



ADDITIONAL MATHEMATICS

0606/11

Paper 1

May/June 2016

MARK SCHEME

Maximum Mark: 80

Published

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0606	11

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

Question	Answer	Marks	Guidance
1 (i)	-27	B1	
(ii)	$9 - 8k = 0$ $k = \frac{9}{8}$ Or $\frac{dy}{dx} = 4x - 3$ when $\frac{dy}{dx} = 0$, $x = \frac{3}{4}$ so $k = \frac{9}{8}$ Or completing the square $y = 2\left(x - \frac{3}{4}\right)^2 + k - \frac{9}{8}$ $k = \frac{9}{8}$	M1 A1 M1 A1 M1 A1	for use of discriminant with a complete method to get to $k =$ for a complete method to get to $k =$ for a complete method to get to $k =$
2 (a)	$2^{4(3x-1)} = 2^{3(x+2)}$ or $4^{2(3x-1)} = 4^{\frac{3}{2}(x+2)}$ or $8^{\frac{4}{3}(3x-1)} = 8^{x+2}$ or $16^{3x-1} = 16^{\frac{3}{4}(x+2)}$ leading to $x = \frac{10}{9}$ cao	B1 M1 A1	B1 for a correct statement for equating indices
(b)	$p = \frac{5}{3}$ $q = -2$	B1 B1	

Question	Answer	Marks	Guidance
3	<p>On x-axis, $2x^2 - 7 = 1$ $x = 2$</p> $\frac{dy}{dx} = \frac{4x}{2x^2 - 7}$ <p>When $x = 2$, $\frac{dy}{dx} = 8$</p> <p>Gradient of normal = $-\frac{1}{8}$</p> <p>Equation of normal $y = -\frac{1}{8}(x - 2)$</p> <p>Required form $x + 8y - 2 = 0$</p>	<p>M1 A1</p> <p>B1</p> <p>M1</p> <p>A1</p>	<p>for equating to 1</p> <p>for attempt at perpendicular through <i>their</i> (2, 0), must be using $y = 0$</p> <p>must be equated to zero with integer coefficients</p>
4 (a)	$\mathbf{A}^2 = \begin{pmatrix} 7 & -2 \\ -3 & 6 \end{pmatrix}$ $\mathbf{A}^2 - 2\mathbf{B} = \begin{pmatrix} 1 & -2 \\ -5 & 2 \end{pmatrix}$	<p>B1</p> <p>M1 A1</p>	<p>for their $\mathbf{A}^2 - 2\mathbf{B}$</p>
(b)	$\begin{pmatrix} 4 & 1 \\ 10 & 3 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ <p>so $\begin{pmatrix} x \\ y \end{pmatrix} = \frac{1}{2} \begin{pmatrix} 3 & -1 \\ -10 & 4 \end{pmatrix} \begin{pmatrix} 1 \\ 1 \end{pmatrix}$</p> <p>leading to $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ -3 \end{pmatrix}$</p> <p>$x = 1$ $y = -3$</p>	<p>M1</p> <p>DM1</p> <p>A1 A1</p>	<p>for pre-multiplication by <i>their</i> inverse matrix</p> <p>DM1 for attempt at matrix multiplication</p> <p>Allow in matrix form</p>
5 (i)	$\frac{d}{dx} \left(\frac{e^{4x}}{4} - xe^{4x} \right) = e^{4x} - ((x \times 4e^{4x}) + e^{4x})$ $= -4xe^{4x}$	<p>B1</p> <p>M1 A1 A1</p>	<p>for $\frac{d}{dx} \left(\frac{e^{4x}}{4} \right) = e^{4x}$</p> <p>for attempt to differentiate a product</p> <p>for a correct product</p> <p>for correct final answer</p>
(ii)	$\int_0^{\ln 2} xe^{4x} dx = -\frac{1}{4} \left[\frac{e^{4x}}{4} - xe^{4x} \right]_0^{\ln 2}$ $= -\frac{1}{4} \left(\left(\frac{16}{4} - 16 \ln 2 \right) - \frac{1}{4} \right)$ $= 4 \ln 2 - \frac{15}{16}$	<p>B1FT</p> <p>B1 M1 A1</p>	<p>FT for use of <i>their</i> $\frac{1}{p} \times \left(\frac{e^{4x}}{4} - xe^{4x} \right)$, must be numerical p, but $\neq 0$</p> <p>for $e^{4 \ln 2} = 16$</p> <p>for correct use of limits, must be an integral of the correct form</p>

