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**ADDITIONAL MATHEMATICS**

**0606/21**

Paper 2

**May/June 2016**

MARK SCHEME

Maximum Mark: 80

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**Published**

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

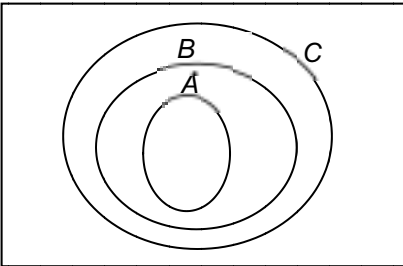
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### Abbreviations

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	Marks	Guidance
<b>1</b>	$x^2 - 2x - 15$  critical values $-3$ and $5$  $x < -3$ $x > 5$	<b>M1</b>  <b>A1</b>  <b>A1</b>	expands and rearranges to form a 3 term quadratic  not from wrong working  mark final inequality; <b>A0</b> if spurious attempt to combine e.g. $5 < x < -3$
<b>2 (a)</b>		<b>B1</b>	It must be clear how the sets are nested
<b>(b) (i)</b>	$h \in P$	<b>B1</b>	Allow $\{m, a, t, h, s\}$ for $P$
<b>(ii)</b>	$n(P \cap Q) = 2$ cao	<b>B1</b>	
<b>(iii)</b>	$\{t, h, s\}$	<b>B1</b>	
<b>3 (i)</b>	$-2$	<b>B1</b>	
<b>(ii)</b>	$-n$	<b>B1</b>	
<b>(iii)</b>	$\frac{\lg 5}{\log_5 10} = [(\lg y)^2]$ or $\frac{\lg 20 - \lg 4}{1/\lg 5} = [(\lg y)^2]$  correct completion to $(\lg 5)^2$ isw	<b>M1</b>  <b>A1</b>	One log law used correctly  answer only does not score
<b>(iv)</b>	$[\log_r] 6x^2 = [\log_r] 600$  $x = 10$ only	<b>B1</b>  <b>B1</b>	Condone base missing

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4 (i)	$\frac{\pi}{3}$ isw	<b>B1</b>	
(ii)	[Area triangle $ABC = ] \frac{1}{2} \times 10^2 \times \sin\left(\text{their} \frac{\pi}{3}\right)$ oe	<b>M1</b>	seen or implied by $25\sqrt{3}$ or 43.3(0...)
	[Area 1 sector = ] $\frac{1}{2} \times 5^2 \times \text{their} \frac{\pi}{3}$ oe or $\pi \times 5^2 \times \frac{\text{their} 60^\circ}{360}$	<b>M1</b>	seen or implied by $\frac{25\pi}{6}$ or 13.0(8...) or 13.09
	Complete correct plan	<b>M1</b>	e.g. <i>their</i> triangle – 3( <i>their</i> sector)
	4.03(1...) or $25\sqrt{3} - \frac{25\pi}{2}$ isw	<b>A1</b>	Units not required
5 (a)	$\frac{\sqrt{8}}{(\sqrt{7}-\sqrt{5})} \times \frac{(\sqrt{7}+\sqrt{5})}{(\sqrt{7}+\sqrt{5})}$ and attempt to multiply	<b>M1</b>	
	$\frac{\sqrt{56} + \sqrt{40}}{2}$ oe	<b>A1</b>	not from wrong working
	$\sqrt{14} + \sqrt{10}$	<b>A1</b>	
(b)	$q^2 + 4q\sqrt{3} + 12$ soi	<b>B1</b>	
	$28 = q^2 + 12$ oe	<b>M1</b>	can be implied by 4 and 16 or –4 and –16
	$q = 4, -4$ $p = 16, -16$	<b>A1</b>	all values
6 (i)	$4(x+1)^2 - 9$	<b>B3,2,1,0</b>	one mark for each of $p, q, r$ correct in a correctly formatted expression; allow correct equivalent values;  If <b>B0</b> then <b>SC2</b> for $4(x+1) - 9$ or <b>SC1</b> for correct 3 values seen in incorrect format e.g. $4(x+1x) - 9$ or $4(x^2 + 1) - 9$ or for a correct completed square form of the original expression in a different but correct format. e.g. $2(\sqrt{2}x + \sqrt{2})^2 - 9$

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(ii)	(-1, 9)	<b>B2FT</b>	<b>B1FT</b> $(-q, -r)$ $r < 0$ for each correct coordinate
(iii)		<b>B1</b> <b>B1</b> <b>B1</b>	Correct symmetric W shape with cusps on x-axis y-intercept marked at 5 only or coords indicated on graph x-intercepts marked at -2.5 and 0.5 only x-axis or coords indicated on graph or close by
7 (i) (a)	$\mathbf{q - p}$	<b>B1</b>	
(b)	$2\mathbf{q - 2p}$ or $2(\mathbf{q - p})$	<b>B1</b>	
(ii)	The points are collinear oe $\overline{PQ}$ is a (scalar) multiple of $\overline{QR}$ and they have a point in common. oe	<b>B1</b> <b>B1</b>	Condone $\overline{PQ}$ is parallel to $\overline{QR}$ and ...
(iii)	$[\overline{OR} =] 4\mathbf{i} - 3\mathbf{j}$ oe soi $\sqrt{4^2 + (-3)^2} (=5)$	<b>B1</b> <b>M1</b>	condone $\sqrt{4^2 + 3^2}$ ; may be implied by correct answer or correct FT answer
	$\frac{1}{5}(4\mathbf{i} - 3\mathbf{j})$ oe	<b>A1</b>	
8 (a) (i)	$a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$ final answer	<b>B2,1,0</b>	-1 each error/omission
(ii)	$6(2x)^2\left(\frac{1}{5x}\right)^2$ soi $\frac{24}{25}$ or 0.96 isw	<b>M1</b> <b>A1</b>	Could be in full expansion Must be explicitly identified
(b)	$\frac{1}{8}\left(\frac{n(n-1)(n-2)}{6}\right) = \frac{5n}{12}$ soi leading to a cubic or quadratic $(n^2 - 3n - 18 = 0)$ Solves <i>their</i> quadratic $[(n-6)(n+3)]$ $[n =] 6$ only, not from wrong working	<b>M1</b> <b>M1</b> <b>A1</b>	Must attempt to expand and remove fractions must have come from a valid attempt Must be $n$ if labelled

