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CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

0872690516

ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **October/November 2016**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 80.

This document consists of **16** printed pages.

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Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$.

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

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1 **(a)** Sets $\mathscr{E}$, A and B are such that

$$\mathrm{n}(\mathscr{E}) = 26,\ \mathrm{n}(A \cap B') = 7,\ \mathrm{n}(A \cap B) = 3 \text{ and } \mathrm{n}(B) = 15\ .$$

Using a Venn diagram, or otherwise, find

(i) $\mathrm{n}(A)$, [1]

(ii) $\mathrm{n}(A \cup B)$, [1]

(iii) $\mathrm{n}(A \cup B)'$. [1]

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(b) It is given that $\mathscr{E} = \{x : 0 < x < 30\}$, $P = \{\text{multiples of } 5\}$, $Q = \{\text{multiples of } 6\}$ and $R = \{\text{multiples of } 2\}$. Use set notation to complete the following statements.

(i) Q ..... R, [1]

(ii) $P \cap Q =$ ..... [1]

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2 Given that $\dfrac{p^{\frac{1}{3}}q^{-\frac{1}{2}}r^{\frac{3}{2}}}{p^{-\frac{2}{3}}\sqrt{(qr)^5}} = p^a q^b r^c$, find the value of each of the integers a, b and c. [3]

3 By using the substitution $y = \log_3 x$, or otherwise, find the values of x for which

$$3(\log_3 x)^2 + \log_3 x^5 - \log_3 9 = 0 \ .$$ [6]

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4 **(i)** Find the first 3 terms in the expansion of $\left(2x^2 - \frac{1}{3x}\right)^5$, in descending powers of x. [3]

(ii) Hence find the coefficient of x^7 in the expansion of $\left(3 + \frac{1}{x^3}\right)\left(2x^2 - \frac{1}{3x}\right)^5$. [2]

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5 **(i)** Find the equation of the normal to the curve $y = \frac{1}{2}\ln(3x + 2)$ at the point P where $x = -\frac{1}{3}$. [4]

The normal to the curve at the point P intersects the y-axis at the point Q. The curve $y = \frac{1}{2}\ln(3x + 2)$ intersects the y-axis at the point R.

(ii) Find the area of the triangle PQR. [3]

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6 **(a)** Matrices **X**, **Y** and **Z** are such that

$$\mathbf{X} = \begin{pmatrix} 2 & 3 \\ 4 & -1 \\ 6 & 5 \end{pmatrix}, \quad \mathbf{Y} = \begin{pmatrix} 1 & -1 & 0 \end{pmatrix} \quad \text{and} \quad \mathbf{Z} = \begin{pmatrix} 0 & -1 \\ 5 & 3 \end{pmatrix}.$$

Write down all the matrix products which are possible using any two of these matrices. Do not evaluate these products. [2]

(b) Matrices **A**, **B** and **C** are such that $\mathbf{A} = \begin{pmatrix} 2 & -1 \\ 4 & 7 \end{pmatrix}$, $\mathbf{B} = \begin{pmatrix} -4 & 2 \\ 10 & 4 \end{pmatrix}$ and $\mathbf{AC} = \mathbf{B}$.

(i) Find $\mathbf{A}^{-1}$. [2]

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(ii) Hence find **C**. [3]

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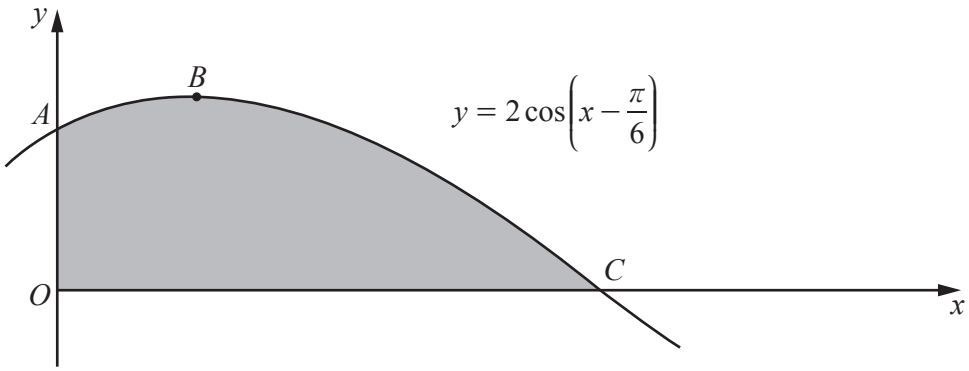
7



