Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/22**

Paper 2 **February/March 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 February/March 2022 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **12** printed pages.

Generic Marking Principles

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

Maths-Specific Marking Principles	
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

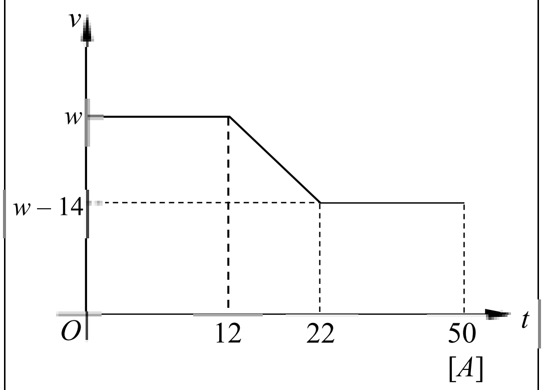
Question	Answer	Marks	Partial Marks
1	Mid-point: $\left(-\frac{5}{2}, 8\right)$ soi	**B1**	
	Gradient: $-\frac{4}{5}$ soi or substitution of mid-point into e.g. $4x+5y=k$	**B1**	
	$y-8=-\frac{4}{5}\left(x+\frac{5}{2}\right)$ or $4x+5y=30$ oe, isw	**B1**	
2	$\log_5\left(\frac{8x+7}{2x}\right)=2$ or $\log_5\left(\frac{8x+7}{2x}\right)=\log_5 25$	**M1**	
	$\frac{8x+7}{2x}=5^2$ oe	**M1**	
	correct completion to $x=\frac{1}{6}$ oe, isw	**A1**	
3(a)	[7! =] 5040	**B1**	
3(b)	3! × 5! oe	**M1**	
	720	**A1**	
3(c)	5040 – (2! × 6!) oe	**M1**	
	3600	**A1**	
4	Eliminates one unknown e.g. $\frac{x^2}{4}+\frac{1}{9}\left(\frac{3}{2x}\right)^2=1$	**M1**	
	Rearranges to solvable form e.g. $x^4-4x^2+1=0$	**A1**	
	Solves : $\frac{-(-4)\pm\sqrt{(-4)^2-4(1)(1)}}{2}$	**M1**	**dep** on attempt to eliminate one unknown and having a 3-term quadratic in x^2
	$x^2=2\pm\sqrt{3}$ oe isw or 3.7320[5...] and 0.2679[4...]	**A1**	
	$x=\pm 1.932$ or $x=\pm 0.518$	**A1**	

Question	Answer	Marks	Partial Marks
5(a)	$f(x)=(x-1)(x-4)$ oe and $f(x)=-(x-1)(x-4)$ oe	**B2**	**B1** for either correct
5(b)	Factorised form: $(5x-1)(x-n)(x-(n+1))$ oe	**B1**	
	their $-1\times(-n)\times(-(n+1))=-2$	**M1**	
	$n = -2$ as the only valid solution	**A1**	
	Multiplies out $(5x-1)(x+2)(x+1)$	**M1**	
	$5x^3+14x^2+7x-2$ or a = 14 and b = 7 following $n = -2$	**A1**	
	Alternative method 1:		
	Factorised form: $(5x-1)(x-n)(x-(n+1))$ oe	**(B1)**	
	Multiplies out $5x^3+(-10n-6)x^2+(5n^2+7n+1)x$ $-(n^2+n)$	**(M1)**	
	their $(n^2+n)=2$ oe	**(M1)**	
	$n = -2$ as the only valid solution	**(A1)**	
	$5x^3+14x^2+7x-2$ or a = 14 and b = 7 following $n = -2$	**(A1)**	

