
MATHEMATICS

9709/21

Paper 2

May/June 2017

MARK SCHEME

Maximum Mark: 50

Published

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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.

- 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 (or dep*) 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.
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The following abbreviations may be used in a mark scheme or used on the scripts:

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 – often written by a ‘fortuitous’ answer
ISW	Ignore Subsequent Working
SOI	Seen or implied
SR	Special Ruling (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)

Penalties

- MR –1 A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
- PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	Take logarithms of both sides and apply power law to both sides	M1	Allow $y = \frac{\log 5}{4 \log 3}$ for M1 A1
	Rearrange to the form $y = \frac{\ln 5}{4 \ln 3} x$ or equivalent	A1	
	Obtain $m = 0.366$	A1	
	Total:	3	
2	State or imply non-modulus inequality $(4-x)^2 \leq (3-2x)^2$ or corresponding equation, pair of linear equations or linear inequalities	M1	
	Attempt solution of 3-term quadratic equation, of two linear equations or of two linear inequalities	M1	
	Obtain critical values -1 and $\frac{7}{3}$	A1	SR Allow B1 for $x \leq -1$ only or $x \geq \frac{7}{3}$ only if first M1 is not given
	State answer $x \leq -1, x \geq \frac{7}{3}$	A1	Do not accept $\frac{7}{3} \leq x \leq -1$ or $-1 \geq x \geq \frac{7}{3}$ for A1
	Total:	4	

Question	Answer	Marks	Guidance
3	Integrate to obtain form $ke^{\frac{1}{2}x+3}$ where k is constant not equal to 4	M1	
	Obtain correct $8e^{\frac{1}{2}x+3}$	A1	Allow unsimplified for A1
	Obtain $8e^{\frac{1}{2}a+3} - 8e^3 = 835$ or equivalent	A1	
	Carry out correct process to find a from equation of form $ke^{\frac{1}{2}a+3} = c$	M1	
	Obtain 3.65	A1	If 3.65 seen with no actual attempt at integration, award B1 if it is thought that trial and improvement with calculator has been used.
	Total:	5	
4(i)	Use iteration correctly at least once	M1	
	Obtain final answer 2.08	A1	
	Show sufficient iterations to 4 dp to justify answer or show sign change in interval (2.075, 2.085)	A1	
	Total:	3	
4(ii)	State or clearly imply equation $x = \frac{2x^2 + x + 9}{(x+1)^2}$ or same equation using α	B1	
	Carry out relevant simplification	M1	
	Obtain $\sqrt[3]{9}$	A1	
		3	

Question	Answer	Marks	Guidance
5(i)	State $R = 3$	B1	Allow marks for (i) if seen in (ii)
	Use appropriate trigonometric formula to find α	M1	
	Obtain 48.19 with no errors seen	A1	
	Total:	3	
5(ii)	Carry out evaluation of $\cos^{-1}\frac{1}{3}(=70.528\dots)$	M1	M1 for $\cos^{-1}\left(\frac{1}{R}\right)$
	Obtain correct answer 118.7	A1	
	Carry out correct method to find second answer	M1	
	Obtain 337.7 and no others between 0 and 360	A1	
	Total:	4	
6(i)	State or imply correct y -values $0, \tan\frac{1}{6}\pi, \tan\frac{2}{6}\pi$	B1	Some candidates have their calculator in degree mode when working out $\tan\frac{\pi}{6}$ etc. this gives 0.00915 and 0.0183. Allow B1 .
	Use correct formula, or equivalent, with $h = \frac{1}{12}\pi$ and y -values	M1	Must be convinced they have considered 3 values for y for M1
	Obtain 0.378	A1	
	Total:	3	

Question	Answer	Marks	Guidance
6(ii)	State or imply $\pi \int (\sec^2 2x - 1) dx$	B1	
	Integrate to obtain $k_1 \tan 2x + k_2 x$, any non-zero constants including π or not	M1	
	Obtain $\frac{1}{2} \tan 2x - x$ or $\pi(\frac{1}{2} \tan 2x - x)$	A1	
	Obtain $\pi(\frac{1}{2}\sqrt{3} - \frac{1}{6}\pi)$ or equivalent	A1	
	Total:	4	
7(i)	Differentiate x and y and form $\frac{dy}{dx}$	M1	
	Obtain $\frac{4t^3 - 6t^2 + 8t - 12}{3t^2 + 6}$	A1	First 2 marks may be implied by an attempt at division
	Carry out division at least as far as kt or equivalent	M1	For M1 , it must be division by a quadratic factor. Allow attempt at factorisation with same conditions as for division
	Obtain $\frac{4}{3}t$	A1	
	Obtain $\frac{4}{3}t - 2$ with complete division shown and no errors seen	A1	
	Total:	5	

