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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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)	$\frac{\mathrm{d}y}{\mathrm{d}x} = k(x-9)^{-\frac{3}{2}}$	M1	If M0 then SC1 for the correct answer with an extra term.
	$k = -\frac{5}{2} \text{ isw}$	A1	condone $5 \times -\frac{1}{2}$
(ii)	$\delta y = their \left(\frac{\mathrm{d}y}{\mathrm{d}x} \Big _{x=13} \right) \times h$	M1	
	-0.3125h oe	A1	
2	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	B3,2,1,0	B2 for C as a proper subset of A 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
	5	B1FT	FT their 5
3	Integrates $9x^2 - 3x^{-2}$	M1	condone one rearrangement error
	$(y=)\frac{9x^3}{3} - \frac{3x^{-1}}{-1}(+c)$	A1	
	Substitute $x = 1$ and $y = 7$ into <i>their</i> expression with 'c'	M1	their expression must be from an attempt to integrate
	$y = 3x^3 + 3x^{-1} + 1$ oe isw	A1	condone $y = 3x^3 + 3x^{-1} + c$ and $c = 1$ seen, isw

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Question	Answer	Marks	Guidance
4 (a)	$a = 10$ $b = 6$ $c = 4$ or $10\cos 6x + 4$	B2,1,0	for B1 allow correct FT of c from a e.g. their $c = 14$ – their a
(b)	1 0 45° 90° 135° 180° X -2	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)	$2187 + 5103kx + 5103k^2x^2$	В3	1 for each term; ignore extra terms
(ii)	$2(5103k) = 5103k^2$	M1	must not include x , x^2
	k=2	A1	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	M1	
	$(x =) \frac{-4 + 14\sqrt{3}}{6 + 2\sqrt{3}} \text{ oe}$	M1	
	$(x =) \frac{-4 + 14\sqrt{3}}{6 + 2\sqrt{3}} \times \frac{6 - 2\sqrt{3}}{6 - 2\sqrt{3}}$	M1	
	p = -27, q = 23 isw	A1 + A1	allow $(x =) \frac{-27 + 23\sqrt{3}}{6}$

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Q	uestion	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} -2 & 0 & 4 \end{pmatrix} \begin{pmatrix} 21 & -6 & 3 \end{pmatrix} $ $ \begin{pmatrix} -14 & 3 & 2 \\ -23 & 6 & 1 \end{pmatrix} $ $ -\frac{1}{2} \begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix} \text{ oe } $	A1	
	(b) (i)	$-\frac{1}{2}\begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix} $ oe	B1 + B1	1 mark for $-\frac{1}{2}$ and 1 mark
				for $k \begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix}$
	(ii)	Valid method	M1	$\mathbf{X}\mathbf{D}^{-1}\mathbf{D} = \mathbf{C}\mathbf{D}$
		$\begin{pmatrix} -8 & -6 \\ 13 & 7 \end{pmatrix}$	A2,1,0	−1 each error
				If M0 then SC1 for $DC = \begin{pmatrix} 4 & 3 \\ -14 & -5 \end{pmatrix}$
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	
		13 $y(y-2)$ or $x^2 = 4$ x = -2, $x = 2$	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)	their $m_{AB} = \frac{1}{2}$ or their $m_{BC} = -2$ 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 $RS = \csc\theta$
	$x = 1 - \frac{1}{2 \tan \theta} - \frac{1}{2 \sin \theta} \text{ oe}$ $\text{or } x = 1 - \frac{\cot \theta}{2} - \frac{\csc \theta}{2} \text{ oe}$	B1FT	FT their RT and their RS, provided both are functions of trig ratios
(ii)	$A = x + \frac{1}{2}\cot\theta \text{ oe soi}$	M1	
	correct completion to given answer $A = 1 - \frac{\csc \theta}{2}$	A1	
(iii)	$\csc\theta = \frac{2\sqrt{3}}{3}$ 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	
	β = 13	A1	
(ii)	$\sqrt{(their\alpha + their\beta)^2 + (-20)^2}$ oe	M1	
	$\frac{15\mathbf{i} - 20\mathbf{j}}{25} \text{ oe}$	A1FT	FT <i>their</i> $\alpha + \beta$ provided nonzero
(b)	$\overrightarrow{OC} = \overrightarrow{OA} + \lambda \overrightarrow{AB} \text{ or } \overrightarrow{OC} = OB + (1 - \lambda)\overrightarrow{BA}$	B 1	
	$[\overrightarrow{OC} =] \mathbf{a} + \lambda(\mathbf{b} - \mathbf{a}) \text{ or}$ $[\overrightarrow{OC} =] \mathbf{b} + (1 - \lambda)(\mathbf{a} - \mathbf{b})$	M1	
	$[\overrightarrow{OC} =] (1 - \lambda)\mathbf{a} + \lambda \mathbf{b}$	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
		A1	correct; allow unsimplified
	$their(1-x^2) = 0$	M1 dep*	
	x = 1, x = -1	A1	from correct working only
	y = 0.5, $y = -0.5$ oe	A1	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)	$\frac{\mathrm{d}}{\mathrm{d}x} \left(\left(x^2 + 1 \right)^2 \right) = 2 \left(x^2 + 1 \right) \left(2x \right) \text{ soi}$	B1	$\frac{d}{dx}(x^4 + 2x^2 + 1) = 4x^3 + 4x$
	$\frac{d^2 y}{dx^2} = (x^2 + 1) \frac{(x^2 + 1)(their - 2x) - (their(1 - x^2))2(2x)}{(x^2 + 1)^4}$	M1	Applies quotient rule and factors out
	Correct completion to given answer $\frac{d^2y}{dx^2} = \frac{2x^3 - 6x}{\left(x^2 + 1\right)^3}$	A1	
	When $x = 1$ their $\frac{d^2 y}{dx^2}\Big _{x=1} = \frac{2(1)^3 - 6(1)}{(1^2 + 1)^3}$ oe < 0 therefore maximum	B1FT	Complete method including comparison to 0; FT <i>their</i> first or second derivative
	When $x = -1$ their $\frac{d^2 y}{dx^2}\Big _{x=-1} = \frac{2(-1)^3 - 6(-1)}{((-1)^2 + 1)^3}$ 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)	$9t^2 - 63t + 90 = 0$ $(9t - 18)(t - 5)$	M1	
	showing that $t = 2$ is smaller value of t	A1	must see evidence of solving e.g. $t = 5$ and $t = 2$ or factors
(ii)	$(a =) \frac{\mathrm{d}v}{\mathrm{d}t}$ attempted	M1	
	18(3.5) - 63 = 0 cao	A1	
(iii)	$\int (9t^2 - 63t + 90) dt$	M1	
	$18(3.5) - 63 = 0 \text{ cao}$ $\int (9t^2 - 63t + 90) dt$ $(s =) \frac{9t^3}{3} - \frac{63t^2}{2} + 90t \text{ isw}$	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 $\left[\frac{9t^3}{3} - \frac{63t^2}{2} + 90t \right]_0^2$ FT their (iii)
	78 [m]	A1	
(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	