rule
	$\dfrac{1}{6250}$ or 0.00016 or 1.6×10^{-4} isw	A1	**dep** on all previous marks awarded
	Alternative method		
	$x=\dfrac{-2y}{3y-5}$ oe	(B1)	
	$\dfrac{\mathrm{d}x}{\mathrm{d}y}=\dfrac{-2(3y-5)-3(-2y)}{(3y-5)^2}$ oe isw or $\dfrac{\mathrm{d}x}{\mathrm{d}y}=-2y\left(-\left(3y-5\right)^{-2}\times 3\right)+(-2)\left(3y-5\right)^{-1}$	(B1)	
	$\dfrac{\delta x}{0.01}=\left(\mathit{their}\dfrac{\mathrm{d}x}{\mathrm{d}y}\bigg\vert_{y=10}\right)$ oe	(M1)	**FT** *their* genuine attempt at a derivative using product or quotient rule
	$\dfrac{1}{6250}$ or 0.00016 or 1.6×10^{-4} isw	(A1)	**dep** on all previous marks awarded
7(c)(i)	$3x^2\ln x+x^3\times\dfrac{1}{x}$ or better, isw	B2	**B1** for $(\mathit{their}\ 3x^2)\ln x+x^3\times(\mathit{their}\dfrac{1}{x})$

Question	Answer	Marks	Partial Marks
7(c)(ii)	$\frac{x^3\ln x}{6}+\frac{x^3}{18}+c$ oe, isw	B3	must have arbitrary constant **B2** for $\frac{x^3\ln x}{6}+\frac{x^3}{18}$ or $\frac{x^3\ln x}{6}+\frac{kx^3}{3}+c$, $k>0$ nfww or **B1** for $\frac{1}{6}\int\left(3x^2\ln x+x^2\right)\mathrm{d}x+\frac{1}{6}\int x^2\,\mathrm{d}x$ soi or $\frac{x^3\ln x}{6}+\int\frac{x^2}{6}\mathrm{d}x$ soi or $\int\left(3x^2\ln x\right)\mathrm{d}x=x^3\ln x-\int x^2\,\mathrm{d}x$ soi or $\int\left(3x^2\ln x\right)\mathrm{d}x=x^3\ln x-\frac{x^3}{3}$ soi
8	$\frac{\mathrm{d}y}{\mathrm{d}x}=-\frac{1}{4}\sin\frac{x}{4}$	M2	**M1** for $\frac{\mathrm{d}y}{\mathrm{d}x}=k\sin\frac{x}{4}$, $k<0$ or $k=\frac{1}{4}$
	$y=0.5$	B1	
	$\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\|_{x=\frac{4\pi}{3}}=-\frac{1}{4}\times\frac{\sqrt{3}}{2}$ or $-\frac{\sqrt{3}}{8}$	M1	**FT** (*their k*) $\times\frac{\sqrt{3}}{2}$ providing at least **M1** awarded
	$[m_{\text{normal}}=]\frac{8}{\sqrt{3}}$ soi	M1	**FT** $\frac{-1}{\textit{their}\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\|_{x=\frac{4\pi}{3}}}$
	$y-0.5=\frac{8}{\sqrt{3}}\left(x-\frac{4\pi}{3}\right)$ oe	A1	**dep** on previous **M1**; must have exact values **FT** *their* m_{normal} and *their* 0.5 providing both are non-zero, exact values
	$\left(\frac{4\pi}{3}-\frac{\sqrt{3}}{16},0\right)$ or exact equivalent; mark final answer	A1	

Question	Answer	Marks	Partial Marks
9	$\int e^{\frac{t}{4}}\,dt = 4e^{\frac{t}{4}}(+c)$ and $\int \frac{16e}{t^2}\,dt = \frac{-16e}{t}(+c)$	B3	**B2** for either correct or **B1** for $\int e^{\frac{t}{4}}\,dt = ae^{\frac{t}{4}}(+c)$ where a is a constant, $a > 0$ or $\int \frac{16e}{t^2}\,dt = \frac{-b}{t}(+c)$ where b is a constant $b > 0$
	Correct plan: $\int_0^4 e^{\frac{t}{4}}\,dt + \int_4^k \frac{16e}{t^2}\,dt = 13.4$ soi	M1	
	Correct equation: $4e^1 - 4e^0 + \left(-\frac{16e}{k} + \frac{16e}{4}\right) = 13.4$ OR [When $t = 4$ $s = 4e - 4$ When $t = k$ $s = \frac{-16e}{k} + 8e - 4$ and] $13.4 = \frac{-16e}{k} + 8e - 4$	A1	**dep** on **B3**; implies **M1**
	$k = 10$ or awrt 10.0	A1	dep on all previous marks awarded
10	$\lambda\left(\mathbf{c} + \frac{2}{5}\mathbf{b}\right)$ isw	B2	**B1** for $\lambda(\mathbf{c} + k\mathbf{b})$ where $k \neq \frac{2}{5}$ or 1, $k > 0$
	$2\mathbf{c} + \mu(\mathbf{b} - \mathbf{c})$ isw or $\mu\mathbf{b} + (2-\mu)\mathbf{c}$ isw or $\mathbf{c} + \mathbf{b} + (1-\mu)(\mathbf{c} - \mathbf{b})$ isw	B2	**B1** for any of the following with $n > 0$ $2\mathbf{c} + \mu(\mathbf{b} - n\,\mathbf{c})$ or $n\mathbf{c} + \mu(\mathbf{b} - \mathbf{c})$ or $\mathbf{c} + \mathbf{b} + (1-\mu)(n\mathbf{c} - \mathbf{b})$ or $n(\mathbf{c} + \mathbf{b}) + (1-\mu)(\mathbf{c} - \mathbf{b})$
	Equates components at least once $\lambda = 2 - \mu$ or $\frac{2}{5}\lambda = \mu$ soi	M1	**FT** providing of equivalent forms e.g.: $\lambda(s\mathbf{c} + t\mathbf{b})$ and $x\mathbf{c} + \mu(y\mathbf{b} + z\,\mathbf{c})$ where *s, t, x, y, z* are scalars
	$\lambda = 2 - \mu$ **and** $\frac{2}{5}\lambda = \mu$ soi, nfww	A1	
	$\mu = \frac{4}{7}$ $\left[\lambda = \frac{10}{7}\right]$	A1	
	[AE : EB =] 4 : 3 oe	A1	must have earned all previous marks

Cambridge Assessment International Education

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ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **May/June 2023**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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.

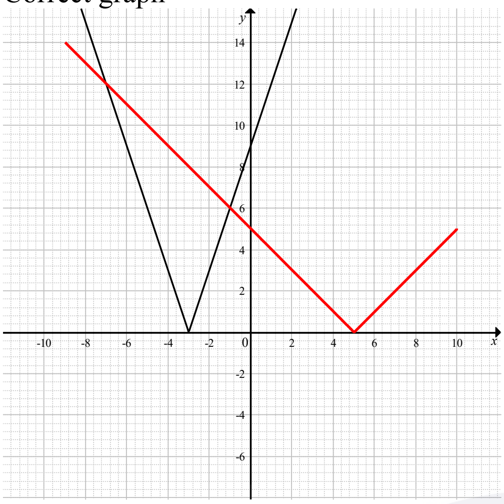
B Mark for a correct result or statement independent of Method marks.

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

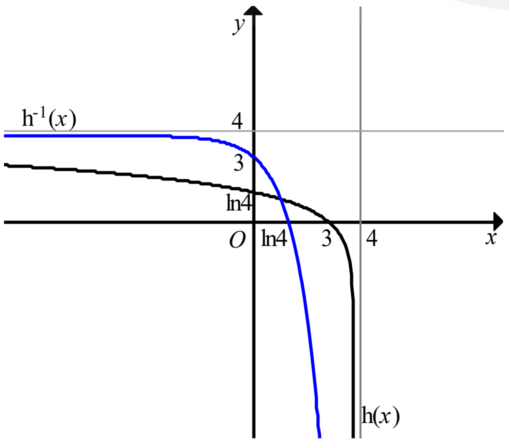
awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1(a)	$4x - 5 = 7$ and $4x - 5 = -7$ oe, soi	**M1**	
	$x = 3, x = -\frac{1}{2}$	**A1**	

Question	Answer	Marks	Partial Marks
1(b)	Correct graph  AND $-7 \leqslant x \leqslant -1$	3	**B1** for correct graph and **B2 dep** for $-7 \leqslant x \leqslant -1$; dependent on a correct graph for $-7 \leqslant x \leqslant -1$ or **B1 STRICT FT** for *their* critical values from the two intersections of *their* straight-line section of graph providing it has negative gradient
2	$\dfrac{7\sqrt{2}x^6\left(3-\sqrt{2}\right)}{\left(3+\sqrt{2}\right)\left(3-\sqrt{2}\right)}$	M2	**M1** for $7\sqrt{2}x^6$ or $\dfrac{\sqrt{98x^{12}}\left(3-\sqrt{2}\right)}{\left(3+\sqrt{2}\right)\left(3-\sqrt{2}\right)}$ or $\dfrac{\sqrt{98}x^6\left(3-\sqrt{2}\right)}{\left(3+\sqrt{2}\right)\left(3-\sqrt{2}\right)}$ or $\dfrac{their\,7\sqrt{2}x^6\left(3-\sqrt{2}\right)}{\left(3+\sqrt{2}\right)\left(3-\sqrt{2}\right)}$
	$\dfrac{21\sqrt{2}x^6-14x^6}{9-2}$ or $\dfrac{7x^6(3\sqrt{2}-2)}{9-2}$ oe	A1	
	$(3\sqrt{2}-2)x^6$	A1	
	Alternative method		
	$\dfrac{\sqrt{98x^{12}}}{3+\sqrt{2}}\times\dfrac{3-\sqrt{2}}{3-\sqrt{2}}$ or $\dfrac{\sqrt{98}x^6}{3+\sqrt{2}}\times\dfrac{3-\sqrt{2}}{3-\sqrt{2}}$	(M1)	
	$\dfrac{3\sqrt{98x^{12}}-\sqrt{196x^{12}}}{9-2}$ or $\dfrac{3\sqrt{98}x^6-\sqrt{196}x^6}{9-2}$	(M1)	
	$\dfrac{3\sqrt{98x^{12}}-\sqrt{196x^{12}}}{\sqrt{49}}$ or $\dfrac{3\times7\sqrt{2}x^6-14x^6}{7}$ oe	(A1)	
	$(3\sqrt{2}-2)x^6$	(A1)	