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0606	11

Question	Answer	Marks	Guidance
6 (i)	$2 - \sqrt{5} < f(x) \leq 2$	B2	B1 for ≤ 2 B1 for $2 - \sqrt{5} <$ or awrt -0.24 Must be using f , $f(x)$ or y , $2 - \sqrt{5} <$, if not then B1 max
(ii)	$f^{-1}(x) = (2-x)^2 - 5$ Domain $2 - \sqrt{5} < x \leq 2$ Range y or $-5 \leq f^{-1}(x) < 0$	M1 A1 B1 B1	for a correct method to find the inverse Must be using the correct variables for the B marks
(iii)	$fg(x) = f\left(\frac{4}{x}\right)$ $= 2 - \sqrt{\frac{4}{x}} + 5$ leading to $x = -4$	M1 DM1 A1	for correct order of functions for solution of equation
7 (i)	Finding an angle of 68.2° or 21.8° $\frac{4.5}{\sin 68.2} = \frac{2.4}{\sin \alpha}$ leading to $\alpha = 29.7^\circ$ (allow ± 0.1) Direction is 82.1° to the bank, upstream (allow $\pm 0.1^\circ$)	B1 B1 B1 B1	for the sine rule
(ii)	$\frac{4.5}{\sin 68.2} = \frac{2.4}{\sin 29.7} = \frac{v_r}{\sin 82.1}$ leading to $v_r = 4.8$ time taken = $\frac{80.78}{4.8} = 16.8$ Alternative method: Finding an angle of 68.2° or 21.8° $4.5^2 = 2.4^2 + v_r^2 - (2 \times 2.4 \times v_r \cos 68.2)$ leading to $v_r = 4.8$ Use of sine rule to obtain angle and direction to obtain direction is 82.1° to the bank, upstream Use of time taken = $\frac{80.78}{4.8} = 16.8$	B1 B1 M1 A1 B1 B1 B1 B1 B1 M1 A1	for the sine rule for resultant velocity for attempt to find AB and hence the time taken for correct use of the cosine rule for resultant velocity for use of the sine rule for $\alpha = 29.7^\circ$ for 82.1° for attempt to find AB and hence the time taken

Question	Answer	Marks	Guidance
8	(i) $y - 6 = -\frac{4}{12}(x + 8)$ ($3y + x = 10$)	M1 A1	for a correct method allow unsimplified
	(ii) $y - 7 = 3(x + 1)$ ($y = 3x + 10$)	DM1 A1	for attempt at a perpendicular line using (-1, 7) allow unsimplified
	(iii) point of intersection (-2, 4) which is the midpoint of <i>AB</i>	M1 M1 A1	for attempt to find the point of intersection using simultaneous equations for attempt to find midpoint for all correct
	Alternative method: Midpoint (-2, 4) Verification that this point lies on <i>CP</i> .	M1 M1 A1	for attempt to find midpoint for full verification for all correct
	(iv) $CP = \sqrt{10}$ or 3.16	B1	
(v)	Area = $\frac{1}{2} \times \sqrt{10} \times 4\sqrt{10}$ = 20	M1 A1	for correct method using CP for 19.9 – 20.1

