



ADDITIONAL MATHEMATICS

0606/12

Paper 12

March 2017

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

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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.

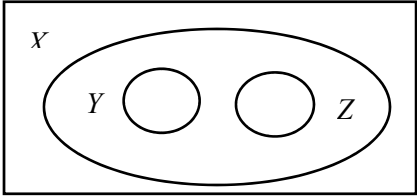
Types of mark

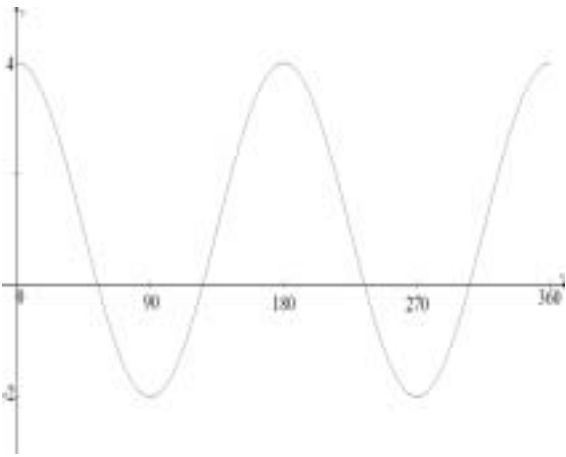
- M** Method marks, awarded for a valid method applied to the problem.
- A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. For accuracy marks to be given, the associated Method mark must be earned or implied.
- B** Mark for a correct result or statement independent 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
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	Part Marks	
1 (a) (i)	0	B1		
	(ii) 10	B1		
	(b)		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)		<p>B1</p> <p>B1</p> <p>B1</p>	<p>2 complete cycles</p> <p>having a maximum at $y = 4$ and a minimum at $y = -2$</p> <p>completely correct curve</p>
(ii)	$(90^\circ, -2)$	B1	
3	$a^5 + 5a^4\left(\frac{x}{4}\right) + 10a^3\left(\frac{x}{4}\right)^2$ $a^5 = 32, \text{ so } a = 2$ $b = 5 \times \frac{1}{4} \times (\text{their } a)^4,$ <p>leading to $b = 20$</p> $c = 10 \times \frac{1}{16} \times (\text{their } a)^3$ <p>leading to $c = 5$</p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p>	<p>correct attempt to obtain b</p>
4 (a) (i)	$\frac{1}{10} \begin{pmatrix} 4 & 3 \\ -2 & 1 \end{pmatrix}$	<p>B1</p> <p>B1</p>	<p>for $\frac{1}{\text{determinant}}$</p> <p>for matrix</p>
(ii)	$\mathbf{M} = \frac{1}{10} \begin{pmatrix} 4 & 3 \\ -2 & 1 \end{pmatrix} \begin{pmatrix} -1 & -5 \\ 4 & 2 \end{pmatrix}$ $\mathbf{M} = \frac{1}{5} \begin{pmatrix} 4 & -7 \\ 3 & 6 \end{pmatrix} \text{ oe}$	<p>M1</p> <p>A2,1,0</p>	<p>pre-multiplication by the matrix from part (i)</p> <p>-1 each element error</p>
(b)	$-3a + 2 = 4(6a - 4)$ $a = \frac{2}{3}$	<p>M1</p> <p>A1</p>	<p>correct use of a determinant</p>

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

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

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

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