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**ADDITIONAL MATHEMATICS**

**0606/22**

Paper 2

**October/November 2016**

MARK SCHEME

Maximum Mark: 80

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**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.

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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
<b>1</b>	$4x - 3 = x \rightarrow x = 1$ $4x - 3 = -x$ $x = 0.6$  <b>OR</b> $(4x - 3)^2 = x^2$ $15x^2 - 24x + 9 = 0$ $3(x - 1)(5x - 3) = 0$ $x = 1$ and $x = 0.6$	<b>B1</b> <b>M1</b> <b>A1</b>  <b>B1</b> <b>M1</b> <b>A1</b>	www use of $-x$ or $-(4x - 3)$ but not both.  solve correct 3 term quadratic www
<b>2</b>	$a(\sqrt{3} - 1) + b(\sqrt{3} + 1)$ $= (\sqrt{3} - 3)(\sqrt{3} - 1)(\sqrt{3} + 1)$ $= 2(\sqrt{3} - 3)$ oe  $a + b = 2$ $-a + b = -6$  $b = -2$ and $a = 4$	<b>M1</b>   <b>DM1</b> <b>A1</b> <b>DM1</b> <b>A1</b>	Common denominator or $\times (\sqrt{3} - 1)(\sqrt{3} + 1)$  equate constant terms and $\sqrt{3}$ terms. both correct solve two <b>linear</b> equations to obtain $a =$ or $b =$ both correct
<b>3</b>	$2\lg x = \lg x^2$ $1 = \lg 10$  $\lg x^2 - \lg \left( \frac{x + 10}{2} \right) = \lg \left( \frac{2x^2}{x + 10} \right)$ oe  $2x^2 - 10x - 100 = 0 \rightarrow 2(x + 5)(x - 10) = 0$  $x = 10$ only	<b>B1</b> <b>B1</b>  <b>B1</b> <b>M1</b> <b>A1</b>	soi anywhere soi anywhere  soi division; logs may be removed  obtain correct 3 term quadratic equation and attempt to solve $x = -5$ must not remain.

Question	Answer	Marks	Part Marks
4 (i)	$t = 10 \rightarrow N = 7000 + 2000e^{-0.5}$ $= 8213$ or 8210	<b>B1</b>	Do not accept non integer responses.
(ii)	$N = 7500 \rightarrow 7500 = 7000 + 2000e^{-0.05t}$ $e^{-0.05t} = \frac{500}{2000}$ $-0.05t = \ln 0.25 \rightarrow t = \frac{\ln 0.25}{-0.05}$ $= 27.7$ (days)	<b>M1</b>  <b>M1</b> <b>A1</b>	insert and make $e^{-0.05t}$ subject  take logs and make $t$ the subject awrt 27.7
(iii)	$\frac{dN}{dt} = -100e^{-0.05t}$ $t = 8 \rightarrow \frac{dN}{dt} = \pm 67$ (.0)	<b>M1</b> <b>A1</b> <b>A1</b>	$ke^{-0.05t}$ where $k$ is a constant $k = -100$ or $-0.05 \times 2000$ awrt $\pm 67$ mark final answer
5 (i)	$\frac{dy}{dx} = 3x^2 + 4x - 7$ $x = -2 \rightarrow \frac{dy}{dx} = 12 - 8 - 7 = -3$ Equation of tangent : $\frac{y-16}{x+2} = -3 \rightarrow y = -3x + 10$	<b>B1</b>  <b>M1</b>  <b>A1</b>	insert $x = -2$ into <i>their</i> gradient and use $(-2, 16)$ and <i>their</i> gradient of tangent in equation of line.
(ii)	Tangent cuts curve again $x^3 + 2x^2 - 7x + 2 = -3x + 10$ $x^3 + 2x^2 - 4x - 8 = 0$ $(x+2)(x+2)(x-2) = 0$ $x = 2, y = 4$	<b>M1</b> <b>A1</b> <b>M1</b> <b>A1A1</b>	equate curve and <i>their</i> linear answer from (i).  factorise: $(x \pm 2)$ and a two or three term quadratic is sufficient. Allow long division withhold final <b>A1</b> if $(2, 4)$ not clearly identified as their sole answer.
6 (i)	$\frac{\cos x}{1 + \tan x} - \frac{\sin x}{1 + \cot x} = \frac{\cos x}{1 + \frac{\sin x}{\cos x}} - \frac{\sin x}{1 + \frac{\cos x}{\sin x}}$ $= \frac{\cos^2 x}{\cos x + \sin x} - \frac{\sin^2 x}{\cos x + \sin x}$ $= \frac{(\cos x - \sin x)(\cos x + \sin x)}{(\cos x + \sin x)}$	<b>M1</b>  <b>M1</b> <b>A1</b>  <b>A1</b>	$\tan x = \frac{\sin x}{\cos x}$ and $\cot x = \frac{\cos x}{\sin x}$  Attempt to multiply by $\cos x$ and $\sin x$  AG
(ii)	$-\sin x + \cos x = 3\sin x - 4\cos x$ $5\cos x = 4\sin x$ $\tan x = \frac{5}{4}$ $x = 51.3^\circ, -128.7^\circ$	<b>M1</b>  <b>A1</b> <b>A1A1</b>	equate and collect $\sin x$ and $\cos x$ oe  <b>FT</b> from $\tan x = k$