The diagram shows part of the graph of $y = 2\cos\left(x - \frac{\pi}{6}\right)$. The graph intersects the y-axis at the point A, has a maximum point at B and intersects the x-axis at the point C.

(i) Find the coordinates of A. [1]

(ii) Find the coordinates of B. [2]

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(iii) Find the coordinates of C. [2]

(iv) Find $\int 2\cos\left(x-\frac{\pi}{6}\right)\mathrm{d}x$. [1]

(v) Hence find the area of the shaded region. [2]

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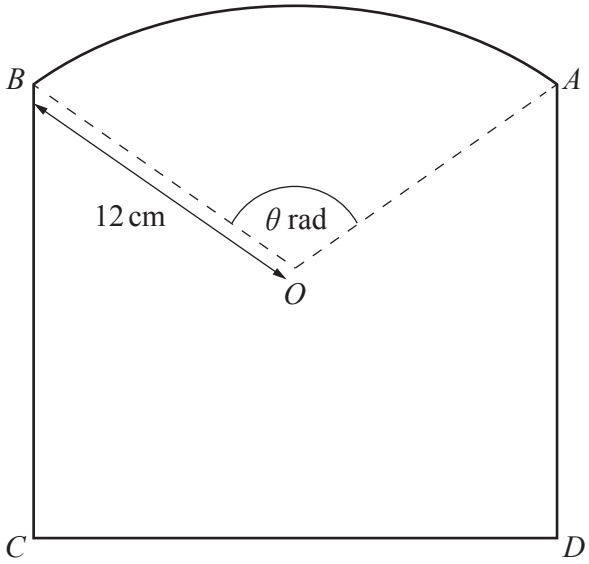
8



The diagram shows a sector AOB of the circle, centre O, radius 12 cm, together with points C and D such that $ABCD$ is a rectangle. The angle AOB is θ radians and the perimeter of the sector AOB is 47 cm.

(i) Show that $\theta = 1.92$ radians correct to 2 decimal places. [2]

(ii) Find the length of CD. [2]

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(iii) Given that the total area of the shape is 425 cm^2, find the length of AD. [5]

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9 Do not use a calculator in this question.

The polynomial $p(x)$ is $ax^3 - 4x^2 + bx + 18$. It is given that $p(x)$ and $p'(x)$ are both divisible by $2x - 3$.

(i) Show that $a = 4$ and find the value of b. [4]

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(ii) Using the values of a and b from part **(i)**, factorise $p(x)$ completely. [2]

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(iii) Hence find the values of x for which $\mathrm{p}(x) = x + 2$. [3]

