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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.

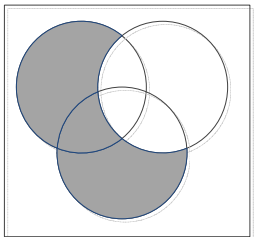
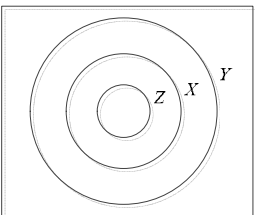
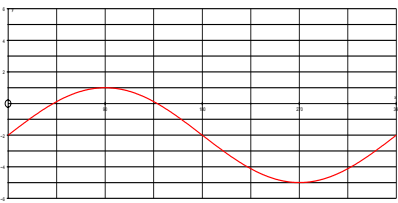
Types of mark

- 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
nfwf	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1(a)		1	
1(b)		1	
2(i)	4	1	
2(ii)	40° or $\frac{2\pi}{9}$ or 0.698 rad	1	
3(i)		3	B1 for a complete cycle starting and ending at -2 B1 for max at $y = 1$ and min at $y = -5$ B1 for a completely correct graph
3(ii)	5	1	FT <i>their</i> min value for y
4(i)	Area = $\frac{1}{2}(3 + 2\sqrt{5})(4 + 6\sqrt{5})$ $= \frac{1}{2}(12 + 26\sqrt{5} + 60)$	M1	use of correct formula and attempt to expand out the brackets
	$= 36 + 13\sqrt{5}$	A1	
4(ii)	$\frac{3 + 2\sqrt{5}}{2 + 3\sqrt{5}}$	B1	
	$= \frac{3 + 2\sqrt{5}}{2 + 3\sqrt{5}} \times \frac{2 - 3\sqrt{5}}{2 - 3\sqrt{5}}$	M1	
	$= \frac{6 - 5\sqrt{5} - 30}{4 - 45}$ $= \frac{24 + 5\sqrt{5}}{41}$	A1	for answer

Question	Answer	Marks	Partial Marks
5	When $x = 4$, $y = 5$	B1	for y
	$\frac{dy}{dx} = \frac{1}{2} \times 4(4x+9)^{-\frac{1}{2}}$	B1	for $2(4x+9)^{-\frac{1}{2}}$, allow unsimplified
	When $x = 4$, $\frac{dy}{dx} = \frac{2}{5}$, so perp grad = $-\frac{5}{2}$	M1	obtaining numerical gradient for normal
	Equation of normal $y - 5 = -\frac{5}{2}(x - 4)$ $(2y = 30 - 5x)$	M1	for equation of normal
	$A(6, 0)$, $B(0, 15)$	A2	A1 for each
	Midpoint $\left(3, \frac{15}{2}\right)$	B1	FT on <i>their</i> x/y intercepts
6(a)(i)	dealing with multiplication and addition	M1	implied by 2 correct elements
	$A + 3C = \begin{pmatrix} -12 & 7 \\ 11 & 7 \end{pmatrix}$	A1	
6(a)(ii)	correct attempt to multiply	M1	implied by 2 correct elements
	$BA = \begin{pmatrix} 17 & 9 \\ 14 & 18 \\ -3 & -1 \end{pmatrix}$	A1	
6(b)(i)	$X^{-1} = \frac{1}{10} \begin{pmatrix} -2 & 3 \\ -4 & 1 \end{pmatrix}$	B2	B1 for $\frac{1}{10}$, B1 for $\begin{pmatrix} -2 & 3 \\ -4 & 1 \end{pmatrix}$
6(b)(ii)	$\begin{pmatrix} a & b \\ c & d \end{pmatrix} = \frac{1}{10} \begin{pmatrix} -2 & 3 \\ -4 & 1 \end{pmatrix} \begin{pmatrix} 5 & -10 \\ 15 & 20 \end{pmatrix}$	M1	pre-multiplication using matrix from (b)(i)
	$= \begin{pmatrix} 3.5 & 8 \\ -0.5 & 6 \end{pmatrix}$	A2	-1 for each incorrect element

Question	Answer	Marks	Partial Marks
7(a)	$\text{LHS} = \frac{\frac{\sin^2 \theta}{\cos^2 \theta} + \sin^2 \theta}{\cos \theta + \frac{1}{\cos \theta}}$	M1	for obtaining all in terms of $\sin \theta$ and $\cos \theta$
	$= \frac{\frac{\sin^2 \theta + \sin^2 \theta \cos^2 \theta}{\cos^2 \theta}}{\frac{\cos^2 \theta + 1}{\cos \theta}}$	M1	for simplification using addition of fractions
	$= \frac{\sin^2 \theta (1 + \cos^2 \theta)}{\cos \theta (\cos^2 \theta + 1)}$ $= \frac{\sin^2 \theta}{\cos \theta}$	M1	for factorisation and subsequent cancelling of common term
	$\tan \theta \sin \theta = \text{RHS}$	A1	correct final simplification
	Alternative $\frac{\sec^2 \theta - 1 - \cos^2 \theta + 1}{\cos \theta + \sec \theta}$	M1	use of correct identities
	$= \frac{(\sec \theta - \cos \theta)(\sec \theta + \cos \theta)}{(\sec \theta - \cos \theta)}$ $= \sec \theta - \cos \theta$	M1	attempt to factorise and simplify
	$= \frac{1 - \cos^2 \theta}{\cos \theta}$	M1	simplification to obtain terms in $\sin \theta$ and $\cos \theta$ only
	$= \frac{\sin^2 \theta}{\cos \theta}$ $= \tan \theta \sin \theta$	A1	for final simplification
7(b)	$\sin \phi = \frac{x}{3}, \cos \phi = \frac{3}{y}$	M1	for obtaining $\sin \phi$ and $\cos \phi$ in terms of x and y and attempt to use correct identity
	Using $\sin^2 \phi + \cos^2 \phi = 1$ leads to $\frac{x^2}{9} + \frac{9}{y^2} = 1$ and hence $x^2 y^2 + 81 = 9y^2$	M1	attempt at simplification
	81	A1	