Question	Answer	Marks	Partial Marks
5(b)	**Alternative method 2:**		
	Using product of roots: $\frac{1}{5}n(n+1)=-\left(\frac{-2}{5}\right)$ oe	**(M1)**	
	$n = -2$ as the only valid solution	**(A1)**	
	Using sum of roots and/or sum of products of pairs of roots, solves to find a or b: $\frac{1}{5}+n+n+1=-\frac{a}{5}$ oe and/or $\frac{1}{5}(n)+n(n+1)+\frac{1}{5}(n+1)=\frac{b}{5}$	**(M1)**	
	$a = 14$ or $b = 7$	**(A1)**	
	$5x^3+14x^2+7x-2$ or $a = 14$ and $b = 7$ following $n = -2$	**(A1)**	
			If 0 scored for any method, **SC3** for $5\left(\frac{1}{5}\right)^3+a\left(\frac{1}{5}\right)^2+b\left(\frac{1}{5}\right)-2=0$ oe **and** $5n^3+an^2+bn-2=0$ oe or $5(n+1)^3+a(n+1)^2+b(n+1)-2=0$ oe leading to $a = 14$, $b = 7$ with $n = -1$ or n not stated or **SC1** for $5\left(\frac{1}{5}\right)^3+a\left(\frac{1}{5}\right)^2+b\left(\frac{1}{5}\right)-2=0$ oe or $5n^3+an^2+bn-2=0$ oe or or $5(n+1)^3+a(n+1)^2+b(n+1)-2=0$ oe
6(a)(i)	$1+21x+189x^2+945x^3$	**B2**	**B1** for three out of the four terms correct or for a correct answer seen then spoilt If 0 scored then **SC1** for $1, 21x, 189x^2, 945x^3$ seen but not summed
6(a)(ii)	$1+21(0.01)+189(0.01)^2+945(0.01)^3$ or 1 + 0.21 + 0.0189 + 0.000945 oe leading to 1.229[845 = 1.23] cao	**B2**	**M1** for use of $x=0.01$ oe in *their* expansion seen or implied by e.g. $1+21(0.01)+189(0.01)^2+945(0.01)^3$ or 1 + 0.21 + 0.0189 + 0.000945 OR 1.229845 without working or from working that is not fully correct

Question	Answer	Marks	Partial Marks
6(b)	${}^{15}C_{12} \times \left(\frac{x^4}{2}\right)^3 \times \left(\frac{2}{x}\right)^{12}$ oe	**M1**	
	232960	**A1**	
7(a)	Uses a valid Pythagorean identity to write in terms of a single trig ratio e.g. $1+\tan^2\theta = \tan\theta + 3$	**B1**	
	Rearranges and factorises/solves e.g. $\tan^2\theta - \tan\theta - 2 = 0$ $(\tan\theta - 2)(\tan\theta + 1) = 0$	**M1**	
	$\tan\theta = 2 \quad \tan\theta = -1$ soi	**A1**	
	1.11, –2.03, $-\frac{\pi}{4}, \frac{3\pi}{4}$ and no extras in range cao	**A2**	**A1** for any 3 correct, ignoring extras
7(b)	Use of $\tan\phi = \frac{\sin\phi}{\cos\phi}$ in a correct expression or correct working	**M1**	
	Use of $1 - \cos^2\phi = \sin^2\phi$ in a correct expression or correct working	**M1**	
	Completion with $\frac{1}{\cos\phi} = \sec\phi$	**A1**	nfww
7(c)	$\cot x = [-]\sqrt{\operatorname{cosec}^2 x - 1}$ soi or $\sin x = -\frac{8}{17}$ and $\tan x = -\frac{8}{15}$ soi or $\sin x = -\frac{8}{17}$ and $\cos x = \frac{15}{17}$ soi or $\frac{1}{\tan\left(\sin^{-1}\left(-\frac{8}{17}\right)\right)}$	**M1**	
	$-\frac{15}{8}$ or –1.875 cao, isw	**A1**	

