
ADDITIONAL MATHEMATICS

4037/23

Paper 2

October/November 2016

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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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	Mark	Part Marks
1	$\frac{(\sqrt{5} + 3\sqrt{3})}{(\sqrt{5} + \sqrt{3})} \times \frac{(\sqrt{5} - \sqrt{3})}{(\sqrt{5} - \sqrt{3})}$ $= \frac{5 + 3\sqrt{15} - \sqrt{15} - 9}{5 - 3}$ $= \frac{2\sqrt{15} - 4}{2} = \sqrt{15} - 2$	<p>M1</p> <p>A1</p> <p>A1</p>	<p>rationalise with $(\sqrt{5} - \sqrt{3})$</p> <p>numerator (3 or 4 terms)</p> <p>denominator and completion</p>
2	$\ln e^{3x} = \ln 6e^x$ $3x = \ln 6e^x$ $3x = \ln 6 + \ln e^x$ $3x = \ln 6 + x$ $x = \frac{1}{2} \ln 6 \text{ or } \ln \sqrt{6} \text{ or } 0.896$	<p>M1</p> <p>M1</p> <p>A1</p>	<p>one law of indices/logs</p> <p>second law of indices/logs</p> <p>www oe in base 10</p>
3 (i)	$\frac{d}{dx} \left(\frac{\sin x}{1 + \cos x} \right) = \frac{(1 + \cos x) \cos x + \sin x \sin x}{(1 + \cos x)^2}$ $= \frac{\cos x + \cos^2 x + \sin^2 x}{(1 + \cos x)^2}$ $= \frac{1 + \cos x}{(1 + \cos x)^2}$	<p>M1</p> <p>A1</p> <p>B1</p> <p>A1</p>	<p>Quotient Rule (or Product Rule from $(\sin x)(1 + \cos x)^{-1}$)</p> <p>correct unsimplified</p> <p>use of $\sin^2 x + \cos^2 x = 1$ oe</p> <p>completion</p>
(ii)	$\int_0^2 \left(\frac{1}{1 + \cos x} \right) dx = \left[\frac{\sin x}{1 + \cos x} \right]_0^2$ <p>awrt 1.56</p>	<p>M1</p> <p>A1</p>	<p>correct integrand</p>

Question	Answer	Mark	Part Marks
4 (i)	$p(2) = 0 \rightarrow 8 + 4a + 2b - 24 = 0$ $\rightarrow (4a + 2b = 16)$ $p(1) = -20 \rightarrow 1 + a + b - 24 = -20$ $\rightarrow (a + b = 3)$ $a = 5$ and $b = -2$	B1 B1 M1 A1	solve <i>their</i> linear equations for a or b
(ii)	$p(x) = x^3 + 5x^2 - 2x - 24$ $= (x - 2)(x^2 + 7x + 12)$ $= (x - 2)(x + 3)(x + 4)$ $p(x) = 0 \rightarrow x = 2, -3, -4.$	M1 A1 M1 A1	find quadratic factor correct quadratic factor soi factorise quadratic factor and write as product of 3 linear factors if 0 scored, SC2 for roots only
5 (i)	$AB^2 = (\sqrt{3} + 1)^2 + (\sqrt{3} - 1)^2$ $\quad - 2(\sqrt{3} + 1)(\sqrt{3} - 1)\cos 60$ $= 3 + 1 + 2\sqrt{3} + 3 + 1 - 2\sqrt{3} - 2$ $= 6$	M1 A1 A1	use cosine rule at least 7 terms correct completion AG
(ii)	$\frac{\sin A}{\sqrt{3} - 1} = \frac{\sin 60}{\sqrt{6}}$ $\sin A = \frac{(\sqrt{3} - 1)\sin 60}{\sqrt{6}} = \frac{\sqrt{6} - \sqrt{2}}{4}$ oe or 0.259 or 0.2588...	M1 A1	sine rule (or cosine rule) correct explicit expression for $\sin A$ AG
(iii)	$\text{Area} = \frac{1}{2}(\sqrt{3} + 1)(\sqrt{3} - 1)\sin 60$ $= \frac{\sqrt{3}}{2}$	M1 A1	correct substitution into $\frac{1}{2}ab \sin C$
6 (i)	$\frac{dy}{dx} = \sec^2 x$ $x = \frac{\pi}{4} \rightarrow \frac{dy}{dx} = \sec^2 \frac{\pi}{4} = 2$ $y = 8$ Equation of tangent $\frac{y - 8}{x - \frac{\pi}{4}} = 2$ $(4 - 2y = \pi - 16, y = 2x + 6.429\dots,$ $\frac{\pi}{4} = 0.7853\dots)$	B1 B1 B1 B1	evaluated

