Cambridge Assessment International Education

Cambridge IGCSE™

ADDITIONAL MATHEMATICS **0606/12**

Paper 12 **March 2020**

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 March 2020 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **10** printed pages.

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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.

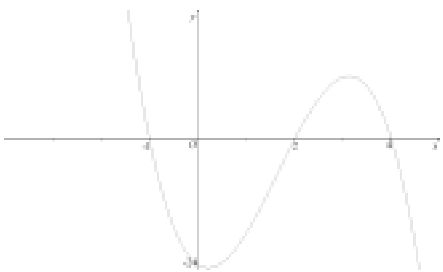
A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.

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(a)		3	**B1** For correct shape with minimum point in the fourth quadrant and the maximum point in the first quadrant. Ends of the curve must be in the 2nd and 4th quadrants **B1** for correct x- intercepts $(-1,0)$, $(2,0)$, $(4,0)$ **B1** for correct y-intercept $(0,-24)$
1(b)	$x < -1$	**B1**	
	$2 < x < 4$	**B1**	

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Question	Answer	Marks	Guidance
2	$2x^2 + 4x + k - 1 = kx + 3$ $2x^2 + (4-k)x + (k-4) = 0$	2	**M1** for attempt to equate the line and curve and simplify to a 3 term quadratic equation = 0 **A1** for a correct equation, allow equivalent form
	$(4-k)^2 = 4\times 2\times (k-4)$	M1	Use of discriminant in any form
	$k^2 - 16k + 48 = 0$ $k = 12$, $k = 4$ Do not isw	2	Dep **M1** on previous M mark, for attempt to solve a quadratic equation in *k* **A1** for both
	Alternative 1		
	$2x^2 + 4x + k - 1 = kx + 3$ $2x^2 + (4-k)x + (k-4) = 0$	**(2**	**M1** for attempt to equate the line and curve and simplify **A1** for a correct equation, allow equivalent form
	$k = 4x + 4$ $2\left(\frac{k-4}{4}\right)^2 + (4-k)\left(\frac{k-4}{4}\right) + (k-4) = 0$	**M1**	Equating gradients and substitution to obtain a quadratic equation in terms of *k*
	$k^2 - 16k + 48 = 0$ $k = 12$ and $k = 4$ Do not isw	**2)**	Dep **M1** on previous M mark, for attempt to solve a quadratic equation in *k* **A1** for both
	Alternative 2		
	$2x^2 + 4x + k - 1 = kx + 3$ $2x^2 + (4-k)x + (k-4) = 0$	**(2**	**M1** for attempt to equate the line and curve and simplify **A1** for a correct equation, allow equivalent form
	$k = 4x + 4$ $2x^2 - 4x = 0$ $x = 0,\ 2$	**M1**	Equating gradients and substitution to obtain a quadratic equation in terms of *x* and solution of this equation to obtain 2 *x* values
	$k = 4x + 4$ $k = 12$ and $k = 4$ Do not isw	**2)**	Dep **M1** on previous M mark, for substitution of their *x* values to obtain *k* values **A1** for both