Question	Answer	Marks	Guidance
7(ii)	State or imply gradient of straight line is $\frac{1}{2}$	B1	Allow B1 if $y = \frac{1}{2}x + \frac{9}{2}$ is seen
	Attempt value of t from their $\frac{dy}{dx}$ = their negative reciprocal of gradient of line	M1	
	Obtain $t = 0$ and hence (1,5)	A1	
	Total:	3	
8(i)	Apply product rule to find first derivative	*M1	
	Obtain $6x \ln\left(\frac{1}{6}x\right) + 3x$ or equivalent	A1	Allow unsimplified for A1
	Identify $x = 6$ at P	B1	
	Substitute their value of x at P into attempt at first derivative	DM1	dep *M
	Obtain 18	A1	
	Total:	5	

Question	Answer	Marks	Guidance
8(ii)	Equate their first derivative to zero and attempt solution of equation of form $k \ln\left(\frac{1}{6}x\right) + m = 0$	*M1	
	Obtain x -coordinate of form $a_1 e^{a_2}$	DM1	dep *M
	Obtain $x = 6e^{-\frac{1}{2}}$ or exact equivalent	A1	
	Substitute exact x -value in the form $a_1 e^{a_2}$ and attempt simplification to remove $\ln$	M1	
	Obtain $-54e^{-1}$ or exact equivalent	A1	
	Total:	5	

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Question	Answer	Marks	Guidance
1	State or imply non-modulus equation $(x+a)^2 = (2x-5a)^2$ or pair of linear equations	B1	SR B1 for $x = 6a$
	Attempt solution of quadratic equation or of pair of linear equations	M1	Allow M1 if $\frac{4}{3}$ and 6 seen
	Obtain, as final answers, $6a$ and $\frac{4}{3}a$	A1	
	Total:	3	
2	Apply logarithms to both sides and apply power law	*M1	
	Obtain $(x+4)\log 3 = 2x\log 5$ or equivalent	A1	
	Solve linear equation for x	DM1	dep *M
	Obtain 2.07	A1	Allow greater accuracy
	Total:	4	
3(i)	Draw sketch of $y = x^3$	*B1	May be implied by part graph in first quadrant
	Draw straight line with negative gradient crossing positive y -axis and indicate one intersection	DB1	dep *B
	Total:	2	
3(ii)	Use iterative formula correctly at least once	M1	
	Obtain final answer 1.926	A1	
	Show sufficient iterations to justify 4 sf or show sign change in interval (1.9255, 1.9265)	A1	
	Total:	3	

Question	Answer	Marks	Guidance
4	Use quotient rule (or product rule) to find first derivative	M1	
	Obtain $\frac{8xe^{4x} + 10e^{4x}}{(2x+3)^2}$ or equivalent	A1	
	Substitute $x = 0$ to obtain gradient $\frac{10}{9}$	A1	
	Form equation of tangent through $(0, \frac{1}{3})$ with numerical gradient	M1	
	Obtain $10x - 9y + 3 = 0$	A1	
	Total:	5	

Question	Answer	Marks	Guidance
5	State or imply $\ln y = \ln K - 2x \ln a$	B1	
	<i>EITHER:</i>		
	Obtain -0.525 as gradient of line	(M1	
	Equate their $-2 \ln a$ to their gradient and solve for a	M1	Allow $2 \ln a =$ their gradient for M1
	Obtain $a = 1.3$	A1	
	Substitute to find value of K	M1	
	Obtain $K = 8.4$	A1)	
	<i>OR:</i>		
	Obtain two equations using coordinates correctly	(M1	
	Solve these equations to obtain $2 \ln a$ or equivalent	M1	
	Obtain $a = 1.3$	A1	
	Substitute to find value of K	M1	
	Obtain $K = 8.4$	A1)	
	Total:	6	

Question	Answer	Marks	Guidance
6(i)	Evaluate expression when $x = -2$	M1	
	Obtain 0 with all necessary detail present	A1	Use of $f(x) = (x+2)(ax^2 + bx + c)$ to find a , b and c , allow M1 A0 Use of $f(x) = (x+2)(ax^2 + bx + c) + d$ to find a , b and c , and show $d = 0$, allow M1 A1
	Carry out division, or equivalent, at least as far as x^2 and x terms in quotient	M1	
	Obtain $6x^2 + x - 35$	A1	
	Obtain factorised expression $(x+2)(2x+5)(3x-7)$	A1	
	Total:	5	
6(ii)	State or imply substitution $x = \frac{1}{y}$ or equivalent	M1	
	Obtain $-\frac{1}{2}$, $-\frac{2}{5}$, $\frac{3}{7}$	A1	
	Total:	2	
7(a)	Obtain $\int (2\cos^2 \theta - \cos \theta - 3) d\theta$	B1	
	Attempt use of identity to obtain integrand involving $\cos 2\theta$ and $\cos \theta$	M1	
	Integrate to obtain form $k_1 \sin 2\theta + k_2 \sin \theta + k_3 \theta$ for non-zero constants	M1	
	Obtain $\frac{1}{2} \sin 2\theta - \sin \theta - 2\theta + c$	A1	
	Total:	4	