Question	Answer	Marks	Partial Marks
3(a)	$\frac{3(x+2)}{x(x+3)}$ or $\frac{3x+6}{x^2+3x}$ or simplified equivalent;	**2**	mark final answer **B1** for $\frac{3x^2+6x}{x^3+3x^2}$ oe
3(b)	$\frac{1}{3}\ln(x^3+3x^2)\ +c$	**2**	**B1** for $\frac{1}{3}\ln(x^3+3x^2)$
4(a)	$2(-4)^3+11(-4)^2+22(-4)+40=0$ oe	**1**	
4(b)	$(x+4)(2x^2+3x+10)$	**B2**	**B1** for $2x^2+3x+10$ with two terms out of three correct
	Correct use of b^2-4ac for *their* 3-term quadratic factor	**M1**	
	$3^2-4(2)(10)<0$ isw or $3^2-4(2)(10)=-71$ oe, cao	**A1**	
5(a)(i)	35700	**2**	**M1** for ${}^{20}C_6-{}^{18}C_4$ or ${}^{18}C_6+{}^{18}C_5\times{}^{2}C_1$ oe
5(a)(ii)	32400	**2**	**M1** for ${}^{6}P_4\times{}^{10}P_2$ or (6 × 5 × 4 × 3) × (10 × 9) oe
5(b)(i)	Correct algebraic method to show $(n-3)\,{}^{n}C_3$ is the same as $4\times{}^{n}C_4$ oe	**2**	**B1** for ${}^{n}C_3=\frac{n!}{3!(n-3)!}$ or ${}^{n}C_4=\frac{n!}{4!(n-4)!}$
5(b)(ii)	$\frac{n(n-1)(n-2)}{6}=5n$ or $n(n-1)(n-2)=30n$ and completion to given answer: $n^2-3n-28=0$	**B2**	**B1** for $\left[{}^{n}C_3=\right]\frac{n(n-1)(n-2)}{6}$ or $n(n-1)(n-2)=30n$ seen
	$(n-7)(n+4)=0$ oe	**M1**	
	$n=7$	**A1**	

Question	Answer	Marks	Partial Marks
6	$\dfrac{dy}{dx} = 10e^{2x}$	**B1**	
	[At A, m =] 10	**B1**	
	[At A, y =] 2	**B1**	
	[Equation tangent is] $y = 10x + 2$ oe	**B1**	
	$AB^2 = \left(\dfrac{-their2}{their10}\right)^2 + \left(their\,2\right)^2$ oe	**M1**	providing *their* 10 is derived using differentiation
	[AB =] 2.01 or 2.009[9…] nfww, isw	**A1**	
7	$\dfrac{d(4x^3 + 2\sin 8x)}{dx} = 12x^2 + 16\cos 8x$ soi	**B2**	**B1** for $12x^2 + k\cos 8x$, where $k > 0$
	Correct quotient rule: $\dfrac{(1-x)\left(their\left(12x^2 + 16\cos 8x\right)\right) - (4x^3 + 2\sin 8x)(-1)}{(1-x)^2}$	**M1**	or applies correct product rule to $(4x^3 + 2\sin 8x)(1-x)^{-1}$: $(4x^3 + 2\sin 8x)\left(-(1-x)^{-2} \times -1\right) +$ $\left(their(12x^2 + 16\cos 8x)\right)(1-x)^{-1}$
	Fully correct derivative; isw	**A1**	**FT** *their* $12x^2 + 16\cos 8x$
	$\dfrac{\delta y}{h} = their\left(\left.\dfrac{dy}{dx}\right\|_{x=0.1}\right)$	**M1**	
	$14.3h$ or $14.29[54...]h$ with coefficient rot to 4 or more figs isw	**A1**	
8(a)(i)	$f \leqslant -1$	1	

Question	Answer	Marks	Partial Marks
8(a)(ii)	$x = -2$ nfww	3	**M1** for $\left[x = \mathrm{f}\left(\frac{2\pi}{3}\right) = \right]\sec\left(\frac{2\pi}{3}\right)$ or $\sec^{-1} x = \frac{2\pi}{3}$ **A1** for $\frac{1}{\cos\left(\frac{2\pi}{3}\right)}$ OR **M1** for a complete attempt to find $\mathrm{f}^{-1}(x)$; includes swapping the variables **A1** for $\mathrm{f}^{-1}(x) = \cos^{-1}\left(\frac{1}{x}\right)$
8(a)(iii)	$\frac{\pi}{2} < x < \frac{3\pi}{2}$	1	
8(a)(iv)	$\mathrm{gf}(x) = 3(\sec^2 x - 1)$	B1	
	$3\tan^2 x = 1$ or $\frac{1}{\cos^2 x} = \frac{4}{3}$ oe	M1	
	$\tan x = [\pm]\sqrt{\frac{1}{3}}$ oe or $\cos x = [\pm]\sqrt{\frac{3}{4}}$ oe and solves for x, soi	M1	
	$x = \frac{5\pi}{6}, \frac{7\pi}{6}$ and no other solutions	A2	**A1** for one correct solution, condoning extras
8(b)	Correct diagram with intercepts indicated and asymptotes shown. 	4	**B1** for correct shape for h; may not be over correct domain but must have positive y-intercept and x-intercept and appear to tend to an asymptote in the 4th quadrant **B1** for 3 and ln4 correctly marked; must have attempted correct shape **B1** for the position of the vertical asymptote indicated; must have attempted correct shape **B1** for h^{-1} the reflection of *their* h in the line $y = x$ **Maximum of 3 marks if not fully correct**

Question	Answer	Marks	Partial Marks
9(a)	$\frac{x+4}{\sqrt[3]{x}} = x^{\frac{2}{3}} + 4x^{-\frac{1}{3}}$	**B1**	
	$\left[\frac{3}{5}x^{\frac{5}{3}} + 6x^{\frac{2}{3}}\right]_1^8$	**M1**	**FT** providing one term is correct in $x^{\frac{2}{3}} + 4x^{-\frac{1}{3}}$
	$\frac{3}{5}(8)^{\frac{5}{3}} + 6(8)^{\frac{2}{3}} - \left(\frac{3}{5}(1)^{\frac{5}{3}} + 6(1)^{\frac{2}{3}}\right) = 36.6$	**A1**	

Question	Answer	Marks	Partial Marks
9(b)	$10(0.1) = 7 - 3x$ and $0.1 = \dfrac{1}{3x+4}$ and evaluates both expressions as $x = 2$ oe	**M2**	**M1** for $10(0.1) = 7 - 3x$ and $0.1 = \dfrac{1}{3x+4}$ oe
	[Area trapezium =] $\dfrac{1}{2}(0.1+0.7)\times \mathit{their}\,2$ oe or $\dfrac{7(\mathit{their}\ 2)}{10} - \dfrac{3(\mathit{their}\ 2)^2}{20} - [0]$ oe or 0.8	**B1**	
	$\left[\int \dfrac{1}{3x+4}\mathrm{d}x = \right]\dfrac{1}{3}\ln(3x+4)\quad [+c]$	**B2**	**B1** for $k\ln(3x+4)$ $k \ne \dfrac{1}{3}$ or for $\dfrac{1}{3}\ln 3x+4$
	$\dfrac{1}{3}\ln(3(2)+4) - \dfrac{1}{3}\ln(3(0)+4)$	**M1**	**dep** on at least previous **B1**
	their 0.8 – 0.3054…oe	**M1**	**dep** previous **M1**; **FT** *their* 0.8 providing the difference results in a positive value
	0.495 or 0.4945[69…] rot to 4 or more sf	**A1**	
10(a)(i)	$a + d$, $a + 13d$, $a + 16d$ soi	**B1**	
	$\dfrac{a+13d}{a+d} = \dfrac{a+16d}{a+13d}$ oe	**M2**	**FT** *their* 3 distinct terms providing of the form $a + kd$ where $k \ne 0$ and at least one is correct **M1** for either $[r =]\dfrac{a+13d}{a+d}$ or $[r =]\dfrac{a+16d}{a+13d}$ or $[r =]\sqrt{\dfrac{a+16d}{a+d}}$
	Clears fractions and expands oe: $a^2 + 26ad + 169d^2$ $= a^2 + 17ad + 16d^2$	**A1**	
	$9ad + 153d^2 = 0$ or $9ad = -153d^2$	**A1**	
	Convincingly derives $a = -17d$ e.g. $9d(a + 17d) = 0$ [therefore] $a = -17d$ oe	**A1**	

Question	Answer	Marks	Partial Marks
10(a)(ii)	$r = 0.25$ oe	**2**	**M1** $\frac{-17d+13d}{-17d+d}$ or $\frac{-17d+16d}{-17d+13d}$ or $-16d$, $-4d$, $-d$
10(b)	$\frac{q}{1-0.25}=\frac{256}{3}$ oe	**M1**	**FT** *their* 0.25 providing it is between –1 and 1
	$q = 64$	**A1**	
	[$a + d =$ *their* 64] $-17d + d =$ *their* 64 or $a-\frac{a}{17}=$ *their* 64	**DM1**	**dep** on previous **M1**
	$d = -4$ and $a = 68$ oe OR $d = -4$ and $S_{20} = -150d$ oe	**A2**	**A1** for either correct
	$S_{20}=\frac{20}{2}\{2(their\,68)+19(their(-4))\}$ or $S_{20}=-150(their\ d)$	**M1**	**FT** *their a* and *d*
	600	**A1**	

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ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **February/March 2023**

MARK SCHEME

Maximum Mark: 80

Published

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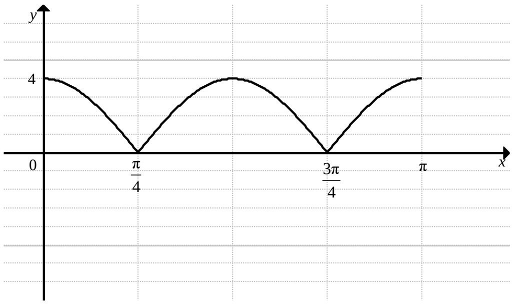
B Mark for a correct result or statement independent of Method marks.