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Question	Answer	Marks	Guidance
3	$b = 243$	**B1**	Must be evaluated
	${}^5C_1 \times 3^4 \times (-a) = -81$	**M1**	Allow equivalent with no negative signs, allow sign error
	$a = \frac{1}{5}$ oe	**A1**	
	${}^5C_2 \times 3^3 \times (-a)^2$	**M1**	Allow with *their* a^2
	$c = \frac{54}{5}$ or 10.8 oe	**A1**	Must be from correct working
4	$\frac{dy}{dx} = \frac{6x}{3x^2 - 4} - \frac{x^2}{2}$	2	**M1** for attempt to differentiate, must have at least one term correct **A1** All correct
	When $x = 2$, $\frac{dy}{dx} = -\frac{1}{2}$	**B1**	
	When $x = 2$, $y = \ln 8 - \frac{4}{3}$, or exact equivalent	**B1**	Allow $\ln 8 - \frac{8}{6}$
	Equation of tangent $y - \left(\ln 8 - \frac{4}{3}\right) = -\frac{1}{2}(x - 2)$ oe	**M1**	Dep on first M mark, allow unsimplified, allow use of decimals
	$\left(0,\ \ln 8 - \frac{1}{3}\right)$, or exact equivalent	**A1**	Allow $x = 0, y = \ln 8 - \frac{1}{3}$
5(a)	$\frac{1}{2}(5 - \sqrt{3})(2 + 4\sqrt{3})$ $\frac{1}{2}(10 - 2\sqrt{3} + 20\sqrt{3} - 12)$	**M1**	Need to see $\frac{1}{2}(10 - 18\sqrt{3} - 12)$ or $(5 - 9\sqrt{3} - 6)$ minimum for M1
	$9\sqrt{3} - 1$	**A1**	
5(b)	$\tan ABC = \frac{5 - \sqrt{3}}{1 + 2\sqrt{3}} \times \frac{1 - 2\sqrt{3}}{1 - 2\sqrt{3}}$ $= \frac{5 - \sqrt{3} - 10\sqrt{3} + 6}{1 - 12}$	**M1**	Attempt at trig ratio and attempt to rationalise. Need to see $5 - 11\sqrt{3} + 6$ in the numerator as a minimum for M1 Allow one error only
	$= \sqrt{3} - 1$	2	**A1** for $\sqrt{3}$, **A1** for -1

Question	Answer	Marks	Guidance
5(c)	$\sec^2 ABC = \tan^2 ABC + 1$ $= \left(\sqrt{3}-1\right)^2 + 1$ oe	M1	Allow use of correct identity with *their* (b)
	$= 5 - 2\sqrt{3}$	A1	
	Alternative		
	$\sec^2 ABC = \left(\dfrac{\sqrt{\left(5-\sqrt{3}\right)^2 + \left(1+2\sqrt{3}\right)^2}}{1+2\sqrt{3}}\right)^2$ leads to $\dfrac{41-6\sqrt{3}}{13+4\sqrt{3}}$ leads to $\dfrac{533+72-242\sqrt{3}}{121}$	(M1	For a complete method using triangle *ABD*, with sufficient detail in the expansions and rationalisation
	$= 5 - 2\sqrt{3}$	A1)	
6(a)	Midpoint = $(2, 7)$	B1	
	Gradient of *AB* = $\dfrac{6}{8}$ oe	B1	
	Perp bisector: $y - 7 = -\dfrac{4}{3}(x-2)$	M1	Must be using a perp gradient and a mid-point
	$4x + 3y - 29 = 0$	A1	Allow in any order but must be equated to zero.
6(b)	3	B1	FT on *their* **(a)**
6(c)	Displacement vector $\overrightarrow{CM} = \begin{pmatrix} -3 \\ 4 \end{pmatrix}$	M1	Allow equivalent vectors or other methods. May be implied by one correct coordinate.
	$(-1, 11)$	A1	Allow $x = -1,\ y = 11$

Question	Answer	Marks	Guidance
7(a)	$\mathrm{p}\left(-\frac{1}{2}\right): -\frac{a}{8}+\frac{3}{4}-\frac{b}{2}-12=0$ $\mathrm{p}(3): 27a+27+3b-12=105$	**M1**	For attempt at an equation using either $\mathrm{p}\left(-\frac{1}{2}\right)$ or $\mathrm{p}(3)$
	$a+4b=-90$	**A1**	Allow equivalent with constants collected
	$9a+b=30$	**A1**	Allow equivalent with constants collected
	$a=6, b=-24$	**2**	**M1** for attempt to solve *their* equations, dep on first M mark **A1** for both
7(b)	$(2x+1)(3x^2-12)$	**2**	**B1** for $3x^2$ **B1** for -12 and no extra term in x
7(c)	$x=-\frac{1}{2}$	**B1**	
	$x=\pm 2$	**B1**	Dep on both B marks in part (b)
8(a)	$\begin{pmatrix}-20\\48\end{pmatrix}$	**B1**	
8(b)	$\begin{pmatrix}-20\\48\end{pmatrix}t$	**B1**	Follow through on *their* (a)
8(c)	$\begin{pmatrix}12\\8\end{pmatrix}+\begin{pmatrix}-25\\45\end{pmatrix}t$ oe	**B1**	
8(d)	$\begin{pmatrix}12\\8\end{pmatrix}+\begin{pmatrix}-5\\-3\end{pmatrix}t$ oe	**B1**	
8(e)	$\lvert\overrightarrow{PQ}\rvert^2=(12-5t)^2+(8-3t)^2$	**M1**	Attempt to find modulus of *their* (d) which must contain terms in t
	$\lvert\overrightarrow{PQ}\rvert=\sqrt{144-120t+25t^2+64-48t+9t^2}$ $PQ=\sqrt{34t^2-168t+208}$	**A1**	Must see correct expansion leading to given answer.

