
MATHEMATICS

9709/21

Paper 2

October/November 2016

MARK SCHEME

Maximum Mark: 50

Published

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS Level – October/November 2016	9709	21

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1	(i)	Carry out method for solving quadratic equation in 3^x Obtain at least $3^x = 7$ Use logarithms to solve an equation of the form $3^x = k$ where $k > 0$ Obtain 1.77	M1 A1 M1 A1	[4]
	(ii)	State ± 1.77 , following positive answer from part (i)	B1 ^{1/2}	[1]
2		State or imply $\ln y = \ln A + px$ Equate gradient of line to p Obtain $p = 0.32$ Substitute to find A Obtain $A = 4.81$ OR 1: $3.17 = \ln A + 5p$ or $4.77 = \ln A + 10p$ Correct attempt to obtain $\ln A$ or p Correct attempt to obtain the other unknown Obtain $A = 4.81$ Obtain $p = 0.32$ OR 2: $e^{3.17} = Ae^{5p}$ or $e^{4.77} = Ae^{10p}$ Correct attempt to obtain p Correct attempt to get A Obtain $A = 4.81$ Obtain $p = 0.32$	B1 M1 A1 M1 A1 B1 M1 M1 A1 A1 B1 M1 M1 A1 A1	[5]
	3	Differentiate to obtain $4\cos 2x + 10\sin 2x$ Equate first derivative to zero and arrange to $\tan 2x = \dots$ Obtain $\tan 2x = -0.4$ Carry out correct method for finding at least one value of x , dependent *M Obtain $x = 1.38$ Obtain $x = 2.95$ and no others between 0 and π	B1 *M1 A1 DM1 A1 A1	[6]
4	(i)	Integrate to obtain $2e^{2x} + 5x$ Apply limits correctly and equate to 100 Rearrange and apply logarithms correctly to reach $a = \dots$ Confirm given result $a = \frac{1}{2}\ln(50 + e^{-2a} - 5a)$	B1 M1 M1 A1	[4]
	(ii)	Use the iterative formula correctly at least once Obtain final answer 1.854 Show sufficient iterations to justify accuracy to 3 dp or show sign change in interval (1.8535, 1.8545)	M1 A1 B1	[3]

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5	(i)	Use $\cos 2x = 2\cos^2 x - 1$ and attempt factorisation of numerator Obtain $(2\cos x + 1)(\cos x + 4)$ Confirm given result $2\cos x + 1$	M1 A1 A1	[3]
	(ii)	Express integrand as $2\cos 2x + 1$ Integrate to obtain $\sin 2x + x$ Apply limits correctly to integral of form $k_1 \sin 2x + k_2 x$ Obtain 2π	B1 B1 M1 A1	[4]
6		Differentiate $4xy$ to obtain $4y + 4x \frac{dy}{dx}$ Differentiate y^2 to obtain $2y \frac{dy}{dx}$ Equate attempt of derivative of left-hand side to zero Substitute (1, 3) to find numerical value of derivative Obtain $-\frac{18}{10}$ or $-\frac{9}{5}$ Obtain $\frac{10}{18}$ or $\frac{5}{9}$ as gradient of normal, following their numerical value of derivative Form equation of normal at (1, 3) Obtain $5x - 9y + 22 = 0$ or equivalent of requested form	B1 B1 M1 M1 A1 A1✓ M1 A1	[8]
7	(i)	Substitute $x = -3$, equate to zero and obtain $27a + 3b = 39$ or equivalent Substitute $x = -2$ and equate to 18 Obtain $8a + 2b = 6$ or equivalent Solve a relevant pair of linear equations for a and b Obtain $a = 2$ and $b = -5$	B1 M1 A1 M1 A1	[5]
	(ii) (a)	Attempt division by $x + 3$ at least as far as $2x^2 + kx$ Obtain quotient $2x^2 - 3x + 4$ Calculate discriminant of 3-term quadratic expression, or equivalent Obtain -23 and conclude appropriately	M1 A1 M1 A1	[4]
	(b)	State $\cos y = -\frac{1}{3}$ Obtain 109.5, dependent *B Obtain -109.5 and no others between -180 and 180 , dependent *B	*B1 B1 DB1	[3]

