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CAMBRIDGE INTERNATIONAL EXAMINATIONS

International General Certificate of Secondary Education

MARK SCHEME for the October/November 2012 series

0606 ADDITIONAL MATHEMATICS

0606/12 Paper 1, maximum raw mark 80

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.

Cambridge is publishing the mark schemes for the October/November 2012 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.



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Page	Mark Scheme	Syllabus
	IGCSE – October/November 2012	0606
	neme Notes s are of the following three types:	1 0606 Thaths Cloud
	Method mark, awarded for a valid method applied to the not lost for numerical errors, algebraic slips or errors usually sufficient for a candidate just to indicate an inter-	in units. However, it is not

Mark Scheme Notes

- Μ Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.
- Α Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).
- В Accuracy 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 generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
- The symbol $\sqrt{\ }$ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.
- Note: B2 or A2 means that the candidate can earn 2 or 0. B2, 1, 0 means that the candidate can earn anything from 0 to 2.

Page 3	Mark Scheme	Syllabus	12 3 3 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	IGCSE – October/November 2012	0606	Than Mains
The follo	Answer Given on the question paper (so extra chec the detailed working leading to the result is valid)		ots:
BOD	Benefit of Doubt (allowed when the validity of a so clear)	lution may not l	be absolutely

AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no "follow through" from a previous error is allowed)
ISW	Ignore Subsequent Working
	ignore cubecquent rremaing
MR	Misread
MR PA	

Penalties

- MR 1A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through √" marks. MR is not applied when the candidate misreads his own figures - this is regarded as an error in accuracy.
- OW –1,2 This is deducted from A or B marks when essential working is omitted.
- PA -1 This is deducted from A or B marks in the case of premature approximation.
- S –1 Occasionally used for persistent slackness – usually discussed at a meeting.
- EX -1 Applied to A or B marks when extra solutions are offered to a particular equation. Again, this is usually discussed at the meeting.

			4 1 300
Page 4	Mark Scheme	Syllabus	· 2
	IGCSE – October/November 2012	0606	1/2 3. E

1	(i) $\left \left(\frac{24}{7} \right) \right = 25$	M1 A1 [2]	M1 for a complete method to find and the modulus
	(ii) $4\lambda - \mu = 21$ $3\lambda + 2\mu = 2$ $\lambda = 4$ and $\mu = -5$	M1 DM1 A1 [3]	M1 for equating like vectors once DM1 for solving simultaneous equations
2	(i) $\frac{1}{2} \begin{pmatrix} 1.5 & 1 \\ 1 & 2 \end{pmatrix}$	B1 B1 [2]	B1 for reciprocal of determinant B1 for matrix
	(ii) $A = \begin{pmatrix} 2 & -1 \\ -1 & 1.5 \end{pmatrix}^{-1} \begin{pmatrix} 1 & 6 \\ -0.5 & 4 \end{pmatrix}$ $= \frac{1}{2} \begin{pmatrix} 1.5 & 1 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} 1 & 6 \\ -0.5 & 4 \end{pmatrix}$	M1	M1 for correct use of inverse matrix — must be using pre-multiplication with their inverse, must see an attempt to multiply out.
	$=\frac{1}{2}\begin{pmatrix}1&13\\0&14\end{pmatrix}\operatorname{or}\begin{pmatrix}0.5&6.5\\0&7\end{pmatrix}$	A2,1,0 [3]	−1 each error

			4	1
Page 5	Mark Scheme	Syllabus	· 25.	1
	IGCSE – October/November 2012	0606	1/2	73.
•			7	(C) (C)

	1	
$3 (i) = \frac{\cos \left(+ \frac{\sin \left(-\frac{\sin \left(-\frac{\sin \left(-\frac{\sin \left(-\frac{\cos \left(-\frac{\sin \left(-\frac{\sin \left(-\frac{\cos \left(-\frac{\cos \left(-\frac{\sin \left(-\frac{\cos c}{\cos \left(-\frac{\cos c}{\cos c}\right) + \cos c \right) + cos c} \right)} - cosin cincilite cionilite} } ciolite cioilite cioilite} } cioilite cioilite cioilite} } cioilite $	B1	B1 for $\cot \theta = \frac{\cos \theta}{\sin \theta}$
$\cos (+\cos^2 (+\frac{[\sin]]^2 ()}{\sin((1+\cos()))}$	M1	M1 for attempt to add fractions
= (("cos" "(" + 1"))/("sin" "(" ("cos"(" -	M1	M1 for use of identity
$=\frac{1}{\sin \zeta}=\cos \zeta$	M1 A1 [5]	M1 for algebra/simplification Must see cosec θ for A1
Alternative scheme:		
$=\frac{1}{\tan (1+\sin (1+\cos (1+\cos (1+\cos (1+\cos (1+\cos (1+\cos (1+\cos (1+\cos$		
= (("1" "+" "cos" ["(") +" "tan" "(" "" "sin" "(
= ("1" "+" "cos" "(" + " (["sin"] ^=2" "(")/"c	3.71	M1 for attempting to add fractions
= ("cos" "(" " + " ["cos"] 1"2" "(" + " ["sin"]		
= (("cos" "(" + 1"))/("sin" "(" ("cos" "(" " " + 1"	B1	B1 for $\tan \theta = \frac{\sin \theta}{\cos \theta}$
$=\frac{1}{\sin (}=\cos ec \theta$		
	M1	M1 for use of identity
	M1 A1	M1 for algebra/simplification Must see cosec θ for A1
(ii) Gives cosec $\theta = 0.5$, leads to sin $\theta = 2$ which has no solutions.	B1 [1]	Needs an explanation

