GradeMax

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/11**

Paper 1 Pure Mathematics 1 **May/June 2021**

MARK SCHEME

Maximum Mark: 75

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.

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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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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, 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.

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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 mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

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

DM or **DB** When a part of a question has two or more 'method' steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

FT Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.

- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
- The total number of marks available for each question is shown at the bottom of the Marks column.
- Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
- Square brackets [ ] around text or numbers show extra information not needed for the mark to be awarded.

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Abbreviations

AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
CAO	Correct Answer Only (emphasising that no 'follow through' from a previous error is allowed)
CWO	Correct Working Only
ISW	Ignore Subsequent Working
SOI	Seen Or Implied
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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Question	Answer	Marks	Guidance
1	$[y =] -\frac{1}{x^3} + 8x^4 \ [+ c]$	**B1 B1**	OE. Accept unsimplified.
	$4 = -8 + \frac{1}{2} + c$	**M1**	Substituting $\left(\frac{1}{2}, 4\right)$ into an integrated expression
	$y = -\frac{1}{x^3} + 8x^4 + \frac{23}{2}$	**A1**	OE. Accept $-x^{-3}$; must be 8; $y =$ must be seen in working.
		4	

Question	Answer	Marks	Guidance
2	$10(2a + 19d) = 405$	**B1**	
	$20(2a + 39d) = 1410$	**B1**	
	Solving simultaneously two equations obtained from using the correct sum formulae [$a = 6$, $d = 1.5$]	**M1**	Reach $a =$ or $d =$
	Using the correct formula for 60th term with their a and d	**M1**	
	60th term = 94.5	**A1**	OE, e.g. $\frac{189}{2}$
		5	

Question	Answer	Marks	Guidance
3(a)	243	**B1**	
	$-810x$	**B1**	
	$+1080x^2$	**B1**	
		3	
3(b)	$(4 + x)^2 = 16 + 8x + x^2$	**B1**	
	Coefficient of x^2 is $16 \times 1080 + 8 \times (-810) + 243$	**M1**	Allow if at least 2 pairs used correctly
	11043	**A1**	Allow $11043x^2$
		3	

Question	Answer	Marks	Guidance
4	$a = 2$	**B1**	
	$b = \frac{\pi}{4}$	**B1**	or $\frac{2\pi}{8}$
	$c = 1$	**B1**	
		3	

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Question	Answer	Marks	Guidance
5	$(-12)^2 = 8k \times 2k$	**M1**	Forming an equation in k
	$k = -3$	**A1**	
	Using correct formula for S_∞ [$r = 0.5$, $a = -384$]	**M1**	With $-1 < r < 1$
	$S_\infty = -768$	**A1**	
	Alternative method for Question 5		
	$r^2 = \frac{2k}{8k}$	**M1**	
	$r = [\pm]0.5$	**A1**	
	Using correct formula for S_∞ [$r = 0.5$, $a = -384$]	**M1**	$-1 < r < 1$
	$S_\infty = -768$	**A1**	
		4	

