



Cambridge International AS Level

MATHEMATICS

9709/21

Paper 2 Pure Mathematics 2

May/June 2020

MARK SCHEME

Maximum Mark: 50

Published

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This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

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Generic Marking Principles

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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
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GENERIC MARKING PRINCIPLE 2:

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Mathematics-Specific Marking Principles	
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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

Question	Answer	Marks
1	Use correct logarithm property to produce one term on LHS	M1
	Use correct process to obtain equation without logarithms	M1
	Obtain $\frac{x+1}{x} = 4$ or equivalent and hence $x = \frac{1}{3}$	A1
		3

Question	Answer	Marks
2	Substitute $x = 2$ and equate to zero	M1
	Substitute $x = -\frac{1}{2}$ and equate to zero	M1
	Obtain $4a + b + 66 = 0$ and $\frac{1}{4}a + b - \frac{21}{4} = 0$ or equivalents	A1
	Solve a relevant pair of linear simultaneous equations (Dependent on at least one M mark)	DM1
	Obtain $a = -19$, $b = 10$	A1
		5

Question	Answer	Marks
3	State $\frac{dx}{dt} = e^t + 2e^{-t}$, $\frac{dy}{dt} = 6e^{2t}$	B1
	Use $\frac{dy}{dx} = \frac{dy}{dt} / \frac{dx}{dt}$ either in terms of t or after substitution of $t = 0$	*M1
	Obtain gradient of tangent is 2	A1
	Attempt equation of tangent with numerical gradient and coordinates	DM1
	Obtain $y = 2x + 6$ or equivalent	A1
		5

Question	Answer	Marks
4(a)	Draw two V-shaped graphs with one vertex on negative x -axis and one vertex on positive x -axis	M1
	Draw correct graphs related correctly to each other	A1
	State correct coordinates $-\frac{2}{3}a$, $2a$, $\frac{4}{3}a$, $4a$	A1
		3
4(b)	Solve linear equation with signs of $3x$ different or solve non-modulus equation $(3x + 2a)^2 = (3x - 4a)^2$	M1
	Obtain $x = \frac{1}{3}a$	A1
	Obtain $y = 3a$	A1
		3

Question	Answer	Marks
4(c)	State $x < \frac{1}{3}a$ (FT from part (b))	B1FT
		1

Question	Answer	Marks
5(a)	Differentiate using the product rule to obtain $ax^2 \cos 2x - bx^3 \sin 2x$	M1
	Obtain $3x^2 \cos 2x - 2x^3 \sin 2x$	A1
	Equate first derivative to zero and confirm $x = \sqrt[3]{1.5x^2 \cot 2x}$ AG	A1
		3
5(b)	Consider sign of $x - \sqrt[3]{1.5x^2 \cot 2x}$ or equivalent for 0.59 and 0.60	M1
	Obtain $-0.009...$ and $0.005...$ or equivalents and justify conclusion	A1
		2
5(c)	Use iteration correctly at least once	M1
	Obtain final answer 0.596	A1
	Show sufficient iterations to 5 sf to justify answer or show sign change in interval $[0.5955, 0.5965]$	A1
		3

Question	Answer	Marks
6(a)	Express left-hand side in terms of $\sin \theta$ and $\cos \theta$	M1
	Obtain $2\cos \theta - 2\sin \theta$	A1
	Attempt to express $a\cos \theta + b\sin \theta$ in $R\cos(\theta + \beta)$ form	M1
	Confirm $R = \sqrt{8}$ AG	A1
	Carry out necessary trigonometry and confirm $\frac{1}{4}\pi$ AG	A1
		5
6(b)	Carry out correct process to find θ from $\cos\left(\theta + \frac{1}{4}\pi\right) = \frac{1}{\sqrt{8}}$	M1
	Obtain 0.424	A1
		2
6(c)	Express integrand as $\sqrt{8}\cos\left(\frac{1}{2}x + \frac{1}{4}\pi\right)$ or as $2\cos\frac{1}{2}x - 2\sin\frac{1}{2}x$	B1
	Integrate to obtain $k\sin\left(\frac{1}{2}x + \frac{1}{4}\pi\right)$ or $k_1\sin\frac{1}{2}x + k_2\cos\frac{1}{2}x$	M1
	Obtain correct $2\sqrt{8}\sin\left(\frac{1}{2}x + \frac{1}{4}\pi\right)$ or $4\sin\frac{1}{2}x + 4\cos\frac{1}{2}x$	A1
		3

