



ADDITIONAL MATHEMATICS

0606/22

Paper 2

May/June 2016

MARK SCHEME

Maximum Mark: 80

Published

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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)	$(2k)^2 - 4(1)(4k - 3) [< 0]$ Correct completion to given inequality $k^2 - 4k + 3 < 0$ isw	M1 A1	clear attempt at $b^2 - 4ac$
	(ii) Critical values 1 and 3 soi $1 < k < 3$ as final answer	M1 A1	May be implied by incorrect inequalities
2 (i)	Clear attempt at quotient rule or equivalent product rule $\left[\frac{dy}{dx} = \right] \frac{14}{(3-x)^2}$ or $\left[\frac{dy}{dx} = \right] \frac{14}{x^2 - 6x + 9}$ cao or correct simplified equivalent	M1 A1	condone omission of brackets allow recovery from bracketing errors or omissions if implied in correct work to the correct answer
	(ii) $[y = 9]_{x=2}$ $\frac{0.07}{\delta x} \approx \left(\textit{their} \frac{dy}{dx} \Big _{x=2} \right)$ oe 0.005 oe	B1 M1 A1	condone $\frac{0.07}{\delta x} = \left(\textit{their} \frac{dy}{dx} \Big _{x=2} \right)$ not from wrong working; answer only does not score
3	Any one of: $[{}^6C_0 \times] {}^7C_3 + {}^6C_1 \times {}^7C_2$ or $35 + 126$ or ${}^{13}C_3 - {}^6C_2 \times {}^7C_1 - {}^6C_3$ or $286 - 105 - 20$ 161	M2 A1	M1 for $[{}^6C_0 \times] {}^7C_3$ or ${}^6C_1 \times {}^7C_2$ or ${}^{13}C_3 - {}^6C_2 \times {}^7C_1$ or ${}^{13}C_3 - {}^6C_3$ or ${}^6C_2 \times {}^7C_1 + {}^6C_3$ or for the numerical equivalent of one of these calculations If M0 then B3 for answer only of 161

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Question	Answer	Marks	Guidance
4 (i)	$2(2)^3 - 3(2)^2 + 2q + 56 = 0$ with one correct interim step leading to $q = -30$	B1	allow for only $16 - 12 + 2q + 56 = 0$ $q = -30$ NB $= 0$ must be seen or may be implied by e.g. $-60 = 2q$ or $60 = -2q$; or convincingly showing $2(2)^3 - 3(2)^2 - 30(2) + 56 = 0$; allow for only $16 - 12 + 2(-30) + 56 = 0$ or correct synthetic division at least as far as $\begin{array}{r rrrr} 2 & 2 & -3 & q & 56 \\ & & 4 & 2 & 2q+4 \\ \hline & 2 & 1 & q+2 & 0 \end{array}$ then $q = -30$
(ii)	$2x^2 + x - 28$ $(x-2)(2x-7)(x+4)$ $x = 2, x = -4, x = 3.5$ oe	B2 M1 A1	B1 for any two terms correct For factorising the correct equation; condone $= 0$; condone $(2x-7)(x+4)$ only for M1 but for A1 must see all 3 factors in this part; do not allow $\left(x - \frac{7}{2}\right)$ not from wrong working; answers only do not score
5 (i)	(2, 8)	B1, B1	
(ii)	$\frac{\text{their } 8 - 0}{\text{their } 2 - p} = -2$ or better [p =] 6	M1 A1	Condone $\frac{\text{their } 8 - 0}{\text{their } 2 - p} = \frac{-1}{\text{their gradient } AB}$ oe