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1	State non-modulus equation $(0.4x - 0.8)^2 = 4$ or equivalent or corresponding pair of linear equations	B1	[3]	SR One solution only – B1
	Solve 3-term quadratic equation or pair of linear equations	M1		Must see some evidence of attempt to solve the quadratic for M1 for at least one value of x For a pair of linear equations, there must be a sign difference
	Obtain -3 and 7	A1		If extra solutions are given then A0
2 (i)	Use $4^y = 2^{2y}$	B1	[3]	
	Attempt solution of quadratic equation in 2^y	M1		
	Obtain finally $2^y = 7$ only	A1		
(ii)	Apply logarithms to solve equation of form $2^y = k$ where $k > 0$	M1	[2]	Must be using their positive answer for (i)
	Obtain 2.81	A1		
3 (i)	Obtain integral of form $k_1 e^{\frac{1}{2}x} + k_2 x$	M1	[3]	Allow $k_1 = 4$
	Obtain correct $8e^{\frac{1}{2}x} + 3x$ oe	A1		
	Use limits correctly to confirm $8e - 2$	A1		
(ii)	Draw increasing curve in first quadrant	M1	[2]	If incorrect y intercept used then M1 A0
	Draw more or less accurate sketch with correct curvature, gradient at $x = 0$ must be > 0	A1		Allow if no intercept stated
(iii)	State more and refer to top(s) of trapezium(s) above curve	B1	[1]	Can be shown using a diagram. Reference to a trapezium must be made

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4	(i)	Substitute $x = -1$ and simplify	M1	Allow attempt at long division, must get down to a remainder
		Obtain $-4 + a - a + 4 = 0$ and conclude appropriately	A1	Allow M1 if at least 2 numerical values of a are used May equate to $(x+1)(Ax^2 + Bx + C) + R$ - allow M1 if they get as far as finding R
				Must have a conclusion - allow 'hence shown', or made a statement of intent at the start of the question [2]
	(ii)	Substitute $x = 2$ and equate to -42 and attempt to solve	M1	May equate to $(x-2)(Ax^2 + Bx + C)$, must have a complete method to get as far as $a = \dots$ to obtain M1
		Obtain $a = -13$	A1	[2]
	(iii)	Divide $p(x)$ with their a at least as far as $4x^2 + kx$	M1	
		Obtain $4x^2 - 17x + 4$	A1	
		Obtain $(x+1)(4x-1)(x-4)$ or equivalent if x^2 already involved	A1	
		Obtain $(x^2 + 1)(2x-1)(2x+1)(x-2)(x+2)$	A1	If $(x+1)(4x-1)(x-4)$ seen with no evidence of long division then allow the marks [4]
5	(i)	Use quotient rule (or product rule) to find first derivative	M1	Quotient: Must have a difference in the numerator and $(x^2 + 1)^2$ in the denominator
		Obtain $\frac{\frac{4}{x}(x^2 + 1) - 8x \ln x}{(x^2 + 1)^2}$ or equivalent	A1	Product: Must see an application of the chain rule.
		State $\frac{4}{x}(x^2 + 1) - 8x \ln x = 0$ or equivalent	A1	Condone missing brackets if correct use is implied by correct work later
		Carry out correct process to produce equation without $\ln$, without any incorrect working	M1	
		Confirm $m = e^{0.5(1+m^{-2})}$ or $x = e^{0.5(1+x^{-2})}$	A1	[5]

Page 6	Mark Scheme	Syllabus	Paper
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	(ii)	Use iterative formula correctly at least once Obtain final answer 1.895 Show sufficient iterations to 6 sf to justify answer or show sign change in interval (1.8945, 1.8955)	M1 A1 A1	[3]	Should not be attempting to use $x_0 = 0$, but if used and ‘recovered’ then SC M1 A1- usually see $m_1 = 1.6487$
	6 (i)	Use $\cos 2\theta = 2\cos^2 \theta - 1$ appropriately twice Simplify to confirm $1 - \frac{1}{2}\sec^2 \theta$	B1 B1		
	(ii)	Use $\sec^2 \alpha = 1 + \tan^2 \alpha$ Obtain equation $\tan^2 \alpha + 10 \tan \alpha + 25 = 0$ or equivalent Attempt solution of 3-term quadratic equation for $\tan \alpha$ and use correct process for finding value of α from negative value of $\tan \alpha$ Obtain 1.77	B1 B1 M1 A1	[4]	Alternative method $\frac{1 - 2\sin^2 \theta}{2\cos^2 \theta} = \frac{1}{2}\sec^2 \theta - \tan^2 \theta \text{ or } \frac{1}{2\cos^2 \theta} - \tan^2 \theta \quad \text{B1}$ then as for 2nd B1 If quadratic is incorrect, need to see evidence of attempt to solve as required to obtain M1 Allow better or in terms of $\pi \left(\frac{1013\pi}{1800} \right)$
	(iii)	State or imply integrand $1 - \frac{1}{2}\sec^2 \frac{1}{2}x$ Obtain integral of form $k_1 x - k_2 \tan \frac{1}{2}x$ Obtain correct $x - \tan \frac{1}{2}x$ Apply limits correctly to obtain $\pi - 2$	B1 M1 A1 A1		

