

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International General Certificate of Secondary Education

MARK SCHEME for the March 2016 series

0606 ADDITIONAL MATHEMATICS

0606/22

Paper 22, maximum raw mark 80

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

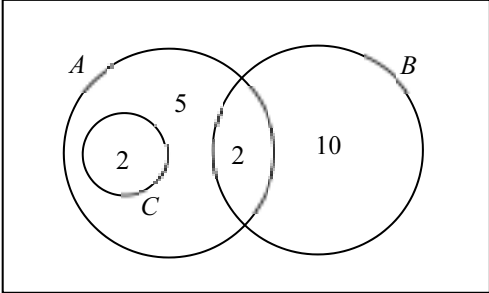
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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – March 2016	0606	22

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied
www	without wrong working

Question	Answer	Marks	Guidance
1 (i)	$\frac{dy}{dx} = k(x-9)^{-\frac{3}{2}}$	M1	If M0 then SC1 for the correct answer with an extra term.
	$k = -\frac{5}{2}$ isw	A1	condone $5 \times -\frac{1}{2}$
(ii)	$\delta y = \text{their} \left(\frac{dy}{dx} \Big _{x=13} \right) \times h$	M1	
	$-0.3125h$ oe	A1	
2	 <p>5</p>	B3,2,1,0	<p>B2 for C as a proper subset of A and B with an intersection B and C mutually exclusive</p> <p>Or</p> <p>B1 for any two of the these and</p> <p>B1 for the number of elements correctly placed</p>
3	<p>Integrates $9x^2 - 3x^{-2}$</p> <p>$(y =) \frac{9x^3}{3} - \frac{3x^{-1}}{-1} (+c)$</p> <p>Substitute $x = 1$ and $y = 7$ into <i>their</i> expression with 'c'</p> <p>$y = 3x^3 + 3x^{-1} + 1$ oe isw</p>	<p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p>	<p>condone one rearrangement error</p> <p><i>their</i> expression must be from an attempt to integrate</p> <p>condone $y = 3x^3 + 3x^{-1} + c$ and $c = 1$ seen, isw</p>

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – March 2016	0606	22

Question	Answer	Marks	Guidance
4 (a) (b)	$a = 10$ $b = 6$ $c = 4$ or $10\cos 6x + 4$	B2,1,0	for B1 allow correct FT of c from a e.g. <i>their c = 14 – their a</i>
		B3,2,1,0	Correct shape; two cycles; both maximum at 1 and minimum at -5; starting at (0, -2) and ending at (180, -2)
5 (i) (ii)	$2187 + 5103kx + 5103k^2x^2$ $2(5103k) = 5103k^2$ $k = 2$	B3 M1 A1	1 for each term; ignore extra terms must not include x, x^2 A0 if $k = 0$ also given as a solution
6	$\frac{x}{1+3\sqrt{3}} = \frac{5-\sqrt{3}}{6+2\sqrt{3}} \text{ oe soi}$ $(x =) \frac{-4+14\sqrt{3}}{6+2\sqrt{3}} \text{ oe}$ $(x =) \frac{-4+14\sqrt{3}}{6+2\sqrt{3}} \times \frac{6-2\sqrt{3}}{6-2\sqrt{3}}$ $p = -27, q = 23 \text{ isw}$	M1 M1 M1 A1 + A1	allow $(x =) \frac{-27+23\sqrt{3}}{6}$

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – March 2016	0606	22

Question	Answer	Marks	Guidance
7 (a)	$\begin{pmatrix} 4 & 6 & 8 \\ -2 & 0 & 4 \end{pmatrix} - \begin{pmatrix} 18 & 3 & 6 \\ 21 & -6 & 3 \end{pmatrix}$	M1	for attempt to multiply and subtract
	$\begin{pmatrix} -14 & 3 & 2 \\ -23 & 6 & 1 \end{pmatrix}$	A1	
(b) (i)	$-\frac{1}{2} \begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix} \text{ oe}$	B1 + B1	1 mark for $-\frac{1}{2} \begin{pmatrix} & \\ & \end{pmatrix}$ and 1 mark for $k \begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix}$
(ii)	Valid method	M1	$\mathbf{XD}^{-1}\mathbf{D} = \mathbf{CD}$
	$\begin{pmatrix} -8 & -6 \\ 13 & 7 \end{pmatrix}$	A2,1,0	-1 each error
			If M0 then SC1 for $\mathbf{DC} = \begin{pmatrix} 4 & 3 \\ -14 & -5 \end{pmatrix}$
8 (i)	Eliminate x (or y)	M1	$3(2y-2)^2 + (2y-2)y - y^2 = 12$
	$13y^2 - 26y = 0$ or $\frac{13}{4}x^2 - 13 = 0$ oe	A1	$3x^2 + x\left(\frac{x+2}{2}\right) - \left(\frac{x+2}{2}\right)^2 = 12$
	$13y(y-2)$ or $x^2 = 4$	M1	
	$x = -2,$ $x = 2$	A1	or for $(-2, 0)$ or $(2, 2)$ from correct working
	$y = 0$ $y = 2$ isw	+ A1FT	FT their x or y values to find their y or x values; or A1 for $(-2, 0)$ and $(2, 2)$
(ii)	<i>their</i> $m_{AB} = \frac{1}{2}$ or <i>their</i> $m_{BC} = -2$ soi	M1	may be unsimplified or Pythagoras' theorem correctly applied to <i>their</i> $(0, -2)$, <i>their</i> $(2, 2)$ and $(0, 6)$
	use of $(m_{AB}) \times (m_{BC}) = -1$ and conclusion	A1	or use of $h^2 = a^2 + b^2$ and conclusion