			4	1
Page 6	Mark Scheme	Syllabus	·3.	2
•	IGCSE – October/November 2012	0606	1/2	100 To
		•		

4 (i) $\log_{a}p + \log_{a}q = 9$ $2 \log_{a}p + \log_{a}q = 15$ $\log_{a}p + \log_{a}q = 3$ Or $ \begin{array}{c} a^{0} = pq \\ a^{15} = p^{2}q \\ a^{6} = p \text{ which leads to } \log_{a}p = 6 \end{array} $ All for obth MI for complete solution of the two equations All for obth MI for complete solution of the two equations All for obth MI for complete solution of the two equations All for obtaining both in correct log form Or $ \begin{array}{c} \log_{a}p^{2}q - \log_{a}pq = 6 \\ \log_{a}\frac{p^{2}q}{pq} = 6, \log_{a}p = 6 \end{array} $ Bl					
Or $a^{9} = pq$ $a^{15} = p^{2}q$ $a^{6} = p \text{ which leads to } \log_{a}p = 6$ $a^{3} = q \text{ which leads to } \log_{a}q = 3$ Or $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q = 6, \log_{a}p = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ $\text{sol } \log_{a}q = 3$ M1 M1 for $\log_{a}p^{2}q - \log_{a}pq = 6$ B1 B1 for $\log_{a}\frac{p^{2}q}{pq} = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ Sol $\log_{a}q = 3$ B1 B1 for $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ A1 M1 for change of both to base a logarithm [2] 5 Using $x = 6 + 2y$ or $y = \frac{x - 6}{2}$ M1 M1 for reducing to a three term quadratic equated to zero $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection $AB = \sqrt{16^{2} + 8^{2}}$ $= \sqrt{320}$ $, 8\sqrt{5}$ or 17.9 M1 for correct attempt to use Pythag. A1 Allow in any of these forms	4	(i)	$\log_a p + \log_a q = 9$	B1	350
Or $a^{9} = pq$ $a^{15} = p^{2}q$ $a^{6} = p \text{ which leads to } \log_{a}p = 6$ $a^{3} = q \text{ which leads to } \log_{a}q = 3$ Or $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q = 6, \log_{a}p = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ $\text{sol } \log_{a}q = 3$ M1 M1 for $\log_{a}p^{2}q - \log_{a}pq = 6$ B1 B1 for $\log_{a}\frac{p^{2}q}{pq} = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ Sol $\log_{a}q = 3$ B1 B1 for $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ A1 M1 for change of both to base a logarithm [2] 5 Using $x = 6 + 2y$ or $y = \frac{x - 6}{2}$ M1 M1 for reducing to a three term quadratic equated to zero $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection $AB = \sqrt{16^{2} + 8^{2}}$ $= \sqrt{320}$ $, 8\sqrt{5}$ or 17.9 M1 for correct attempt to use Pythag. A1 Allow in any of these forms		()		B1	6/0
Or $a^{9} = pq$ $a^{15} = p^{2}q$ $a^{6} = p \text{ which leads to } \log_{a}p = 6$ $a^{3} = q \text{ which leads to } \log_{a}q = 3$ Or $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q = 6, \log_{a}p = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ $\text{sol } \log_{a}q = 3$ M1 M1 for $\log_{a}p^{2}q - \log_{a}pq = 6$ B1 B1 for $\log_{a}\frac{p^{2}q}{pq} = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ Sol $\log_{a}q = 3$ B1 B1 for $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ A1 M1 for change of both to base a logarithm [2] 5 Using $x = 6 + 2y$ or $y = \frac{x - 6}{2}$ M1 M1 for reducing to a three term quadratic equated to zero $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection $AB = \sqrt{16^{2} + 8^{2}}$ $= \sqrt{320}$ $, 8\sqrt{5}$ or 17.9 M1 for correct attempt to use Pythag. A1 Allow in any of these forms				M1	M1 for solution of the two equations
Or $a^{9} = pq$ $a^{15} = p^{2}q$ $a^{6} = p \text{ which leads to } \log_{a}p = 6$ $a^{3} = q \text{ which leads to } \log_{a}q = 3$ Or $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}p^{2}q = 6, \log_{a}p = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ $\log_{a}q = 3$ M1 M1 for $\log_{a}p^{2}q - \log_{a}pq = 6$ B1 B1 for $\log_{a}\frac{p^{2}q}{pq} = 6$ B1 B1 for $\log_{a}\frac{p^{2}q}{pq} = 6$ B1 B1 for $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ A1 M1 for change of both to base a logarithm (ii) $\log_{p}a + \log_{q}a = \frac{1}{\log_{a}p} + \frac{1}{\log_{a}q}, = 0.5$ M1 M1 for attempt to obtain an equation in one variable. $y^{2} + 4y - 12 = 0 \text{ or } x^{2} - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection $AB = \sqrt{16^{2} + 8^{2}}$ $= \sqrt{320}, 8\sqrt{5} \text{ or } 17.9$ M1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms			$\log_a p = 6$ and $\log_a q = 3$	A1	A1 for both
$a^{9} = pq$ $a^{15} = p^{2}q$ $a^{6} = p \text{ which leads to } \log_{a}p = 6$ $a^{3} = q \text{ which leads to } \log_{a}q = 3$ $A1 \qquad \text{A1 for obtaining both in correct log form}$ Or $\log_{a}p^{2}q - \log_{a}pq = 6$ $\log_{a}\frac{p^{2}q}{pq} = 6, \log_{a}p = 6$ $\log_{a}pq = \log_{a}p + \log_{a}q = 9$ $\text{so } \log_{a}q = 3$ $\text{(ii)} \log_{p}a + \log_{q}a = \frac{1}{\log_{a}p} + \frac{1}{\log_{a}q}, = 0.5$ $M1 \qquad \text{M1 for } \log_{a}p^{2}q - \log_{a}pq = 6$ $\text{B1} \qquad \text{B1 for } \log_{a}\frac{p^{2}q}{pq} = 6$ $\text{B2} \qquad \text{B1 for } \log_{a}\frac{p^{2}q}{pq} = 6$ $\text{B3} \qquad \text{B1 for } \log_{a}pq = \log_{a}p + \log_{a}q = 9$ A1 for both $\text{M1 for change of both to base } a \log_{a}ithm$ $\text{M2 for change of both to base } a \log_{a}ithm$ $\text{M3 for reducing to a three term quadratic equated to zero}$ $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ $\text{DM1 for correct attempt to solve, must be from points of intersection}$ $\text{A2 for each correct pair}$ $\text{A3 for each correct pair}$ $\text{A4 for correct attempt to use Pythag.}$ $\text{A5 for } 17.9$ $\text{A1 Allow in any of these forms}$				[4]	