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(iii)	$[MB =]\sqrt{(6 - \text{their} 2)^2 + (10 - \text{their} 8)^2}$ soi or $\left[\frac{1}{2} AB = \right]\frac{1}{2}\sqrt{(6 - 2)^2 + (10 - 6)^2}$ soi or $[MC =]\sqrt{(\text{their} 2 - \text{their } p)^2 + (\text{their} 8 - 0)^2}$ soi or $\tan[\dots] = \frac{8}{4}$ soi or $4.47^2 = 8.94^2 + 10^2 - 2(8.94)(10)\cos[\dots]$ or $8.94^2 = 10^2 + 10^2 - 2(10)(10)\cos[\dots]$ $\sin^{-1}\left(\frac{\sqrt{20}}{10}\right)$ oe soi	M1 M1	implied by $[MB =]\sqrt{20}$ or $\left[\frac{1}{2} AB = \right]\frac{1}{2}\sqrt{80}$ e.g. 4.47, or $[MC =]\sqrt{80}$ or e.g. 8.94 or 63.4° or equivalents or $\cos^{-1}\left(\frac{\sqrt{80}}{10}\right)$ or $\tan^{-1}\left(\frac{\sqrt{20}}{\sqrt{80}}\right)$ or $\tan^{-1}\left(\frac{4}{8}\right)$ or $90 - \tan^{-1}\left(\frac{8}{4}\right)$ or equivalent complete correct method; implies first M1
	26.56 to 26.6° or 0.4636 to 0.464 rads cao	A1	Not from wrong working
6 (i)	Valid explanation	B1	e.g. arc length is greater than the radius or 7 is greater than 5
(ii)	$7 = 5\theta$ $\theta = 1.4$ oe	M1 A1	implies M1
(iii)	$\frac{1}{2} \times 5^2 \times \text{their} 1.4$ oe 17.5oe	M1 A1	

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Question	Answer	Marks	Guidance
(iv)	$\left[\text{triangle area} = \right] \frac{1}{2} \times 5^2 \times \sin \theta = 12.3$ or 12.3 to 12.32 or for $\left[\frac{1}{2} \times \text{base} \times \text{height} = \right]$ $\frac{1}{2} \times 6.4[4\dots] \times 3.8[2\dots]$ oe	M1	may be embedded in a difference calculation
	5.18 to 5.2 inclusive	A1	implies M1
7 (i)	$\begin{pmatrix} 12 & 15 \\ 9 & 6 \end{pmatrix} + \begin{pmatrix} 4 & 2 \\ 1 & 3 \end{pmatrix}$ soi	M1	if no method shown, may be implied by their answer with at least 2 correct elements
	$\begin{pmatrix} 16 & 17 \\ 10 & 9 \end{pmatrix}$	A1	
(ii)	$\det \mathbf{A} = 4 \times 2 - 3 \times 5 = -7$ or $\det \mathbf{B} = 4 \times 3 - 2 \times 1 = 10$ $\mathbf{AB} = \begin{pmatrix} 21 & 23 \\ 14 & 12 \end{pmatrix}$ $\det(\mathbf{AB}) = 21 \times 12 - 23 \times 14 = -70$	B1	allow for e.g. $(4 \times 2 - 3 \times 5) \times (4 \times 3 - 2 \times 1) = -70$ or $\det \mathbf{A} = 8 - 15 = -7$ or $\det \mathbf{B} = 12 - 2 = 10$
		B2	or B1 for two elements correct
		B1	allow for $\det(\mathbf{AB}) = 252 - 322 = -70$ For full marks must conclude that $\det \mathbf{AB} = \det \mathbf{A} \times \det \mathbf{B}$ or show the product $-7 \times 10 = -70$ otherwise max 3 marks
(iii)	$\frac{1}{\text{their } \det \mathbf{AB}} \times \text{their} \begin{pmatrix} 12 & -23 \\ -14 & 21 \end{pmatrix}$ isw	B2	correct or correct FT; FT their AB and their non-zero det AB ; their AB must be an attempt at a matrix product e.g. $\begin{pmatrix} 16 & 10 \\ 3 & 6 \end{pmatrix}$ B1 for $\frac{1}{\text{their } \det \mathbf{AB}} \times \text{their} \begin{pmatrix} & \\ & \end{pmatrix}$ or for $k \times \text{their} \begin{pmatrix} 12 & -23 \\ -14 & 21 \end{pmatrix}$