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

Abbreviations

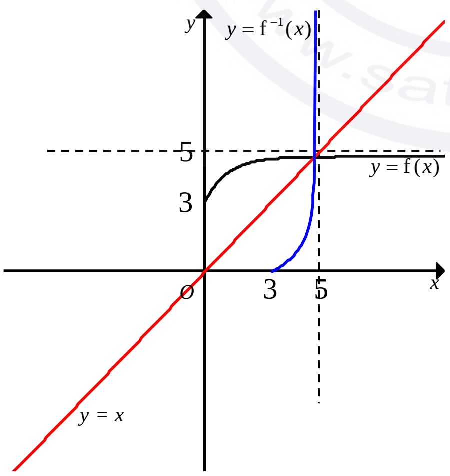
awrt answers which round to
cao correct answer only
dep dependent
FT follow through after error
isw ignore subsequent working
nfww not from wrong working
oe or equivalent
rot rounded or truncated
SC Special Case
soi seen or implied

Question	Answer	Marks	Partial Marks
1	Correct sketch 	**3**	**B1** for correct shape, with 3 consistent maxima, 2 cusps on the *x*-axes and reasonable symmetry **B1** for $\left(\frac{\pi}{4},\ 0\right)$ and $\left(\frac{3\pi}{4},\ 0\right)$ either seen on the graph or stated; must have attempted a graph of correct shape **B1** for starts with (0, 4) **and** ends with (π, 4) and (0, 4) either seen on the graph or stated; must have attempted a graph correct shape
2	$\dfrac{11x^2}{12+1-4\sqrt{3}}$	**B1**	
	$\dfrac{11x^2\left(13+4\sqrt{3}\right)}{\left(13-4\sqrt{3}\right)\left(13+4\sqrt{3}\right)}$	**M1**	**FT** *their* expression of equivalent difficulty
	$\dfrac{11x^2\left(13+4\sqrt{3}\right)}{169-48}$ or $\dfrac{143x^2+44\sqrt{3}x^2}{169-48}$	**A1**	
	$\dfrac{x^2\left(13+4\sqrt{3}\right)}{11}$ or $\dfrac{13x^2+4\sqrt{3}x^2}{11}$	**A1**	mark final answer
	Alternative method		
	$\left(\dfrac{x\sqrt{11}(2\sqrt{3}+1)}{(2\sqrt{3}-1)(2\sqrt{3}+1)}\right)^2$	**(M1)**	
	$\left(\dfrac{x\sqrt{11}(2\sqrt{3}+1)}{12-1}\right)^2$ or $\left(\dfrac{2\sqrt{33}x+x\sqrt{11}}{12-1}\right)^2$	**(A1)**	
	$\dfrac{11x^2(12+1+4\sqrt{3})}{121}$ or $\dfrac{132x^2+11x^2+4\sqrt{363}x^2}{121}$	**(A1)**	
	$\dfrac{x^2\left(13+4\sqrt{3}\right)}{11}$	**(A1)**	mark final answer

Question	Answer	Marks	Partial Marks
3	$(5x+4)^2 * (2x-3)^2$ soi where * is any inequality sign or =	**M1**	
	$21x^2+52x+7*0$	**A1**	
	Critical values: $-\frac{1}{7}$, $-\frac{7}{3}$ soi	**A1**	
	$-\frac{7}{3} \leqslant x \leqslant -\frac{1}{7}$ mark final answer	**A1**	**FT** *their* derived critical values
	Alternative method		
	$5x+4*2x-3$ oe soi and $5x+4*3-2x$ oe soi where * is any inequality sign or =	**(M1)**	
	Critical values: $-\frac{1}{7}$, $-\frac{7}{3}$ soi	**(A2)**	**A1** for $-\frac{1}{7}$ or $-\frac{7}{3}$
	$-\frac{7}{3} \leqslant x \leqslant -\frac{1}{7}$ mark final answer	**(A1)**	**FT** *their* derived critical values
4	$[y=]\frac{1}{\operatorname{cosec}5x}=\sin 5x$ nfww	**B1**	
	$\int_0^{\frac{\pi}{5}} y\,dx=\left[-\frac{\cos 5x}{5}\right]_0^{\frac{\pi}{5}}$	**B1**	**FT** *their* $a\sin 5x$
	$-\frac{1}{5}\cos\left(5\times\frac{\pi}{5}\right)-\left(-\frac{1}{5}\cos(5\times 0)\right)$	**M1**	**FT** *their* $a(k\cos bx)$ where $k<0$ or $k=\frac{1}{5}$
	$\frac{2}{5}$	**A1**	
5(a)	$1^3-2(1^2)-19+20=0$	**1**	
5(b)	$(x-1)(x^2-x-20)$	**M2**	**M1** for two terms correct in the quadratic factor
	$(x-1)(x+4)(x-5)$	**A1**	
5(c)	$e^y=1, e^y=5$	**M1**	
	$y=0, y=\ln 5$ mark final answer	**A1**	1.61 or decimal equivalent for ln5 seen is A0 as calculator use not permitted

Question	Answer	Marks	Partial Marks
6(a)(i)	$\frac{1}{8}$ or 0.125	**2**	**M1** for $64(0.5)^9$ oe
6(a)(ii)	$\frac{1023}{8}$ or 127.875	**2**	**M1** for $\frac{64(1-0.5^{10})}{1-0.5}$ oe
6(a)(iii)	128	**1**	
6(b)	$\frac{20}{2}\{2a+19d\}-400=2\times\frac{10}{2}\{2a+9d\}$ oe, soi	**M2**	**M1** for $\frac{20}{2}\{2a+19d\}$ or $\frac{10}{2}\{2a+9d\}$ soi
	$5a = a + 5d$ soi	**M1**	
	$d = 4$	**A1**	
	$a = 5$	**A1**	
	27 nfww	**B1**	must have earned all previous marks
7(a)	$\frac{\mathrm{d}}{\mathrm{d}x}(\cos^2 x)=-2\cos x\sin x$ soi	**B1**	
	Attempts the quotient rule $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{-2\cos x\sin x\tan x-(1+\cos^2 x)\sec^2 x}{\tan^2 x}$	**M1**	**FT** *their* $\frac{\mathrm{d}}{\mathrm{d}x}(\cos^2 x)$
	Fully correct isw	**A1**	**FT** *their* $\frac{\mathrm{d}}{\mathrm{d}x}(\cos^2 x)$ only
	$\frac{\delta y}{h}\approx \textit{their}\left.\frac{\mathrm{d}y}{\mathrm{d}x}\right\|_{x=\frac{\pi}{4}}$	**M1**	
	$\delta y\approx -4h$ cao	**A1**	

Question	Answer	Marks	Partial Marks
7(a)	**Alternative method 1**		
	$\frac{d}{dx}(\cos^3 x) = -3\cos^2 x \sin x$ soi	**(B1)**	
	Attempts the quotient rule: $\frac{dy}{dx} = \frac{(\sin x)(-\sin x - 3\cos^2 x \sin x) - (\cos x + \cos^3 x)\cos x}{\sin^2 x}$	**(M1)**	**FT** *their* $\frac{d}{dx}(\cos^3 x)$
	Fully correct isw	**(A1)**	**FT** *their* $\frac{d}{dx}(\cos^3 x)$ only
	$\frac{\delta y}{h} \approx their \left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{4}}$	**(M1)**	
	$\delta y \approx -4h$ cao	**(A1)**	
	Alternative method 2		
	$\frac{d}{dx}\left(\frac{2}{\tan x}\right) = -2(\tan x)^{-2}\sec^2 x$	**(B1)**	
	Attempts the product rule $\frac{dy}{dx} = -2(\tan x)^{-2}\sec^2 x - (\sin x(-\sin x) + \cos x(\cos x))$	**(M1)**	**FT** *their* $\frac{d}{dx}\left(\frac{2}{\tan x}\right)$
	Fully correct isw	**(A1)**	**FT** *their* $\frac{d}{dx}\left(\frac{2}{\tan x}\right)$ only
	$\frac{\delta y}{h} \approx their \left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{4}}$	**(M1)**	
	$\delta y \approx -4h$ cao	**(A1)**	

Question	Answer	Marks	Partial Marks
7(b)	$\dfrac{dy}{dx} = -3(x-3)^{-4}$ oe, soi	**B1**	
	$\dfrac{d^2y}{dx^2} = -4 \times -3(x-3)^{-5}$ oe, soi	**B1**	
	$\dfrac{(x-3)^2+3(x-3)-4}{(x-3)^5}$ or $\left[\dfrac{x-3+3}{(x-3)^4} - \dfrac{4}{(x-3)^5} = \right]\dfrac{x(x-3)-4}{(x-3)^5}$	**M1**	**FT** $\dfrac{dy}{dx} = k(x-3)^{-4}$ and $\dfrac{d^2y}{dx^2} = m(x-3)^{-5}$ where k and m are constants
	Correct completion to given answer: $\dfrac{x^2-3x-4}{(x-3)^5} = \dfrac{(x+1)(x-4)}{(x-3)^5}$	**A1**	
8(a)(i)	$3 \leqslant x < 5$	**B2**	**B1** for $x \geqslant 3$ or for $x < 5$ or for 3 and 5 in an incorrect inequality
8(a)(ii)	$x = \sqrt{5x-4}$ and rearrangement to $x^2 - 5x + 4[=0]$	**B1**	
	Factorises $x^2 - 5x + 4$ or solves *their* $x^2 - 5x + 4 = 0$	**M1**	
	$x = 4$ only, nfww	**A1**	
8(a)(iii)	Correct pair of graphs. 	**4**	**B1** for correct shape for f; may not be over correct domain but must have positive y-intercept and appear to tend to an asymptote in the 1st quadrant **B1** for (0, 3) and f in 1st quadrant only; must have attempted correct shape **B1** for asymptote at $y = 5$; must have attempted correct shape **B1** for a correct reflection of *their* f in the line $y = x$ **Maximum of 3 marks if not fully correct**

