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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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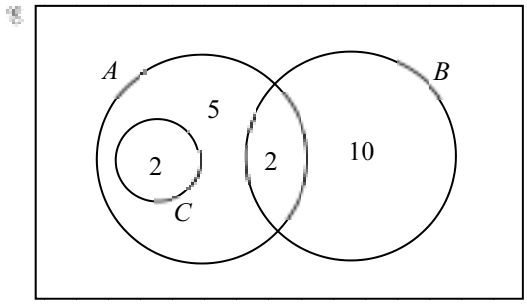
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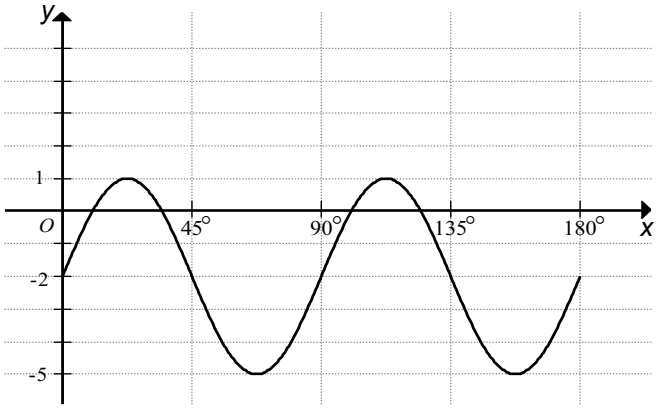
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Abbreviations

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)	$\delta y = their\left(\left.\frac{dy}{dx}\right\|_{x=13}\right) \times h$	M1	
	$-0.3125h$ oe	A1	
2		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 *their* 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)		**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)	$2187 + 5103kx + 5103k^2x^2$	**B3**	**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**	
	$(x =)\frac{-4+14\sqrt{3}}{6+2\sqrt{3}}$ oe	**M1**	
	$\left(x =\right)\frac{-4+14\sqrt{3}}{6+2\sqrt{3}} \times \frac{6-2\sqrt{3}}{6-2\sqrt{3}}$	**M1**	
	$p = –27$, $q = 23$ isw	**A1 + A1**	allow $(x =)\frac{-27+23\sqrt{3}}{6}$

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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	M1	$\mathbf{XD^{-1}D = CD}$
	$\begin{pmatrix} -8 & -6 \\ 13 & 7 \end{pmatrix}$	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	
	$13y(y-2)$ or $x^2 = 4$	M1	
	$x = -2$, $x = 2$	A1 + A1FT	or for (–2, 0) or (2, 2) from correct working **FT** *their* x or y values to find *their* y or x values; or **A1** for (–2, 0) and (2, 2)
	$y = 0$ $y = 2$ isw		
(ii)	*their* $m_{AB} = \frac{1}{2}$ or *their* $m_{BC} = -2$ soi	M1	may be unsimplified or Pythagoras' theorem correctly applied to *their* (0, –2), *their* (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)	$RT = \dfrac{1}{\tan\theta}$	B1	or $RT = \cot\theta$
	$RS = \dfrac{1}{\sin\theta}$	B1	or $RS = \operatorname{cosec}\theta$
	$x = 1 - \dfrac{1}{2\tan\theta} - \dfrac{1}{2\sin\theta}$ oe or $x = 1 - \dfrac{\cot\theta}{2} - \dfrac{\operatorname{cosec}\theta}{2}$ oe	B1FT	**FT** *their RT* and *their RS*, provided both are functions of trig ratios
(ii)	$A = x + \dfrac{1}{2}\cot\theta$ oe soi	M1	
	correct completion to given answer $A = 1 - \dfrac{\operatorname{cosec}\theta}{2}$	A1	
(iii)	$\operatorname{cosec}\theta = \dfrac{2\sqrt{3}}{3}$ oe	M1	equivalent must be exact
	$\theta = \dfrac{\pi}{3}$ 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)	$\sqrt{(their\alpha + their\beta)^2 + (-20)^2}$ oe	M1	
	$\dfrac{15\mathbf{i} - 20\mathbf{j}}{25}$ oe	A1FT	**FT** *their* $\alpha + \beta$ provided non-zero
(b)	$\overrightarrow{OC} = \overrightarrow{OA} + \lambda\overrightarrow{AB}$ or $\overrightarrow{OC} = OB + (1-\lambda)\overrightarrow{BA}$	B1	
	$[\overrightarrow{OC} =]$ $\mathbf{a} + \lambda(\mathbf{b} - \mathbf{a})$ or $[\overrightarrow{OC} =]$ $\mathbf{b} + (1 - \lambda)(\mathbf{a} - \mathbf{b})$	M1	
	$[\overrightarrow{OC} =]$ $(1 - \lambda)\mathbf{a} + \lambda\,\mathbf{b}$	A1	
(c)	$\dfrac{2}{\mu + 3} = \dfrac{\mu}{9}$	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 *their* correct equation to find *their* 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)	$\frac{dy}{dx} = \frac{(x^2+1)(1)-(x)(2x)}{(x^2+1)^2}$ 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)	$\frac{d}{dx}\left((x^2+1)^2\right) = 2(x^2+1)(2x)$ soi	B1	$\frac{d}{dx}(x^4+2x^2+1) = 4x^3+4x$
	$\frac{d^2y}{dx^2} = (x^2+1)\frac{(x^2+1)(\textit{their}-2x)-(\textit{their}(1-x^2))2(2x)}{(x^2+1)^4}$	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* $\left.\frac{d^2y}{dx^2}\right\|_{x=1} = \frac{2(1)^3-6(1)}{(1^2+1)^3}$ oe < 0 therefore maximum	B1FT	Complete method including comparison to 0; **FT** *their* first or second derivative
	When $x = -1$ *their* $\left.\frac{d^2y}{dx^2}\right\|_{x=-1} = \frac{2(-1)^3-6(-1)}{((-1)^2+1)^3}$ oe > 0 therefore minimum	B1FT	Complete method including comparison to 0; **FT** *their* 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)	$(a =)\dfrac{\mathrm{d}v}{\mathrm{d}t}$ attempted	**M1**	
	$18(3.5) - 63 = 0$ cao	**A1**	
(iii)	$\int(9t^2 - 63t + 90)\,\mathrm{d}t$	**M1**	
	$(s =)\dfrac{9t^3}{3} - \dfrac{63t^2}{2} + 90t$ isw	**A2,1,0**	−1 for each error or for $+c$ left in
(iv) (a)	$(s =)\dfrac{9(2)^3}{3} - \dfrac{63(2)^2}{2} + 90(2)$	**M1**	or $\left[\dfrac{9t^3}{3} - \dfrac{63t^2}{2} + 90t\right]_0^2$ **FT** *their* **(iii)**
	78 [m]	**A1**	
(b)	$(s =)\dfrac{9(3)^3}{3} - \dfrac{63(3)^2}{2} + 90(3) = 67.5$	**M1**	**FT** *their* **(iii)**
	their 78 + 10.5 = 88.5 [m]	**A1FT**	

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