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Question	Answer	Marks	Part Marks
7 (i)	$h = \sqrt{9 - x^2}$ $A = \frac{\sqrt{9 - x^2}}{2}(14 + x + x) = \sqrt{9 - x^2}(7 + x)$	<b>B2/1/0</b>	Must be clear that $\sqrt{9 - x^2}$ is the height of the trapezium. $14 + 2x$ oe must be seen AG
(ii)	$\frac{dA}{dx} = \sqrt{9 - x^2} + (7 + x) \frac{1}{2}(9 - x^2)^{-0.5} \times -2x$ $\frac{dA}{dx} = 0 \rightarrow 9 - x^2 = 7x + x^2$ $2x^2 + 7x - 9 = 0$ $x = 1$ $A = 16\sqrt{2} \text{ or } 8\sqrt{8} \text{ or } \sqrt{512} \text{ or } 22.6$	<b>M1</b> <b>A2/1/0</b>  <b>M1</b> <b>A1</b> <b>A1</b> <b>A1</b>	product rule on correct function minus 1 each error, allow unsimplified.  equate to 0 and simplify to a linear or quadratic equation. correct three term quadratic obtained  Extra positive answer loses penultimate <b>A1</b> . ignore negative solution.
8 (i)	$f'(x) = \frac{(x^3 + 1)9x^2 - (3x^3 - 1)3x^2}{(x^3 + 1)^2}$ $= \frac{12x^2}{(x^3 + 1)^2}$	<b>M1</b> <b>A1</b>  <b>A1</b>	quotient rule or product rule all correct  www beware $9x^6 - 9x^6$ gets <b>A0</b>
(ii)	$\int_1^2 \frac{x^2}{(x^3 + 1)^2} dx = \frac{1}{12} \left[ \frac{3x^3 - 1}{x^3 + 1} \right]_1^2$ $= \frac{1}{12} \left[ \frac{23}{9} - \frac{2}{2} \right]$ $= \frac{7}{54}$	<b>M1</b> <b>A1</b>  <b>DM1</b>  <b>A1</b>	$c \times \frac{3x^3 - 1}{x^3 + 1}$ <b>FT</b> $c = \frac{1}{\text{their } 12}$  top limit – bottom limit in <i>their</i> integral.  or 0.130 or 0.1296 or 0.12
(iii)	$x = \frac{3y^3 - 1}{y^3 + 1}$ $y^3 = \frac{x + 1}{3 - x}$ $f^{-1}(x) = \sqrt[3]{\frac{x + 1}{3 - x}}$ $\text{Domain : } -1 \leq x \leq 2\frac{6}{7}$	<b>B1</b>  <b>B1</b>  <b>B1</b> <b>B1</b> <b>B1</b>	make $y^3$ or $x^3$ the subject  <b>FT</b> take cube root (as long as $y^3$ or $x^3$ equals a fraction with terms in $x$ or $y$ only) oe <b>FT</b> change $x$ and $y$ – can be done at any time Allow upper limit of 2.86. Do not isw

