



**Cambridge International Examinations**  
Cambridge International General Certificate of Secondary Education

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**ADDITIONAL MATHEMATICS**

**0606/13**

Paper 1

**October/November 2016**

MARK SCHEME

Maximum Mark: 80

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**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	Part Marks
1		<p><b>B1</b></p> <p><b>B1</b></p> <p><b>B1</b></p>	<p>for symmetrical shape as in the diagram with curved maxima of equal height and cusps on the <math>x</math>-axis</p> <p>for a complete ‘curve’ with all low points on the <math>x</math>-axis and all high points on <math>y = 2</math></p> <p>for a complete ‘curve’ meeting the <math>x</math>-axis at <math>x = 30^\circ, 90^\circ, 150^\circ</math> only.</p>
2	$= \frac{4m^2 - 9}{2m + 3}$ $= \frac{(2m - 3)(2m + 3)}{2m + 3}$ $= 2m - 3$ <p><b>Alternative Method</b></p> $(4m\sqrt{m} - \frac{9}{\sqrt{m}})$ $= (2\sqrt{m} + \frac{3}{\sqrt{m}})(Am + B)$ <p>Comparing coefficients  <math>2A = 4, 3A + 2B = 0, 3B = -9</math></p>	<p><b>M1</b></p> <p><b>A1</b></p> <p><b>A1</b></p> <p><b>M1</b></p> <p><b>A1</b></p> <p><b>A1</b></p>	<p>for multiplying each term by <math>\sqrt{m}</math>, using a common denominator of <math>\sqrt{m}</math> or for multiplying numerator and denominator by <math>2\sqrt{m} - \frac{3}{\sqrt{m}}</math></p> <p>for a correct expression that will cancel <math>\frac{(2m - 3)(2m + 3)}{2m + 3}, \frac{(4m^2 - 9)(2m - 3)}{(4m^2 - 9)}</math>  <math>\frac{(2m - 3)(2m + 3)(2m - 3)}{(2m + 3)(2m - 3)}</math>, or equivalents</p> <p>for <math>2m - 3</math> or <math>A = 2, B = -3</math></p> <p>for correct expansion</p> <p>for correct comparisons to obtain <math>A</math> and <math>B</math>  for <math>2m - 3</math> or <math>A = 2, B = -3</math></p>

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Question	Answer	Marks	Part Marks
3 (i)	$3x^2 - 2xp + (p+3) = 0$ $(-2p)^2 - 4 \times 3 \times (p+3) \geq 0$ oe  $p^2 \geq 3(p+3)$ or $4p^2 - 12p - 36 \geq 0$ $p^2 - 3p - 9 \geq 0$	<b>M1</b>  <b>DM1</b>  <b>A1</b>	for obtaining a 3-term quadratic in the form $ax^2 + bx + c (=0)$  for correct substitution of <i>their</i> $a$ , $b$ and $c$ into ' $b^2 - 4ac$ ' and use of discriminant.  for full correct working, $\geq$ the only sign used, $\geq$ used before division by 4 and $\geq$ used in answer line and penultimate line.
3 (ii)	Correct method of solution $p^2 - 3p - 9 = 0$ leading to critical values $p = \frac{3 \pm 3\sqrt{5}}{2}$  $p \leq \frac{3 - 3\sqrt{5}}{2}$ , $p \geq \frac{3 + 3\sqrt{5}}{2}$	<b>M1</b>  <b>A1</b>  <b>A1</b>	for correct substitution in the quadratic formula or for correct attempt to complete the square. (allow 1 sign error in either method)  for both correct critical values  for correct range
4 (i)	$64 - 48x + 15x^2$	<b>B3</b>	for each correct term
4 (ii)	$(4 \times '64') + (2 \times '-48') + (3 \times '15')$  $= 205$ cao	<b>M1</b>  <b>A1</b>  <b>A1</b>	for correctly obtaining three products using <i>their</i> coefficients in (i)  for two correct out of three products (unsimplified) cao  for 205 selected as final answer
5 (i)	$\log_9 xy = \log_9 x + \log_9 y$  $= \frac{\log_3 x}{\log_3 9} + \frac{\log_3 y}{\log_3 9}$  $= \frac{\log_3 x}{2} + \frac{\log_3 y}{2} = \frac{5}{2}$  $\log_3 x + \log_3 y = 5$  <b>Alternative method</b> $\log_9 xy = \frac{5}{2}$ $xy = 9^{\frac{5}{2}} = 3^5$ $\log_3 xy = 5$ $\log_3 x + \log_3 y = 5$	<b>M1</b>  <b>M1</b>  <b>A1</b>  <b>M1</b>  <b>M1</b>  <b>A1</b>	for use of $\log AB = \log A + \log B$  for correct method for change of base. Division by $\log_3 9$ should be seen and not implied.  for dealing with 2 correctly and 'finishing off'  for obtaining $xy$ as a power of 3  for correct use of $\log_3$  for using law for logs and arriving at correct answer