Question	Answer	Marks	Partial Marks
8(b)	$\mathrm{f}^{-1}(x) = -\ln\dfrac{5-x}{2}$ or $\mathrm{f}^{-1}(x) = \ln\dfrac{2}{5-x}$ oe	2	**M1** for a complete attempt to find the inverse function with at most one sign or arithmetic error: Putting $y = \mathrm{f}(x)$ and changing subject to x and swopping x and y or swopping x and y and changing subject to y
	Correct simplified form e.g. $\left[\mathrm{f}^{-1}\mathrm{g}(x) =\right] - \ln\dfrac{2-5x}{2(1-x)}$ or $\left[\mathrm{f}^{-1}\mathrm{g}(x) =\right]\ln\dfrac{2-2x}{2-5x}$	2	**M1 FT** for a correct unsimplified form of the function; FT providing of equivalent difficulty
9(a)	$6.5\left(\dfrac{3\pi}{8}\right) + 5.2\left(\dfrac{3\pi}{8}\right) + 2(6.5-5.2)$	M2	**M1** for $6.5\left(\dfrac{3\pi}{8}\right)$ or $5.2\left(\dfrac{3\pi}{8}\right)$
	16.38 to 16.4	A1	
9(b)	[Angle PRQ =] 2ϕ soi	B1	
	$y = 2a\cos\phi$ oe or $y = \dfrac{a\sin(\pi-2\phi)}{\sin\phi}$ oe $y^2 = a^2 + a^2 - 2a^2\cos(\pi - 2\phi)$ oe or $y^2 = a^2 + a^2 + 2a^2\cos(2\phi)$ oe	B1	
	Complete and correct plan soi: $\pi a^2 - \dfrac{1}{2}(2a\cos\phi)^2(2\phi)$ oe or $\pi a^2 - \dfrac{1}{2}\left(\dfrac{a\sin(\pi-2\phi)}{\sin\phi}\right)^2(2\phi)$ oe or $\pi a^2 - \dfrac{1}{2}(a^2 + a^2 - 2a^2\cos(\pi-2\phi))(2\phi)$ oe or $\pi a^2 - \dfrac{1}{2}(a^2 + a^2 + 2a^2\cos(2\phi))(2\phi)$	M1	**FT** *their* 2ϕ and *their* expression for y or y^2 in terms of a and ϕ
	$a^2\left(\pi - 4\phi\cos^2\phi\right)$ or $\pi a^2 - \dfrac{a^2\phi\sin^2(\pi-2\phi)}{\sin^2\phi}$ or $\pi a^2 - 2\phi(a^2 - a^2\cos(\pi-2\phi))$ or $\pi a^2 - 2\phi(a^2 + a^2\cos 2\phi)$ oe	A1	

Question	Answer	Marks	Partial Marks
10(a)(i)	$v = 3t^2 + c$	**M1**	
	$v = 3t^2 - 1$	**A1**	
	When $t = 3$ $v = 26$	**A1**	
10(a)(ii)	$s = t^3 - t + c$	**M1**	**FT** $kt^2 + c$
	$s = t^3 - t - 4$	**A1**	
	When $t = 3$ $s = 20$	**A1**	
10(b)	$v = \frac{-18e^3}{e^t} + c$ oe	**M1**	
	$v = \frac{-18e^3}{e^t} + 44$ oe	**A1**	**FT** (*their* 26) + 18
	$s = \frac{18e^3}{e^t} + their\,44t + d$ oe	**M1**	**dep** on previous **M1**
	$s = \frac{18e^3}{e^t} + 44t - 130$ oe, cao	**A1**	

Question	Answer	Marks	Partial Marks
11	Solves $\sin(4x-\pi)=0$ oe	**M1**	
	$a = \frac{3\pi}{4}$	**A1**	
	$\frac{dy}{dx}=4\cos(4x-\pi)$	**B2**	**B1** for $\frac{dy}{dx}=k\cos(4x-\pi)$, where $k>0$ or $k=-4$
	$\left[\frac{-1}{4\cos(4\times \mathit{their}\frac{3\pi}{4}-\pi)}=\right]-\frac{1}{4}$	**B2**	**FT** *their* $a = \frac{n\pi}{4}$, n is a positive integer **B1** for $\frac{-1}{\mathit{theirk}\cos(4\times \mathit{their}\frac{3\pi}{4}-\pi)}$
	$y-0=-\frac{1}{4}\left(x-\frac{3\pi}{4}\right)$ or $0=-\frac{1}{4}\left(\frac{3\pi}{4}\right)+c$ oe	**M1**	**FT** *their* perpendicular gradient and *their a*
	$B\left(0,\frac{3\pi}{16}\right)$ soi	**B1**	
	[Exact area =] $\frac{9\pi^2}{128}$	**B1**	

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ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2022**

MARK SCHEME

Maximum Mark: 80

Published

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

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

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

Cambridge International is publishing the mark schemes for the October/November 2022 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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

[Turn over

Generic Marking Principles

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

Abbreviations

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

Question	Answer	Marks	Guidance
1	Finds by elimination $3y+\sqrt{7}y=4$ oe or substitutes $x=11-3y$ into $x-\sqrt{7}y=7$ oe OR Finds by elimination $3y+\sqrt{7}y=21+11\sqrt{7}$ oe or substitutes $y=\frac{11-x}{3}$ into $x-\sqrt{7}y=7$ oe	**M1**	
	$y=\frac{4}{3+\sqrt{7}}$ or $x=\frac{21+11\sqrt{7}}{3+\sqrt{7}}$	**A1**	
	$y=\frac{4}{3+\sqrt{7}}\times\frac{3-\sqrt{7}}{3-\sqrt{7}}$ oe or $x=\frac{21+11\sqrt{7}}{3+\sqrt{7}}\times\frac{3-\sqrt{7}}{3-\sqrt{7}}$ oe	**M1**	**FT** *their* value of x or y providing of equivalent difficulty
	$y=6-2\sqrt{7}$ and $x=6\sqrt{7}-7$	**A2**	**A1** for either and no extra values
2	$2x^3+3x^2-29x+30\,[=0]$	**B1**	
	Uses a correct factor $x-2$ or $x+5$ to find a quadratic factor with at least 2 terms correct	**M1**	
	$(x-2)\to(2x^2+7x-15)\quad[=0]$ or $(x+5)\to(2x^2-7x+6)\quad[=0]$	**A1**	
	Factorises or solves *their* 3-term quadratic: $(x+5)(2x-3)$ [= 0] or $(x-2)(2x-3)$ [= 0] or $[x=]\frac{-7\pm\sqrt{7^2-4(2)(-15)}}{2(2)}$ or $\frac{7\pm\sqrt{(-7)^2-4(2)(6)}}{2(2)}$	**M1**	**dep** on previous **M1**
	x = 2, –5, 1.5	**A1**	

Question	Answer	Marks	Guidance
3(a)	$\frac{dy}{dx} = \frac{1}{2}(1+3x)^{-\frac{1}{2}} \times 3$ oe, isw	**B2**	**B1** for $\frac{dy}{dx} = \frac{1}{2}(1+3x)^{-\frac{1}{2}} \times ...$ or $\frac{dy}{dx} = \frac{1}{2}(...)^{-\frac{1}{2}} \times 3$ or $\frac{dy}{dx} = their\ \frac{1}{2}(1+3x)^{\left(their\ \frac{1}{2}\right)-1} \times 3$ or $\frac{dy}{dx} = k(1+3x)^{-\frac{1}{2}} \times 3$, k is a constant, $k \neq \frac{1}{2}$
	$m_{\text{tangent}} = \frac{3}{8}$ or 0.375 or $m_{\text{normal}} = \frac{-2}{3(1+3x)^{-\frac{1}{2}}}$ oe	**B1**	**FT** *their* $\frac{dy}{dx}$ if necessary providing at least **B1** previously awarded
	$\left(their\ \frac{dy}{dx}\right) = \frac{3}{8}$ or $\left(their\left(-\frac{dx}{dy}\right)\right) = -\frac{8}{3}$	**M1**	**FT** *their* $\frac{dy}{dx}$ if necessary providing at least **B1** previously awarded
	(5, 4)	**A1**	
3(b)	$m_{\text{normal}} = -\frac{10}{3}$	**B1**	
	$y - 5 = -\frac{10}{3}(x - 8)$ or $y = \frac{-10}{3}x + c$ and $5 = \left(\frac{-10}{3}\right)(8) + c$ oe soi	**M1**	**FT** *their* m_{normal}
	$y = -\frac{10}{3}x + \frac{95}{3}$	**A1**	**FT** *their* m_{normal}
4(a)	$(3x + 1)\log 2 = (x - 2)\log 5$ oe	**B1**	
	$(3\log 2 - \log 5)x = -\log 2 - 2\log 5$	**M1**	**FT** if of equivalent difficulty
	$x = -8.32$	**A1**	

Question	Answer	Marks	Guidance
4(b)	Writes as a quadratic in e^{2y+1} or states $u = e^{2y+1}$ and writes as a quadratic in u oe, soi	**M1**	condone one error
	$\left(e^{2y+1}\right)^2 - e^{2y+1} - 6 \quad [=0]$ oe or $u^2 - u - 6 \quad [=0]$ oe	**A1**	
	$(e^{2y+1} + 2)(e^{2y+1} - 3) \quad [=0]$ leading to $e^{2y+1} = 3$ or $(u + 2)(u - 3)$ [=0] leading to $e^{2y+1} = 3$	**A1**	
	$y = 0.0493$ and no other solutions	**A1**	
5(a)	$\dfrac{dy}{dx} = -(\cos 2x)^{-2} \times -2\sin 2x = \dfrac{2\sin 2x}{\cos^2 2x}$ or $\dfrac{dy}{dx} = \dfrac{0[\cos 2x] - (-2\sin 2x)}{\cos^2 2x} = \dfrac{2\sin 2x}{\cos^2 2x}$	**B2**	**B1** for $-(\cos 2x)^{-2} \times m\sin 2x$ or $\dfrac{0[\cos 2x] - (m\sin 2x)}{\cos^2 2x}$ where $m = 2$ or $m < 0$
5(b)	$2\tan^2 2x = 5$ or $7\cos^2 2x = 2$ or $7\sin^2 2x = 5$	**M1**	**FT** *their k*
	$\tan 2x = [\pm]\sqrt{\dfrac{5}{2}}$ or $\cos 2x = [\pm]\sqrt{\dfrac{2}{7}}$ or $\sin 2x = [\pm]\sqrt{\dfrac{5}{7}}$	**A1**	
	0.503 or 0.5034[26…] rot to 4 or more sf 1.07 or 1.067[36…] rot to 4 or more sf and no extras in range	**A2**	**A1** for either, ignoring extras
6(a)	$3\left(x + \dfrac{5}{2}\right)^2 - \dfrac{155}{4}$	**B4**	**B2** for $3\left(x + \dfrac{5}{2}\right)^2$ or $3(x + 2.5)^2$ or **B1** for $\left(x + \dfrac{5}{2}\right)^2$ or $(x + 2.5)^2$ **B2** for $c = -\dfrac{155}{4}$ or –38.75 or **B1** for $-\dfrac{25}{4} \times 3 - 20$ oe
6(b)	Min value $-\dfrac{155}{4}$ when x is $-\dfrac{5}{2}$	**B2**	**FT** *their c* from part **a** and **–***their b* from **(a)** **B1** for either without contradiction