$a^{6} = p \text{ which leads to } \log_{\sigma} p = 6$ $a^{3} = q \text{ which leads to } \log_{\sigma} q = 3$ Al Al for obtaining both in correct log form Or $\log_{\sigma} p^{2}q - \log_{\sigma} pq = 6$ $\log_{\sigma} \frac{p^{2}q}{pq} = 6, \log_{\sigma} p = 6$ $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 9$ $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 9$ $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 0$ Bl Bl for $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 9$ Al for both M1, Al [2] M1 for change of both to base a logarithm M1 for reducing to a three term quadratic equated to zero M1 for correct attempt to solve, must be from points of intersection Al for correct pair Al for correct attempt to use Pythag. Al for correct attempt to use Pythag. Al Al low in any of these forms	Or		0		
$a^{6} = p \text{ which leads to } \log_{\sigma} p = 6$ $a^{3} = q \text{ which leads to } \log_{\sigma} q = 3$ Al Al for obtaining both in correct log form Or $\log_{\sigma} p^{2}q - \log_{\sigma} pq = 6$ $\log_{\sigma} \frac{p^{2}q}{pq} = 6, \log_{\sigma} p = 6$ $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 9$ $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 9$ $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 0$ Bl Bl for $\log_{\sigma} pq = \log_{\sigma} p + \log_{\sigma} q = 9$ Al for both M1, Al [2] M1 for change of both to base a logarithm M1 for reducing to a three term quadratic equated to zero M1 for correct attempt to solve, must be from points of intersection Al for correct pair Al for correct attempt to use Pythag. Al for correct attempt to use Pythag. Al Al low in any of these forms			a' = pq		
cquations $a^{3} = q \text{ which leads to } \log_{a} q = 3$ Al for obtaining both in correct log form Or $\log_{a} p^{2}q - \log_{a} pq = 6$ $\log_{a} \frac{p^{2}q}{pq} = 6, \log_{a} p = 6$ Bl for $\log_{a} \frac{p^{2}q}{pq} = 6$ Bl for $\log_{a} pq = \log_{a} p + \log_{a} q = 9$ So $\log_{a} q = 3$ Bl for $\log_{a} pq = \log_{a} p + \log_{a} q = 9$ Al for both MI for change of both to base a logarithm The second of th			$a^{6} = p^{2}q$ $a^{6} = a^{6} + b^{6} + b^{$		
Or $\log_a p^2 q - \log_a pq = 6$ $\log_a \frac{p^2 q}{pq} = 6, \log_a p = 6$ $\log_a pq = \log_a p + \log_a q = 9$ $\log_a pq = \log_a p + \log_a q = 9$ $\log_a pq = \log_a p + \log_a q = 9$ $\log_a pq = \log_a p + \log_a q = 0$ B1 B1 for $\log_a pq = \log_a p + \log_a q = 9$ A1 for both B1 for change of both to base a logarithm [2] $M1 = \frac{p^2 q}{pq} = 6$ $M1 = \frac{p^2 q}{pq} = 6$ $M2 = \frac{p^2 q}{pq} = 6$ $M3 = \frac{p^2 q}{pq} = 6$ $M4 = \frac{p^2 q}{pq} = 6$ $M3 = \frac{p^2 q}{pq} = 6$ $M4 = \frac{p^2 q}{pq} = 6$ $M3 = \frac{p^2 q}{pq} = 6$ $M4 = \frac{p^2 q}{pq} = 6$ $M1 = \frac{p^2 q}{pq} = 6$ $M2 = \frac{p^2 q}{pq} = 6$ $M3 = \frac{p^2 q}{pq} = 6$ $M4 = \frac{p^2 q}{pq} = 6$ $M1 = \frac{p^2 q}{pq} = \frac{p^2 q}{pq} = 6$ $M1 = \frac{p^2 q}{pq} = \frac{p^2 q}{pq} = \frac{p^2 q}{pq} = \frac{p^2 q}{pq} = p^2 q$			$a - p$ which leads to $\log_a p - 6$	MH	•
Or $\log_a p^2 q - \log_a pq = 6$ $\log_a \frac{p^2 q}{pq} = 6, \log_a p = 6$ $\log_a pq = \log_a p + \log_a q = 9$ $\log_a pq = \log_a p + \log_a q = 9$ $\log_a pq = \frac{1}{\log_a p} + \frac{1}{\log_a p} + \frac{1}{\log_a q} = 0.5$ B1 B1 for $\log_a \frac{p^2 q}{pq} = 6$ B1 B1 for $\log_a pq = \log_a p + \log_a q = 9$ A1 for both M1, A1 [2] M1 for change of both to base a logarithm M1 for attempt to obtain an equation in one variable. M1 M1 for reducing to a three term quadratic equated to zero M2 + 4y - 12 = 0 or $x^2 - 4x - 60 = 0$ M1 M1 for correct attempt to solve, must be from points of intersection M2 M3 for each correct pair M3 M4 for correct attempt to use Pythag. M4 M5 for correct attempt to use Pythag. A5 N5 or 17.9					equations
Or $\log_a p^2 q - \log_a pq = 6$ $\log_a \frac{p^2 q}{pq} = 6, \log_a p = 6$ $\log_a pq = \log_a p + \log_a q = 9$ $\log_a pq = \log_a p + \log_a q = 9$ $\log_a pq = \frac{1}{\log_a p} + \frac{1}{\log_a p} + \frac{1}{\log_a q} = 0.5$ B1 B1 for $\log_a \frac{p^2 q}{pq} = 6$ B1 B1 for $\log_a pq = \log_a p + \log_a q = 9$ A1 for both M1, A1 [2] M1 for change of both to base a logarithm M1 for attempt to obtain an equation in one variable. M1 M1 for reducing to a three term quadratic equated to zero M2 + 4y - 12 = 0 or $x^2 - 4x - 60 = 0$ M1 M1 for correct attempt to solve, must be from points of intersection M2 M3 for each correct pair M3 M4 for correct attempt to use Pythag. M4 M5 for correct attempt to use Pythag. A5 N5 or 17.9			$a^3 = a$ which leads to $\log_a a = 3$	Δ1	A1 for obtaining both in correct log form
$\log_a p^2 q - \log_a pq = 6$ $\log_a \frac{p^2 q}{pq} = 6, \log_a p = 6$ $\log_a pq = \log_a p + \log_a q = 9$ $\operatorname{sol} \log_a q = \frac{1}{\log_a p} + \frac{1}{\log_a q}, = 0.5$ B1 B1 for $\log_a \frac{p^2 q}{pq} = 6$ B1 B1 for $\log_a pq = \log_a p + \log_a q = 9$ $\operatorname{Sol} \log_p a + \log_q a = \frac{1}{\log_a p} + \frac{1}{\log_a q}, = 0.5$ M1, A1 [2] M1 for change of both to base a logarithm M1 for attempt to obtain an equation in one variable. M2 + 4y - 12 = 0 or $x^2 - 4x - 60 = 0$ M1 for reducing to a three term quadratic equated to zero M1 for each correct attempt to solve, must be from points of intersection A1 for each correct pair A3 for correct attempt to use Pythag. A4 Allow in any of these forms			a q which reads to loga q s	711	741 for obtaining both in correct log form
