Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/12**

Paper 1 **February/March 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 February/March 2023 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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Generic Marking Principles

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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

MARK SCHEME NOTES

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

Types of mark

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

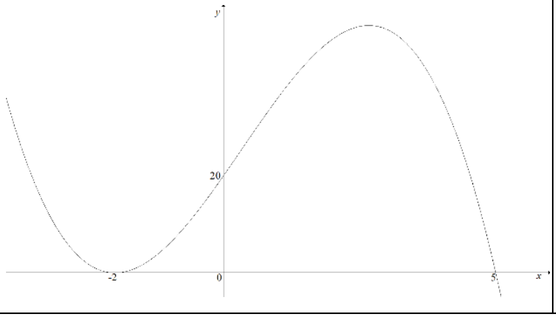
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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

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

Abbreviations

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

Question	Answer	Marks	Guidance
1	$kx^2+2x+3k-1\ [=0]$	2	**M1** for attempt to equate equations of the line and curve, re-arrange and equate to zero. Allow one sign error.
	$4=4k\times\ their(3k-1)$ oe	M1	**Dep** for attempt to use the discriminant of *their* quadratic equation and solve to obtain *k*.
	$k=\dfrac{1\pm\sqrt{13}}{6}$ isw	A1	
	Alternative method		
	$kx^2+2x+3k-1=0$	2	**M1** for attempt to equate equations of the line and curve, re-arrange and equate to zero. Allow one sign error.
	Grad of straight line = -1 Gradient function of curve = $2kx+1$ Substitution to obtain $3k^2-k-1=0$ oe with attempt to solve to obtain *k*	M1	**Dep**
	$k=\dfrac{1\pm\sqrt{13}}{6}$ isw	A1	
2(a)	$\dfrac{dy}{dx}=2(x+2)(5-x)+(-1)(x+2)^2$ or $y=-x^3+x^2+16x+20$ $\dfrac{dy}{dx}=-3x^2+2x+16$	2	**M1** for attempt at differentiation of a product, or expansion and then differentiation. **A1** for all correct
	$(x+2)(8-3x)=0$	M1	**Dep** for attempt to solve *their* quadratic $\dfrac{dy}{dx}=0$
	$x=-2,\ \dfrac{8}{3}$	A1	For both.
2(b)		3	**B1** for correctly shaped curve, with maximum point in the first quadrant **B1** for $(5,\ 0)$ and a stationary point at $(-2,\ 0)$, must have a cubic graph. **B1** for $(0,\ 20)$, must have a cubic graph

Question	Answer	Marks	Guidance
2(c)	When $x = \frac{8}{3}$, $y = \frac{1372}{27}$ or awrt 50.8	**M1**	For attempt to find the value of y using *their* $\frac{8}{3}$.
	$k > \frac{1372}{27}$ or awrt 50.8	**A1**	
	$k < 0$	**B1**	
3	${}^{10}C_2 (2x)^8 \left(-\frac{1}{x}\right)^2$ or ${}^{10}C_1 (2x)^9 \left(-\frac{1}{x}\right)^1$	**M1**	For attempting to find terms which will give terms of x^8 or x^6, allow coefficients. Allow as part of an expansion
	$45 \times 256 \left[x^6\right]$ oe	**A1**	
	$[-]$ 5120 $\left[x^8\right]$	**A1**	
	$their(-11520) + their(-5120)$	**M1**	**Dep**
	–16 640	**A1**	Condone inclusion of x^8
4(a)	$\lg \frac{x^3}{1000y^4}$ oe	**3**	**B1** for $3 = \lg 1000$ **M1** for correct use of power rule at least once and division rule at least once **A1** cao
4(b)	$\log_x 3 = \frac{1}{\log_3 x}$ soi	**B1**	For change of base.
	$2(\log_3 x)^2 - 5(\log_3 x) + 2 = 0$	**M1**	For attempt to obtain a 3-term quadratic equation, equated to zero. Allow one sign error. May be using a substitution.
	$2\log_3 x = 1$ $\log_3 x = 2$	**M1**	**Dep** for attempt to solve *their* quadratic equation and a correct attempt to obtain at least one value of x.
	$x = \sqrt{3}$ oe	**A1**	Allow 1.73(2…)
	$x = 9$	**A1**	