Question	Answer	Marks	Guidance
6(c)	$3\left(y^{\frac{1}{3}}+\frac{5}{2}\right)^2=\frac{155}{4}$ soi	**M1**	**FT** an expression of correct form from **(a)**
	Rearranges as far as: $y^{\frac{1}{3}}=-\frac{5}{2}\pm\sqrt{\frac{155}{12}}$ soi	**A1**	
	y = 1.31 or –226	**A1**	
7	$\frac{a(1-r^3)}{1-r}=17.5$ oe or $a+ar+ar^2=17.5$ oe	**B1**	
	$\frac{a}{1-r}=20$	**B1**	
	Correctly eliminates *a* or eliminates *r*	**M1**	**FT** *their* equations providing at least **B1** awarded
	$20(1-r^3)=17.5$ or $a^3-60a^2+1200a-7000=0$	**A1**	
	$r=\frac{1}{2}$, a = 10	**A2**	**A1** for either
8(a)	Product rule attempted	**M1**	at most one error
	$\left[\frac{dy}{dx}=\right]\sin x+x\cos x$ oe	**A1**	
8(b)	$\left[\text{When } x=\frac{\pi}{2}\right] y=\frac{\pi}{2}$	**B1**	
	$\left[\text{When } x=\frac{\pi}{2}\right]\frac{dy}{dx}=1$	**M1**	**FT** *their* derivative providing at least M1 awarded in **(a)**
	$y = x$	**A1**	
8(c)	$x\sin x+\cos x+c$	**B3**	**B2** for $x\sin x+\cos x$ or **B1** for $\left[\int x\cos x\,dx=\right]x\sin x-\int\sin x\,dx$
8(d)	$\frac{\pi}{4}\sin\frac{\pi}{4}+\cos\frac{\pi}{4}-(0+\cos 0)$	**M1**	
	0.26	**A1**	
9(a)	$(\ln(3x+2))^2+1$ oe isw	**B1**	

Question	Answer	Marks	Guidance
9(b)	$\ln(3x + 2) = [\pm]\ 2$	**B1**	
	$e^2 = 3x + 2$	**M1**	**FT** $\ln(3x + 2) = k$, where $k > 0$
	$x = \dfrac{e^2 - 2}{3}$ as only solution	**A1**	
9(c)	$\ln(3\ln(3x + 2) + 2)$	**B1**	
	their$(3\ln(3x + 2) + 2) = e$	**M1**	**FT** *their* $gg(x)$ with at most one error
	$3\ln(3x + 2) + 2 = e$	**A1**	
	$\ln(3x + 2) = \dfrac{e-2}{3}$ or 0.239[42…]	**M1**	**FT** *their* $a\ln(3x + 2) + b = e$, where a and b are non-zero constants
	$3x + 2 = e^{\frac{e-2}{3}}$ or $3x + 2 = 1.270[52…]$	**A1**	
	awrt –0.243	**A1**	
10(a)	$\left[v = \int \dfrac{-45}{(t+1)^2}\,dt = \right] \dfrac{-45(t+1)^{-1}}{-1} + C$ or better	**B2**	**B1** for $\left[v = \int \dfrac{-45}{(t+1)^2}\,dt = \right] k(t+1)^{-1}$
	$50 = \dfrac{their\,45}{0+1} + C$	**M1**	
	$[v =] \dfrac{45}{t+1} + 5$	**A1**	
10(b)	$[F(t) =] \quad [45\ln(t+1) + 5t]_1^{10}$	**B2**	**B1** for (*their* 45)$\ln(t + 1)$
	$F(10) – F(1)$	**M1**	**dep** on at least **B1**
	122 (m) or 121.7[13…] rot to 4 or more sf	**A1**	**dep** on all previous marks awarded

Question	Answer	Marks	Guidance
11(a)	1080	**3**	**M2** for a fully correct method e.g. [starts with 1, 2, 4, 5 and ends in 3, 6] $4 \times 6 \times 5 \times 4 \times 2$ or 960 **and** [starts with 3 and ends in 6] $1 \times 6 \times 5 \times 4 \times 1$ or 120 **OR** [ends with 6 and starts with 1, 2, 3, 4, 5] $5 \times 6 \times 5 \times 4 \times 1$ or 600 **and** [ends with 3 and starts with 1, 2, 4, 5] $4 \times 6 \times 5 \times 4 \times 1$ or 480 or **M1** for a partially correct method equivalent to one of the above two steps
11(b)	2160	**3**	**M2** for a fully correct method e.g. [starts with 1, 3, 5 and ends in 2, 4, 6, 8] $3 \times 6 \times 5 \times 4 \times 4$ or 1440 **and** [starts with 2 or 4 and ends in 6, 8 or one of 2 or 4] $2 \times 6 \times 5 \times 4 \times 3$ or 720 **OR** [ends with 6, 8 and starts with 1, 2, 3, 4, 5] $5 \times 6 \times 5 \times 4 \times 2$ or 1200 **and** [ends with 2, 4 and starts with 1, 3, 5 or one of 2 or 4] $4 \times 6 \times 5 \times 4 \times 2$ or 960 or **M1** for a partially correct method equivalent to one of the above two steps

Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS	**0606/22**
Paper 2	**October/November 2022**
MARK SCHEME	
Maximum Mark: 80	

Published

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GENERIC MARKING PRINCIPLE 2: Marks awarded are always **whole marks** (not half marks, or other fractions).
GENERIC MARKING PRINCIPLE 3: Marks must be awarded **positively**: • marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate • marks are awarded when candidates clearly demonstrate what they know and can do • marks are not deducted for errors • marks are not deducted for omissions • answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.
GENERIC MARKING PRINCIPLE 4: Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.
GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

Abbreviations

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

Question	Answer	Marks	Guidance
1	$3y-(-5y-4)y=6$ oe or $3\left(\frac{-4-x}{5}\right)-x\left(\frac{-4-x}{5}\right)=6$ or $x+5\left(\frac{6}{3-x}\right)=-4$ oe	**M1**	
	$5y^2+7y-6=0$ or $x^2+x-42=0$	**A1**	
	Factorises *their* 3-term quadratic expression or solves *their* 3-term quadratic equation, e.g. $(5y-3)(y+2)$ [= 0] or $(x-6)(x+7)$ [= 0]	**M1**	
	$x=6$, $y=-2$ $x=-7$, $y=0.6$	**A2**	**A1** for either $x=6$, $x=-7$ or $y=-2$, $y=0.6$ or for an x, y pair from a correct factorisation or correct solving of a correct equation. The method of solution **must** be seen in this case.
2	$e^{2x-3-(5-x)}=\frac{7}{4}$ oe or $e^{5-x-(2x-3)}=\frac{4}{7}$ oe	**M1**	
	$e^{3x-8}=\frac{7}{4}$ oe, soi or $e^{8-3x}=\frac{4}{7}$ oe, soi	**A1**	
	$3x-8=\ln\frac{7}{4}$ oe or $8-3x=\ln\frac{4}{7}$ oe	**M1**	**FT** expression of similar structure which has at most one sign or arithmetic slip
	$x=\frac{\ln 1.75+8}{3}$ oe or $x=\frac{8-\ln\frac{4}{7}}{3}$ oe or 2.85[32…] rot to 3 or more sf	**A1**	

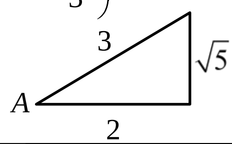
Question	Answer	Marks	Guidance
2	**Alternative method**		
	$\ln 4 + \ln e^{2x-3} = \ln 7 + \ln e^{5-x}$ oe, soi	**(M1)**	
	$\ln 4 + 2x - 3 = \ln 7 + 5 - x$ oe	**(A1)**	
	$2x + x = \ln 7 + 5 - \ln 4 + 3$ or $3x - 8 = \ln\frac{7}{4}$ oe or $8 - 3x = \ln\frac{4}{7}$ oe	**(M1)**	**FT** expression of similar structure which has at most one sign or arithmetic slip
	$x = \frac{\ln 7 - \ln 4 + 8}{3}$ oe or 2.85[32…] rot to 3 or more sf	**(A1)**	
3	$\left[m_{\text{tangent}} =\right] - ax^{-2} + 3$ oe	**B1**	
	[When x = 1, m_{normal} =] $\frac{-1}{3-a}$ oe or gradient of tangent = 4 soi	**B1**	**FT** $\frac{-1}{\textit{their}\left.\frac{dy}{dx}\right\|_{x=1}}$ if appropriate
	$\frac{-1}{\textit{their}(3-a)} = -\frac{1}{4}$ oe or *their* (3 – *a*) = 4 oe	**M1**	**FT** $\frac{-1}{\textit{their}\left.\frac{dy}{dx}\right\|_{x=1}}$ or *their* $\left.\frac{dy}{dx}\right\|_{x=1}$ and *their* evaluation of $\frac{-1}{-\frac{1}{4}}$
	a = –1 nfww	**A1**	
	[When x = 1] $\textit{their}\, 0 = -\frac{1}{4}[1] + b$ oe	**M1**	**FT** y = **(***their a*) + 1 providing at least 2 of the first 3 marks awarded
	$b = \frac{1}{4}$ nfww	**A1**	