$\log_a \frac{p^2 q}{pq} = 6, \log_a p = 6$ $\log_a pq = \log_a p + \log_a q = 9$ $\operatorname{solog}_a q = 3$ B1 B1 for $\log_a \frac{p^2 q}{pq} = 6$ B1 B1 for $\log_a pq = \log_a p + \log_a q = 9$ A1 for both M1, A1 [2] M1 for change of both to base a logarithm [2] M1 for attempt to obtain an equation in one variable. M1 for reducing to a three term quadratic equated to zero M2 + 4y - 12 = 0 or $x^2 - 4x - 60 = 0$ M1 for correct attempt to solve, must be from points of intersection M3 for each correct pair A4 for each correct pair M1 for correct attempt to use Pythag. A1 A1 Allow in any of these forms	Or				
$\log_a \frac{p^2 q}{pq} = 6, \log_a p = 6$ $\log_a pq = \log_a p + \log_a q = 9$ $\operatorname{so} \log_a q = 3$ B1 B1 for $\log_a \frac{p^2 q}{pq} = 6$ B1 B1 for $\log_a pq = \log_a p + \log_a q = 9$ A1 for both M1, A1 [2] M1 for change of both to base a logarithm [2] M1 for attempt to obtain an equation in one variable. M1 for reducing to a three term quadratic equated to zero M2 + 4y - 12 = 0 or $x^2 - 4x - 60 = 0$ $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ DM1 for correct attempt to solve, must be from points of intersection A1 for each correct pair A2 A1 for correct attempt to use Pythag. A1 A1 Allow in any of these forms			$\log_a p^2 q - \log_a pq = 6$	M1	M1 for $\log_a p^2 q - \log_a pq = 6$
$\log_a pq = \log_a p + \log_a q = 9$ $\operatorname{so} \log_a q = 3$ B1 a1 B1 for $\log_a pq = \log_a p + \log_a q = 9$ A1 for both M1, A1 [2] M1 for change of both to base a logarithm M1 for attempt to obtain an equation in one variable. M1 for reducing to a three term quadratic equated to zero M1 b1 for correct attempt to solve, must be from points of intersection M3 for each correct pair A3 for each correct pair M4 for correct attempt to use Pythag. A1 Allow in any of these forms			p^2q		
So $\log_a q = 3$ Al A1 for both (ii) $\log_p a + \log_q a = \frac{1}{\log_a p} + \frac{1}{\log_a q}$, = 0.5 M1, A1 [2] M1 for change of both to base a logarithm Solve, $a = 6 + 2y$ or $b = \frac{x-6}{2}$ M1 M1 for attempt to obtain an equation in one variable. M1 M2 for reducing to a three term quadratic equated to zero M2 + 4y - 12 = 0 or $b = 2$ M3 M2 for reducing to a three term quadratic equated to zero M3 DM1 for correct attempt to solve, must be from points of intersection A1 A2 for each correct pair A2 A3 for each correct pair A3 A1 A3 for correct attempt to use Pythag. A3 A1 A3			$\log_a \frac{1}{pq} = 6$, $\log_a p = 6$	B1	B1 for $\log_a \frac{P}{na} = 6$
So $\log_a q = 3$ Al A1 for both (ii) $\log_p a + \log_q a = \frac{1}{\log_a p} + \frac{1}{\log_a q}$, = 0.5 M1, A1 [2] M1 for change of both to base a logarithm Solve, $a = 6 + 2y$ or $b = \frac{x-6}{2}$ M1 M1 for attempt to obtain an equation in one variable. M1 M2 for reducing to a three term quadratic equated to zero M2 + 4y - 12 = 0 or $b = 2$ M3 M2 for reducing to a three term quadratic equated to zero M3 DM1 for correct attempt to solve, must be from points of intersection A1 A2 for each correct pair A2 A3 for each correct pair A3 A1 A3 for correct attempt to use Pythag. A3 A1 A3					PY
So $\log_a q = 3$ Al Al for both (ii) $\log_p a + \log_q a = \frac{1}{\log_a p} + \frac{1}{\log_a q}$, $= 0.5$ M1, Al [2] M1 for change of both to base a logarithm Sology $a + \log_q a = \frac{1}{\log_a p} + \frac{1}{\log_a q}$, $= 0.5$ M1 M1 for attempt to obtain an equation in one variable. M2 $+ 4y - 12 = 0$ or $x^2 - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero M2 $+ 6)(y - 2) = 0$ or $(x + 6)(x - 10) = 0$ M3 DM1 for correct attempt to solve, must be from points of intersection M3 $+ 6 + 6 + 2y = 0$ M4 Al for each correct pair Al for each correct pair M6 $+ 6 + 2y = 0$ Al Al for each correct pair M8 $+ 6 + 2y = 0$ Al Al for each correct pair Al Al for correct attempt to use Pythag. Al Al for correct attempt to use Pythag. Al Al for each correct pair Al Al Allow in any of these forms			$\log_a pq = \log_a p + \log_a q = 9$		
(ii) $\log_p a + \log_q a = \frac{1}{\log_a p} + \frac{1}{\log_a q}$, = 0.5 M1, A1 [2] M1 for change of both to base a logarithm Solve $a = 6 + 2y$ or $b = \frac{x-6}{2}$ M1 M1 for attempt to obtain an equation in one variable. M1 M1 for reducing to a three term quadratic equated to zero M2 + 4y - 12 = 0 or $b = x^2 - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero M2 DM1 for correct attempt to solve, must be from points of intersection M3 A1 for each correct pair A4 A1 for each correct pair A5 M1 M1 for correct attempt to use Pythag. A6 A1				A1	A1 for both
5 Using $x = 6 + 2y$ or $y = \frac{x - 6}{2}$ M1 M1 for attempt to obtain an equation in one variable. $y^2 + 4y - 12 = 0$ or $x^2 - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection $\begin{vmatrix} a & b & b & b \\ b & b & b \\ c & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b & b \\ c & b & b \\ c & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b & b \\ c & b & b \\ c & b & b \\ c & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b & b \\ c & b & b \\$					