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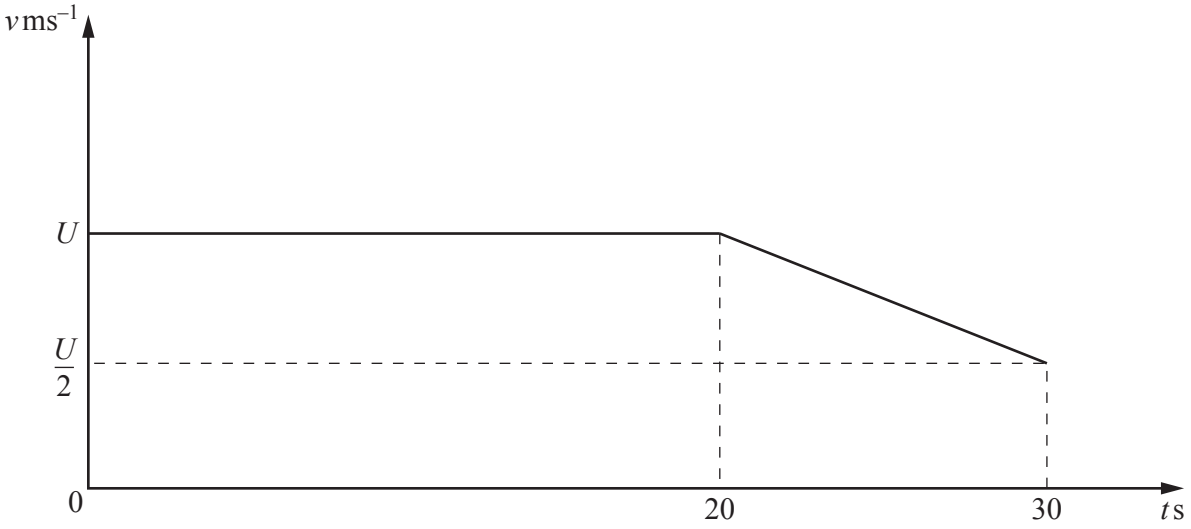
10 (a)



The diagram shows part of the velocity-time graph for a particle, moving at $v\,\text{ms}^{-1}$ in a straight line, t s after passing through a fixed point. The particle travels at $U\,\text{ms}^{-1}$ for 20 s and then decelerates uniformly for 10 s to a velocity of $\frac{U}{2}\text{ms}^{-1}$. In this 30 s interval, the particle travels 165 m.

(i) Find the value of U. [3]

(ii) Find the acceleration of the particle between $t = 20$ and $t = 30$. [2]

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(b) A particle P travels in a straight line such that, t s after passing through a fixed point O, its velocity, v ms^{-1}, is given by $v = \left(e^{\frac{t^2}{8}} - 4\right)^3$.

(i) Find the speed of P at O. [1]

(ii) Find the value of t for which P is instantaneously at rest. [2]

(iii) Find the acceleration of P when $t = 1$. [4]

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Question 11 is printed on the next page.

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11 The variables x and y are such that when $\ln y$ is plotted against x, a straight line graph is obtained. This line passes through the points $x = 4, \ln y = 0.20$ and $x = 12, \ln y = 0.08$.

(i) Given that $y = Ab^x$, find the value of A and of b. [5]

(ii) Find the value of y when $x = 6$. [2]

(iii) Find the value of x when $y = 1.1$. [2]

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ADDITIONAL MATHEMATICS **0606/11**

Paper 1 **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.

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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 (a) (i)	10	**B1**	
(ii)	22	**B1**	
(iii)	4	**B1**	
(b) (i)	$Q \subset R$	**B1**	
(ii)	$P \cap Q = \varnothing$, or { }	**B1**	
2	$a = 1,\ b = -3,\ c = -1$	**B3**	**B1** for each
3	$3y^2 + 5y - 2 = 0$	**B1**, **B1**	**B1** for $5y$ or $5\log_3 x$, **B1** for -2
	$y = \frac{1}{3},\ y = -2$	**M1**	for correct attempt at the solution of *their* quadratic equation
	$x = 3^{\frac{1}{3}},\ x = 3^{-2}$	**M1**	for dealing with one base 3 logarithm correctly
	$x = 1.44,\ x = \frac{1}{9}$	**A1**, **A1**	**A1** for each
4 (i)	$32x^{10} - \frac{80}{3}x^7 + \frac{80}{9}x^4$	**B3**	**B1** for each term, powers of x must be simplified
(ii)	Coefficients needed:		
	$\left(3 \times their - \frac{80}{3}\right) + \left(1 \times their\ 32\right)$	**M1**	for dealing with 2 terms
	$= -48$	**A1**	Allow **A1** for $-48x^7$