Question	Answer	Marks	Guidance
4	$\log_3\left(\frac{11x-8}{x^2}\right)=1$ or $\log_3(11x-8)=\log_3(3x^2)$ soi OR $\log_x\left(\frac{11x-8}{3}\right)=2$ or $\log_x(11x-8)=\log_x(3x^2)$ soi	**M2**	**M1** for correct use change of base in a correct equation so that all logs have consistent base: $\log_x 3=\frac{\log_3 3}{\log_3 x}$ or $\log_x 3=\frac{1}{\log_3 x}$ oe, soi **OR** $\log_3(11x-8)=\frac{\log_x(11x-8)}{\log_x 3}$ oe, soi
	$3x^2-11x+8[=0]$ oe, nfww	**A1**	
	$(3x-8)(x-1)$ [= 0]	**M1**	**FT** *their* 3-term quadratic **dep** on at least **M1** previously awarded
	$x=\frac{8}{3}$ or 2.67 or 2.666[6…] rot to 3 or more dp as only solution	**A1**	
5	$6x^3-5x^2-13x+12\quad[=0]$	**B1**	
	Uses the correct factor $x-1$ to find a quadratic factor with at least 2 terms correct	**M1**	
	$6x^2+x-12$	**A1**	
	Factorises or solves *their* 3-term quadratic: $(2x+3)(3x-4)$ [= 0] or $[x=]\frac{-1\pm\sqrt{1-4(6)(-12)}}{2(6)}$ oe	**M1**	**dep** on previous **M1**
	$x=1, -1.5, \frac{4}{3}$ nfww	**A1**	**dep** on all previous marks awarded

Question	Answer	Marks	Guidance
6(a)	510	**3**	**M2** for a fully correct method e.g. [starts with 5, 7, 9 and ends in 3 or two of 5, 7, 9] $3 \times 6 \times 5 \times 3$ or 270 **and** [starts with 6, 8 and ends in 3,5,7, 9] $2 \times 6 \times 5 \times 4$ or 240 **OR** [ends with 3 and starts with 5, 6, 7, 8, 9] $5 \times 6 \times 5 \times 1$ or 150 **and** [ends with 5, 7, 9 and starts with 6, 8 or two of 5, 7, 9] $4 \times 6 \times 5 \times 3$ or 360 or **M1** for a partially correct method equivalent to one of the above two steps
6(b)	540	**3**	**M2** for a fully correct method e.g. [starts with 5, 7 and ends with 2, 3 and 5 or 7] $2 \times 6 \times 5 \times 3 = 180$ **and** [starts with 6, 8, 9 and ends with 2, 3, 5, 7] $3 \times 6 \times 5 \times 4 = 360$ OR [ends with 2, 3 and starts with 5, 6, 7, 8, 9] $5 \times 6 \times 5 \times 2$ or 300 **and** [ends with 5, 7 and starts with 6, 8, 9 and 5 or 7] $2 \times 6 \times 5 \times 4$ or 240 or **M1** for a partially correct method equivalent to one of the above two steps

Question	Answer	Marks	Guidance
7(a)	$\dfrac{\sin^2 x+(1-\cos x)^2}{(1-\cos x)\sin x}$ or $\dfrac{\sin^2 x}{(1-\cos x)\sin x}+\dfrac{(1-\cos x)^2}{(1-\cos x)\sin x}$	**M1**	
	$\dfrac{\sin^2 x+1-2\cos x+\cos^2 x}{(1-\cos x)\sin x}$	**A1**	OR $\dfrac{1-\cos^2 x+(1-\cos x)^2}{(1-\cos x)\sin x}$
	$\dfrac{1+1-2\cos x}{(1-\cos x)\sin x}$ or $\dfrac{1-\cos^2 x+1-2\cos x+\cos^2 x}{(1-\cos x)\sin x}$	**A1**	OR $\dfrac{(1-\cos x)(1+\cos x)+(1-\cos x)^2}{(1-\cos x)\sin x}$
	Fully correct justification of given answer: $\dfrac{2(1-\cos x)}{(1-\cos x)\sin x}=2\operatorname{cosec} x$ or $\dfrac{2-2\cos x}{(1-\cos x)\sin x}=\dfrac{2}{\sin x}=2\operatorname{cosec} x$ or equivalent	**A1**	All steps correct and final step justified OR $\dfrac{1+\cos x+1-\cos x}{\sin x}=2\operatorname{cosec} x$
	Alternative		
	$\dfrac{\sin x(1+\cos x)}{(1-\cos x)(1+\cos x)}+\dfrac{(1-\cos x)\sin x}{\sin x\sin x}$ or $\dfrac{\sin x(1+\cos x)}{1-\cos^2 x}+\dfrac{(1-\cos x)\sin x}{\sin^2 x}$	**(M1)**	
	$\dfrac{\sin x+\sin x\cos x}{\sin^2 x}+\dfrac{\sin x-\cos x\sin x}{\sin^2 x}$	**(A1)**	
	$\dfrac{2\sin x}{\sin^2 x}$	**(A1)**	
	Fully correct justification of given answer: $\dfrac{2}{\sin x}=2\operatorname{cosec} x$	**(A1)**	All steps correct and final step justified

Question	Answer	Marks	Guidance
7(b)	$3\sin^2 x - \sin x - 2 \quad [=0]$ soi	**B1**	
	$(3\sin x + 2)(\sin x - 1)$ [= 0] oe	**M1**	
	$\sin x = -\frac{2}{3}$, $\sin x = 1$	**A1**	
	90 221.8 or 221.81[03…] rot to 2 or more dp 318.2 or 318.18[96…] rot to 2 or more dp	**A1**	and no extras in range If **B1 M1 A0 A0** allow **SC1** for 221.8 or 221.81[03…] rot to 2 or more dp **and** 318.2 or 318.18[96…] rot to 2 or more dp and no extras in range
8(a)	$2\pi rh + 2\pi r^2 + \pi r^2 \, [= 300]$ oe	**M1**	
	$h = \frac{300 - 3\pi r^2}{2\pi r}$ oe, isw	**A1**	
8(b)	$V = \pi r^2 \left(\textit{their}\, \frac{300 - 3\pi r^2}{2\pi r} \right) + \frac{2}{3}\pi r^3$ oe	**M2**	**FT** *their h* providing in terms of *r* and derived from a dimensionally correct equation in **(a)**; **M1** for $V = \pi r^2 \left(\textit{their}\, \frac{300 - 3\pi r^2}{2\pi r} \right) + k\pi r^3$, $k \neq \frac{2}{3}$ oe
	Correct completion to given answer: $150r - \frac{5}{6}\pi r^3$ nfww	**A1**	
8(c)	Derivative of V: $150 - \frac{5}{2}\pi r^2$ oe, soi, isw	**B1**	
	$\textit{their} \left(150 - \frac{5}{2}\pi r^2 \right) = 0$ and solves as far as $r = \ldots$	**M1**	**FT** *their* $\frac{\mathrm{d}V}{\mathrm{d}r}$ providing that at least one term is correct
	$r = \sqrt{\frac{300}{5\pi}}$ oe or 4.37 (cm)	**A1**	
	$150(\textit{their}\, 4.37) - \frac{5}{6}\pi(\textit{their}\, 4.37)^3$	**M1**	**FT** *their* 4.37
	437 or awrt 437 (cm^3) isw	**A1**	

Question	Answer	Marks	Guidance
9(a)	$\frac{1}{2}(\sqrt{5}-1)(\sqrt{5}+1)\sin A=\frac{2\sqrt{5}}{3}$	**M1**	OR $\frac{1}{2}\times(\sqrt{5}+1)\times\text{height}=\frac{2\sqrt{5}}{3}$ **and** $\sin A=(\textit{their}\ \text{height})\div(\sqrt{5}-1)$
	Simplifies to $\frac{1}{2}\times(5-1)\times\sin A=\frac{2\sqrt{5}}{3}$ oe	**A1**	OR $\sin A=\frac{4\sqrt{5}}{3(\sqrt{5}+1)}\div(\sqrt{5}-1)$ or $\sin A=\frac{5-\sqrt{5}}{3}\div(\sqrt{5}-1)$
	$\frac{\sqrt{5}}{3}$ isw	**A1**	
9(b)	$\cos A=\frac{2}{3}$ or exact equivalent	**B2**	**B1** for $\cos A=\sqrt{1-\textit{their}\left(\frac{\sqrt{5}}{3}\right)^2}$ or for $\cos A=\cos\left(\sin^{-1}\frac{\sqrt{5}}{3}\right)$ or for a sketch 
	$(\sqrt{5}-1)^2+(\sqrt{5}+1)^2-2(\sqrt{5}-1)(\sqrt{5}+1)\times\cos A$ soi	**M1**	
	$(\sqrt{5}-1)^2+(\sqrt{5}+1)^2-2(\sqrt{5}-1)(\sqrt{5}+1)\times\frac{2}{3}$ soi	**A1**	
	$x=\sqrt{\frac{20}{3}}$ or $\frac{2}{3}\sqrt{15}$ or $2\sqrt{\frac{5}{3}}$ oe, isw	**A1**	

Question	Answer	Marks	Guidance
9(c)	$\dfrac{\textit{their } x}{\textit{their} \sin A} = \dfrac{\sqrt{5}+1}{\sin B}$ oe, soi or $\dfrac{1}{2}\times(\sqrt{5}-1)\times \textit{their } x \times \sin B = \dfrac{2\sqrt{5}}{3}$ oe, soi	**M1**	**FT** *their x* and *their* sin*A*
	Correct expression $\dfrac{\sqrt{\dfrac{20}{3}}}{\dfrac{\sqrt{5}}{3}} = \dfrac{\sqrt{5}+1}{\sin B}$ oe or $\dfrac{1}{2}\times(\sqrt{5}-1)\times\sqrt{\dfrac{20}{3}}\times\sin B = \dfrac{2\sqrt{5}}{3}$ oe	**A1**	
	$\dfrac{\sqrt{15}+\sqrt{3}}{6}$ or $\dfrac{\sqrt{3}}{6}\left(\sqrt{5}+1\right)$ or $\dfrac{\sqrt{5}+1}{2\sqrt{3}}$ oe, isw	**A1**	
10(a)	$ar^2 = 4.5$ and $ar^5 = 15.1875$ soi	**B1**	
	Correctly eliminates one unknown using correct equations e.g $\left(\dfrac{4.5}{r^2}\right)r^5 = 15.1875$ or $\sqrt{\dfrac{4.5}{a}} = \sqrt[5]{\dfrac{15.1875}{a}}$ oe, soi	**M1**	
	$r = 1.5$, $a = 2$	**A2**	**A1** for either
10(b)	$S_{15} = \dfrac{2(1-1.5^{15})}{1-1.5}$ and $S_{25} = \dfrac{2(1-1.5^{25})}{1-1.5}$ oe	**B2**	**M1 FT** *their a* and *r* for $S_{15} = \dfrac{2(1-1.5^{15})}{1-1.5}$ or $S_{25} = \dfrac{2(1-1.5^{25})}{1-1.5}$ oe
	Correct plan: $S_{25} - S_{15}$ oe attempted	**M1**	**FT** *their a* and *r*
	99 253	**A1**	