5 Using $x = 6 + 2y$ or $y = \frac{x - 6}{2}$ M1 M1 for attempt to obtain an equation in one variable. $y^2 + 4y - 12 = 0$ or $x^2 - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero $(y + 6)(y - 2) = 0 \text{ or } (x + 6)(x - 10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection $\begin{vmatrix} a & b & b & b \\ b & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b \\ b & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b \\ b & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b \\ b & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b \\ b & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b \\ b & b & b \end{vmatrix}$ M1 for correct attempt to use Pythag. $\begin{vmatrix} a & b & b & b \\ b & b & b \end{vmatrix}$ $\begin{vmatrix} a & b & b & b \\ b & b & b \end{vmatrix}$ M1 for correct attempt to use Pythag. A1 Allow in any of these forms		(ii)	$\log_{n} a + \log_{a} a = \frac{1}{1} + \frac{1}{1} = 0.5$	-	M1 for change of both to base a logarithm
one variable. $y^2 + 4y - 12 = 0$ or $x^2 - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero $(y+6)(y-2) = 0$ or $(x+6)(x-10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection A1 for each correct pair $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}$, $8\sqrt{5}$ or 17.9 M1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms		` '	$\log_a p - \log_a q$	[2]	
one variable. $y^2 + 4y - 12 = 0$ or $x^2 - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero $(y+6)(y-2) = 0$ or $(x+6)(x-10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection A1 for each correct pair $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}$, $8\sqrt{5}$ or 17.9 M1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms	_	** .	x-6) (1	
$y^2 + 4y - 12 = 0$ or $x^2 - 4x - 60 = 0$ M1 M1 for reducing to a three term quadratic equated to zero $(y + 6)(y - 2) = 0$ or $(x + 6)(x - 10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection A1 for each correct pair $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}$, $8\sqrt{5}$ or 17.9 M1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms	5	Usi	$\log x = 6 + 2y \text{ or } y = \frac{1}{2}$	MI	
equated to zero $(y+6)(y-2) = 0 \text{ or } (x+6)(x-10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection $A1 = \sqrt{16^2 + 8^2} $ All for each correct pair $A1 = \sqrt{320}, 8\sqrt{5} \text{ or } 17.9$ M1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms			-		one variable.
$(y+6)(y-2) = 0$ or $(x+6)(x-10) = 0$ DM1 DM1 for correct attempt to solve, must be from points of intersection All for each correct pair $AB = \sqrt{16^2 + 8^2}$ M1 M1 for correct attempt to use Pythag. $AB = \sqrt{320}$, $B\sqrt{5}$ or 17.9 M1 Allow in any of these forms		$y^{2} +$	$4y - 12 = 0$ or $x^2 - 4x - 60 = 0$	M1	M1 for reducing to a three term quadratic
leading to $y = -6$, $y = 2$ and $x = -6$, $x = 10$ A1 A1 for each correct pair $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}$ A1 M1 for correct attempt to use Pythag. A1 A1 Allow in any of these forms					equated to zero
leading to $y = -6$, $y = 2$ and $x = -6$, $x = 10$ A1 A1 for each correct pair $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}$ A1 M1 for correct attempt to use Pythag. A1 A1 Allow in any of these forms					
leading to $y = -6$, $y = 2$ and $x = -6$, $x = 10$ A1 A1 for each correct pair $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}$ A1 M1 for correct attempt to use Pythag. A1 A1 Allow in any of these forms		(y +	(6)(y-2) = 0 or $(x+6)(x-10) = 0$	DM1	_
and $x = -6, x = 10$ $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}, 8\sqrt{5} \text{ or } 17.9$ A1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms					from points of intersection
and $x = -6, x = 10$ $AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320}, 8\sqrt{5} \text{ or } 17.9$ A1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms		1			
$AB = \sqrt{16^2 + 8^2}$ $= \sqrt{320} , 8\sqrt{5} or 17.9$ M1 M1 for correct attempt to use Pythag. A1 Allow in any of these forms					A1 for each correct pair
$= \sqrt{320}$, $8\sqrt{5}$ or 17.9 Allow in any of these forms		and	x 0, x = 10	Al	
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		1	QX OX
6		B1	If sin 15° is not used, then no man available B1 for correct statement of the sine rule
	or equivalent	M1	M1 for correct manipulation to obtain $u = \text{an expression in surd form}$
$\theta = \frac{2\sqrt{2}}{3\sqrt{2} + 4}$		M1	M1 for attempt to obtain $2\sqrt{2}$, $\sqrt{18}\sqrt{2}$ or reasonable attempt at simplification of their numerator
		M1	M1 for attempt to rationalise, must see an attempt at simplification.
		A1 [5]	
$\sin (= 6 - 4)$	$\sqrt{2}$		
7 (i) BC, BE,	EC: $y - 4 = m(x - 8)$ or $y - 8 = m(x - 6)$	M1	M1 for attempt to obtain the equation of BC, BE, EC, (gives $y = 20 - 2x$)
AD, AE	$y-4=-\frac{1}{m}$ (x + 5)	M1	M1 for attempt to obtain the equation of AD, AE, (gives $2y = x + 13$)
For D, 3	y = 8 and x = 3	B1, A1	B1 for $y = 8$, allow anywhere A1 for $x = 3$
	40 - 4x = x + 13 or equivalent to $x = 5.4$, $y = 9.2$	M1	M1 for attempt at the point of intersection of <i>BE</i> with AD, not dependent.
		A1 [6]	A1 for both
(ii) Area =	$\frac{1}{2} (13+3) \times 4$		
or $=\frac{1}{2}\Big _{0}^{2}$	3 6 8 -5 3 6 8 4 4 8	M1	M1 for a correct attempt at the area – allow odd arithmetic slip
= 32		A1 [2]	