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Question	Answer	Marks	Part Marks
5 (i)	$\frac{dy}{dx} = \frac{3}{2(3x+2)}$	**B1**	for correct derivative of log function
	When $x = -\frac{1}{3}$, $y = 0$, $\frac{dy}{dx} = \frac{3}{2}$	**B1**	for $y = 0$
	Equation of normal: $y = -\frac{2}{3}\left(x + \frac{1}{3}\right)$	**M1** **A1**	**M1** for attempt at a gradient of a perpendicular from differentiation and the equation of the normal
(ii)	$Q\left(0, -\frac{2}{9}\right)$ or $(0, 0.22)$ or better	**B1 ft**	Follow through on *their c* from part (i)
	$R\left(0, \frac{1}{2}\ln 2\right)$ or $(0, 0.35)$ or better	**B1**	
	Area of PQR $= \frac{1}{2}\left(\frac{1}{2}\ln 2 + \frac{2}{9}\right) \times \frac{1}{3}$ $= 0.0948$	**B1**	Allow 0.095
6 (a)	**YX**, **XZ**	**B2**	**B2** for both with no extras **B1** for 1 correct with or without extras **B1** for both correct with extras **B0** for anything else
(b) (i)	$\frac{1}{18}\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}$	**B1**, **B1**	**B1** for $\frac{1}{18}$, **B1** for $\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}$
(ii)	$\mathbf{C} = \mathbf{A}^{-1}\mathbf{B}$ $= \frac{1}{18}\begin{pmatrix} 7 & 1 \\ -4 & 2 \end{pmatrix}\begin{pmatrix} -4 & 2 \\ 10 & 4 \end{pmatrix}$	**M1**	for pre-multiplication
	$= \begin{pmatrix} -1 & 1 \\ 2 & 0 \end{pmatrix}$	**A1**, **A1**	**A1** for any correct pair of elements, but must be from correct matrices

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Question	Answer	Marks	Part Marks
7 (i)	$(0, \sqrt{3})$ or $(0, 1.73)$ or better	B1	
(ii)	$\left(\frac{\pi}{6}, 2\right)$ or $(0.524, 2)$ or better	B1, B1	B1 for each
(iii)	$\cos\left(x - \frac{\pi}{6}\right) = 0$	M1	for correct attempt to solve trigonometric equation
	$x = \frac{2\pi}{3}$ oe or 2.09 or better	A1	
(iv)	$2\sin\left(x - \frac{\pi}{6}\right)$ (+c)	B1	
(v)	Area $= \left[2\sin\left(x - \frac{\pi}{6}\right)\right]_0^{\frac{2\pi}{3}}$	M1	for correct use of **their** limits, in radians, into $k\sin\left(x - \frac{\pi}{6}\right)$.
	$= 2 + 1$ $= 3$	A1	
8 (i)	$47 - 24 = 12\theta$		
	$\theta = \frac{23}{12}$, so $\theta = 1.917$ or better	M1	for complete correct method to get $\theta =$
	$\theta = 1.92$ to 2dp	A1	must have evidence of working to more than 2 dp, allow if 1.916 seen (truncated)
(ii)	$\sin\frac{\theta}{2} = \frac{CD/2}{12}$	M1	for a complete method, may use cosine rule to get *CD*
	CD = awrt 19.6 or 19.7	A1	
(iii)	Area of sector = awrt 138	B1	for sector area, allow unsimplified
	Area of triangle *AOB* = awrt 67 or 68	M1	for a correct attempt at area
	Area of segment = awrt 70 or 71	M1	for segment area (*their* sector area – *their* triangle area)
	AD × *AB* + segment area = 425	M1	for complete method to find *AD*
	leading to *AD* = awrt 18.1 or 18.0	A1	Allow **A1** for 18
	Alternative method:		
	Area of sector = awrt 138	B1	for sector area
	Difference in length between *BC* (or *AD*) and *OM* where *M* is the midpoint of *CD* = 6.88, allow awrt 6.9	M1	for attempt to find difference between parallel sides
	Remaining area consists of two trapezia each of width 9.85 and each of area 143.4 $\frac{1}{2}(2BC - 6.88) \times 9.85 = 143.4$ oe	M1	for area of one trapezium $\frac{1}{2}(2BC - \textit{their } 6.88) \times \textit{their } 9.85$ oe
	leading to *AD* = awrt 18.1 or 18.0	M1 A1	for attempt to find either *BC* or *AD*

