



ADDITIONAL MATHEMATICS

0606/22

Paper 22

March 2018

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 International will not enter into discussions about these mark schemes.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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

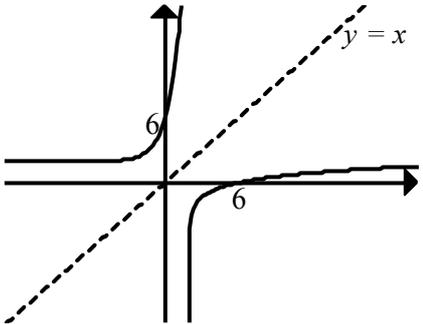
awrt	answers which round to
cao	correct answer only
dep	dependent
FT	follow through after error
isw	ignore subsequent working
nfww	not from wrong working
oe	or equivalent
rot	rounded or truncated
SC	Special Case
soi	seen or implied

Question	Answer	Marks	Partial Marks
1(a)	$(P \cup Q) \cap R'$ oe	B1	
1(b)(i)		B3	B3, 2, 1, 0: key statements: 2 correctly placed 3, 4, 8 correctly placed 1, 5, 7, 6, 10 correctly placed 9 correctly placed
1(b)(ii)	1	B1	FT <i>their</i> (b)(i); do not allow (1) or {1} etc.
2	$(2k - 3)^2 - 4(3 - 2k)(1)$	M1	
	$4k^2 - 4k - 3$	A1	
	$(2k - 3)(2k + 1)$	M1	
	critical values are -0.5 and 1.5	A1	
	<i>(their</i> $-0.5) < k < $ <i>their</i> 1.5	A1	FT <i>their</i> distinct critical values provided both M marks awarded; mark final answer; allow a pair of correctly connected inequalities e.g. $k > -0.5$ and $k < 1.5$
3(i)	${}^3P_2 \times {}^3P_1$ or $3 \times 2 \times 3$ oe soi	M1	
	18	A1	If M0 then SC1 for ${}^3P_2 \times {}^2P_1 = 12$ or $3 \times 2 \times 2 = 12$
3(ii)	24	B1	
3(iii)	$2 \times 4!$ oe soi	M1	
	48	A1	If M0 then SC1 for an answer following one omitted or incorrect factor/factorial e.g. $4! = 24$ or ${}^4P_4 = 24$ or ${}^3P_3 \times 4 = 24$ or $2! \times 3! = 12$ or $2! \times 4 = 8$ or $(2! \times 3!) \times 3 = 36$
4(a)(i)	15	B1	
4(a)(ii)	180° or π (radians)	B1	
4(b)(i)	$\tan x, -\tan x$	B2	B1 for each
4(b)(ii)	4	B1	

Question	Answer	Marks	Partial Marks
5	$\frac{104}{1.6}$ oe	M1	or e.g. $\frac{104}{\cos 17.354\dots} \div \sqrt{1.6^2 + 0.5^2}$
	65 or 64.9 to 65.1 (seconds)	A1	
	$0.5 \times$ <i>their</i> 65 oe	M1	or $\sqrt{\left(\frac{104}{\cos 17.354\dots}\right)^2 - 104^2}$ or finds a correct angle using trigonometry and then uses trigonometry again to find BC e.g. $104 \times \tan 17.354\dots$
	32.5 or 32.49 to 32.6 (metres)	A1	
6(i)	$\frac{d}{dx} \left(\tan \left(\frac{x}{3} \right) \right) = k \sec^2 \left(\frac{x}{3} \right)$	M1	
	$\frac{1}{3} \sec^2 \left(\frac{x}{3} \right)$ cao	A1	
6(ii)	$3 \tan \left(\frac{x}{3} \right) + c$ oe	B2	B1 for $3 \tan \left(\frac{x}{3} \right) + 3$ or M1 for \int <i>their</i> $\frac{dy}{dx} dx = \tan \left(\frac{x}{3} \right) +$ a constant
7(i)	$\frac{1}{2} \times 8^2 \times \theta = 20$ or $\pi \times 8^2 \times \frac{\theta}{360} = 20$	M1	
	$[\theta =] \frac{5}{8}$ or 0.625 rads oe	A1	
7(ii)	$8 \times$ <i>their</i> θ oe	M1	
	5 (cm) cao	A1	
7(iii)	$\frac{1}{2} \times 8^2 \times 1.4$ and $\frac{1}{2} \times 8^2 \times \sin 1.4$ soi	M2	M1 for either area seen
	13.3 or 13.26 to 13.27 [cm ²]	A1	
8(a)(i)	$3x + 4 = \ln \left(\frac{14}{5} \right)$ oe	M1	
	OR $3x + 4 = \ln 14 - \ln 5$ oe		
	$x = -0.99(012\dots)$ isw or exact equivalent	A1	