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7	(i) Use correct addition formula for either $\cos(\theta + \frac{1}{6}\pi)$ or, after diffn, $\sin(\theta + \frac{1}{6}\pi)$ Differentiate to obtain $\frac{dy}{d\theta}$ of form $k_1 \sin \theta + k_2 \cos \theta$ or $k \sin(\theta + \frac{1}{6}\pi)$ Divide attempt at $\frac{dy}{d\theta}$ by attempt at $\frac{dx}{d\theta}$ Obtain $\frac{-\frac{3\sqrt{3}}{2} \sin \theta - \frac{3}{2} \cos \theta}{4 \cos \theta}$ or equivalent Simplify to obtain $-\frac{3}{8}(1 + \sqrt{3} \tan \theta)$	B1 M1 M1 A1 A1	[5]	Condone ‘missing brackets’
	(ii) Identify $\theta = 0$ Substitute 0 into formula for $\frac{dy}{dx}$ and take negative reciprocal Obtain gradient of normal $\frac{8}{3}$ Form equation of normal through point $(0, 1 + \frac{3\sqrt{3}}{2})$ Obtain $y = \frac{8}{3}x + 1 + \frac{3\sqrt{3}}{2}$ or equivalent	B1 M1 A1 M1 A1	[5]	soi be implied by $y = 1 + \frac{3\sqrt{3}}{2}$ or 3.6 Must be from correct (i)

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	(ii)	State equation $x = \frac{4}{x^2} + \frac{2}{3}x$ or equivalent Obtain exact value $12^{\frac{1}{3}}$ or $\sqrt[3]{12}$	B1 B1	[2]
2		State or imply $\ln y = \ln K + p \ln x$ Calculate gradient of line Obtain $p = 1.35$ Substitute to find K Obtain $K = 7.11$ or $K = 7.12$	B1 M1 A1 M1 A1	[5]
3	(i)	Rewrite integrand as $\sec^2 4x - 1$ Integrate to obtain $\frac{1}{4} \tan 4x - x$, condoning absence of $+c$	B1 B1	[2]
	(ii)	Integrate to obtain $2 \sin 2x - 2 \cos 3x$ Apply limits correctly to integral of form $k_1 \sin 2x + k_2 \cos 3x$ Obtain $3 - \sqrt{2}$ or exact equivalent	B1 M1 A1	[3]
4	(i)	Substitute $x = \frac{1}{2}$ and equate to zero Obtain $a = 2$	M1 A1	[2]
	(ii)	Divide by $2x - 1$ at least as far as $x^2 + kx$ Obtain quotient $x^2 + 2x + 5$ Calculate discriminant of 3-term quadratic expression or equivalent Obtain -16 and conclude appropriately	M1 A1 M1 A1	[4]
	(iii)	Use logarithms with power law shown in solving $6^y = \frac{1}{2}$ Obtain -0.387	M1 A1	[2]
5	(i)	State or imply correct ordinates $\sqrt{2}$, $\sqrt{1+e}$, $\sqrt{1+e^2}$ or decimal equivalents Use correct formula, or equivalent, correctly with $h = 3$ and three ordinates Obtain answer 12.25 with no errors seen	B1 M1 A1	[3]
	(ii)	Refer to top of each trapezium being above curve or equivalent	B1	[1]
	(iii)	State or imply volume is $\int \pi(1 + e^{\frac{1}{3}x}) dx$ Integrate to obtain form $k_1x + k_2e^{\frac{1}{3}x}$ with or without π Obtain correct $\pi(x + 3e^{\frac{1}{3}x})$ or $x + 3e^{\frac{1}{3}x}$ Obtain $\pi(3 + 3e^2)$ or exact equivalent	B1 M1 A1 A1	[4]

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6	(i)	State $\frac{dx}{dt} = \frac{1}{t+1}$ Use product rule for derivative of y Obtain $2t \ln t + t$ or equivalent Use $\frac{dy}{dx} = \frac{dy}{dt} \div \frac{dx}{dt}$ Obtain $(t+1)(2t \ln t + t)$	B1 M1 A1 M1 A1	[5]
	(ii)	Solve $2 \ln t + 1 = 0$ Obtain $t = e^{-\frac{1}{2}}$	M1 A1	[2]
	(iii)	Identify $t = 1$ only Obtain 2	B1 B1	[2]
7	(i)	State $\frac{3}{\cos \theta} + \frac{4}{\sin \theta}$ Use identity for $\sin 2\theta$ and obtain expression of form $a \sin \theta + b \cos \theta$ Obtain $6 \sin \theta + 8 \cos \theta$	B1 M1 A1	[3]
	(ii)	State $R = 10$, following their $a \sin \theta + b \cos \theta$ Use appropriate trigonometry to find α Obtain 53.1(3) with no errors seen	B1 M1 A1	[3]
	(iii)	Carry out correct process to find one angle between 0 and 360 Obtain 82.4 or 82.5 Carry out correct process to find second angle between 0 and 360 Obtain 351.3 and no others between 0 and 360	M1 A1 M1 A1	[4]