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8	(i)	Area = $\frac{1}{2} 18^2 \sin 1.5 - \frac{1}{2} 10^2 (1.5)$	M1	M1 for attempt at area of a sector with $r = 10$
		= 161.594 – 75	M1	M1 for attempt at area of triangle with correct lengths used
		= 86.6	A1 [3]	
		(or area of triangle = $\frac{1}{2} \times 24.539 \times 13.170$)		
	(ii)	$AC = 15 \text{ or } 10 \times 1.5$ $LBD = 36 \sin 0.75$ $BD = \sqrt{18^2 + 18^2 - (2 \times 18 \times 18 \cos 1.5)}$	B1 M1	B1 for AC M1 for correct attempt at BD – can be given if seen in (i)
		$BD = \sqrt{18 + 18 - (2 \times 18 \times 18 \cos 1.5)}$ $= 24.5$		
		Perimeter = 15 + 24.5 + 16 = 55.5	M1 A1 [4]	M1 for attempt to obtain perimeter
9	(a)	(i)	B1 B1 B1	B1 for either correct amplitude or period for $y = \sin 2x$ B1 for $y = \sin 2x$ all correct B1 for translation of +1 parallel to y-axis
			B1 [4]	or correct period for $y = 1 + \cos 2x$ B1 for $y = 1 + \cos 2x$ all correct
		$(ii) x = \frac{\pi}{4}, \frac{\pi}{2}$	B1, B1 [2]	Allow in degrees
	(b)	(i) Amplitude = 5, Period = $\frac{\pi}{2}$ or 90°	B1,B1 [2]	B1 for each
		(ii) Period = $\frac{\pi}{3}$ or 60°	B1 [1]	

