

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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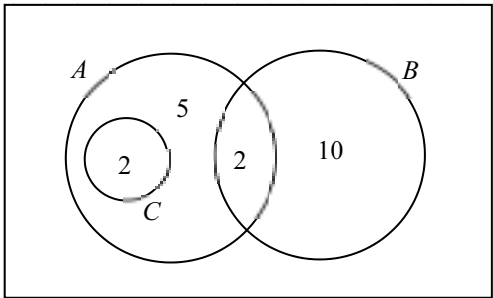
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Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
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	 5	B3,2,1,0	B2 for C as a proper subset of A and B with an intersection B and C mutually exclusive Or B1 for any two of the these and B1 for the number of elements correctly placed
3	Integrates $9x^2 - 3x^{-2}$ $(y =) \frac{9x^3}{3} - \frac{3x^{-1}}{-1} (+c)$ Substitute $x = 1$ and $y = 7$ into <i>their</i> expression with ' c ' $y = 3x^3 + 3x^{-1} + 1$ oe isw	M1 A1 M1 A1	condone one rearrangement error <i>their</i> expression must be from an attempt to integrate condone $y = 3x^3 + 3x^{-1} + c$ and $c = 1$ seen, isw

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Question	Answer	Marks	Guidance
4 (a) (b)	$a = 10$ $b = 6$ $c = 4$ or $10\cos 6x + 4$	B2,1,0 B3,2,1,0	for B1 allow correct FT of c from a e.g. <i>their</i> $c = 14 - \text{their } a$ 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	$\frac{x}{1+3\sqrt{3}} = \frac{5-\sqrt{3}}{6+2\sqrt{3}}$ oe soi $(x =) \frac{-4+14\sqrt{3}}{6+2\sqrt{3}}$ oe $(x =) \frac{-4+14\sqrt{3}}{6+2\sqrt{3}} \times \frac{6-2\sqrt{3}}{6-2\sqrt{3}}$ $p = -27, q = 23$ isw	M1 M1 M1 A1 + A1	allow $(x =) \frac{-27+23\sqrt{3}}{6}$

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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) $-\frac{1}{2} \begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix}$ 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 $\begin{pmatrix} -8 & -6 \\ 13 & 7 \end{pmatrix}$	M1 A2,1,0	$\mathbf{XD}^{-1}\mathbf{D} = \mathbf{CD}$ -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	$3(2y-2)^2 + (2y-2)y - y^2 = 12$ $3x^2 + x \left(\frac{x+2}{2} \right) - \left(\frac{x+2}{2} \right)^2 = 12$
	$13y^2 - 26y = 0$ or $\frac{13}{4}x^2 - 13 = 0$ oe	A1	
	$13y(y-2)$ 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 <i>their</i> x or y values to find <i>their</i> 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

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Question	Answer	Marks	Guidance
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	B1FT	FT <i>their</i> RT and <i>their</i> RS , provided both are functions of trig ratios
	or $x = 1 - \frac{\cot \theta}{2} - \frac{\operatorname{cosec} \theta}{2}$ oe		
	(ii) $A = x + \frac{1}{2} \cot \theta$ oe soi	M1	
	correct completion to given answer $A = 1 - \frac{\operatorname{cosec} \theta}{2}$	A1	
(iii)	$\operatorname{cosec} \theta = \frac{2\sqrt{3}}{3}$ oe	M1	equivalent must be exact
	$\theta = \frac{\pi}{3}$ cao	A1	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	M1	FT <i>their</i> $\alpha + \beta$ provided non-zero
	$\frac{15\mathbf{i} - 20\mathbf{j}}{25}$ oe	A1FT	
	(b) $\overrightarrow{OC} = \overrightarrow{OA} + \lambda \overrightarrow{AB}$ or $\overrightarrow{OC} = \overrightarrow{OB} + (1 - \lambda) \overrightarrow{BA}$	B1	
	$[\overrightarrow{OC}] = \mathbf{a} + \lambda(\mathbf{b} - \mathbf{a})$ or	M1	
	$[\overrightarrow{OC}] = \mathbf{b} + (1 - \lambda)(\mathbf{a} - \mathbf{b})$		
	$[\overrightarrow{OC}] = (1 - \lambda)\mathbf{a} + \lambda \mathbf{b}$	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

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Question	Answer	Marks	Guidance
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
	$their(1 - x^2) = 0$ $x = 1, x = -1$ $y = 0.5, y = -0.5 \text{ oe}$	A1 M1 dep* A1 A1	correct; allow unsimplified from correct working only from correct working only or A1 for each of (1, 0.5), (-1, -0.5) oe from correct working; unsupported answers do not score
(ii)	$\frac{d}{dx}((x^2 + 1)^2) = 2(x^2 + 1)(2x) \text{ soi}$	B1	$\frac{d}{dx}(x^4 + 2x^2 + 1) = 4x^3 + 4x$
	$\frac{d^2y}{dx^2} = (x^2 + 1) \frac{(x^2 + 1)(their - 2x) - (their(1 - x^2))2(2x)}{(x^2 + 1)^4}$	M1	Applies quotient rule and factors out
	Correct completion to given answer $\frac{d^2y}{dx^2} = \frac{2x^3 - 6x}{(x^2 + 1)^3}$	A1	
	When $x = 1$ $their \frac{d^2y}{dx^2} \Big _{x=1} = \frac{2(1)^3 - 6(1)}{(1^2 + 1)^3} \text{ oe} < 0$ therefore maximum	B1FT	Complete method including comparison to 0; FT <i>their</i> first or second derivative
	When $x = -1$ $their \frac{d^2y}{dx^2} \Big _{x=-1} = \frac{2(-1)^3 - 6(-1)}{((-1)^2 + 1)^3} \text{ oe} > 0$ therefore minimum	B1FT	Complete method including comparison to 0; FT <i>their</i> first or second derivative

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