Question	Answer	Mark	Part Marks
(ii)	$\sec^2 x = \tan x + 7$ $\tan^2 x - \tan x - 6 = 0$ oe $(\tan x - 3)(\tan x + 2) = 0$ $\tan x = 3$ or $\tan x = -2$ $x = 1.25, 2.03$	M1 M1 A1A1	use $\sec^2 x = 1 + \tan^2 x$ to obtain a 3 term quadratic in $\tan x$ solve three term quadratic for $\tan x$ extras in range lose final A1
7 (i)	$r^2 + h^2 = (0.5h + 2)^2$ oe $r^2 = 0.25h^2 + 2h + 4 - h^2$ $r^2 = 2h + 4 - 0.75h^2$	M1 A1	correct expansion and r^2 subject and completion www AG
(ii)	$V = \frac{1}{3}\pi r^2 h = \frac{\pi}{3}(2h^2 + 4h - 0.75h^3)$ $\frac{dV}{dh} = \frac{\pi}{3}(4h + 4 - 2.25h^2)$ $\frac{dv}{dh} = 0 \rightarrow 2.25h^2 - 4h - 4 = 0$ $h = 2.49$ only	B1 M1 A1 M1 A1	any correct form in terms of h only differentiate V correct differentiation equate to 0 and solve 3 term quadratic cao
(iii)	$\frac{d^2V}{dh^2} = \frac{\pi}{3}(4 - 4.5h)$ when $h = 2.49$ $(-7.545\dots) < 0$ so maximum	M1 A1	differentiate <i>their</i> 3 term $\frac{dV}{dh}$ and substitute <i>their h</i> draw correct conclusion www
8 (i)	$\cos TOA = \frac{6}{10} \rightarrow$ $TOA = 0.927$	M1 A1	any method
(ii)	area of major sector = $\frac{1}{2}6^2(2\pi - 2 \times \text{their } 0.927)$ (= 79.7) area of half kite = $\frac{1}{2}(6)\sqrt{10^2 - 6^2}$ (=24) area of kite $\times 2$ (=48)	M2 M1 DM1	or M1 for $\frac{1}{2}6^2(2 \times \text{their } 0.927)$ DM1 for $\pi \times 6^2 - \frac{1}{2}6^2(2 \times \text{their } 0.927)$ any method
(iii)	complete correct plan awrt 128 arc length = $6 \times (2\pi - 2 \times \text{their } 0.927) + 2 \times \sqrt{10^2 - 6^2}$ awrt 42.6	DM1 A1 M1 A1	<i>their</i> major sector + <i>their</i> kite complete correct method

Question	Answer	Mark	Part Marks
9 (i)	$p = 4$	B1	
(ii)	$\tan \alpha = \pm \frac{1}{3}$ or ± 3 or 18.4° or 71.6° seen 108	M1 A1	could use cos or sin
(iii)	$r_A = \begin{pmatrix} 1 \\ 5 \end{pmatrix} + t \begin{pmatrix} \text{their } p \\ -3 \end{pmatrix}$	B1	
(iv)	$r_B = \begin{pmatrix} q \\ -15 \end{pmatrix} + t \begin{pmatrix} 3 \\ -1 \end{pmatrix}$	B1	
(v)	$5 - 3t = -15 - t$ $\rightarrow t = 10$	M1 A1	$r_A = r_B$ and equate y/j and solve for t
(vi)	$\begin{pmatrix} 41 \\ -25 \end{pmatrix}$ only	B1	
(vii)	$q = 11$ only	B1	
10 (i)	$fg(x) = \ln(2e^x + 3) + 2$	B1	isw
(ii)	$ff(x) = \ln(\ln x + 2) + 2$	B1	isw
(iii)	$x = 2e^y + 3$ $e^y = \frac{x-3}{2}$ $g^{-1}(x) = \ln\left(\frac{x-3}{2}\right)$ oe	M1 A1	change x and y and make e^y the subject
(iv)	e^2 or 7.39	B1	
(v)	$gf(x) = 2e^{(\ln x + 2)} + 3 = 20$ $2e^{\ln x} e^2 + 3 = 20$ $2xe^2 = 17$ $x = \frac{17}{2e^2}$ or 1.15	B1 M1 M1 A1	gf correct and equation set up correctly one law of indices/logs second law of indices/logs www if 0 scored, SC2 for 17.3...

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Question	Answer	Mark	Part Marks
11 (i)	$\mathbf{A}^2 = \begin{pmatrix} 2 & q \\ p & 3 \end{pmatrix} \begin{pmatrix} 2 & q \\ p & 3 \end{pmatrix} = \begin{pmatrix} 4 + pq & 2q + 3q \\ 2p + 3p & pq + 9 \end{pmatrix}$	B2,1,0	-1 each error
	$\mathbf{A}^2 - 5\mathbf{A} = 2\mathbf{I} \rightarrow 4 + pq - 10 = 2$ $\text{or } 9 + pq - 15 = 2$ $\rightarrow pq = 8$	M1 A1	equate top left or bottom right elements accept $p = \frac{8}{q}, q = \frac{8}{p}$
(ii)	$\det \mathbf{A} = 6 - pq$	B1	
	$6 - pq = -3p \text{ and solve}$	M1	<i>their</i> $\det \mathbf{A} = -3p$ and use <i>their</i> $pq = k$ oe to solve for p or q
	$\rightarrow p = \frac{2}{3}$ $q = 12$	A1 A1	FT from <i>their</i> $pq = k$