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – March 2016	0606	22

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9 (i)	$RT = \frac{1}{\tan \theta}$	B1	or $RT = \cot \theta$
	$RS = \frac{1}{\sin \theta}$	B1	or $RS = \operatorname{cosec} \theta$
	$x = 1 - \frac{1}{2 \tan \theta} - \frac{1}{2 \sin \theta}$ oe or $x = 1 - \frac{\cot \theta}{2} - \frac{\operatorname{cosec} \theta}{2}$ oe	B1FT	FT <i>their RT and their RS</i> , provided both are functions of trig ratios
(ii)	$A = x + \frac{1}{2} \cot \theta$ oe soi correct completion to given answer $A = 1 - \frac{\operatorname{cosec} \theta}{2}$	M1 A1	
(iii)	$\operatorname{cosec} \theta = \frac{2\sqrt{3}}{3}$ oe $\theta = \frac{\pi}{3}$ cao	M1 A1	equivalent must be exact implies M1
10 (a) (i)	$(\alpha + \beta)\mathbf{i} - 20\mathbf{j} = 15\mathbf{i} + (2\alpha - 24)\mathbf{j}$	M1	implied by $\alpha + \beta = 15$ or $2\alpha - 24 = -20$
	$\alpha = 2$	A1	
	$\beta = 13$	A1	
	(ii)	$\sqrt{(\text{their } \alpha + \text{their } \beta)^2 + (-20)^2}$ oe $\frac{15\mathbf{i} - 20\mathbf{j}}{25}$ oe	M1 A1FT
(b)	$\overline{OC} = \overline{OA} + \lambda \overline{AB}$ or $\overline{OC} = \overline{OB} + (1 - \lambda)\overline{BA}$	B1	
	$[\overline{OC} =] \mathbf{a} + \lambda(\mathbf{b} - \mathbf{a})$ or $[\overline{OC} =] \mathbf{b} + (1 - \lambda)(\mathbf{a} - \mathbf{b})$	M1	
	$[\overline{OC} =] (1 - \lambda)\mathbf{a} + \lambda \mathbf{b}$	A1	
(c)	$\frac{2}{\mu + 3} = \frac{\mu}{9}$	M1	or multiplies one of the vectors by a general scale factor and finds a pair of simultaneous equations to solve
	Solves $\mu^2 + 3\mu - 18 = 0$	M1	or solves <i>their</i> correct equation to find <i>their</i> scale factor and attempts to use it to find μ
	$\mu = 3$	A1	A0 if -6 not discarded

Page 6	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – March 2016	0606	22

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11 (i)	$\frac{dy}{dx} = \frac{(x^2 + 1)(1) - (x)(2x)}{(x^2 + 1)^2} \text{ oe}$	M1*	Attempts to differentiate using the quotient rule
	<p><i>their</i> $(1 - x^2) = 0$</p> <p>$x = 1, x = -1$</p> <p>$y = 0.5, y = -0.5$ oe</p>	<p>A1</p> <p>correct; allow unsimplified</p> <p>M1 dep*</p> <p>A1</p> <p>from correct working only</p> <p>A1</p> <p>from correct working only</p> <p>or A1 for each of (1, 0.5), (-1, -0.5) oe from correct working;</p> <p>unsupported answers do not score</p>	
(ii)	$\frac{d}{dx} \left((x^2 + 1)^2 \right) = 2(x^2 + 1)(2x) \text{ soi}$	B1	$\frac{d}{dx} (x^4 + 2x^2 + 1) = 4x^3 + 4x$
	$\frac{d^2y}{dx^2} = (x^2 + 1) \frac{(x^2 + 1)(\text{their} - 2x) - (\text{their}(1 - x^2))2(2x)}{(x^2 + 1)^4}$	M1	Applies quotient rule and factors out
	<p>Correct completion to given answer $\frac{d^2y}{dx^2} = \frac{2x^3 - 6x}{(x^2 + 1)^3}$</p>	A1	
	<p>When $x = 1$ <i>their</i> $\left. \frac{d^2y}{dx^2} \right _{x=1} = \frac{2(1)^3 - 6(1)}{(1^2 + 1)^3} \text{ oe} < 0$ therefore</p> <p style="text-align: center;">maximum</p>	B1FT	Complete method including comparison to 0; FT <i>their</i> first or second derivative
<p>When $x = -1$ <i>their</i> $\left. \frac{d^2y}{dx^2} \right _{x=-1} = \frac{2(-1)^3 - 6(-1)}{((-1)^2 + 1)^3} \text{ oe} > 0$</p> <p style="text-align: center;">therefore minimum</p>	B1FT	Complete method including comparison to 0; FT <i>their</i> first or second derivative	

Page 7	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – March 2016	0606	22

Question	Answer	Marks	Guidance
12 (i)	$9t^2 - 63t + 90 = 0$ $(9t - 18)(t - 5)$	M1	must see evidence of solving e.g. $t = 5$ and $t = 2$ or factors
	showing that $t = 2$ is smaller value of t	A1	
(ii)	$(a =) \frac{dv}{dt}$ attempted	M1	
	$18(3.5) - 63 = 0$ cao	A1	
(iii)	$\int(9t^2 - 63t + 90)dt$	M1	
	$(s =) \frac{9t^3}{3} - \frac{63t^2}{2} + 90t$ isw	A2,1,0	-1 for each error or for +c left in
(iv) (a)	$(s =) \frac{9(2)^3}{3} - \frac{63(2)^2}{2} + 90(2)$	M1	or $\left[\frac{9t^3}{3} - \frac{63t^2}{2} + 90t \right]_0^2$
	78 [m]	A1	FT their (iii)
(b)	$(s =) \frac{9(3)^3}{3} - \frac{63(3)^2}{2} + 90(3) = 67.5$	M1	FT their (iii)
	their $78 + 10.5 = 88.5$ [m]	A1FT	