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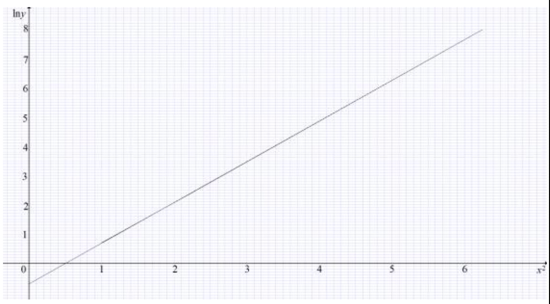
Question	Answer	Marks	Guidance
4(b)	**Alternative method 1**		
	$\log_3 x = \frac{1}{\log_x 3}$ soi	**B1**	For change of base.
	$2(\log_x 3)^2 - 5(\log_x 3) + 2 = 0$	**M1**	For attempt to obtain a 3-term quadratic equation, equated to zero. Allow one sign error.
	$2\log_x 3 = 1 \quad \log_x 3 = 2$	**M1**	**Dep** for attempt to solve *their* quadratic equation and a correct attempt to obtain at least one value of *x*.
	$x = \sqrt{3}$ oe	**A1**	Allow 1.73(2…)
	$x = 9$	**A1**	
	Alternative method 2		
	$\log_3 x = \frac{\lg x}{\lg 3}$ and $\log_x 3 = \frac{\lg 3}{\lg x}$ oe	**B1**	For a consistent change of base.
	$2(\lg x)^2 - 5(\lg x) + 2(\lg 3)^2 = 0$ oe	**M1**	For attempt to obtain a 3-term quadratic equation, equated to zero. Allow one sign error.
	$2\lg x = \lg 3 \;\; \lg x = 2\lg 3$ oe	**M1**	**Dep** for attempt to solve *their* quadratic equation and a correct attempt to obtain at least one value of *x*.
	$x = \sqrt{3}$ oe	**A1**	Allow 1.73(2…)
	$x = 9$ oe	**A1**	
5(a)		2	**B1** for 3 or 4 correctly plotted points

Question	Answer	Marks	Guidance
5(b)	$\ln y = mx^2 + c$ soi	**B1**	$m \neq \ln A,\ c \neq \ln b$
	Gradient = $\ln b$	**M1**	For attempt to find the numerical gradient of *their* straight line graph and equate to $\ln b$. May be implied by later work
	$b = 4$	**A1**	
	Intercept on vertical axis = $\ln A$	**M1**	For use of *their* intercept on the vertical axis of *their* straight line graph oe.
	$A = 0.5$	**A1**	
	Alternative method		
	$\ln y = mx^2 + c$ soi	**B1**	$m \neq \ln A,\ c \neq \ln b$
	Forming 2 equations correctly using points on *their* graph	**M1**	
	Solving the equations to obtain either A or b	**M1**	**Dep**
	$b = 4$	**A1**	
	$A = 0.5$	**A1**	
	Special case		
	$A = 0.5$ not using transformed data	**B1**	
	$b = 4$ not using transformed data	**B1**	
5(c)	35 nfww Allow answers between 33 and 37	**2**	**M1** for attempt at a complete method using *their* straight line graph or equation
5(d)	1.63 nfww Allow answers between 1.5 and 1.7	**2**	**M1** for attempt at a complete method using *their* straight line graph or equation

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Question	Answer	Marks	Guidance
6	$k(5x+2)^{\frac{3}{5}}$	**M1**	
	$f'(x) = \frac{1}{3}(5x+2)^{\frac{3}{5}} \quad (+c)$	**A1**	Condone omission of *c*
	$\frac{17}{3} = \frac{1}{3}(32)^{\frac{3}{5}} + c$ oe	**M1**	**Dep** for use of $f'(6)$ and attempt to evaluate *c*
	$c = 3$	**A1**	
	$k(5x+2)^{\frac{8}{5}}$	**M1**	
	$\frac{1}{24}(5x+2)^{\frac{8}{5}} + cx$	**A1**	**FT** on *their c*
	$\frac{26}{3} = \frac{1}{24}(32)^{\frac{8}{5}} + d + ((3\times 6))$ oe	**M1**	**Dep** for use of $f(6)$ and attempt to evaluate *d*.
	$[f(x)] = \frac{1}{24}(5x+2)^{\frac{8}{5}} + 3x - 20$	**A1**	
7(a)(i)	154 440	**B1**	
7(a)(ii)	124 200	**2**	**B1** for ${}^{10}P_5$
	Alternative method		
	124 200	**2**	**B1** for 1 symbol: 75 600 2 symbols: 43 200 3 symbols: 5400
7(b)	$16(n-11) = 12(n+1)$ oe	**B2**	**B1** for correct numbers or correct factors must be using combinations
	$n = 47$	**B1**	**Dep** on both previous **B** marks Must be the only solution