Question	Answer	Marks	Guidance
6	$(2k-3)x^2-kx-(k-2)=3x-4$	***M1**	Equating curve and line
	$(2k-3)x^2-(k+3)x-(k-6)[=0]$	**DM1**	Forming a 3-term quadratic
	$(k+3)^2+4(2k-3)(k-6)[=0]$	**DM1**	Use of discriminant (dependent on **both** previous M marks)
	$9k^2-54k+81[=0]$ [leading to $k^2-6k+9=0$]	**M1**	Simplifying and solving *their* 3-term quadratic in k
	$k=3$	**A1**	
	Alternative method for Question 6		
	$(2k-3)x^2-kx-(k-2)=3x-4$	***M1**	Equating curve and line
	$2(2k-3)x-k=3 \Rightarrow x=\dfrac{k+3}{4k-6}$ or $k=\dfrac{3+6x}{4x-1}$	**DM1**	Differentiating and solving for x or k
	Either $(2k-3)\left(\dfrac{k+3}{4k-6}\right)^2-k\left(\dfrac{k+3}{4k-6}\right)-(k-2)=3\left(\dfrac{k+3}{4k-6}\right)-4$ **Or** $4x\left(\dfrac{3x^2+3x-6}{2x^2-x-1}\right)-6x-\left(\dfrac{3x^2+3x-6}{2x^2-x-1}\right)=3$	**DM1**	Substituting *their* x into equation or *their* $k=\dfrac{3x^2+3x-6}{2x^2-x-1}$ or $k=\dfrac{3x+6}{2x+1}$ into derivative equation (dependent on **both** previous M marks)
	$9k^2-54k+81[=0]$ [leading to $k^2-6k+9=0$]	**M1**	Simplifying and solving *their* 3-term quadratic in k (or solving for x)
	$k=3$	**A1**	
			SC If M0, B1 for differentiating, equating to 3 and solving for x or k
		5	

Question	Answer	Marks	Guidance
7(a)	Reach $\frac{\cos^2\theta-\sin^2\theta}{\cos^2\theta}$ **or** $\frac{1-\sin^2\theta}{1-\sin^2\theta}-\frac{\sin^2\theta}{\cos^2\theta}$ **or** $\frac{\sin^2\theta+\cos^2\theta}{\cos^2\theta}-2\tan^2\theta$ **or** $\sec^2\theta-\frac{2\sin^2\theta}{\cos^2\theta}$ **or** $2-\sec^2\theta$ **or** $\frac{\cos 2\theta}{\cos^2\theta}$	**M1**	May start with $1-\tan^2\theta$
	$1-\tan^2\theta$	**A1**	AG, must show sufficient stages
		2	
7(b)	$1-\tan^2\theta=2\tan^4\theta \Rightarrow 2\tan^4\theta+\tan^2\theta-1$ [= 0]	**M1**	Forming a 3-term quadratic in $\tan^2\theta$ or e.g. u
	$\tan^2\theta = 0.5$ or -1 leading to $\tan\theta=[\pm]\sqrt{0.5}$	**M1**	
	$\theta = 35.3°$ and $144.7°$ (AWRT)	**A1**	Both correct. Radians 0.615, 2.53 scores A0.
		3	

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Question	Answer	Marks	Guidance
8(a)	**Either** Let midpoint of PQ be H: $\sin HCP = \frac{2}{4} \Rightarrow$ Angle $HCP = \frac{\pi}{6}$ **Or** $\sin PSQ = \frac{4}{8} \Rightarrow$ Angle $PSQ = \frac{\pi}{6}$ **Or** using cosine rule: angle $PCQ = \frac{\pi}{3}$ **Or** by inspection: triangle PCQ or PCT is equilateral so angle $PCQ = \frac{\pi}{3}$	**M1**	
	Angle $PCS = \pi - \frac{\pi}{6} - \frac{\pi}{6} = \frac{2}{3}\pi$	**A1**	AG
		2	
8(b)	Perimeter $= 2 \times 4 \times \frac{2\pi}{3}$ or $8\pi - \frac{8\pi}{3}$	**M1**	Length of two arcs PS and QR
	$+2\pi \times 2$	**M1**	Adding circumference of two semicircles
	$\frac{28\pi}{3}$	**A1**	Must be a single term
		3	