Question	Answer	Marks	Guidance
7(b)(i)	Integrate to obtain form $k_1 \ln(2x+1) + k_2 \ln(x)$ or $k_1 \ln(2x+1) + k_2 \ln(2x)$	M1	
	Obtain $2\ln(2x+1) + \frac{1}{2}\ln x$ or $2\ln(2x+1) + \frac{1}{2}\ln(2x)$	A1	
	Total:	2	
7(b)(ii)	Use relevant logarithm power law for expression obtained from application of limits	M1	
	Use relevant logarithm addition / subtraction laws	M1	
	Obtain $\ln 18$	A1	
	Total:	3	
8(i)	Obtain $\frac{dx}{dt} = 2 \sin 2t$	B1	
	Obtain $\frac{dy}{dt} = 6 \sin^2 t \cos t - 9 \cos^2 t \sin t$	B1	
	Use $\frac{dy}{dx} = \frac{dy}{dt} / \frac{dx}{dt}$ for their first derivatives	M1	
	Use identity $\sin 2t = 2 \sin t \cos t$	B1	
	Simplify to obtain $\frac{3}{2} \sin t - \frac{9}{4} \cos t$ with necessary detail present	A1	
	Total:	5	

Question	Answer	Marks	Guidance
8(ii)	Equate $\frac{dy}{dx}$ to zero and obtain $\tan t = k$	M1	
	Obtain $\tan t = \frac{3}{2}$ or equivalent	A1	
	Substitute value of t to obtain coordinates (2.38, 2.66)	A1	
	Total:	3	
8(iii)	Identify $t = \frac{1}{4}\pi$	B1	
	Substitute to obtain exact value for gradient of the normal	M1	
	Obtain gradient $\frac{4}{3}\sqrt{2}$, $\frac{8}{3\sqrt{2}}$ or similarly simplified exact equivalent	A1	
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	Obtain, as final answers, $6a$ and $\frac{4}{3}a$	A1	
	Total:	3	
2	Apply logarithms to both sides and apply power law	*M1	
	Obtain $(x+4)\log 3 = 2x\log 5$ or equivalent	A1	
	Solve linear equation for x	DM1	dep *M
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	Substitute $x = 0$ to obtain gradient $\frac{10}{9}$	A1	
	Form equation of tangent through $(0, \frac{1}{3})$ with numerical gradient	M1	
	Obtain $10x - 9y + 3 = 0$	A1	
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	EITHER:		
	Obtain -0.525 as gradient of line	(M1	
	Equate their $-2 \ln a$ to their gradient and solve for a	M1	Allow $2 \ln a =$ their gradient for M1
	Obtain $a = 1.3$	A1	
	Substitute to find value of K	M1	
	Obtain $K = 8.4$	A1)	
	OR:		
	Obtain two equations using coordinates correctly	(M1	
	Solve these equations to obtain $2 \ln a$ or equivalent	M1	
	Obtain $a = 1.3$	A1	
	Substitute to find value of K	M1	
	Obtain $K = 8.4$	A1)	
	Total:	6	

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6(i)	Evaluate expression when $x = -2$	M1	
	Obtain 0 with all necessary detail present	A1	Use of $f(x) = (x+2)(ax^2 + bx + c)$ to find a , b and c , allow M1 A0 Use of $f(x) = (x+2)(ax^2 + bx + c) + d$ to find a , b and c , and show $d = 0$, allow M1 A1
	Carry out division, or equivalent, at least as far as x^2 and x terms in quotient	M1	
	Obtain $6x^2 + x - 35$	A1	
	Obtain factorised expression $(x+2)(2x+5)(3x-7)$	A1	
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	Obtain $-\frac{1}{2}$, $-\frac{2}{5}$, $\frac{3}{7}$	A1	
	Total:	2	
7(a)	Obtain $\int (2\cos^2 \theta - \cos \theta - 3) d\theta$	B1	
	Attempt use of identity to obtain integrand involving $\cos 2\theta$ and $\cos \theta$	M1	
	Integrate to obtain form $k_1 \sin 2\theta + k_2 \sin \theta + k_3 \theta$ for non-zero constants	M1	
	Obtain $\frac{1}{2} \sin 2\theta - \sin \theta - 2\theta + c$	A1	
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	Use $\frac{dy}{dx} = \frac{dy}{dt} / \frac{dx}{dt}$ for their first derivatives	M1	
	Use identity $\sin 2t = 2 \sin t \cos t$	B1	
	Simplify to obtain $\frac{3}{2} \sin t - \frac{9}{4} \cos t$ with necessary detail present	A1	
	Total:	5	

Question	Answer	Marks	Guidance
8(ii)	Equate $\frac{dy}{dx}$ to zero and obtain $\tan t = k$	M1	
	Obtain $\tan t = \frac{3}{2}$ or equivalent	A1	
	Substitute value of t to obtain coordinates (2.38, 2.66)	A1	
	Total:	3	
8(iii)	Identify $t = \frac{1}{4}\pi$	B1	
	Substitute to obtain exact value for gradient of the normal	M1	
	Obtain gradient $\frac{4}{3}\sqrt{2}$, $\frac{8}{3\sqrt{2}}$ or similarly simplified exact equivalent	A1	
	Total:	3	