



ADDITIONAL MATHEMATICS

0606/23

Paper 2

May/June 2016

MARK SCHEME

Maximum Mark: 80

Published

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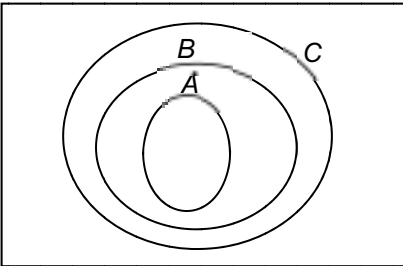
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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0606	23

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

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0606	23

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

Question	Answer	Marks	Guidance
(ii)	(-1, 9)	B2FT	B1FT $(-q, -r)$ $r < 0$ for each correct coordinate
(iii)		B1 B1 B1	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)	$\mathbf{q - p}$	B1	
(b)	$2\mathbf{q} - 2\mathbf{p}$ or $2(\mathbf{q} - \mathbf{p})$	B1	
(ii)	The points are collinear oe \overline{PQ} is a (scalar) multiple of \overline{QR} and they have a point in common. oe	B1 B1	Condone \overline{PQ} is parallel to \overline{QR} and ...
(iii)	$[\overline{OR} =] 4\mathbf{i} - 3\mathbf{j}$ oe soi $\sqrt{4^2 + (-3)^2} (=5)$	B1 M1	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	A1	
8 (a) (i)	$a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$ final answer	B2,1,0	-1 each error/omission
(ii)	$6(2x)^2\left(\frac{1}{5x}\right)^2$ soi $\frac{24}{25}$ or 0.96 isw	M1 A1	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	M1 M1 A1	Must attempt to expand and remove fractions must have come from a valid attempt Must be n if labelled

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

Page 6	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0606	23

Question	Answer	Marks	Guidance
(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> $\frac{81}{2} - \textit{their} \frac{243}{10}$	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	
	ALT using $y = \frac{-12x^2 + 14x - 5}{x-1}$	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	

Page 7	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0606	23

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