Question	Answer	Marks	Guidance
8(c)	Area sector $CPQ = \frac{1}{2}\times 4^2 \times \frac{\pi}{3} = \frac{8\pi}{3}$	**M1**	Uses correct formula for sector
	Area of segment of large circle beyond CPQ $= \frac{8\pi}{3} - \frac{1}{2}\times 4^2 \times \sin\left(\frac{\pi}{3}\right) = \frac{8\pi}{3} - 4\sqrt{3}$	**M1**	Attempts to find area of segment
	Area of small semicircle = $\pi \times 2$ or area of small circle = $\pi \times 2^2$	**M1**	
	Area of plate = Large circle – [2 ×] small semicircle – [2 ×] segment area	**M1**	
	$\pi \times 4^2 - \pi \times 2^2 - 2\times\left(\frac{8\pi}{3} - 4\right) = \frac{20\pi}{3} + 8\sqrt{3}$	**A1**	AG
	Alternative method for Question 8(c)		
	Area of sector $PCS = \frac{1}{2}\times 4^2 \times \frac{2\pi}{3} = \frac{16\pi}{3}$	**M1**	Uses correct formula for sector
	Area of triangle $PCQ = \frac{1}{2}\times 4^2 \times \sin\frac{\pi}{3} = 4\sqrt{3}$	**M1**	Uses correct formula for triangle
	Area of small semicircle = $\pi \times 2$ or area of circle = $\pi \times 2^2$	**M1**	
	Area of plate = [2 ×] large sector + [2 ×] triangle – [2 ×] small semicircle	**M1**	
	$2\left(\frac{16\pi}{3}\right) + 2\left(4\right) - \pi \times 2^2 = \frac{20\pi}{3} + 8\sqrt{3}$	**A1**	AG
		5	

Question	Answer	Marks	Guidance
9(a)	Range of f is f(x) $\geqslant -4$	**B1**	Allow y, f or 'range' or $[-4,\infty)$
		1	
9(b)	$y=(x-2)^2-4 \Rightarrow (x-2)^2=y+4 \Rightarrow x-2=+\sqrt{(y+4)}$ or $\pm\sqrt{(y+4)}$	**M1**	May swap variables here
	$\left[\mathrm{f}^{-1}(x)\right]=\sqrt{(x+4)}+2$	**A1**	
		2	
9(c)	$(x-2)^2-4=-\frac{5}{3}x+2 \Rightarrow x^2-4x+4-4=-\frac{5}{3}x+2$ $[\Rightarrow x^2-\frac{7}{3}x-2=0]$	**M1**	Equating and simplifying to a 3-term quadratic
	$(3x+2)(x-3)[=0]$ or $\frac{7\pm\sqrt{7^2-4(3)(-6)}}{6}$ OE	**M1**	Solving quadratic
	$x=3$ only	**A1**	
		3	

Question	Answer	Marks	Guidance
9(d)	$f^{-1}(12) = 6$	**M1**	Substitute 12 into *their* $f^{-1}(x)$ and evaluate
	$g(f^{-1}(12)) = 6a + 2$	**M1**	Substitute *their* '6' into $g(x)$
	$g(g(f^{-1}(12))) = a(6a + 2) + 2 = 62$	**M1**	Substitute the result into $g(x)$ and = 62
	$6a^2 + 2a - 60$ [= 0]	**M1**	Forming and solving a 3-term quadratic
	$a = -\frac{10}{3}$ or 3	**A1**	
	Alternative method for Question 9(d)		
	$g(f^{-1}(x)) = a\left(\sqrt{x+4}+2\right)+2$ or $gg(x) = a(ax+2)+2$	**M1**	Substitute *their* $f^{-1}(x)$ or $g(x)$ into $g(x)$
	$g(g(f^{-1}(x))) = a\left(a\left(\sqrt{x+4}+2\right)+2\right)+2$	**M1**	Substitute the result into $g(x)$
	$g(g(f^{-1}(12))) = a(6a + 2) + 2 = 62$	**M1**	Substitute 12 and = 62
	$6a^2 + 2a - 60$ [= 0]	**M1**	Forming and solving a 3-term quadratic
	$a = -\frac{10}{3}$ or 3	**A1**	
		5	

Question	Answer	Marks	Guidance
10(a)	When $y = 0$ $\quad x^2 - 4x - 77 = 0$ [$\Rightarrow (x+7)(x-11) = 0$ or $(x-2)^2 = 81$]	**M1**	Substituting $y = 0$
	So x-coordinates are −7 and 11	**A1**	
		2	