Question	Answer	Marks	Guidance
9 (i)	$2 \cos x \cot x = \cot x + 2 \cos x$ $2 \cos x \frac{\cos x}{\sin x} + 1 = \frac{\cos x}{\sin x} + 2 \cos x$ $2 \cos^2 x + \sin x = \cos x + 2 \cos x \sin x$ $2 \cos^2 x - 2 \cos x \sin x = \cos x - \sin x$ $2 \cos x (\cos x - \sin x) = \cos x - \sin x$ $(2 \cos x - 1)(\cos x - \sin x) = 0$ <p>Alternative method:</p> $a \cos^2 x - a \cos x \sin x - b \cos x$ $+ b \sin x = 0$ $a \cos x \cot x - a \cos x - b \cot x + b = 0$ $a = 2, \quad b = 1$	<p>M1</p> <p>DM1</p> <p>DM1</p> <p>A1</p> <p>M1</p> <p>DM1 DM1</p> <p>A1</p>	<p>for use of $\cot x = \frac{\cos x}{\sin x}$ for both terms</p> <p>for multiplication throughout by $\sin x$</p> <p>for attempt to factorise</p> <p>for completely correct solution www</p> <p>for expansion of RHS</p> <p>for division by $\sin x$</p> <p>for comparing like terms to obtain both a and b</p> <p>for both correct www</p>
(ii)	$(2 \cos x - 1)(\cos x - \sin x) = 0$ $\cos x = \frac{1}{2}, \tan x = 1$ $x = \frac{\pi}{3}, x = \frac{\pi}{4}$ <p>Alternative method:</p> $(2 \cos x - 1)(\cot x - 1) = 0$ <p>Leading to $\cos x = \frac{1}{2}, \tan x = 1$</p> $x = \frac{\pi}{3}, x = \frac{\pi}{4}$	<p>M1</p> <p>A1,A1</p> <p>M1</p> <p>A1,A1</p>	<p>for either</p> <p>A1 for each, penalise extra solutions within the range by withholding the last A mark</p> <p>for attempt to factorise the original equation and attempt to solve</p> <p>A1 for each, penalise extra solutions within the range by withholding the last A mark</p>
10 (i)	$f(-2) = -32 - 2k + p = 0$ $f'\left(\frac{1}{2}\right) = \frac{12}{4} + k = 0$ <p>leading to $k = -3$ and $p = 26$</p>	<p>M1</p> <p>M1</p> <p>A1,A1</p>	<p>for attempt at $f(-2)$</p> <p>for attempt at $f'\left(\frac{1}{2}\right)$</p> <p>A1 for each</p>
(ii)	$(x+2)(4x^2 - 8x + 13)$	<p>B1FT</p> <p>B1</p>	<p>FT for <i>their</i> $\frac{p}{2}$</p> <p>all correct</p>
(iii)	<p>Showing that $4x^2 - 8x + 13 = 0$ has no real roots</p> <p>so $x = -2$ only www</p>	<p>M1,</p> <p>A1</p>	<p>M1 for a valid attempt at solution of equation leading to no solution or consideration of the discriminant</p>

Question	Answer	Marks	Guidance
11 (i)	$AB = 2r \sin \theta$ or $\sqrt{r^2 + r^2 - 2r^2 \cos 2\theta}$ or $\frac{r \sin 2\theta}{\sin\left(\frac{\pi}{2} - \theta\right)}$ or $\frac{r \sin 2\theta}{\cos \theta}$	B1	
(ii)	$2r \sin \theta + 2r\theta = 20$ $r = \frac{10}{\theta + \sin \theta}$	M1 A1	for use of (i) + arc length = 20, oe must be convinced
(iii)	$\frac{dr}{d\theta} = -\frac{10(1 + \cos \theta)}{(\theta + \sin \theta)^2}$ When $\theta = \frac{\pi}{6}$, $\frac{dr}{d\theta} = -17.8$	M1 A2,1,0 A1	for a correct attempt to differentiate –1 each error allow awrt –17.8
(iv)	$\frac{dr}{dt} = 15$ $\frac{d\theta}{dt} = \frac{dr}{dt} \div \frac{dr}{d\theta}$ $\frac{d\theta}{dt} = -0.842$	B1 M1 A1	may be implied for use of $\frac{15}{\text{their (iii)}}$ allow –0.84 or –0.843