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Question	Answer	Marks	Part Marks
9 (i)	$\text{p}\left(\frac{3}{2}\right)$: $\frac{27a}{8}-\left(4\times\frac{9}{4}\right)+\frac{3b}{2}+18\ \ (=0)$	**M1**	for attempt at $\text{p}\left(\frac{3}{2}\right)$
	$\text{p}'\left(\frac{3}{2}\right)=\left(3a\times\frac{9}{4}\right)-\left(8\times\frac{3}{2}\right)+b\ \ (=0)$	**M1**	for differentiation and attempt at $\text{p}'\left(\frac{3}{2}\right)$
	leading to $9a+4b+24=0$ oe		
	and $27a+4b-48=0$ oe	**M1**	for solution of simultaneous equations, to get either a or b
	leading to $a=4,\ b=-15$	**A1**	for both
(ii)	$(x+2)(2x-3)^2$ oe	**M1, A1**	**M1** for attempt at long division or factorisation
(iii)	$(x+2)(2x-3)^2=x+2$		
	$x+2=0,\ x=-2$	**B1**	Must be using $(x+2)$ correctly using part (ii) to get $x=-2$
	$(2x-3)^2=1$	**M1**	for solution of the quadratic equation
	leading to $x=1,\ x=2$	**A1**	
10 (a) (i)	$20U+\frac{1}{2}\left(U+\frac{U}{2}\right)10=165$	**M1**	for realising that area under the graph is needed and attempt to find an area
		DM1	for equating their area to 165 and attempt to solve
	leading to $U=6$	**A1**	
(ii)	Gradient of line: -0.3	**M1, A1**	**M1** for use of the gradient, must be negative
(b) (i)	27	**B1**	
(ii)	$t^2=8\ln 4$	**M1**	for a correct attempt to solve $\text{e}^{\frac{t^2}{8}}=4$
	$t=3.33$ or better	**A1**	
(iii)	acceleration $=3\frac{2t}{8}\text{e}^{\frac{t^2}{8}}\left(\text{e}^{\frac{t^2}{8}}-4\right)^2$	**M1, A1**	**M1** for a correct attempt to differentiate using the chain rule
	When $t=1$, $a=6.98$	**M1, A1**	**M1**for use of $t=1$ in their acceleration