Question	Answer	Marks	Partial Marks
8(a)(ii)	$\lg(2y^2 - 7y) = \lg 3^2$ soi	B2	B1 for each of 2 correct moves
	$2y^2 - 7y - 9 = 0$ and attempt to solve	M1	
	$y = 4.5$ oe only	A1	
8(b)	$\log_2\left(\frac{p}{q}\right)$ as final answer www	B2	B1 for numerator correctly simplified to $\log_2 p - \log_2 q = \log_2\left(\frac{p}{q}\right)$ or change of base $\log_r 2 = \frac{1}{\log_2 r}$ oe soi
9(i)	$m_{PQ} = \frac{6-2}{11-8}$ or better	M1	
	$m_L = \frac{-1}{\text{their } \frac{4}{3}}$ oe	M1	
	$y - 2 = -\frac{3}{4}(x - 8)$ isw or $y = -\frac{3}{4}x + c$ $c = 8$ isw	A1	

Question	Answer	Marks	Partial Marks
9(ii)	$PQ^2 = (11-8)^2 + (6-2)^2$	M1	or attempts to solve $\frac{1}{2} \begin{vmatrix} 8 & 11 & x & 8 \\ 2 & 6 & -\frac{3}{4}x+8 & 2 \end{vmatrix} = [\pm]12.5 \text{ oe}$ or $\frac{1}{2} \begin{vmatrix} 8 & 11 & x & 8 \\ 2 & 6 & y & 2 \end{vmatrix} = [\pm]12.5$
	$PQ = 5$ soi	A1	or expands correctly $\frac{1}{2} \left(8(6) + 11 \left(-\frac{3}{4}x + 8 \right) + 2x - 2(11) - 6x - 8 \left(-\frac{3}{4}x + 8 \right) \right) = [\pm]12.5 \text{ oe}$ or $\frac{1}{2} (8(6) + 11y + 2x - 2(11) - 6x - 8y) = [\pm]12.5 \text{ oe}$
	$PR = 5$ soi	A1	or simplifies to $\frac{1}{2} \left(-\frac{25}{4}x + 50 \right) = [\pm]12.5 \text{ oe}$ or $4x - 3y = 51$ or $3y - 4x = -1$ oe
	Valid method of solution e.g. $R(8 \pm 4, 2 \mp 3)$ or attempts to solve <i>their</i> $y = -\frac{3}{4}x + 8$ and $25 = (x-8)^2 + (y-2)^2$ oe or attempts to solve e.g. $4x - 3y = 51$ $3x + 4y = 32$ oe	M1	
	$(4, 5)$ $(12, -1)$	A2	A1 for each or for $x = 4, x = 12$ or $y = 5, y = -1$
10(a)(i)	Valid comment referencing the graph e.g. the function f is not one to one, as shown by the fact that the graph has a turning point	B1	or equivalent statement or arrows marked on a diagram; must validly reference the graph in some way.
10(a)(ii)	$\sqrt{1 + (\sqrt{1+x^2})^2}$	M1	
	$\sqrt{2+x^2}$	A1	mark final answer; must be simplified as far as possible
10(b)(i)	Any value greater than or equal to 0	B1	
10(b)(ii)	Correct method for finding inverse	M1	
	$g^{-1}(x) = \sqrt{x^2 - 1}$	A1	mark final answer

Question	Answer	Marks	Partial Marks
10(c)	fully correct pair of graphs 	B4	B1 for exponential shape of h; must cross y-axis B1 for an attempt at the graph of h and (0, 6) soi B1 for correct reflection of <i>their</i> h in the line $y = x$ or logarithmic shape of inverse B1 for an attempt at the graph of h^{-1} and (6, 0) soi Max 3 marks if not fully correct
11(a)(i)	$(1 - \sin A)(1 + \sin A)$ $= 1 - \sin^2 A$ $= \cos^2 A$	M1	
	$\frac{\cos^2 A}{\sin A \cos A} = \frac{\cos A}{\sin A} (= \cot A)$	A1	
11(a)(ii)	$\frac{1}{\tan 3x} = \frac{1}{2}$ or better	M1	
	Any triple angle correct from 63.4(349...) 243.4(349...) 423.4(349...)	M1	
	21.1(4...) 81.1(4...) 141.1(4...)	A2	A1 for 21.1(4...) and 81.1(4...) or for 141.1(4...)
11(b)	$10(\sec^2 y - 1) - \sec y - 1 (= 0)$ soi	M1	
	$(10\sec y - 11)(\sec y + 1)$ oe	M1	
	$\cos y = \frac{10}{11}$ $\cos y = -1$ nfw	A1	
	$\pi, 0.43[0], 5.85$	A2	A1 for any one correct
12(i)	$\frac{dV}{dr} = 4\pi r^2$ soi	B1	
	$\frac{dr}{dt} = \frac{dr}{dV} \times \frac{dV}{dt}$ oe attempted	M1	
	$\frac{dr}{dt} = \frac{1}{\text{their } 4\pi(10)^2} \times 200$ soi	M1	
	0.159 isw or 0.1591(54...) rot to 4 or more figs	A1	

Question	Answer	Marks	Partial Marks
12(ii)	$\frac{dS}{dr} = 8\pi r$ soi	B1	
	$\frac{dS}{dt} = 8\pi(10) \times \text{their } 0.159$	M1	
	awrt 40	A1	following correct solution