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10 (i) $f\left(\frac{1}{2}\right): \frac{3}{2} + \frac{a}{2} + b = 0$	M1	M1 for use of $x = \frac{1}{2}$ and equating to $\sum_{k=0}^{\infty} (x^k)^k$
$f'(x) = 12x^2 + 8x + a$	M1	M1 for differentiation
$f'\left(\frac{1}{2}\right): 3+4+a=0$	M1	M1 for attempt to obtain $a = -7$ from $f'\left(\frac{1}{2}\right)$
Leading to $a = -7$ and $b = 2$	A1 A1 [5]	
(ii) $f(-3) = -49$	M1 A1 [2]	M1 for use of $x = -3$ in either the remainder theorem or algebraic long division.
(iii) $f(x) = (2x-1)(2x^2+3x-2)$	M1, A1 [2]	M1 for attempt to obtain quadratic factor
(iv) $f(x) = (2x - 1)(2x - 1)(x + 2)$ Leading to $x = 0.5, -2$	B1 B1 [2]	B1 for each – must be correct from work

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11 EITHER		1sc/oug
(i)		
	M1 A2,1,0	M1 for attempt to differentiate a quotient –1 each error
		1 cuch cirol
	A1 [4]	
$=\frac{10x}{(1+x^2)^2}$		
or		
$\frac{\mathrm{d}y}{\mathrm{d}x} 5x^2 (-2x(1+x^2)^{-2}) + (1+x^2)^{-1} 10x$		
(ii) Stationary point at (0, 0)	B1	
$\frac{\mathbf{d}^2 y}{\mathbf{d}x^2} = \frac{\left(1 + x^2\right)^2 10 - 10x(4x)\left(1 + x^2\right)}{(1 + x^2)^4}$	M1	M1 for a correct attempt to determine the nature of the turning point (allow change of sign method) – just finding the second derivative is not enough.
When $x = 0$, $\frac{d^2 y}{dx^2}$ is +ve, minimum	A1 [3]	Must have attempted to solve $\frac{\delta}{dx} = 0$ If using second derivative, must be either a product or quotient for M1 together with some sort of conclusion.
(iii) $\int \frac{x}{(1+x^2)^2} dx = \frac{1}{2} \frac{x^2}{(1+2^x)} (+c)$ $\int_{-1}^2 \frac{x}{(1+x^2)^2} dx = \frac{1}{2} \left[\frac{4}{5} - \frac{1}{2} \right]$	B1 B1 M1	B1 for $\frac{xx^2}{(1+x^2)}$, B1 for $\frac{1}{2}\frac{x^2}{(1+x^2)}$ M1 for correct use of limits in an attempt at integration
= 0.15	A1 [4]	attempt at integration