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Question	Answer	Marks	Part Marks
11 (i)	$\ln y = \ln A + x \ln b$	**B1**	may be implied, if equation not seen specifically, by correct values for A and b
	Gradient: $\ln b = -\dfrac{0.12}{8}$, $= -0.015$	**M1**	for use of gradient to obtain ln b
	$b = 0.985$	**A1**	Allow **A1** for $e^{-0.015}$
	Intercept: $\ln A = 0.26$	**DM1**	for use of one of the given points correctly
	$A = 1.30$	**A1**	Allow **A1** for $e^{0.26}$ or 1.3
	Alternative 1		
	$\ln y = \ln A + x \ln b$	**B1**	
	$0.2 = 4 \ln b + \ln A$	**M1**	for one correct equation
	$0.08 = 12 \ln b + \ln A$	**DM1**	for attempt to obtain either ln$A$ or ln$b$ from simultaneous equations
	$A = 1.30$ and $b = 0.985$	**A1**, **A1**	Allow **A1** for $b = e^{-0.015}$ and $a = e^{0.26}$ or 1.3
	Alternative 2		
	$1.22 = Ab^4$	**B1**	
	$1.08 = Ab^{12}$	**B1**	
		M1	for correct attempt to obtain b or A, must already have **B2**
	$A = 1.30$ and $b = 0.985$	**A1**, **A1**	Allow **A1** for $b = e^{-0.015}$ and $a = e^{0.26}$ or 1.3
(ii)	When $x = 6$, $\ln y = 0.17$	**M1**	for $\ln y = their \ln A + 6\ their \ln b$ or $y = their\ A \times (their\ b)^6$
	$y = 1.19$	**A1**	allow awrt 1.18 to 1.20
(iii)	When $y = 1.1$, $\ln y = 0.095$	**M1**	for $\ln 1.1 = their \ln A + x\ their \ln b$ or $1.1 = their A \times (their b)^x$
	$x = 11$	**A1**	allow 10.5 to 11.5

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ADDITIONAL MATHEMATICS **0606/21**

Paper 2 **October/November 2016**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 80.

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Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Theorem

$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!}$

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

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1 Solve the equation $|4x - 3| = x$. [3]

2 **Without using a calculator**, find the integers a and b such that $\frac{a}{\sqrt{3}+1} + \frac{b}{\sqrt{3}-1} = \sqrt{3} - 3$. [5]

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3 Solve the equation $2\lg x - \lg\left(\frac{x+10}{2}\right) = 1$. [5]

4 The number of bacteria, N, present in a culture can be modelled by the equation $N = 7000 + 2000e^{-0.05t}$, where t is measured in days. Find

(i) the number of bacteria when $t = 10$, [1]

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(ii) the value of t when the number of bacteria reaches 7500, [3]

(iii) the rate at which the number of bacteria is decreasing after 8 days. [3]

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5 The curve with equation $y = x^3 + 2x^2 - 7x + 2$ passes through the point A (−2, 16). Find

(i) the equation of the tangent to the curve at the point A, [3]

(ii) the coordinates of the point where this tangent meets the curve again. [5]

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6 **(i)** Prove that $\dfrac{\cos x}{1+\tan x} - \dfrac{\sin x}{1+\cot x} = \cos x - \sin x$. [4]

(ii) Hence solve the equation $\dfrac{\cos x}{1+\tan x} - \dfrac{\sin x}{1+\cot x} = 3\sin x - 4\cos x$ for $-180° < x < 180°$. [4]

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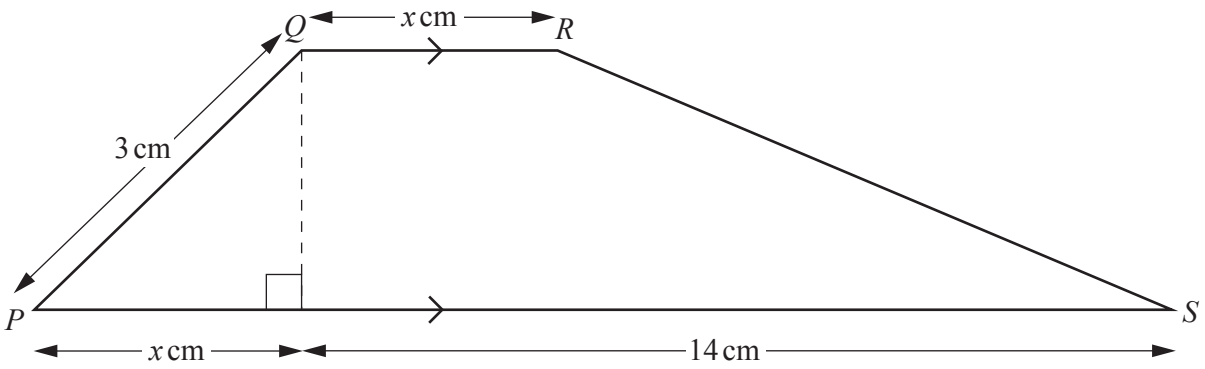