Question	Answer	Marks	Guidance
10(b)	**Alternative 1**		
	first term = (*their*2)(*their*1.5)^{15} and an attempt at S_{10}	**(M1)**	**FT** *their* a and r
	Correct sum $S_{10} = \dfrac{875.7...(1-1.5^{10})}{1-1.5}$ oe	**(B2)**	**M1 FT** *their* first term and r for $S_{10} = \dfrac{\textit{their}875.7...(1-\textit{their}1.5^{10})}{1-\textit{their}1.5}$
	99 253	**(A1)**	
	Alternative 2		
	Correct sum: $2(1.5)^{15} + 2(1.5)^{16} + 2(1.5)^{17} + 2(1.5)^{18} + 2(1.5)^{19} + 2(1.5)^{20} + 2(1.5)^{21} + 2(1.5)^{22} + 2(1.5)^{23} + 2(1.5)^{24}$ oe or $2(1.5)^{15}\{1 + 1.5 + (1.5)^2 + (1.5)^3 + (1.5)^4 + (1.5)^5 + (1.5)^6 + (1.5)^7 + (1.5)^8 + (1.5)^9\}$	**(M3)**	**M2 FT** *their* a and r for sum starting with $2(1.5)^{15}$ **and** ending with $2(1.5)^{24}$ with at most one omission or error or **M1 FT** *their* a and r for sum starting with $2(1.5)^{15}$ **or** ending with $2(1.5)^{24}$ with at most two omissions or errors
	99 253	**(A1)**	
11(a)	(–2, 2)	**B2**	**B1** for one correct coordinate nfww **M1** for $\overrightarrow{AC} = \frac{1}{3}\begin{pmatrix}9\\-12\end{pmatrix}$ or $\overrightarrow{CA} = \frac{1}{3}\begin{pmatrix}-9\\12\end{pmatrix}$ for $x = -5 + 3$ or $x = 4 - 6$ or for $y = 6 - 4$ or $y = -6 + 8$ or for $x + 5 = \dfrac{4-x}{2}$ or $6 - y = \dfrac{y+6}{2}$ or for $2\left(\overrightarrow{OC} - \begin{pmatrix}-5\\6\end{pmatrix}\right) = \begin{pmatrix}4\\-6\end{pmatrix} - \overrightarrow{OC}$ oe

Question	Answer	Marks	Guidance
11(b)	$m_{AB} = \frac{-6-6}{4-(-5)}$ oe or $-\frac{12}{9}$ or $-\frac{4}{3}$	**B1**	
	$m_{CD} = \frac{3}{4}$	**M1**	**FT** $\frac{-1}{their\ m_{AB}}$
	$y - 2 = \frac{3}{4}(x+2)$ oe or $y = \frac{3}{4}x + c$ and $2 = \left(\frac{3}{4}\right)(-2)+c$ oe soi	**M1**	**FT** *their* (–2, 2) and $\frac{-1}{their\ m_{AB}}$
	$y = \frac{3}{4}x + \frac{7}{2}$ or equivalent in form $y = mx + c$	**A1**	
11(c)	$(x-4)^2 + (y+6)^2 = 125$ oe, soi	**B1**	
	Uses *their* $y = \frac{3}{4}x + \frac{7}{2}$ to eliminate one unknown	**M1**	if correct implies **B1**
	Correct equation in one unknown $[BD^2 =](x-4)^2 + \left(\frac{3}{4}x + \frac{7}{2} + 6\right)^2 = 125$ oe	**A1**	
	Writes in solvable form: $25x^2 + 100x - 300 = 0$ oe	**A1**	
	Factorises or solves a correct 3-term quadratic	**A1**	
	(2, 5) and (–6, –1)	**A1**	If **B1, M0** award: **SC2** for identifying one correct point by inspection from the length equation and testing it in the correct equation of *CD* **and** **SC2** for identifying the second correct point by inspection from the length equation and testing it in the correct equation of *CD*

Question	Answer	Marks	Guidance
11(c)	**Alternative**		
	[BC =] $\sqrt{(4-(their\ -2))^2+(-6-(their\ 2))^2}$	**(B1)**	**FT** *their C*
	CD = $\sqrt{125\ - their 100}$	**(M1)**	**FT** *their* BC^2 providing 125 – *their* 100 > 0
	CD = 5	**(A1)**	
	$\begin{pmatrix}4\\3\end{pmatrix}+\begin{pmatrix}-2\\2\end{pmatrix}$ or $\begin{pmatrix}-4\\-3\end{pmatrix}+\begin{pmatrix}-2\\2\end{pmatrix}$ OR finds $25x^2 + 100x - 300 = 0$ oe	**(A2)**	**A1** for $\overrightarrow{CD_1}=\begin{pmatrix}4\\3\end{pmatrix}$ or $\overrightarrow{CD_2}=\begin{pmatrix}-4\\-3\end{pmatrix}$ soi OR **A1** for finds $(x+2)^2+\left(\frac{3}{4}x+\frac{7}{2}-2\right)^2=25$
	(2, 5) and (–6, –1)	**(A1)**	

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ADDITIONAL MATHEMATICS **0606/23**

Paper 2 **October/November 2022**

MARK SCHEME

Maximum Mark: 80

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

GENERIC MARKING PRINCIPLE 1: Marks must be awarded in line with: • the specific content of the mark scheme or the generic level descriptors for the question • the specific skills defined in the mark scheme or in the generic level descriptors for the question • the standard of response required by a candidate as exemplified by the standardisation scripts.
GENERIC MARKING PRINCIPLE 2: Marks awarded are always **whole marks** (not half marks, or other fractions).
GENERIC MARKING PRINCIPLE 3: Marks must be awarded **positively**: • marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate • marks are awarded when candidates clearly demonstrate what they know and can do • marks are not deducted for errors • marks are not deducted for omissions • answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.
GENERIC MARKING PRINCIPLE 4: Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.
GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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

MARK SCHEME NOTES

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

Types of mark

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

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

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

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

Abbreviations

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

Question	Answer	Marks	Guidance
1	$2x^2 - 8x + 3x - 12 * 3x^2 - 3x + 4x - 4$	B1	Correctly expands all brackets * is any inequality or equals sign
	$[0*]\ x^2 + 6x + 8$	B1	Collects terms to correct 3-term quadratic in solvable form
	$[0*](x+2)(x+4)$	M1	Factorises or solves *their* 3-term quadratic
	-4 and -2	A1	Correct critical values
	$-4 < x < -2$ mark final answer	A1	
2	$\frac{dy}{dx} = 2ax - 5$	B1	
	$2a \times 2 - 5 = 7$ oe	M1	**FT** *their* $\left(\frac{dy}{dx}\Big\vert_{x=2} \right) = 7$
	$a = 3$	A1	
	$7 \times 2 + b = their\ 4$ or $b = 2 - 4 \times their\ a$	M1	**dep** on previous **M1** where *their* 4 is an attempt to evaluate $y = ax^2 - 5x + 2$ using $x = 2$ and *their a*
	$b = -10$	A1	
	Alternative		
	$(-12)^2 - 4a(2-b) = 0$ oe	(B1)	for use of discriminant on $ax^2 - 12x + 2 - b = 0$
	$144 - 8a + 4a(4a - 22) = 0$ oe or $144 - (b+22)(2-b) = 0$ oe	(M1)	Condone one sign or arithmetic error
	$a^2 - 6a + 9\ [=0]$ oe or $b^2 + 20b + 100\ [=0]$ oe	(A1)	for correct 3-term quadratic in solvable form
	$a = 3$ and $b = -10$	(A2)	**A1** for $a = 3$ or $b = -10$

Question	Answer	Marks	Guidance
3	$\lg\left((2x-1)(x+2)\right)=\lg\frac{100}{4}$ oe or $10^2=4(2x-1)(x+2)$ oe	**M2**	**M1** for one log law correctly applied within a correct equation e.g. $\lg 4(2x-1)(x+2) \quad =2$
	$2x^2+3x-27[=0]$	**A1**	Collects terms to correct 3-term quadratic in solvable form
	$(2x+9)(x-3)[=0]$	**M1**	**dep** on at least **M1** previously awarded Factorises *their* $2x^2+3x-27$ or solves *their* $2x^2+3x-27=0$
	x = 3 indicated as only valid solution	**A1**	nfww
4(a)	$2k+6=8-16+6k+2$ oe	**M1**	For equating line to curve and substituting x = 2, or vice versa
	k = 3	**A1**	
4(b)	$x^3-4x^2+(2\times their\ k)x-4\ [=0]$ or $x^3-4x^2+6x-4\ [=0]$	**M1**	**FT** *their k* in correct cubic
	x^2-2x+2	**A2**	Correct quadratic factor from correct cubic **A1** for a quadratic factor with two terms correct, from correct cubic
	$(-2)^2-4(1)(2)<0$ oe or $4-8<0$ oe [and so x = 2 is the only solution]	**A1**	Uses discriminant correctly on the correct quadratic factor

