
MATHEMATICS

9709/21

Paper 2

October/November 2017

MARK SCHEME

Maximum Mark: 50

Published

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- AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
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Question	Answer	Marks	Guidance
1	Use subtraction or addition property of logarithms	*M1	
	Obtain $\frac{3x+1}{x+2} = e$ or equivalent with no presence of logarithm	A1	
	Use correct process to solve equation	DM1	
	Obtain $\frac{2e-1}{3-e}$ or exact equivalent	A1	
		4	

Question	Answer	Marks	Guidance
2	Use $\cos 2\theta = 2\cos^2 \theta - 1$	B1	
	Obtain $10\cos^3 \theta = 4$ or equivalent	B1	
	Use correct process to find at least one value of θ from equation of form $k_1 \cos^3 \theta = k_2$	M1	
	Obtain 42.5	A1	
	Obtain 317.5 and no others between 0 and 360	A1	
		5	

Question	Answer	Marks	Guidance
3	Take logarithms of both sides and apply power law	M1	Condone incorrect inequality signs until final answer. The first 6 marks are for obtaining the correct critical values.
	Obtain $2x < \frac{\ln 80}{\ln 1.3}$ or equivalent using $\log_{10}$	A1	
	Obtain $x = 8.35\dots$	A1	
	State or imply non-modulus inequality $(3x-1)^2 > (3x-10)^2$ or corresponding equation or linear equation $3x-1 = -(3x-10)$	B1	
	Attempt solution of inequality or equation (obtaining 3 terms when squaring each bracket or solving linear equation with signs of $3x$ different)	M1	
	Obtain $x = \frac{11}{6}$ or $x = 1.83\dots$	A1	
	Conclude $1.83 < x < 8.35$	A1	
		7	

Question	Answer	Marks	Guidance
4(a)	Obtain integrand of form $a \sec^2 \theta + b$	M1	
	Obtain correct $5 \sec^2 \theta - 1$	A1	
	Integrate to obtain form $a \tan \theta + b\theta$	M1	
	Obtain $5 \tan \theta - \theta + c$	A1	
		4	
4(b)	Obtain integral of form $k \ln(3x+1)$	*M1	
	Apply limits and obtain $\frac{2}{3} \ln(3a+1) = \ln 16$	A1	
	Obtain equation with no presence of $\ln$	DM1	
	Obtain 21	A1	
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Question	Answer	Marks	Guidance
5(i)	Substitute $x = -2$ and equate to zero	*M1	
	Substitute $x = \frac{1}{2}$ and equate to 40	*M1	
	Obtain $-8a + 4b - 64 = 0$ and $\frac{1}{8}a + \frac{1}{4}b = \frac{23}{2}$ or equivalents	A1	
	Solve a pair of simultaneous equations for a or for b	DM1	Needs at least one of the two previous M marks
	Obtain $a = 12$ and $b = 40$	A1	
		5	
5(ii)	Attempt division by $(x + 2)$ or inspection at least as far as $kx^2 + mx$	M1	
	Obtain $12x^2 + 16x + 5$	A1	
	Conclude $(x + 2)(2x + 1)(6x + 5)$	A1	
		3	

Question	Answer	Marks	Guidance
6(i)	Obtain $\frac{dx}{dt} = 4e^{2t} + 4e^t$	B1	
	Use product rule to find $\frac{dy}{dt}$	M1	
	Obtain $\frac{dy}{dx} = \frac{5e^{2t} + 10te^{2t}}{4e^{2t} + 4e^t}$ or equivalent	A1	
	Equate first derivative of the form $\frac{ae^{2t} + bte^{2t}}{ce^{2t} + de^t}$ to zero and solve to find t	M1	
	Obtain $t = -\frac{1}{2}$ from completely correct work	A1	
	Obtain $(3.16, -0.92)$	A1	
		6	

Question	Answer	Marks	Guidance
6(ii)	Identify $t = 0$	B1	
	Substitute $t = 0$ in expression for first derivative and find negative reciprocal	M1	
	Obtain $-\frac{8}{5}$ or equivalent	A1	
		3	

Question	Answer	Marks	Guidance
7(i)	Differentiate to obtain form $k_1x + k_2 + k_3 \sin \frac{1}{2}x$	*M1	
	Obtain correct $2x + 3 - \frac{5}{2} \sin \frac{1}{2}x$ and deduce or imply gradient at P is 3	A1	
	Equate first derivative to their -3 and rearrange	DM1	
	Obtain $x = \frac{5}{4} \sin \frac{1}{2}x - 3$	A1	
		4	
7(ii)	Consider sign of their $2x + 6 - \frac{5}{2} \sin \frac{1}{2}x$ at -4.5 and -4.0 or equivalent	M1	
	Complete argument correctly for correct expression with appropriate calculations	A1	
		2	
7(iii)	Use iteration formula correctly at least once	M1	
	Obtain final answer -4.11	A1	
	Show sufficient iterations to justify accuracy to 3 sf or show sign change in interval $(-4.115, -4.105)$	A1	
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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	Introduce logarithms to both sides and use power law	*M1	
	Obtain $(3x-1)\log 5 = 4x\log 2$ or equivalent	A1	Allow A1 for poor use of brackets if recovered later
	Solve linear equation for x	DM1	dep *M
	Obtain 0.783	A1	Allow 3 sf or better
		4	