Question	Answer	Marks	Partial Marks
	Alternative method using substitution $\left(9 \times \frac{9}{\cos^2 \phi}\right) - \left(\frac{9}{\cos^2 \phi} \times 9 \sin^2 \phi\right)$	M1	attempt to substitute in for x and y
	$= \left(\frac{81}{\cos^2 \phi}\right) - \left(\frac{81 \sin^2 \phi}{\cos^2 \phi}\right)$	M1	simplification of fractions
	$= \frac{81(1 - \sin^2 \phi)}{\cos^2 \phi}$ or $81(\sec^2 \phi - \tan^2 \phi)$ leading to 81	A1	use of correct identity to obtain 81
8(i)	$p\left(-\frac{1}{2}\right) = -\frac{2}{8} + \frac{a}{4} - 2 + b$	M1	for attempt at $p\left(-\frac{1}{2}\right)$
	leading to $a + 4b = 9$ oe	A1	
	$p(1) = 2 + a + 4 + b$ leading to $a + b = -18$ oe	B1	
	solution of simultaneous equations	M1	
	$a = -27, b = 9$	A1	for both
8(ii)	attempt at factorisation using either long division or observation	M1	
	$(2x + 1)(x^2 - 14x + 9)$	A1	
8(iii)	attempt to solve $q(x) = 0$	M1	
	$x = 7 \pm 2\sqrt{10}, -\frac{1}{2}$	A1	for all 3 solutions
9(i)	$\left[3e^{5x} + e^{-5x}\right]_{-k}^k = 6$	B2	B1 for each term integrated correctly
	$(3e^{5k} + e^{-5k}) - (3e^{-5k} + e^{5k}) = 6$	M1	for use of limits with $ae^{5x} + be^{-5x}$
	$2e^{5k} - 2e^{-5k} = 6$	A1	correct unsimplified
	$e^{5k} - e^{-5k} = 3$	A1	correct simplification to obtain given answer

Question	Answer	Marks	Partial Marks
9(ii)	$y^2 - 3y - 1 = 0$	M1	for correct attempt to obtain a quadratic equation in terms of y or e^{5x}
	$y = \frac{3 \pm \sqrt{9+4}}{2}$, $y = e^{5k} = 3.303$ only	DM1	for attempt to solve quadratic equation and solve for k
	$k = 0.239$	A1	A0 if more than one solution is given
10(i)	for attempt to differentiate a product	M1	
	$\frac{5}{5x+1}$	B2	B1 for $\frac{1}{5x+1}$
	$\frac{dy}{dx} = (10x+2) \times \frac{5}{5x+1} + 10 \ln(5x+1)$	A1	all else correct
10(ii)	$(10x+2) \times \frac{5}{5x+1} = 10$	B1	simplification to obtain 10, allow if seen in (i)
	$10 \int \ln(5x+1) dx$ $= (10x+2) \ln(5x+1) - 10x$	M1	use of result from part (i)
	$\int \ln(5x+1) dx$ $= \frac{(5x+1)}{5} \ln(5x+1) - x$	A1	
10(iii)	$\left[(x+0.2) \ln(5x+1) - x \right]_0^{\frac{1}{5}}$	M1	use of limits in result from (ii)
	$= -\frac{1}{5} + \frac{2}{5} \ln 2 = \frac{-1 + \ln 4}{5}$ cao	A1	
11(i)	attempt to differentiate	M1	
	$\frac{dy}{dx} = 6 - \frac{3}{2}x^{\frac{1}{2}}$	A1	
	When $\frac{dy}{dx} = 0$	M1	equating to zero and attempt to solve
	$x = 16$, $y = 32$	A1	both correct

Question	Answer	Marks	Partial Marks
11(ii)	$\frac{d^2y}{dx^2} = -\frac{3}{4}x^{-\frac{1}{2}}$	B1	correct differentiation
	This is negative so a maximum point	DB1	correct conclusion
11(iii)	When $x = 4$, $\frac{dy}{dx} = 3$	B1	
	$\partial y \approx \frac{dy}{dx} \times h$	M1	use of small increases
	$\approx 3h$	A1	FT <i>their</i> (iii)
12(i)	attempt to differentiate	M1	
	$6 \cos 2t + 6$	A1	
12(ii)	$\cos 2t = -1$	M1	attempt to equate (i) to zero and solve
	$t = \frac{\pi}{2}$	A1	
12(iii)	attempt to integrate	M1	
	$x = -\frac{3}{2} \cos 2t + 3t^2 + 2t \quad (+c)$	A2	–1 for each error
	When $t = 0$, $x = 0$, so $c = \frac{3}{2}$	M1	attempt to find c
	$x = \frac{3}{2} - \frac{3}{2} \cos 2t + 3t^2 + 2t$	A1	