Question	Answer	Marks	Guidance
10(b)	Centre of circle C is (2, −3)	**B1**	
	Gradient of AC is $-\frac{1}{3}$ or Gradient of BC is $\frac{1}{3}$	**M1**	For either gradient (M1 sign error, M0 if x-coordinate(s) in numerator)
	Gradient of tangent at A is 3 or Gradient of tangent at B is −3	**M1**	For either perpendicular gradient
	Equations of tangents are $y = 3x + 21$, $y = -3x + 33$	**A1**	For either equation
	Meet when $3x + 21 = -3x + 33$	**M1**	OR: (centre of circle has x coordinate 2) so x coordinate of point of intersection is 2
	Coordinates of point of intersection (2, 27)	**A1**	
	Alternative method for Question 10(b)		
	Implicit differentiation: $2y\frac{\mathrm{d}y}{\mathrm{d}x}$ seen	**B1**	
	$2x-4+2y\frac{\mathrm{d}y}{\mathrm{d}x}+6\frac{\mathrm{d}y}{\mathrm{d}x}=0$	**M1**	Fully differentiated $= 0$ with at least one term involving y differentiated correctly
	Gradient of tangent at A is 3 or Gradient of tangent at B is −3	**M1**	For either gradient
	Equations of tangents are $y = 3x + 21$, $y = -3x + 33$	**A1**	For either equation
	Meet when $3x + 21 = -3x + 33$	**M1**	OR: (centre of circle has x coordinate 2) so x coordinate of point of intersection is 2
	Coordinates of point of intersection (2, 27)	**A1**	
		6	

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Question	Answer	Marks	Guidance
11(a)	$\frac{dy}{dx} = 3(3x+4)^{-0.5} - 1$	**B1 B1**	B1 All correct with 1 error, B2 if all correct
	Gradient of tangent = $-\frac{1}{4}$ and Gradient of normal = 4	***M1**	Substituting $x = 4$ into a differentiated expression and using $m_1 m_2 = -1$
	Equation of line is $(y - 4) = 4(x - 4)$ **or** evaluate c	**DM1**	With (4, 4) and *their* gradient of normal
	So $y = 4x - 12$	**A1**	
		5	
11(b)	$3(3x+4)^{-0.5} - 1 = 0$	**M1**	Setting *their* $\frac{dy}{dx} = 0$
	Solving as far as $x =$	**M1**	Where $\frac{dy}{dx}$ contains $a(bx+c)^{-0.5}$ a, b, c any values
	$x = \frac{5}{3}$, $y = 2\left(3\times\frac{5}{3}+4\right)^{0.5} - \frac{5}{3} = \frac{13}{3}$	**A1**	
		3	
11(c)	$\frac{d^2y}{dx^2} = -\frac{9}{2}(3x+4)^{-1.5}$	**M1**	Differentiating *their* $\frac{dy}{dx}$ OR checking $\frac{dy}{dx}$ to find +ve and -ve either side of their $x = \frac{5}{3}$
	At $x = \frac{5}{3}$ $\frac{d^2y}{dx^2}$ is negative so the point is a maximum	**A1**	
		2	

Question	Answer	Marks	Guidance
11(d)	Area $= \left[\int 2(3x+4)^{0.5} - x\,\mathrm{d}x = \right] \frac{4}{9}(3x+4)^{1.5} - \frac{1}{2}x^2$	**B1 B1**	B1 for each correct term (unsimplified)
	$\left(\frac{4}{9}(16)^{1.5} - \frac{1}{2}(4)^2\right) - \frac{4}{9}(4)^{1.5} = \frac{256}{9} - 8 - \frac{32}{9}$	**M1**	Substituting limits 0 and 4 into an expression obtained by integrating y
	$16\frac{8}{9}$	**A1**	Or $\frac{152}{9}$
		4	