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Question	Answer	Marks	Part Marks
9	(i) tangent touches circle $x^2 + (kx - 4)^2 - 2(kx - 4) = 8$ $k^2x^2 + x^2 - 8kx - 2kx + 16 = 0$ or better	M1 A1	eliminate $y$ or $x$ allow unsimplified
	Equal roots as tangent touches circle : $b^2 = 4ac$ $(-10k)^2 = 4(k^2 + 1) \times 16$ $36k^2 = 64$ $k = +\frac{4}{3}$ only	DM1 A1 A1	use of discriminant on 3 term quadratic so oe any inequality loses last A1
	(ii) $x = \frac{-b}{2a} \rightarrow x = \frac{\frac{4}{3} \times 10}{\frac{25}{9}}$ $x = \frac{12}{5} \quad y = -\frac{4}{5}$	M1 A1A1	use $x = \frac{-b}{2a}$
	OR tangent $y = \frac{4}{3}x - 4$ cuts radius $y = -\frac{3}{4}x + 1$ at $x = \frac{12}{5}$ $y = -\frac{4}{5}$	M1 A1 A1	find equation of radius and attempt to solve with tangent
	OR Obtain $25x^2 - 120x + 144 = 0$ oe $(5x - 12)(5x - 12) = 0$ $x = \frac{12}{5} \rightarrow y = -\frac{4}{5}$	M1 A1A1	obtain any 3 term quadratic using <i>their</i> non zero $k$ and reach $x = \dots$
	(iii) $TP = \sqrt{(0 - 2.4)^2 + (-4 + 0.8)^2} = 4$	M1A1	M1 for using <i>their</i> $T$ and $(0, -4)$ . Signs must be correct.

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Question	Answer	Marks	Part Marks
10 (i)	$r_j = \begin{pmatrix} 5000 \\ 1000p \end{pmatrix} + \begin{pmatrix} -2\cos 40 \\ 2\cos 50 \end{pmatrix} t$	B1 B1	x coordinate oe y coordinate oe
(ii)	$2.5t\cos 70 = 5000 - 2t\cos 40$ $t = \frac{5000}{2.5\cos 70 + 2\cos 40}$ $= 2095$ awrt or 2090 or 2100 $(2.5\cos 20 - 2\cos 50) \times 2095 = 1000p$ $p = 2.23$ awrt	M1 DM1 A1 M1 A1	equate <i>their</i> x values (must be 3 terms) make <i>t</i> the subject allow one sign error equate <i>their</i> y values (must be 3 terms) and insert <i>their</i> <i>t</i> or $ t $ .
11 (i)	Free choice : no. of ways ${}^6C_4 \times {}^5C_2 = 15 \times 10$ $= 150$	B1 B1	${}^6C_4 \times$ another ${}^nC_r$ term only $\times {}^5C_2$ and answer or vice versa
(ii)	Both Mr and Mrs Coldicott ${}^5C_3 \times {}^4C_1 = 10 \times 4$ $= 40$	B1 B1	${}^5C_3 \times$ another ${}^nC_r$ term only $\times {}^4C_1$ and answer or vice versa
(iii)	Mr C and not Mrs C ${}^5C_3 \times {}^4C_2 (= 60)$ Not Mr C and Mrs C ${}^5C_4 \times {}^4C_1 (= 20)$ Total = 80  <b>OR</b> Total = (i) – (ii) – neither Neither = ${}^5C_4 \times {}^4C_2 = 30$ Total = $150 - 40 - 30 = 80$	B1 B1 B1  M1 A1 A1	An incorrect final answer does not affect the awarding of the first two B1 marks.  www