Question	Answer	Marks	Guidance
8(f)	$34t^2 - 168t + 204 = 0$	M1	For dealing with square root correctly and attempt to solve a 3 term quadratic equation
	2.15 only	A1	
9(a)(i)	360	B1	
9(a)(ii)	60	B1	**FT** on *their* (b)(i) divided by 6
9(a)(iii)	A complete plan for dealing with odd numbers and numbers greater than 7000, see below	M1	Must be considering each case
	Starts with 8 and ends with odd = 48	B1	
	Starts with 7 or 9 and ends with odd = 72	B1	
	120	A1	
	Alternative		
	Their answer to **(a)(i)** –odd numbers starting with 2–odd number starting with 3 or 5–all even numbers	(M1	Must be considering each case
	All even numbers =120 Odd and starting with 2 = 48 Odd and starting with 3 or 5 = 72	2	**B1** for 1 correct
	120	A1)	
9(b)	$\frac{n!}{(n-3)!3!} = 92n$	B1	
	$n(n-1)(n-2) = 552n$	M1	Attempt to simplify factorials
	$n(n^2 - 3n - 550) = 0$ $n(n-25)(n+22) = 0$	M1	Dep on previous M mark for expansion and simplification to a cubic or quadratic in n and attempt to solve
	$n = 25$	A1	For $n = 25$ only
10(a)	$\alpha + 45° = 144.7°,\ 324.7°$ $\alpha = 99.7°,\ 279.7°$	3	**M1** for attempt to solve using a correct order of operations, may be implied by one correct solution **A1** for 1 correct solution **A1** for a second correct solution and no extras

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Question	Answer	Marks	Guidance
10(b)(i)	$\frac{(\sin\theta+1)-(\sin\theta-1)}{\sin^2\theta-1}$	**M1**	For dealing with fractions
	$\frac{2}{-\cos^2\theta}$	**M1**	For simplification of numerator and use of the correct identity
	$-2\sec^2\theta$ $a=-2$	**A1**	Must see previous line for A1
10(b)(ii)	$-2\sec^2 3\phi=-8$ oe $\sec 3\phi=\pm 2$	**M1**	For making use of (i) and attempt to simplify in terms of 3ϕ
	$\cos 3\phi=\pm\frac{1}{2}$	**A1**	
	$3\phi=-\frac{2\pi}{3},\ -\frac{\pi}{3},\ \frac{\pi}{3},\ \frac{2\pi}{3}$ $\phi=-\frac{2\pi}{9},\ -\frac{\pi}{9},\ \frac{\pi}{9},\ \frac{2\pi}{9}$ or ± 0.349 , ± 0.698 ,	**3**	Dep **M1** for attempt to solve, may be implied by one correct solution **A1** for each pair of correct solutions
11	$\left[\ln(2x+3)+\ln(3x-1)-\ln x\right]_1^a$	**2**	**B1** for 1 term correct **B1** all correct
	$(\ln(2a+3)+\ln(3a-1)-\ln a)$ $-(\ln 5+\ln 2)$	**M1**	Correct substitution of limits, dep on first B1, ignore equality Must have 3 terms involving x
	$\ln\frac{(2a+3)(3a-1)}{10a}=\ln 2.4$	**M1**	For use of both addition and subtraction rules, ignore equality Or for use of addition rule on each side of an equation.
	$6a^2-17a-3=0$	**A1**	
	$a=3$	**2**	**M1** for solution of their quadratic **A1** for $a=3$ only