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(i)		
$\frac{dy}{dx} = \frac{(x^2 - 2)2Ax - (Ax^2 + B)2x}{(x^2 - 2)^2}$	M1 A2,1,0	M1 for attempt to differentiate a quotient –1 each error
$=\frac{2x(Ax^2-2A-Ax^2-B)}{(x^2-2)^2}$		
$=\frac{2x(2A+B)}{(x^2-2)^2}$	A1 [4]	Answer given
$\frac{\mathrm{d}y}{\mathrm{d}x} = (x^2 - 2)^{-1} 2Ax + (-2x)(x^2 - 2)^{-2} (Ax^2 + B)$		
(ii) $5 = 2A + B$ 3 = A + B	M1	M1 for use of conditions once M1 for use of conditions a second time
		and attempt to solve resulting equations
Leading to $A = 2$, $B = 1$	A1 [3]	
(iii) when $\frac{dy}{dx} = 0, x = 0$	B1	B1 for correct <i>x</i>
$y = -\frac{1}{2}$	∲ B1	$ ^{\text{h}} B1 \text{ for } y = -\frac{B}{2} $
$\frac{d^2y}{dx^2} = \frac{(x^2 - 2)^2(-10) - (-10x) 4x(x^2 - 2)}{(x^2 - 2)^4}$	M1	M1 for a correct attempt to determine the nature of the turning point (allow change of sign method) – just finding the second derivative is not enough.
		Must have attempted to solve $\frac{dy}{dx} = 0$
		If using second derivative, must be either a product or a quotient for M1 together with some sort of conclusion.
When $x = 0$, $\frac{d^2 y}{dx^2}$ is -ve : max	A1 [4]	A1 for a correct conclusion from completely correct work.
	(i) $\frac{dy}{dx} = \frac{(x^2 - 2)2Ax - (Ax^2 + B)2x}{(x^2 - 2)^2}$ $= \frac{2x(Ax^2 - 2A - Ax^2 - B)}{(x^2 - 2)^2}$ $= \frac{2x(2A + B)}{(x^2 - 2)^2}$ $\frac{dy}{dx} = (x^2 - 2)^{-1}2Ax + (-2x)(x^2 - 2)^{-2}(Ax^2 + B)$ (ii) $5 = 2A + B$ $3 = A + B$ Leading to $A = 2$, $B = 1$ (iii) when $\frac{dy}{dx} = 0$, $x = 0$ $y = -\frac{1}{2}$ $\frac{d^2y}{dx^2} = \frac{(x^2 - 2)^2(-10) - (-10x)4x(x^2 - 2)}{(x^2 - 2)^4}$	(i) $\frac{dy}{dx} = \frac{(x^2 - 2)2Ax - (Ax^2 + B)2x}{(x^2 - 2)^2} \qquad \text{M1} A2,1,0$ $= \frac{2x(Ax^2 - 2A - Ax^2 - B)}{(x^2 - 2)^2} \qquad \text{A1} [4]$ $\frac{dy}{dx} = (x^2 - 2)^{-1}2Ax + (-2x)(x^2 - 2)^{-2}(Ax^2 + B)$ (ii) $5 = 2A + B \text{M1} \text{M1}$ $\text{Leading to } A = 2, B = 1 \qquad \text{A1} [3]$ (iii) when $\frac{dy}{dx} = 0, x = 0 \text{B1}$ $y = -\frac{1}{2} \text$