Question	Answer	Marks	Partial Marks
8(a)	[Area of sector =] $\frac{1}{2}(15)^2\left(\frac{\pi}{6}\right)$ soi	B1	
	[Area of triangle =] $\frac{1}{2}(15)(15-a)\sin\left(\frac{\pi}{6}\right)$ soi	B1	
	Forms correct equation and attempts to solve for a or $15-a$ or OC e.g. $\frac{1}{2}(15)^2\left(\frac{\pi}{6}\right)-\frac{15(15-a)}{4}=\frac{15(15-a)}{4}$ or $\frac{75\pi}{8}=\frac{15}{4}OC$ and solves as far as $a = \ldots$ or $15-a=\ldots$ or $OC=\ldots$	M1	
	$15-\frac{5}{2}\pi$ (cm) or exact equivalent	A1	
8(b)	[CA + arc AB + BC =] $\sqrt{15^2+\left(\frac{5}{2}\pi\right)^2-2\times15\times\frac{5}{2}\pi\times\cos\frac{\pi}{6}}$ $+\left(15\times\frac{\pi}{6}\right)+\left(15-\frac{5}{2}\pi\right)$ oe, soi	M2	**FT** *their*$(15-\frac{5}{2}\pi)$ and $\frac{5}{2}\pi$ **M1** for $15\times\frac{\pi}{6}$ oe seen or $\sqrt{15^2+\left(\frac{5}{2}\pi\right)^2-2\times15\times\frac{5}{2}\pi\times\cos\frac{\pi}{6}}+\left(15-\frac{5}{2}\pi\right)$ oe seen
	24.1 (cm)	A1	

Question	Answer	Marks	Partial Marks
9(a)	Correct *v*-*t* graph soi e.g. 	**B1**	
	Equates 'area' and distance e.g. $12w+\frac{1}{2}\times10\times(w+w-14)+28(w-14)=458$	**M2**	implies **B1** **M1** for $12w + ... + 28(w-14) = 458$ soi or $12w + 70 + 10(w-14) + ... = 458$ soi or $... + 70 + 10(w-14) + 28(w-14) = 458$
	18.4 (m s^{-1})	**A1**	
9(b)(i)	$v=t^2-9t+20$, $a=2t-9$ or $a = t-5+t-4$ from product rule	**M1**	
	$t = 4.5$	**A1**	
9(b)(ii)	Critical values 4, 5	**M1**	
	$4 < t < 5$	**A1**	
9(b)(iii)	$\int_0^4(t^2-9t+20)\,\mathrm{d}t+\left\vert\int_4^5(t^2-9t+20)\,\mathrm{d}t\right\vert$ oe, soi	**M1**	**FT** *their* $t^2-9t+20$ providing 3 terms
	$\left[\frac{t^3}{3}-\frac{9t^2}{2}+20t\right]_0^4+\left\vert\left[\frac{t^3}{3}-\frac{9t^2}{2}+20t\right]_4^5\right\vert$	**B1**	
	$\frac{64}{3}-72+80+\left\vert\frac{125}{3}-\frac{225}{2}+100-\left(\frac{64}{3}-72+80\right)\right\vert$	**M1**	**dep** on an attempt to integrate
	$\frac{59}{2}$ oe or 29.5	**A1**	

Question	Answer	Marks	Partial Marks
10(a)	$\overrightarrow{PQ} = 5\mathbf{i} + 15\mathbf{j}$ or $\overrightarrow{OQ} - \overrightarrow{OP} = 5\left(\overrightarrow{OR} - \overrightarrow{OP}\right)$	**B1**	
	$\overrightarrow{OR} = 3\mathbf{i} - 2\mathbf{j} + \frac{1}{5}(their(5\mathbf{i} + 15\mathbf{j}))$ or $\overrightarrow{OR} = x\mathbf{i} + y\mathbf{j}$ $\overrightarrow{PR} = \mathbf{i} + 3\mathbf{j}$ and $\overrightarrow{PR} = (x-3)\mathbf{i} + (y+2)\mathbf{j}$ $x - 3 = 1$ and $y + 2 = 3$ oe or $5\overrightarrow{OR} = \overrightarrow{OQ} + 4\overrightarrow{OP} = 8\mathbf{i} + 13\mathbf{j} + 4(3\mathbf{i} - 2\mathbf{j})$ oe	**M1**	**FT** $\overrightarrow{PR} = \frac{1}{5}(their(5\mathbf{i} + 15\mathbf{j}))$
	$\overrightarrow{OR} = 4\mathbf{i} + \mathbf{j}$	**A1**	
	$\left\|their\ \overrightarrow{OR}\right\| = \sqrt{their(4^2) + their(1^2)}$	**M1**	**FT** *their* $a\mathbf{i} + b\mathbf{j}$
	$\frac{4\mathbf{i} + \mathbf{j}}{\sqrt{17}}$ oe	**A1**	
10(b)	$\overrightarrow{RS} = \lambda\mathbf{j} - their(4\mathbf{i} + \mathbf{j}) = -4\mathbf{i} + (\lambda - 1)\mathbf{j}$ soi or finds [equation RS is] $y = 3x + c$	**M1**	
	Correct method to find λ: $\frac{-4}{5} = \frac{\lambda - 1}{15}$ oe or [for some scalar t, $t(\lambda - 1) = 15$ and $-4t = 5$, therefore] $-\frac{5}{4}(\lambda - 1) = 15$ oe or finds e.g. $-2 = 3(3) + c$ oe	**M1**	**dep** on prev **M1** **FT** *their* $\overrightarrow{PQ}$
	$\lambda = -11$ cao	**A1**	