(i) Show that the area, $A\,\text{cm}^2$, of the trapezium $PQRS$ is given by $A = (7 + x)\sqrt{9 - x^2}$. [2]

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(ii) Given that x can vary, find the stationary value of A. [7]

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8 The function $\mathrm{f}(x)$ is given by $\mathrm{f}(x) = \dfrac{3x^3 - 1}{x^3 + 1}$ for $0 \leqslant x \leqslant 3$.

(i) Show that $\mathrm{f}'(x) = \dfrac{kx^2}{(x^3 + 1)^2}$, where k is a constant to be determined. [3]

(ii) Find $\displaystyle\int \frac{x^2}{(x^3 + 1)^2}\mathrm{d}x$ and hence evaluate $\displaystyle\int_1^2 \frac{x^2}{(x^3 + 1)^2}\mathrm{d}x$. [4]

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(iii) Find $f^{-1}(x)$, stating its domain. [4]

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9 The line $y = kx - 4$, where k is a positive constant, passes through the point $P\,(0, -4)$ and is a tangent to the curve $x^2 + y^2 - 2y = 8$ at the point T. Find

(i) the value of k, [5]

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(ii) the coordinates of T, [3]

(iii) the length of TP. [2]

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10 The town of Cambley is 5 km east and p km north of Edwintown so that the position vector of Cambley from Edwintown is $\begin{pmatrix} 5000 \\ 1000p \end{pmatrix}$ metres. Manjit sets out from Edwintown at the same time as Raj sets out from Cambley. Manjit sets out from Edwintown on a bearing of 020° at a speed of $2.5\,\text{ms}^{-1}$ so that her position vector relative to Edwintown after t seconds is given by $\begin{pmatrix} 2.5t\cos 70° \\ 2.5t\cos 20° \end{pmatrix}$ metres. Raj sets out from Cambley on a bearing of 310° at $2\,\text{ms}^{-1}$.

(i) Find the position vector of Raj relative to Edwintown after t seconds. [2]

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Manjit and Raj meet after T seconds.

(ii) Find the value of T and of p. [5]

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Question 11 is printed on the next page.

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11 Mr and Mrs Coldicott have 5 sons and 4 daughters. All 11 members of the family play tennis. Six members of the family enter a tennis competition where teams consist of 4 males and 2 females.

Find the number of different teams of 4 males and 2 females that could be selected if

(i) there are no further restrictions, [2]

(ii) Mr and Mrs Coldicott must both be in the team, [2]

(iii) either Mr or Mrs Coldicott is in the team but not both. [3]

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ADDITIONAL MATHEMATICS **0606/21**

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.

