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ADDITIONAL MATHEMATICS

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MARK SCHEME

Maximum Mark: 80

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MARK SCHEME NOTES

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

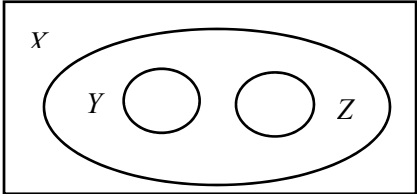
Types of mark

- M** Method marks, awarded for a valid method applied to the problem.
- A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.
- B** Mark for a correct result or statement independent of Method marks.

When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. The notation ‘**dep**’ is used to indicate that a particular M or B mark is dependent on an earlier mark in the scheme.

Abbreviations

awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfw	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	Part Marks
1 (a) (i)	0	B1	
	(ii) 10	B1	
		B1	either $X \cap Y = Y$ or $X \cap Z = Z$
		B1	$Y \cap Z = \emptyset$
		B1	completely correct Venn diagram.

Question	Answer	Marks	Part Marks
2 (i)		B1 B1 B1	2 complete cycles having a maximum at $y = 4$ and a minimum at $y = -2$ completely correct curve
(ii)	$(90^\circ, -2)$	B1	
3	$a^5 + 5a^4\left(\frac{x}{4}\right) + 10a^3\left(\frac{x}{4}\right)^2$ $a^5 = 32$, so $a = 2$ $b = 5 \times \frac{1}{4} \times (\text{their } a)^4$, leading to $b = 20$ $c = 10 \times \frac{1}{16} \times (\text{their } a)^3$ leading to $c = 5$	B1 M1 A1 M1 A1	correct attempt to obtain b
4 (a) (i)	$\frac{1}{10} \begin{pmatrix} 4 & 3 \\ -2 & 1 \end{pmatrix}$	B1 B1	for $\frac{1}{\text{determinant}}$ for matrix
(ii)	$\mathbf{M} = \frac{1}{10} \begin{pmatrix} 4 & 3 \\ -2 & 1 \end{pmatrix} \begin{pmatrix} -1 & -5 \\ 4 & 2 \end{pmatrix}$ $\mathbf{M} = \frac{1}{5} \begin{pmatrix} 4 & -7 \\ 3 & 6 \end{pmatrix}$ oe	M1 A2,1,0	pre-multiplication by the matrix from part (i) –1 each element error
(b)	$-3a + 2 = 4(6a - 4)$ $a = \frac{2}{3}$	M1 A1	correct use of a determinant

Question	Answer	Marks	Part Marks
5 (i)	$\begin{aligned} \text{LHS} &= \frac{1}{\sin \theta} - \sin \theta \\ &= \frac{1 - \sin^2 \theta}{\sin \theta} \\ &= \frac{\cos^2 \theta}{\sin \theta} \\ &= \cot \theta \cos \theta \end{aligned}$	M1 M1 A1	dealing with $\operatorname{cosec} \theta$ and attempt at dealing with fractions correct use of identity completely correct proof
(ii)	$\begin{aligned} \cot \theta \cos \theta &= \frac{1}{3} \cos \theta \\ 3 \cot \theta \cos \theta - \cos \theta &= 0 \\ \cos \theta (3 \cot \theta - 1) &= 0 \\ \cos \theta = 0 \quad \cot \theta &= \frac{1}{3}, \text{ so } \tan \theta = 3 \\ \theta &= \frac{\pi}{2}, \frac{3\pi}{2}, \theta = 1.25, 4.39 \end{aligned}$	M1 M1 A1,A1	use of part (i), manipulation and factorisation dealing with $\cot \theta$ and attempt to solve A1 for each pair of solutions (allow 1.57 and 4.71)
6 (a) (i)	40 320	B1	
(ii)	720	B1	
(iii)	5040	B1	
(b) (i)	35	B1	
(ii)	1	B1	
(iii)	Twins in team of 4 ${}^5C_2 = 10$ Twins in team of 3 $= 5$ Total = 15 www	B1 B1 B1	