Question	Answer	Marks	Guidance
8	$A\ (2.5,\ 0)$ soi	**B1**	
	$C\ (4.5,\ 0)$ soi	**B1**	
	$2x^2 + x - 21 = 0$	**M1**	For a correct attempt to find the intersection of the straight line and the curve. Must have attempt to solve the resulting quadratic equation to obtain *x* = .
	$x = 3,\ \left[-\frac{7}{2}\right]$	**A1**	
	$B\left(3,\ \frac{1}{2}\right)$ soi	**A1**	
	$\int\left(2 - \frac{3}{x-1}\right)\mathrm{d}x = 2x - 3\ln(x-1)$	**B1**	
	e.g. $\left[2x - 3\ln(x-1)\right]_{\frac{5}{2}}^{3} =$ $(6 - 3\ln 2) - \left(5 - 3\ln\frac{3}{2}\right)$	**M1**	**Dep** for application of appropriate limits e.g. $x = their\ \frac{5}{2}$ and $x = their\ 3$ $x = their\ \frac{5}{2}$ and $x = their\ \frac{9}{2}$ $x = their\ 3$ and $x = their\ \frac{9}{2}$ Integral must be in the form $ax + b\ln(x-1)$
	$1 + 3\ln\frac{3}{4}$ oe	**A1**	
	Area of an appropriate triangle	**B1**	**FT** on $\frac{1}{2} \times their\ \frac{1}{2} \times their\ \frac{3}{2}$ oe $\frac{1}{2} \times their\ 2 \times their\ \frac{2}{3}$ oe Must be appropriate for *their* method
	Area = $\frac{11}{8} + \ln\frac{27}{64}$	**2**	**B1** for each correct term
9(a)(i)	$\begin{pmatrix} 2 \\ 5 \end{pmatrix}$	**B1**	
9(a)(ii)	Velocity vector = $\begin{pmatrix} 12 \\ -5 \end{pmatrix}$ soi by correct speed	**B1**	
	Speed = 13	**B1**	

Question	Answer	Marks	Guidance
9(a)(iii)	$2+12t=158$ and $5-5t=-48$ $t=13,\ t=10.6$ soi	**M1**	Either for finding two values of *t* or for finding one value of *t* and substitute to obtain a position vector.
	Times are different so *P* does not pass through the given point or time calculated gives an inconsistent position vector	**A1**	For a valid conclusion
9(b)	$\overrightarrow{AB}=\mathbf{b}-\mathbf{a}$ and $\overrightarrow{AC}=\mathbf{c}-\mathbf{a}$	**B1**	
	$4(\mathbf{b}-\mathbf{a})=\mathbf{c}-\mathbf{a}$ oe	**M1**	For substitution into a valid equation from *their* ratio. **FT** on *their* $\overrightarrow{AB}$ and *their* $\overrightarrow{AC}$
	$\mathbf{c}=4\mathbf{b}-3\mathbf{a}$	**A1**	
	Alternative method		
	$\overrightarrow{AB}=\mathbf{b}-\mathbf{a}$ and $\overrightarrow{AC}=4\mathbf{b}-4\mathbf{a}$ oe	**B1**	
	$\left(\overrightarrow{OC}=\right)$ $\mathbf{c}=\mathbf{a}+4\mathbf{b}-4\mathbf{a}$	**M1**	**FT** on *their* $\overrightarrow{AB}$ and *their* $\overrightarrow{AC}$
	$\mathbf{c}=4\mathbf{b}-3\mathbf{a}$	**A1**	
10(a)	$\cos\theta=x-2$ and $\sin\theta=\dfrac{2}{y}$ soi	**B1**	
	$(x-2)^2+\dfrac{4}{y^2}=1$	**M1**	For a correct attempt to use $\cos^2\theta+\sin^2\theta=1$ or other relevant identity
	$y^2=\dfrac{4}{1-(x-2)^2}$ oe	**M1**	**Dep** for attempt to rearrange to obtain y^2
	$y=\dfrac{2}{\sqrt{1-(x-2)^2}}$ or $\dfrac{2}{\sqrt{4x-x^2-3}}$ oe	**A1**	Must be positive
	Alternative method		
	$\theta=\cos^{-1}(x-2)$ and $\theta=\sin^{-1}\left(\dfrac{2}{y}\right)$	**B1**	
	$\cos^{-1}(x-2)=\sin^{-1}\left(\dfrac{2}{y}\right)$	**M1**	
	$y=\dfrac{2}{\sin\left(\cos^{-1}(x-2)\right)}$	**2**	**Dep M1** for correct attempt to rearrange to obtain *y* = ...

Question	Answer	Marks	Guidance
10(b)	$\tan\frac{\phi}{2}=\sqrt{3}$ or $\sin\frac{\phi}{2}=\frac{\sqrt{3}}{2}$ or $\cos\frac{\phi}{2}=\frac{1}{2}$	**B1**	
	$\frac{\phi}{2}=\frac{\pi}{3}$ or awrt 1.05	**M1**	**Dep** for a correct attempt to solve *their* equation, must be using $\frac{\phi}{2}$.
	$\phi=\frac{2\pi}{3}$ or awrt 2.09	**M1**	**Dep** for correct order of operations, may be implied by one correct solution.
	$\phi=-\frac{10\pi}{3},-\frac{4\pi}{3},\frac{2\pi}{3},\frac{8\pi}{3}$ or $-10.5,\ -4.19,\ 2.09,\ 8.38$	**A2**	**A1** for a correct pair of solutions. **A1** for a second correct pair of solutions and no extra solutions within the range. Allow greater accuracy if decimals used.