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Question	Answer	Marks	Part Marks
(ii)	$\log_3 x(5 - \log_3 x) = -6$ $-(\log_3 x)^2 + 5\log_3 x = -6$ $(\log_3 x)^2 - 5\log_3 x - 6 = 0$ leading to $\log_3 x = 6, \log_3 x = -1$ $x = 729, x = \frac{1}{3}$ $y = \frac{1}{3}, y = 729$	<b>M1</b> <b>A1</b> <b>A1</b> <b>DM1</b> <b>A1</b>	for substitution, correct expansion of brackets and manipulation to get a 3 term quadratic for a correct quadratic equation in the form $ax^2 + bx + c = 0$ for both solutions for method of solution of $\log_3 x = k$ or $\log_3 y = k$ for all $x$ and $y$ correct
6 (i)	$\frac{6x}{3x^2 - 11}$	<b>M1</b> <b>A1</b>	<b>M1</b> for $\frac{mx}{3x^2 - 11}$
(ii)	$p = \frac{1}{6}$	<b>B1</b>	<b>FT</b> for $p = \frac{1}{m}$
(iii)	$\frac{1}{6}\ln(3a^2 - 11) - \frac{1}{6}\ln 1 = \ln 2$ $\ln(3a^2 - 11) = \ln 2^6$ $3a^2 - 11 = 64$ $a = 5$ only	<b>M1</b> <b>DM1</b> <b>DM1</b> <b>A1</b>	for correct use of limits in $p \ln(3x^2 - 11)$ May be implied by following equation for dealing with logs correctly for solution of $3a^2 - 11 = k$ for 5 obtained from an exact method



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Question	Answer	Marks	Part Marks
8 (a) (i)	$\frac{\operatorname{cosec} \theta}{\operatorname{cosec} \theta - \sin \theta} = \frac{\frac{1}{\sin \theta}}{\frac{1}{\sin \theta} - \sin \theta}$ $= \frac{1}{1 - \sin^2 \theta} \text{ or } = \frac{\frac{1}{\sin \theta}}{\frac{(1 - \sin^2 \theta)}{\sin \theta}}$ $= \frac{1}{\cos^2 \theta}$ $= \sec^2 \theta$ <p><b>Alternative Method using cosec</b></p> $\frac{\operatorname{cosec} \theta}{\operatorname{cosec} \theta - \sin \theta} = \frac{\operatorname{cosec} \theta}{\operatorname{cosec} \theta - \frac{1}{\operatorname{cosec} \theta}}$ $= \frac{\operatorname{cosec}^2 \theta}{\operatorname{cosec}^2 \theta - 1}$ $= \frac{1 + \cot^2 \theta}{\cot^2 \theta}$ $= \tan^2 \theta + 1 = \sec^2 \theta$	<p><b>M1</b></p> <p><b>DM1</b></p> <p><b>A1</b></p>	<p>for using <math>\operatorname{cosec} \theta = \frac{1}{\sin \theta}</math> and either attempt to multiply top and bottom by <math>\sin \theta</math> or an attempt to combine terms in denominator.</p> <p>for correct use of <math>1 - \sin^2 \theta = \cos^2 \theta</math></p> <p>for completing the proof</p>
(ii)	$\cos^2 \theta = \frac{1}{4}, \quad \cos \theta = \pm \frac{1}{2}$ $\text{or } \tan^2 \theta = 3, \quad \tan \theta = \pm \sqrt{3}$ $\text{or } \sin^2 \theta = \frac{3}{4}, \quad \sin \theta = \pm \frac{\sqrt{3}}{2}$ $\theta = 60^\circ, 120^\circ, 240^\circ, 300^\circ$	<p><b>M1</b></p> <p><b>DM1</b></p> <p><b>A1</b></p> <p><b>A1</b></p>	<p>for using (i) to obtain a value for <math>\cos^2 \theta</math>, <math>\tan^2 \theta</math> or <math>\sin^2 \theta</math> and then taking the square root.</p> <p>for two correct values</p> <p>for two further correct values and no extras in range.</p>
(b)	$\tan\left(x + \frac{\pi}{4}\right) = \frac{1}{\sqrt{3}}$ $x = \frac{\pi}{6} - \frac{\pi}{4}, \frac{7\pi}{6} - \frac{\pi}{4}, \frac{13\pi}{6} - \frac{\pi}{4}$ $x = \left(-\frac{\pi}{12}\right), \frac{11\pi}{12}, \frac{23\pi}{12}$	<p><b>M1</b></p> <p><b>A1,A1</b></p>	<p>for correct order of operations, can be implied by</p> $x = -\frac{\pi}{12}$ <p><b>A1</b> for <math>x = \frac{11\pi}{12}</math></p> <p><b>A1</b> for <math>x = \frac{23\pi}{12}</math></p> <p>If there are extra solutions in range in addition to the two correct ones then <b>A1A0</b></p>

