GradeMax

CAMBRIDGE
International Education

# Cambridge IGCSE™

**ADDITIONAL MATHEMATICS** **0606/22**

Paper 2 **February/March 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 February/March 2024 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 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.

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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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## 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<br>and<br>$8 - 4x = -10$ oe soi<br><br>OR<br>$16x^2 - 64x - 36[=0]$ oe | **M1** | |
| | $x = -\frac{1}{2},\ x = \frac{9}{2}$ | **A2** | mark final answer<br><br>**A1** for $x = -\frac{1}{2}$ or $x = \frac{9}{2}$ |
| 1(b) | $-30x^2 + 105x - 75$ [*0] oe<br>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** | |
| | $[20\times]\frac{1+7\sqrt{5}}{4+2\sqrt{5}}\times\frac{4-2\sqrt{5}}{4-2\sqrt{5}}$<br>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 |
| | $\frac{20(28\sqrt{5}-70+4-2\sqrt{5})}{16-20}$<br>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:<br>$20+140\sqrt{5} = 4a+4b\sqrt{5}+2a\sqrt{5}+10b$ | **(M1)** | condone one sign or arithmetic error |
| | Correct pair of simultaneous equations<br>$4a + 10b = 20$ oe $2a + 4b = 140$ oe<br>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<br>or for $3(\overrightarrow{OP} - \mathbf{a}) = \mathbf{b} - \overrightarrow{OP}$ oe |

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

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| Question | Answer | Marks | Partial Marks |
|---|---|---|---|
| 7(a) | Correctly eliminates $x$ or $y$ e.g.<br>$4x^2 - 3\left(\frac{2}{x}\right)^2 + x\left(\frac{2}{x}\right) = 24$ oe or<br>$4\left(\frac{2}{y}\right)^2 - 3y^2 + y\left(\frac{2}{y}\right) = 24$ oe | **M1** | |
| | Rearranges to a 3-term quadratic in $x^2$ or $y^2$ soi e.g.<br>$4x^4 - 22x^2 - 12[=0]$ or $2x^4 - 11x^2 - 6[=0]$<br>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.<br>$(2x^2 + 1)(x^2 - 6)$ 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;<br>**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<br>$x$: 1, 3, 5, 10, 12<br>lg$y$: 1.6, 2.2, 2.8, 4.3, 4.9<br>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 |

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| 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* = ]<br>$x + 0.5x + 2 + 2(x+2) + (x+2-y) + y + y$ | **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<br>leading to given answer<br>$A = \frac{91}{8}x^2 - 68x + 132$ | **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<br>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<br>30.4 or 30.37[36...] rot to 4 or more sf | **A1** | |

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| 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.<br>$\frac{a^{n-2}}{a^{\frac{3}{4}n}} = \frac{48}{n}$ | **M1** | **dep** previous **M1** |
| | Simplifies $a$ terms e.g.<br>$a^{\frac{n}{4}-2} = \frac{48}{n}$ 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.<br>$\left(a^{\frac{n}{4}-2}\right)^2 = \left(\frac{48}{n}\right)^2$ or $\left(a^{\frac{3n}{4}-6}\right)^{\frac{2}{3}} = \left(\frac{48}{n}\right)^{3\times\frac{2}{3}}$<br>→ $a^{\frac{n}{2}-4} = \left(\frac{48}{n}\right)^2$ | **A1** | |
| 10(b) | Correct equation in $a$, $b$, $n$<br>$\frac{n(n-1)}{2} \times a^{n-2} \times \frac{1}{a^2} = 1056b^2$ oe, soi | **M1** | |
| | Correct equation in $a$, $n$<br>$\frac{n(n-1)}{2} \times a^{n-2} \times \frac{1}{a^2} = 1056a^{\frac{n}{2}}$ oe | **A1** | |
| | $\left[\frac{n(n-1)}{2} \times a^{\frac{n}{2}-4} = 1056 \text{ oe} \rightarrow\right]$<br><br>Correct equation in $n$ only<br>$\frac{n(n-1)}{2} \times \left(\frac{48}{n}\right)^2 = 1056$ 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** | |

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