Question	Answer	Marks	Guidance
5(a)	$\dfrac{\cos^2 x+(1-\sin x)^2}{(1-\sin x)\cos x}$ or $\dfrac{\cos^2 x}{(1-\sin x)\cos x}+\dfrac{(1-\sin x)^2}{(1-\sin x)\cos x}$	**M1**	Correctly takes common denominator
	$\dfrac{\cos^2 x+1-2\sin x+\sin^2 x}{(1-\sin x)\cos x}$	**A1**	OR $\dfrac{1-\sin^2 x+(1-\sin x)^2}{(1-\sin x)\cos x}$
	$\dfrac{1+1-2\sin x}{(1-\sin x)\cos x}$ or $\dfrac{1-\sin^2 x+1-2\sin x+\sin^2 x}{(1-\sin x)\cos x}$	**A1**	OR $\dfrac{(1-\sin x)(1+\sin x)+(1-\sin x)^2}{(1-\sin x)\cos x}$
	$\dfrac{2(1-\sin x)}{(1-\sin x)\cos x}=2\sec x$ or $\dfrac{2-2\sin x}{(1-\sin x)\cos x}=\dfrac{2}{\cos x}=2\sec x$ or equivalent	**A1**	All steps correct and final step justified OR $\dfrac{1+\sin x+1-\sin x}{\cos x}=2\sec x$
	Alternative ***Must work with LHS only***		
	$\dfrac{(\cos x)(1+\sin x)}{(1-\sin x)(1+\sin x)}+\dfrac{(1-\sin x)\cos x}{(\cos x)\cos x}$	**(M1)**	Forms fractions with common denominator in different form
	$\dfrac{(\cos x)(1+\sin x)}{\cos^2 x}+\dfrac{(1-\sin x)\cos x}{\cos^2 x}$	**(A1)**	Uses difference of two squares and $\sin^2 x+\cos^2 x=1$ to write fractions with a common denominator in the same form
	$\dfrac{2\cos x}{\cos^2 x}$	**(A1)**	Combine as a single fraction and collects terms
	$\dfrac{2}{\cos x}=2\sec x$	**(A1)**	All steps correct and final step justified
5(b)	$\cos^3\dfrac{\theta}{2}=\dfrac{1}{4}$	**B1**	
	$\cos\dfrac{\theta}{2}=\sqrt[3]{their\ \dfrac{1}{4}}$ soi	**M1**	**dep** on starting with $2\sec\dfrac{\theta}{2}=8\cos^2\dfrac{\theta}{2}$
	±101.9 awrt	**A2**	and no extras in range **A1** for either, ignoring extras in range If **A0** then **SC1** for ±102 with no extras in range

Question	Answer	Marks	Guidance
6	$81+108ax+54a^2x^2+12a^3x^3$ soi or $12a^3=\frac{3}{2}$ $b=108a$ $c=54a^2$ soi	M3	**M2** for any 3 correct terms or 2 correct equations or **M1** for any 2 correct terms, 1 correct equation or for correct but insufficiently simplified expansion e.g. $3^4+4\times3^3\times ax+\frac{4\times3}{2}\times3^2\times(ax)^2$ $+\frac{4\times3\times2}{3\times2}\times3\times(ax)^3$
	$a=\frac{1}{2}$ oe	A1	
	$b = 54$	A1	**FT** 108 × *their a*, providing at least **M1** awarded
	$c=\frac{27}{2}$ oe	A1	**FT** 54 × (*their a*)^2, providing at least **M1** awarded
7	${}^nC_4=\frac{n!}{(n-4)!4!}$ and ${}^nC_2=\frac{n!}{(n-2)!2!}$ soi	B1	
	$\frac{n(n-1)(n-2)(n-3)}{24}=\frac{13n(n-1)}{2}$ or $(n-2)(n-3)=\frac{13\times24}{2}$ oe, soi	M1	Writes in a correct form, free of factorials
	$n^2-5n-150$ $[=0]$	A1	
	$n = 15$ only, nfww	A1	**dep** on previous A1
	${}^{15}C_8=6435$ only	B1	
8(a)	(Velocity vector =) $\frac{26}{\sqrt{12^2+5^2}}\begin{pmatrix}12\\5\end{pmatrix}$ oe	M2	**M1** for $\sqrt{12^2+5^2}$ or 13 or 2 seen
	(Position vector =) $\begin{pmatrix}3\\-2\end{pmatrix}+t\begin{pmatrix}24\\10\end{pmatrix}$ oe	A1	

Question	Answer	Marks	Guidance
8(b)	(Direction vector =) $\begin{pmatrix}4\\3\end{pmatrix}$ soi or x component: $\cos\alpha = \frac{4}{5}$ y component: $\sin\alpha = \frac{3}{5}$ soi	**B1**	
	(Velocity vector =) $\frac{20}{\sqrt{4^2+3^2}} \times \textit{their}\begin{pmatrix}4\\3\end{pmatrix}$ oe soi or $20\begin{pmatrix}\textit{their}\cos\alpha\\ \textit{their}\sin\alpha\end{pmatrix}$ soi	**M1**	
	(Position vector =) $\begin{pmatrix}67\\-18\end{pmatrix}+t\begin{pmatrix}16\\12\end{pmatrix}$ oe	**A2**	**A1 FT** $\begin{pmatrix}67\\-18\end{pmatrix}+t\times\textit{their}\begin{pmatrix}16\\12\end{pmatrix}$ If zero scored, **SC2** for one correct component, either $67+16t$ or $-18+12t$
8(c)	$3+24t=67+16t$ oe or $-2+10t=-18+12t$ oe	**M1**	**FT** Equates *their x* components, or *their y* components from parts **(a)** and **(b)**, providing of equivalent difficulty, e.g. $a+bt=c+dt$
	t = 8	**A1**	**dep** on full marks in **(a)** and **(b)**
	(Position of meeting =) $\begin{pmatrix}195\\78\end{pmatrix}$	**A1**	**dep** on full marks in **(a)** and **(b)**
9(a)	$\frac{d}{dx}\left(e^{-2x}\right)=-2e^{-2x}$ soi	**B1**	
	$\frac{dy}{dx}=ke^{-2x}-2kxe^{-2x}$ oe, isw	**B1**	**FT** for use of product rule $k.e^{-2x}+kx.\left(\textit{their}\frac{d}{dx}\left(e^{-2x}\right)\right)$
	Alternative		
	$\frac{d}{dx}\left(e^{2x}\right)=2e^{2x}$ soi	**(B1)**	
	$\frac{dy}{dx}=\frac{ke^{2x}-2kxe^{2x}}{\left(e^{2x}\right)^2}$ oe, isw	**(B1)**	**FT** for use of quotient rule $\frac{k.e^{2x}-kx.\left(\textit{their}\ 2e^{2x}\right)}{\left(e^{2x}\right)^2}$

Question	Answer	Marks	Guidance
9(b)	Equates $\frac{dy}{dx} = 0$ and finds 10 – 20x = 0 oe	**M1**	**FT** *their* (a), provided of the form $me^{-2x} + nxe^{-2x}$ or $me^{2x} + nxe^{2x}$
	$\left(\frac{1}{2}, \frac{5}{e}\right)$ oe only	**A2**	For both values: $x = 0.5$ **and** $y = 5e^{-1}$ or 1.84 or 1.839[39...] rot to 4 or more sf **A1** for $x = \frac{1}{2}$ only
9(c)	$-2xe^{-2x} - e^{-2x} + c$	**B3**	For fully correct answer or **B2** for $-2xe^{-2x} - e^{-2x}$ or $\left[\int 4xe^{-2x}dx\right] = -2xe^{-2x} + \int 2e^{-2x}dx$ or **B1** for $kxe^{-2x} = \int\left(ke^{-2x} - 2kxe^{-2x}\right)dx$ or better
9(d)	$-2e^{-2} - e^{-2} - \left(0 - e^{0}\right)$ oe	**M1**	Correct substitution of limits into correct expression
	$1 - \frac{3}{e^2}$ or $1 - 3e^{-2}$	**A1**	
10(a)	$a + (3-1)d = 10$ soi	**B1**	
	$\frac{8}{2}\{2a + (8-1)d\} = 116$ soi	**B1**	
	Correct method to eliminate one unknown and attempt to solve to find a or d	**M1**	**dep** on at least **B1** awarded
	a = 4 and d = 3	**A2**	**A1** for either
10(b)	$S_{30} = \frac{30}{2}\{2(4) + 29(3)\}$ and $S_{11} = \frac{11}{2}\{2(4) + 10(3)\}$	**B2**	**M1 FT** *their a* and *their d* for $S_{30} = \frac{30}{2}\{2(\textit{their } 4) + 29(\textit{their } 3)\}$ or $S_{11} = \frac{11}{2}\{2(\textit{their } 4) + 10(\textit{their } 3)\}$
	Correct plan $S_{30} - S_{11}$ attempted	**M1**	**FT** *their a* and *their d*
	1216	**A1**	

Question	Answer	Marks	Guidance
10(b)	**Alternative 1**		
	first term = 4 + 11×3 or 37 and an attempt at S_{19}	**(M1)**	**FT** *their a* + 11×*their d*
	$\frac{19}{2}\{2(37)+(19-1)\times 3\}$ oe or $\frac{19}{2}\{37+91\}$ oe	**(B2)**	**M1 FT** for *their* first term and *their d* in $\frac{19}{2}\{2(\textit{their}\,37)+(19-1)\times \textit{their}\,3\}$ or for *their* first term and *their* last term in $\frac{19}{2}\{\textit{their}\,37+\textit{their}\,91\}$
	1216	**(A1)**	
	Alternative 2		
	Correct sum of terms: 37 + 40 + 43 + 46 + 49 + 52 + 55 + 58 + 61 + 64 + 67 + 70 + 73 + 76 + 79 + 82 + 85 + 88 + 91	**(M3)**	**M2 FT** *their a* and *their d* for sum starting with *their* 37 **and** ending with *their* 91, with at most one omission or error or **M1 FT** *their a* and *their d* for sum starting with *their* 37 **or** ending with *their* 91, with at most two omissions or errors
	1216	**(A1)**	
11(a)	$2\mathbf{a}+\lambda(3\mathbf{b}-2\mathbf{a})$ oe isw or $3\mathbf{b}-(1-\lambda)(3\mathbf{b}-2\mathbf{a})$ oe isw	**B3**	**B1** for $\overrightarrow{PS}=3\mathbf{b}-2\mathbf{a}$ soi and **B1** for correct route using λ, either $\overrightarrow{OX}=\overrightarrow{OP}+\lambda\overrightarrow{PS}$ soi or $\overrightarrow{OX}=\overrightarrow{OS}-(1-\lambda)\overrightarrow{PS}$ soi
11(b)	$\mu(5\mathbf{a}+2\mathbf{b})$ isw	**B2**	**B1** for $\overrightarrow{OQ}=3\mathbf{b}+5\mathbf{a}-\mathbf{b}$ oe soi
11(c)	$2-2\lambda=5\mu$ and $3\lambda=2\mu$ oe	**M2**	for correctly equating scalars for both components **FT** *their* **(a)** and **(b)** if possible **M1 FT** for equating scalars for either component
	Solves to find $\lambda=\frac{4}{19}$ or $\mu=\frac{6}{19}$	**A1**	
	$\lambda=\frac{4}{19}$ and $\mu=\frac{6}{19}$	**A1**	
11(d)	$\frac{6}{19}$ isw	**B1**	
11(e)	$\frac{4}{15}$ isw	**B1**	