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Question	Answer	Marks	Part Marks
9 (a) (i)	${}^{18}C_5 = 8568$ mmm	<b>B1</b>	
	(ii) <b>Either</b>	<b>B1</b>	for a correct plan
	${}^{10}C_4 \times {}^8C_1 = 1680$	<b>B2,1,0</b>	<b>B2</b> 4 correct numbers with no extras
	${}^{10}C_3 \times {}^8C_2 = 3360$		<b>B1</b> 3 correct numbers (out of 3 or 4)
	${}^{10}C_2 \times {}^8C_3 = 2520$		
	${}^{10}C_1 \times {}^8C_4 = 700$		
	Total = 8260	<b>B1</b>	for correct total
	<b>Or</b>	<b>B1</b>	for correct plan
	their ${}^{18}C_5 - ({}^{10}C_5 + {}^8C_5)$	<b>B1</b>	for 252 subtracted
	$8568 - (252 + 56)$	<b>B1</b>	for 56 subtracted
Total = 8260	<b>B1</b>	for correct total	
(b) (i)	${}^{10}P_6 = 151200$	<b>B1</b>	
(ii)	$4 \times {}^8P_4 \times 3$ = 20160	<b>M1</b> <b>A1</b>	for correct unsimplified for correct numerical answer
(iii)	Answer to (i) - ${}^7P_6$ = 146160	<b>M1</b> <b>A1</b> <b>A1</b>	for correct plan for correct unsimplified for correct numerical answer
	Alternative: 1 symbol: 45360 2 symbols: 75600 3 symbols: 25200 Total: 146160	<b>B2,1,0</b>  <b>B1</b>	<b>B2</b> for all 3 correct <b>B1</b> for 2 correct (out of 2 or 3) for correct sum

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Question	Answer	Marks	Part Marks
10 (i)	$f(x) = 3x^2 - 4e^{2x} (+c)$  passing through $(0, -3)$ $-3 = 3 \times 0 - 4e^0 + c$ $f(x) = 3x^2 - 4e^{2x} + 1$	<b>M1</b> <b>A1</b> <b>A1</b> <b>DM1</b>	for one correct term for one correct term $3x^2$ or $-4e^{2x}$ for a second correct term with no extras for correct method to find $c$ .
(ii)	$f'(0) = -8$  Normal: $y + 3 = \frac{1}{8}x$ $8y + 24 = x$ $y = 2 - 3x$  leads to $x = \frac{8}{5}$ oe $\text{Area} = \frac{1}{2} \times 3 \times \frac{8}{5} = 2.4$ oe	<b>B1</b> <b>M1</b> <b>DM1</b> <b>A1</b> <b>B1</b>	for $m = \frac{1}{8}$ for equation of normal using $m = \frac{1}{8}$ for solving normal equation simultaneously with $y = 2 - 3x$ to get a value of $x$ for $x = \frac{8}{5}$ , 1.6 oe <b>FT</b> for a numerical answer equal to $\left  \frac{1}{2} \times 3 \times \text{their } x \right $
11 (i)	$a = 8t - 8$ When $t = 3$ , $a = 16$	<b>B1</b> <b>B1</b>	for $8t - 8$ for 16
(ii)	0.5, 1.5	<b>B1,B1</b>	<b>B1</b> for each
(iii)	$s = \frac{4}{3}t^3 - 4t^2 + 3t$  when $t = \frac{1}{2}$ , $s = \frac{2}{3}$  when $t = \frac{3}{2}$ , $s = 0$  total distance travelled = $\frac{4}{3}$	<b>M1</b> <b>A1</b> <b>DM1</b> <b>DM1</b> <b>A1</b>	for at least two terms correct all correct for calculating displacement when either $t = \frac{1}{2}$ or $t = \frac{3}{2}$ for calculating displacement at $t = \frac{1}{2}$ and doubling. for $\frac{4}{3}$ oe allow 1.33
	<b>Alternative method</b>	<b>M1A1</b> <b>DM1</b> <b>DM1</b> <b>A1</b>	As before <b>DM1</b> for calculating displacement when $t = 0.5$ or for calculating distance travelled between $t = 0.5$ and $t = 1.5$ <b>DM1</b> for doubling distance travelled between $t = 0.5$ and $t = 1.5$ or for adding that distance to displacement at $t = 0.5$ <b>A1</b> for $\frac{4}{3}$ oe allow 1.33