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8	<p>Eliminates y e.g. $4 + \frac{5}{15x+10} + \frac{3}{x} = 0$ or eliminates x e.g. $4 + \frac{5}{y} + \frac{3}{(y-10)/15} = 0$</p> <p>Rearrange to a 3-term quadratic $60x^2 + 90x + 30 = 0$ oe or $4y^2 + 10y - 50 = 0$ oe</p> <p>Factorise or solve 3-term quadratic $x = -\frac{1}{2}, x = -1$ isw $y = 2\frac{1}{2}, y = -5$ isw</p>	<p>M1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>A1</p>	<p>allow even after incorrect rearrangement of the equation of the curve (dependent on resulting equation still in terms of x and y); condone substitution of e.g. $\frac{y+10}{15}$</p> <p>condone sign slips/arithmetic slips</p> <p>or $y = 2\frac{1}{2}, y = -5$ or $x = -\frac{1}{2}, x = -1$</p> <p>If final A marks not awarded then A1 for a correct x, y pair</p>
9 (a)	$\frac{x^2}{2} + x - \frac{1}{x} (+c)$ isw	B3	<p>B1 for each term allow $\frac{x^2}{2} + x + \frac{x^{-1}}{-1} (+c)$ isw for B3</p>
(b) (i)	<p>$k \cos(5x + \pi)$ where $k < 0$ or $\frac{\cos(5x + \pi)}{5}$ $\frac{-\cos(5x + \pi)}{5} (+c)$</p>	<p>M1</p> <p>A1</p>	
(ii)	<p>$\frac{-\cos(5(0) + \pi)}{5} - \frac{-\cos(5(-\pi/5) + \pi)}{5}$ or $\frac{-\cos(\pi)}{5} - \left(\frac{-\cos(0)}{5} \right)$ 0.4 oe</p>	<p>M1</p> <p>A1</p>	<p>correct substitution of the given limits into <i>their</i> expression of the form $k \cos(5x + \pi)$, dep on M1 in (b)(i) answer only does not score</p>
10 (a)	<p>$2 = p - q$ and $14 = 4p - 2q$ oe $p = 5$ $q = 3$</p>	<p>M1</p> <p>A1</p> <p>A1</p>	
(b)	<p>Factorise $10^{2x} - 2(10^x) - 24 [= 0]$ or factorise $u^2 - 2u - 24 [= 0]$ $10^x = 6$ $x = \lg 6$ cao as final answer</p>	<p>M1</p> <p>A1</p> <p>A1</p>	<p>or applies the formula or completes the square ignore $10^x = -4$ for this mark or exact equivalent</p>

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(c)	$\frac{x+1}{x} = 2^3$ oe www $x = \frac{1}{7}$ or 0.143 or 0.1428 to 0.1429	M2 A1	combines logs and anti-logs or B1 for one correct log move e.g. $\log_2\left(\frac{x+1}{x}\right) = 3$ or $\log_2(x+1) - \log_2(x) = \log_2 8$ or $\log_2(x+1) - \log_2(x) = 3\log_2 2$
11 (a)	Valid method when $x = \frac{1}{2}$ [greatest value =] $\frac{1}{4}$	M1 A1 B1	Completing the square as far as e.g. constant $-\left(x - \frac{1}{2}\right)^2$ or calculus as far as $1 - 2x = 0$ or finding roots $x = 0$ and $x = 1$ and using symmetry soi Implies M1 if not clearly from wrong working
(b)	Valid comment e.g. when $x \geq 1$, f' is always decreasing	B1	Allow e.g. a sketch with a comment such as the curve is one-one [when $x \geq 1$] or e.g. the curve is one-one when $x > \frac{1}{2}$
(c) (i)	$k(10) = 8$ or $5 + \sqrt{10-1} = 8$ or stating $h(8)$ $h(8) = 1$ or $\lg(8+2) = 1$ cao	M1 A1	or $[hk(x) =] \lg(7 + \sqrt{x-1})$ $[hk(10) =] \lg(7 + \sqrt{10-1}) = 1$
(ii)	$(y-5)^2 = x-1$ $k^{-1}(x) = (x-5)^2 + 1$ isw or $k^{-1}(x) = x^2 - 10x + 26$ isw $5 < x < 15$	M1 A1 B1, B1	or $(x-5)^2 = y-1$ B1 for $5 < x$ oe and B1 for $x < 15$ oe allow (5, 15); one mark for each limit of the interval; if B0 then SC1 for $5 \leq x \leq 15$ or '5 to 15' or [5, 15] etc.
	$1 < k^{-1}(x) < 101$	B1	allow (1, 101)

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12 (i)	$8(1 - \cos^2 A) + 2 \cos A = 7$ or better Solves or factorises <i>their</i> 3-term quadratic in $\cos A$	B1 M1	with no extras in range; not from clearly wrong working but allow recovery from minor slips or A1 for either, ignoring extras
	60, 104.477... rounded or truncated to 1 dp or more;	A2	
(ii)	$\sin(3B + 1) = 0.4$ soi	B1	may be implied by $\frac{1}{\sin(3B + 1)} = 2.5$
	$[3B + 1 =] 0.41$ or better	M1	implies B1
	0.577, 1.9[0], 2.67 or 0.57669..., 1.89823..., 2.67108... rounded or truncated to 4 or more sf	A2	with no extras in range; or A1 for any one correct ignoring extras If M0 then B2 for all 3 correct angles found or B1 for 1 or 2 correct angles found