Question	Answer	Marks
7(a)	Carry out division at least as far as $3x^2 + kx$	M1
	Obtain quotient $3x^2 - 4x - 4$	A1
	Confirm remainder is 9 AG	A1
		3
7(b)	Integrate to obtain at least k_1x^3 and $k_2 \ln(3x + 2)$ terms	*M1
	Obtain $x^3 - 2x^2 - 4x + 3\ln(3x + 2)$ (FT from quotient in part (a))	A1FT
	Apply limits correctly	DM1
	Apply appropriate logarithm properties correctly	M1
	Obtain $125 + \ln 64$	A1
		5
7(c)	State or imply $9x^3 - 6x^2 - 20x - 8 = (3x + 2)(3x^2 - 4x - 4)$ (FT from quotient in part (a))	B1FT
	Attempt to solve cubic eqn to find positive value of x (or of e^{3y})	M1
	Use logarithms to solve equation of form $e^{3y} = k$ where $k > 0$	M1
	Obtain $\frac{1}{3} \ln 2$ or exact equivalent	A1
		4



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Question	Answer	Marks
1	Apply logarithms to both sides and apply power law at least once	M1
	Rearrange to the form $y = \frac{3 \ln 9}{\ln 2} x$ OE	A1
	Obtain $k = 9.51$	A1
		3

Question	Answer	Marks
2	Differentiate using product rule to obtain $ae^{\frac{1}{2}x} + bxe^{\frac{1}{2}x}$	*M1
	Obtain correct $5e^{\frac{1}{2}x} + \frac{5}{2}xe^{\frac{1}{2}x}$ OE	A1
	Equate first derivative to zero and solve for x	DM1
	Obtain x -coordinate -2	A1
	Obtain y -coordinate $-10e^{-1}$	A1
		5

Question	Answer	Marks
3	Differentiate $\cos 3x$ to obtain $-3\sin 3x$	B1
	Differentiate $5\sin y$ to obtain $5\cos y \frac{dy}{dx}$	B1
	Obtain $-3\sin 3x + 5\cos y \frac{dy}{dx} = 0$ OE	B1
	Substitute x and y values to find value of first derivative	M1
	Obtain $\frac{3}{5}$	A1
		5

Question	Answer	Marks
4	State or imply equation is $\ln y = \ln A - 2p \ln x$	B1
	Equate gradient of line to $-2p$	M1
	Obtain $-2p = -2.6$ and hence $p = 1.3$	A1
	Substitute appropriate values to find $\ln A$	M1
	Obtain $\ln A = 1.252$ and hence $A = 3.5$	A1
	Alternative method for question 4	
	State or imply equation is $\ln y = \ln A - 2p \ln x$	B1
	Substitute given coordinates to obtain 2 simultaneous equations and solve to obtain $3.5p$	M1
	Obtain $3.5p = 4.55$ and hence $p = 1.3$	A1
	Substitute appropriate values to find $\ln A$	M1
	Obtain $\ln A = 1.252$ and hence $A = 3.5$	A1
		5

Question	Answer	Marks
5(a)	Draw V-shaped graph with vertex on positive x -axis	B1
	Draw (more or less) correct graph of $y = 3x + 5$	B1
		2
5(b)	State equation $3x + 5 = -(2x - 3)$ or corresponding inequality	B1
	Attempt solution of linear equation / inequality where signs of $3x$ and $2x$ are different	M1
	State answer $x < -\frac{2}{5}$	A1
	Alternative method for question 5(b)	
	Square both sides of equation / inequality and attempt solution of 3-term quadratic equation / inequality	M1
	Obtain (eventually) only $-\frac{2}{5}$	A1
	State answer $x < -\frac{2}{5}$	A1
		3

Question	Answer	Marks
6(a)	Substitute $x = -3$, equate to zero and attempt solution for a	M1
	Obtain $a = 17$	A1
		2
6(b)	Divide by $x + 3$ at least as far as the x term	M1
	Obtain $6x^2 - x - 1$	A1
	Conclude $(x + 3)(3x + 1)(2x - 1)$	A1
		3
6(c)	Attempt solution of $\sin \theta = k$ where $-1 \leq k \leq 1$	M1
	Obtain 199.5	A1
	Obtain 340.5	A1
		3

Question	Answer	Marks
7(a)	Integrate to obtain the form $k_1 \ln(2x + 1) + k_2 x^2$	*M1
	Obtain correct $2 \ln(2x + 1) + 4x^2$	A1
	Use limits correctly and attempt rearrangement	DM1
	Confirm $a = \sqrt{2.5 - 0.5 \ln(2a + 1)}$ AG	A1
		4