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9 (a)	$a = 2 \quad b = 4 \quad c = -2$	<b>B3</b>	<b>B1</b> for each correct value
(b) (i)		<b>B3,2,1,0</b>	sinusoidal curve symmetrical about $y$ -axis clear intent to have amplitude of 2 2 cycles If not fully correct max <b>B2</b>
(ii)	$-\frac{\pi}{2}, -\frac{\pi}{6}, \frac{\pi}{6}, \frac{\pi}{2}, -\frac{\pi}{3}, \frac{\pi}{3}$ cao	<b>B2</b>	<b>B1</b> for any 4 correct
10 (a) (i)	$2 \times 4!$ or $\frac{2}{5} \times 5!$ oe 48	<b>M1</b> <b>A1</b>	
(ii)	${}^5P_3$ or $\frac{5!}{2!}$ or $5 \times 4 \times 3$ oe 60	<b>M1</b> <b>A1</b>	
(b) (i)	$4 \times 2[!] \times 3$ oe 24	<b>M1</b> <b>A1</b>	Correct first step implied by a correct product of two elements
(ii)	$3!$ or $3 \times 3$ seen 18	<b>M1</b> <b>A1</b>	
11 (i)	$\frac{3x^2}{2} - \frac{2x^{5/2}}{5} (+c)$ isw	<b>B1+B1</b>	
(ii)	$(9, 0)$ oe	<b>B1</b>	Not just $x = 9$
(iii)	Substitute $(3, 9)$ into <b>both</b> lines Or solves simultaneously ( $6x = 27 - 3x$ oe) to get $x = 3, y = 9$	<b>B1</b>	$3 \times 3 = 9$ and $\frac{27 - 3 \times 3}{2} = 9$

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(iv)	$[\text{Area } AOB =] \frac{1}{2} \times 9 \times 9$ oe $(\frac{81}{2}$ or 40.5)	M1	Uses <i>their</i> (ii). May split into 2 triangles (13.5 and 27). May integrate. Must be a complete method.
	<i>their</i> $\left[ \frac{3(9)^2}{2} - \frac{2(9)^{5/2}}{5} \right] - [0]$ (= 24.3)	M1	lower limit may be omitted but must be correct if seen
	<i>their</i> $\frac{81}{2} - \text{their} \frac{243}{10}$	M1	must be from genuine attempts at area of triangle and area under curve
	16.2	A1	
12 (i)	$\left[ \frac{dy}{dx} = \right] \frac{2(x-1) - (2x-5)}{(x-1)^2}$	M1A1	Allow slips in $\frac{du}{dx}$ and $\frac{dv}{dx}$ but must be explicit. Allow $(x-1)^2 = x^2 - 2x + 1$
	- 12 isw	B1	
	<b>ALT using</b> $y = \frac{-12x^2 + 14x - 5}{x-1}$	B1	
	-24x + 14	B1	
	$\left[ \frac{dy}{dx} = \right] \frac{(x-1)(-24x+14) - (-12x^2 + 14x - 5)}{(x-1)^2}$	M1	
	A1FT	FT on their derivative of 3 term quadratic	
(ii)	$\left[ \frac{d^2y}{dx^2} = \right] k(x-1)^{-3}$	M1	No additional terms
	$k = -6$ isw	A1	

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(iii)	<p>their <math>\left[ \frac{3}{(x-1)^2} - 12 \right] = 0</math> and find a value for <math>x</math></p> <p><math>x = 0.5</math> and <math>x = 1.5</math></p> <p><math>y = 2</math> and <math>y = -22</math></p> <p><math>\frac{-6}{(-0.5)^3} &gt; 0</math> therefore min when <math>x = 0.5</math> oe</p> <p><math>\frac{-6}{(0.5)^3} &lt; 0</math> therefore max when <math>x = 1.5</math> oe</p>	<p><b>M1</b></p> <p><b>A1</b></p> <p><b>A1</b></p> <p><b>B1</b></p> <p><b>B1</b></p>	<p><math>12x^2 - 24x + 9 = 0</math> oe  <math>(2x - 3)(2x - 1) = 0</math> oe</p> <p>if <b>A0 A0</b> then <b>A1</b> for a correct <math>(x, y)</math> pair</p> <p>or <math>\left[ \frac{-6}{(-0.5)^3} = \right] 48</math> therefore min when <math>x = 0.5</math> oe</p> <p>or <math>\left[ \frac{-6}{(0.5)^3} = \right] -48</math> therefore max when <math>x = 1.5</math> oe</p> <p><b>M1A1</b> is possible from other methods</p>