Question	Answer	Marks	Partial Marks
11	Length of rectangle: $6 + e^3$ or $\left[(6+e^3)x\right]_0^2$	M1	
	Area of rectangle: $2(6 + e^3)$ soi	A1	
	Area between curve and x-axis: $\int_0^2 (6+e^{4x-5})\,dx = \left[6x+\frac{1}{4}e^{4x-5}\right]_0^2$	M2	**M1** for $\frac{1}{4}e^{4x-5}$
	Correct use of limits in *their* $6x+\frac{1}{4}e^{4x-5}$: $F(2) - F(0)$	M1	dep on an attempt to integrate that results in $ax + be^{4x-5}$
	their area of rectangle – *their* area between curve and x-axis	M1	dep on an attempt to integrate using correct limits
	$\frac{7}{4}e^3+\frac{1}{4e^5}$ or 35.2 or 35.15.... isw	A1	nfww
11	**Alternative method**		
	Length of rectangle: $6 + e^3$ soi	(M1)	
	$\int_0^2 \left(their(6+e^3)-(6+e^{4x-5})\right)dx$	(M1)	
	$\int_0^2 \left((6+e^3)-(6+e^{4x-5})\right)dx$ oe	(A1)	
	$\int_0^2 (e^3-e^{4x-5})\,dx = \left[e^3x-\frac{1}{4}e^{4x-5}\right]_0^2$ oe	(M2)	**M1** for $\frac{1}{4}e^{4x-5}$
	Correct use of limits in *their* $e^3x-\frac{1}{4}e^{4x-5}$ $F(2) - F(0)$	(M1)	dep on an attempt to integrate that results in $ax + be^{4x-5}$; may be unsimplified
	$\frac{7}{4}e^3+\frac{1}{4e^5}$ or 35.2 or 35.151374.... rot to 4 or more sf	(A1)	nfww

Question	Answer	Marks	Partial Marks
12(a)	$\frac{PQ}{8}=\frac{12-h}{12}$ oe or $\left(\frac{12-h}{12}\right)^2=\frac{\text{Area } \Delta PQR}{16\sqrt{3}}$ oe	**M1**	
	$PQ=\frac{8(12-h)}{12}$ oe or Area $\Delta PQR=16\sqrt{3}\left(\frac{12-h}{12}\right)^2$ oe	**A1**	
	$V=\frac{1}{2}\times\left(\frac{8(12-h)}{12}\right)^2\times\sin\frac{\pi}{3}\times h$ oe or $16\sqrt{3}\left(\frac{12-h}{12}\right)^2\times h$	**M1**	**FT** *their* PQ or Area ΔPQR providing of correct structure
	$V=\frac{\sqrt{3}}{9}\left(h^3-24h^2+144h\right)$	**A1**	
12(b)	$\frac{dV}{dh}=\frac{\sqrt{3}}{9}\left(3h^2-48h+144\right)$	**B1**	**FT** *their* $V=\frac{\sqrt{3}}{9}\left(h^3-24h^2+144h\right)$ if of the same structure
	their $\frac{\sqrt{3}}{9}\left(3h^2-48h+144\right)=0$ and factorises/solves	**M1**	must be a 3-term quadratic; must be an attempt at a derivative
	4 oe identified as the only solution; cao	**A1**	