Question	Answer	Marks
7(b)	Consider sign of $a - \sqrt{2.5 - 0.5 \ln(2a + 1)}$ or equivalent for 1 and 2	M1
	Obtain $-0.3...$ and $0.6...$ or equivalents and justify conclusion	A1
		2
7(c)	Use iteration process correctly at least once	M1
	Obtain final answer 1.358	A1
	Show sufficient iterations to 6 sf to justify answer or show a sign change in the interval $[1.3575, 1.3585]$	A1
		3

Question	Answer	Marks
8(a)	Use at least one of $\sin 2\theta = 2 \sin \theta \cos \theta$ and $\cot \theta = \frac{\cos \theta}{\sin \theta}$	B1
	Use both and conclude $6 \cos^2 \theta$ AG	B1
		2
8(b)	Attempt solution of $\cos^2 \theta = \frac{5}{6}$ to find at least one value	M1
	Obtain 0.421	A1
	Obtain 2.72	A1
		3

Question	Answer	Marks
8(c)	Express integrand in form $a + b \cos x$	M1
	Obtain correct integrand $3 + 3 \cos x$	A1
	Integrate to obtain $px + q \sin x$	*M1
	Apply limits correctly	DM1
	Obtain $\frac{3}{4}\pi + 3 - \frac{3}{\sqrt{2}}$ or exact equivalent	A1
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	Obtain $k = 9.51$	A1
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	Equate first derivative to zero and solve for x	DM1
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	Obtain y -coordinate $-10e^{-1}$	A1
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	State or imply equation is $\ln y = \ln A - 2p \ln x$	B1
	Substitute given coordinates to obtain 2 simultaneous equations and solve to obtain $3.5p$	M1
	Obtain $3.5p = 4.55$ and hence $p = 1.3$	A1
	Substitute appropriate values to find $\ln A$	M1
	Obtain $\ln A = 1.252$ and hence $A = 3.5$	A1
		5

Question	Answer	Marks
5(a)	Draw V-shaped graph with vertex on positive x -axis	B1
	Draw (more or less) correct graph of $y = 3x + 5$	B1
		2
5(b)	State equation $3x + 5 = -(2x - 3)$ or corresponding inequality	B1
	Attempt solution of linear equation / inequality where signs of $3x$ and $2x$ are different	M1
	State answer $x < -\frac{2}{5}$	A1
	Alternative method for question 5(b)	
	Square both sides of equation / inequality and attempt solution of 3-term quadratic equation / inequality	M1
	Obtain (eventually) only $-\frac{2}{5}$	A1
	State answer $x < -\frac{2}{5}$	A1
		3

Question	Answer	Marks
6(a)	Substitute $x = -3$, equate to zero and attempt solution for a	M1
	Obtain $a = 17$	A1
		2
6(b)	Divide by $x + 3$ at least as far as the x term	M1
	Obtain $6x^2 - x - 1$	A1
	Conclude $(x + 3)(3x + 1)(2x - 1)$	A1
		3
6(c)	Attempt solution of $\sin \theta = k$ where $-1 \leq k \leq 1$	M1
	Obtain 199.5	A1
	Obtain 340.5	A1
		3

Question	Answer	Marks
7(a)	Integrate to obtain the form $k_1 \ln(2x + 1) + k_2 x^2$	*M1
	Obtain correct $2 \ln(2x + 1) + 4x^2$	A1
	Use limits correctly and attempt rearrangement	DM1
	Confirm $a = \sqrt{2.5 - 0.5 \ln(2a + 1)}$ AG	A1
		4

Question	Answer	Marks
7(b)	Consider sign of $a - \sqrt{2.5 - 0.5 \ln(2a + 1)}$ or equivalent for 1 and 2	M1
	Obtain $-0.3...$ and $0.6...$ or equivalents and justify conclusion	A1
		2
7(c)	Use iteration process correctly at least once	M1
	Obtain final answer 1.358	A1
	Show sufficient iterations to 6 sf to justify answer or show a sign change in the interval $[1.3575, 1.3585]$	A1
		3

Question	Answer	Marks
8(a)	Use at least one of $\sin 2\theta = 2 \sin \theta \cos \theta$ and $\cot \theta = \frac{\cos \theta}{\sin \theta}$	B1
	Use both and conclude $6 \cos^2 \theta$ AG	B1
		2
8(b)	Attempt solution of $\cos^2 \theta = \frac{5}{6}$ to find at least one value	M1
	Obtain 0.421	A1
	Obtain 2.72	A1
		3

Question	Answer	Marks
8(c)	Express integrand in form $a + b \cos x$	M1
	Obtain correct integrand $3 + 3 \cos x$	A1
	Integrate to obtain $px + q \sin x$	*M1
	Apply limits correctly	DM1
	Obtain $\frac{3}{4}\pi + 3 - \frac{3}{\sqrt{2}}$ or exact equivalent	A1
		5