Question	Answer	Marks	Guidance
2	Solve 3-term quadratic equation or a pair of linear equations	M1	For M1 , must square both sides when attempting a quadratic equation
	Obtain $x = -5$ and $x = 3$	A1	
	Substitute (at least) one value of x (less than 4) into $ x+4 - x-4 $, showing correct evaluation of modulus and producing only one answer in each case	M1	
	Obtain -8 and 6 and no others	A1	
		4	

Question	Answer	Marks	Guidance
3	Differentiate to obtain form $k_1 \sec^2 \frac{1}{2}x + k_2 \cos \frac{1}{2}x$	M1	If a factor of 0.5 is missed, can still get 5/6, penalise at first A1
	Obtain $\frac{1}{2}\sec^2 \frac{1}{2}x + \frac{3}{2}\cos \frac{1}{2}x$	A1	
	Equate first derivative to zero and produce $\cos^3 \frac{1}{2}x = k_3$	*M1	
	Use correct process to find one value of x	DM1	Dep on *M, allow for obtaining 1.609....., 92.2° or 268°
	Obtain $x = 4.67$	A1	Allow $x = 4.67$ or better for A1
	Obtain $y = 1.12$	A1	Allow $y = 1.12$ from $x = 4.66$ but nothing else
		6	

Question	Answer	Marks	Guidance
4(i)	Substitute $x = -3$ into either $p(x)$ or $q(x)$ and equate to zero (may be implied)	M1	Allow long division, but the remainder needs to be independent of x
	Obtain $a = -11$	A1	
	Obtain $b = -8$	A1	
		3	
4(ii)	Divide $x + 3$ into expression for $q(x) - p(x)$ (may be a four term cubic equation), or Obtain a 3 term cubic equation by subtraction	*M1	Allow *M1 for their $x^3 + 3x + 36$, but must have integer values for a and b
	Obtain $x^2 - 3x + 12$ or $x^2 - 2x - 5$ and $2x^2 - 5x + 7$	A1	
	Apply discriminant to quadratic factor of $q(x) - p(x)$ or equivalent	DM1	dep on *M
	Obtain -39 or equivalent and conclude appropriately	A1	
		4	

Question	Answer	Marks	Guidance
5(i)	Obtain derivative of the form ke^{-2x}	*M1	Condone $k = 4$ for M1
	State or imply gradient of curve at P is -8	A1	
	Form equation of straight line through $(0, 9)$ with negative gradient	*DM1	dep on *M
	Obtain $y = -8x + 9$ or equivalent	A1	
	Equate equation of curve and equation of straight line	DM1	dep on both *M
	Rearrange to confirm $x = \frac{9}{8} - \frac{1}{2}e^{-2x}$	A1	
		6	

Question	Answer	Marks	Guidance
5(ii)	Use iterative process correctly at least once	M1	
	Obtain final answer 1.07	A1	
	Show sufficient iterations to 5 sf to justify answer or show sign change in interval (1.065, 1.075)	A1	
		6	

Question	Answer	Marks	Guidance
6(a)	Obtain $2 - 2\cos 2x$ as part of integrand	B1	
	Obtain $3\sin 2x$ as part of integrand	B1	Allow second B1 for writing
	Integrate to obtain form $k_1x + k_2\sin 2x + k_3\cos 2x$	M1	$\int 6\sin x \cos x \, dx = 6\left(\frac{1}{2}\sin^2 x\right)$, M1 may then be implied by subsequent work
	Obtain $2x - \sin 2x - \frac{3}{2}\cos 2x$ or $2x - \sin 2x + 3\sin^2 x$	A1	
	Apply limits to obtain $\frac{1}{2}\pi + \frac{1}{2}$	A1	
		5	
6(b)	Integrate to obtain $2\ln(3x + 2)$	B1	Allow $\frac{6}{3}\ln(3x + 2)$ for B1
	Use at least one relevant logarithm property	*M1	
	Obtain $\frac{3a+2}{2} = 7$ or $\frac{(3a+2)^2}{4} = 49$ or equivalent without $\ln$	A1	
	Solve relevant equation to find a	DM1	Dep on *M1 , allow for $49 = (3a + 2)^2$ OE or correct working involving $(3a + 2)$
	Obtain $a = 4$ only	A1	
		5	

Question	Answer	Marks	Guidance
7(i)	Obtain $4y + 4x \frac{dy}{dx}$ as derivative of $4xy$	B1	
	Obtain $4y \frac{dy}{dx}$ as derivative of $2y^2$	B1	
	State $2x + 4y + 4x \frac{dy}{dx} + 4y \frac{dy}{dx} = 0$	B1	3rd B1 may be implied by later work
	Substitute $x = -1$, $y = 3$ to find gradient of line	*M1	dep at least one B1
	Form equation of tangent through $(-1, 3)$ with numerical gradient	DM1	dep *M
	Obtain $5x + 4y - 7 = 0$ or equivalent of required form	A1	Allow any 3 term integer form for A1
		6	
7(ii)	Substitute $\frac{dy}{dx} = \frac{1}{2}$ to find relation between x and y	*M1	dep at least one B1 in part (i), must be linear
	Obtain $4x + 6y = 0$ or equivalent	A1	
	Substitute for x or y in equation of curve	DM1	dep on *M
	Obtain $-\frac{7}{4}y^2 = 7$ or $-\frac{7}{9}x^2 = 7$ or equivalent and conclude appropriately	A1	
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6(ii)	Identify $t = 0$	B1	
	Substitute $t = 0$ in expression for first derivative and find negative reciprocal	M1	
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