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

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

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Question	Answer	Marks	Part Marks
7 (i)	$h=\sqrt{9-x^2}$ $A=\frac{\sqrt{9-x^2}}{2}(14+x+x)=\sqrt{9-x^2}\,(7+x)$	**B2/1/0**	Must be clear that $\sqrt{9-x^2}$ is the height of the trapezium. $14+2x$ oe must be seen AG
(ii)	$\frac{dA}{dx}=\sqrt{9-x^2}+(7+x)\frac{1}{2}(9-x^2)^{-0.5}\times -2x$	**M1** **A2/1/0**	product rule on correct function minus 1 each error , allow unsimplified.
	$\frac{dA}{dx}=0\rightarrow 9-x^2=7x+x^2$	**M1**	equate to 0 and simplify to a linear or quadratic equation.
	$2x^2+7x-9=0$	**A1**	correct three term quadratic obtained
	$x=1$	**A1**	Extra positive answer loses penultimate **A1**.
	$A=16\sqrt{2}$ or $8\sqrt{8}$ or $\sqrt{512}$ or22.6	**A1**	ignore negative solution.
8 (i)	$f'(x)=\frac{(x^3+1)9x^2-(3x^3-1)3x^2}{(x^3+1)^2}$	**M1**	quotient rule or product rule
		A1	all correct
	$=\frac{12x^2}{(x^3+1)^2}$	**A1**	www beware $9x^6-9x^6$ gets **A0**
(ii)	$\int_1^2 \frac{x^2}{(x^3+1)^2}dx=\frac{1}{12}\left[\frac{3x^3-1}{x^3+1}\right]_1^2$	**M1**	$c\times\frac{3x^3-1}{x^3+1}$
		A1	**FT** $c=\frac{1}{their\,12}$
	$=\frac{1}{12}\left[\frac{23}{9}-\frac{2}{2}\right]$	**DM1**	top limit – bottom limit in *their* integral.
	$=\frac{7}{54}$	**A1**	or 0.130 or 0.1296 or 0.12
(iii)	$x=\frac{3y^3-1}{y^3+1}$		
	$y^3=\frac{x+1}{3-x}$	**B1**	make y^3 or x^3 the subject
	$f^{-1}(x)=\sqrt[3]{\frac{x+1}{3-x}}$	**B1**	**FT** take cube root (as long as y^3 or x^3 equals a fraction with terms in x or y only) oe
		B1	**FT** change x and y – can be done at any time
	Domain : $-1\leqslant x\leqslant 2\frac{6}{7}$	**B1**	Allow upper limit of 2.86 . Do not isw

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Question	Answer	Marks	Part Marks
9 (i)	tangent touches circle $x^2+(kx-4)^2-2(kx-4)=8$	M1	eliminate y or x allow unsimplified
	$k^2x^2+x^2-8kx-2kx+16=0$ or better	A1	
	Equal roots as tangent touches circle : $b^2=4ac$	DM1	use of discriminant on 3 term quadratic soi
	$(-10k)^2=4(k^2+1)\times 16$ $36k^2=64$	A1	
	$k=+\frac{4}{3}$ only	A1	oe any inequality loses last **A1**
(ii)	$x=\frac{-b}{2a} \rightarrow x=\frac{\frac{4}{3}\times 10}{\frac{25}{9}}$	M1	use $x=\frac{-b}{2a}$
	$x=\frac{12}{5}$ $y=-\frac{4}{5}$	A1A1	
	OR tangent $y=\frac{4}{3}x-4$ cuts radius	M1	find equation of radius and attempt to solve with tangent
	$y=-\frac{3}{4}x+1$ at $x=\frac{12}{5}$	A1	
	$y=-\frac{4}{5}$	A1	
	OR Obtain $25x^2-120x+144=0$ oe	M1	obtain any 3 term quadratic using *their* non zero k and reach x = …
	$(5x-12)(5x-12)=0$ $x=\frac{12}{5} \rightarrow y=-\frac{4}{5}$	A1A1	
(iii)	$TP=\sqrt{(0-2.4)^2+(-4+0.8)^2}=4$	M1A1	**M1** for using *their* 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)	$2.5t\cos 70 = 5000 - 2t\cos 40$	**M1**	equate *their x* values (must be 3 terms)
	$t = \dfrac{5000}{2.5\cos 70 + 2\cos 40}$	**DM1**	make t the subject allow one sign error
	$= 2095$ awrt or 2090 or 2100	**A1**	
	$(2.5\cos 20 - 2\cos 50) \times 2095 = 1000p$	**M1**	equate *their y* values(must be 3 terms) and insert *their* t or $\lvert t \rvert$.
	$p = 2.23$ awrt	**A1**	
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	**B1** **B1** **B1**	An incorrect final answer does not affect the awarding of the first two **B1** marks. www
	OR Total = (i) – (ii) – neither Neither = ${}^5C_4 \times {}^4C_2 = 30$ Total = 150 – 40 – 30 = 80	**M1** **A1** **A1**	

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