Question	Answer	Marks	Part Marks
7 (a)	$\frac{102}{17} \begin{pmatrix} 8 \\ -15 \end{pmatrix}$	M1	attempt to obtain magnitude of $\begin{pmatrix} 8 \\ -15 \end{pmatrix}$ and use it
	$\begin{pmatrix} 48 \\ -90 \end{pmatrix}$	A1	
	(b) $\begin{pmatrix} 2p-2q+4 \\ 10p+2q+3 \end{pmatrix} = \begin{pmatrix} p^2 \\ 27 \end{pmatrix}$	M1	dealing with the scalar and with addition
	$2p-2q+4 = p^2$ $10p+2q+3 = 27$	M1 A1	equating like vectors and simplifying both equations correct
	leading to $p^2 - 12p + 20 = 0$	M1	elimination of q and subsequent solution of quadratic
	$p = 2, q = 2$ $p = 10, q = -38$	A1 A1	
8 (i)	$\frac{dy}{dx} = -2\cos 2x (+c)$	M1 A1	integration to obtain the form $a \cos 2x$ correct, condone omission of c
	$5 = -2\cos \pi + c$	M1	attempt to find c
	$\frac{dy}{dx} = 3 - 2\cos 2x$	A1	May be implied by a correct c
	(ii) $y = 3x - \sin 2x (+c)$	M1 A1	integration to obtain the form $a \sin 2x$ correct, condone omission of c
	$-\frac{1}{2} = \frac{\pi}{4} - \frac{1}{2} + c$	M1	attempt to find c
	$y = 3x - \sin 2x - \frac{\pi}{4}$ oe	A1	
	(iii) When $x = \frac{\pi}{12}$, $\frac{dy}{dx} = 3 - \sqrt{3}$		
	Normal equation: $y + \frac{1}{2} = \frac{1}{\sqrt{3}-3} \left(x - \frac{\pi}{12} \right)$	M1 A1FT	attempt to obtain perpendicular gradient and normal equation FT on their $\frac{dy}{dx}$ from (i). Allow unsimplified
	$y = -0.789x - 0.294$ cao	A1	

Question	Answer	Marks	Part Marks
9	(i)	$\frac{1}{2} \times 10^2 \times \theta = 20\pi$	M1 use of sector area to obtain θ
		$\theta = \frac{2\pi}{5}$	A1
	(ii)	Arc length $AB = 4\pi$	B1FT FT their θ
		$BC^2 = 10^2 + 10^2 - (2 \times 10 \times 10 \times \cos 2\theta)$	
		or $\frac{BC}{\sin \frac{4\pi}{5}} = \frac{10}{\sin \frac{\pi}{10}}$	M1 valid attempt to obtain BC
		$BC = 19.02$ Perimeter = 50.6	A1 A1
(iii)	Area = Either		
	$\left(\frac{1}{2} \times 19.02^2 \sin \frac{\pi}{5} \right)$	M1	area of triangle ACB
	$+ \left(20\pi - \left(\frac{1}{2} \times 10^2 \sin \frac{2\pi}{5} \right) \right)$	M1	area of relevant segment
	= 121.6 allow awrt 122	A1	
	Or		
	$20\pi + 2 \left(\frac{1}{2} \times 10 \times 10 \sin \frac{4\pi}{5} \right)$	M1,M1	M1 for area of triangle AOB or AOC
	= 121.6 allow awrt 122	A1	M1 for a complete method

Question	Answer	Marks	Part Marks
10	$(2x-5)^{\frac{3}{2}} = 3\sqrt{3}$ $x = 4$ At A $x = 2.5$ Either $\text{Area} = \frac{1}{2} \times \frac{3}{2} \times 3\sqrt{3} - \int_{2.5}^4 (2x-5)^{\frac{3}{2}} dx$ $= \frac{9\sqrt{3}}{4} - \left[\frac{1}{5} (2x-5)^{2.5} \right]_{2.5}^4$ $= \frac{9\sqrt{3}}{4} - \left(\frac{1}{5} (3)^{2.5} - 0 \right)$ $= \frac{9\sqrt{3}}{20}$ Or line AB: $y = 2\sqrt{3}x - 5\sqrt{3}$ $\text{Area} = \int_{2.5}^4 2\sqrt{3}x - 5\sqrt{3} - (2x-5)^{\frac{3}{2}} dx$ $= \left[\sqrt{3}x^2 - 5\sqrt{3}x - \frac{(2x-5)^{\frac{5}{2}}}{5} \right]_{2.5}^4$ $= \frac{9\sqrt{3}}{4} - \frac{9\sqrt{3}}{5}$ $= \frac{9\sqrt{3}}{20}$	M1 A1 B1 M1 M1 A1 DM1 A1 M1 M1 A1 DM1 A1	attempt to find x-coordinate of B x-coordinate of B x-coordinate of A plan and attempt to find the area of the triangle. Allow unsimplified attempt at integration, must be in the form $(2x-5)^{2.5}$ correct integration attempt to use limits correctly equation of AB and attempt to integrate attempt at integration, must contain the form $(2x-5)^{2.5}$ correct integration attempt to use correct limits correctly
11 (i)	$\ln y = \ln A + bx$ $0.7 = \ln A + b$ $3.7 = \ln A + 2.5b$ leading to $b = 2$ and $\ln A = -1.3$, so $A = 0.273$ or $e^{-1.3}$	B1 M1 A1 A1 M1,A1	may be implied by later work use of either point correctly in above equation or equivalent one correct equation M1 for dealing with $\ln$ correctly to obtain A.
(ii)	$\ln y = -1.3 + 2x$ $\ln y = 2.7$ $y = 14.9$	M1 A1	valid attempt to find y. Must include correct substitution and dealing with $\ln$ correctly.