



Oxford Cambridge and RSA

FSMQ

Additional Mathematics

6993/01: Additional Mathematics: Paper 1

Free Standing Mathematics Qualification

Mark Scheme for June 2023

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It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal <http://www.rm.com/support/ca> . The paper should have been sent to you in advance; the Mark scheme will be sent by your Team Leader just after completion of the SSU.
3. Log-in to RM Assessor and mark the 5 practice scripts. Once you are happy and you have read all the comments, mark the 10 standardisation scripts.

MARKING

1. Mark strictly to the mark scheme.
2. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
3. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or the RM Assessor messaging system, or by email.
4. **Crossed Out Responses**
Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.
5. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen. The “additional pages” at the end of the Printed Answer book, where candidates are invited to add extra responses, have been added to the front of the question 1 window. This is so that you do not miss anything. Mark blank pages with a BP, tick or cross. Note that this is so for all scripts, not just the ones where there is work written on the pages. “Additional objects” means an additional answer booklet. These will appear on the left of your marking screen and you will be alerted to this when you download the script. Link the page containing the extra material to the original window. Pages not used must be marked with BP.

6. Award No Response (NR) if:
- there is nothing written in the answer space
- Award Zero '0' if:
- anything is written in the answer space – note that this is a change from previous years.
- Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.
7. The **comments box** is used by your team leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the messaging system, or e-mail.
8. Assistant Examiners should send a brief report on the performance of candidates to their Team Leader (Supervisor) by the end of the marking period. The report should contain notes on particular strength displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

9. Annotations and abbreviations

Annotation in RM Assessor	Meaning
BP	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓ and ✖	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Other abbreviations in mark scheme	Meaning
AG	Answer given
DM1	M mark dependent on previous M mark
DB1	B mark dependent on previous B mark(s)
Cao	Correct answer only
Oe	Or equivalent
Soi	Seen or implied
www	Without wrong working

10. **Marking Instructions**

- a** Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

- b** An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

- c** The following types of marks are available.

M

A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually 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, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A

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). Therefore M0 A1 cannot ever be awarded.

B

Mark for a correct result or statement independent of Method marks.

- d** 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 mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.
- e** The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be ‘follow through’. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

- f** Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

- g** Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark the better attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

- h** For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question	Answer	Marks	Guidance
1	$= x^6 + 6 \times 2x^4 + 15 \times 4x^2 + 20 \times 8 + \dots$ $\Rightarrow 20 \times 2^3$ $= 160$	M1* DM1 A1	Sight of expansion with at least two terms with correct (possibly unsimplified) powers of x and a binomial coefficient $\neq 1$ in one term soi Or sight of correct term Accept nC_r for coefficients Correct powers of 2 in independent term soi Must be clearly identified and not just embedded in the expansion Correct answer is full marks
		[3]	

Question	Answer	Marks	Guidance
2	$P(0) = \left(\frac{5}{6}\right)^4 \quad \left(= 0.4823 = \frac{625}{1296}\right)$ $P(\text{at least } 1) = 1 - \left(\frac{5}{6}\right)^4$ $= 0.518 \quad \left(= \frac{671}{1296}\right)$	B1 M1 A1	soi Subtract <i>their</i> term from 1 Awrt 0.518 or exact fraction N.B. P(exactly one 3) is 0
	Alternative method: $P(\text{one or more}) = P(1) + P(2) + P(3) + P(4)$ $= 4 \left(\frac{1}{6}\right) \left(\frac{5}{6}\right)^3 + 6 \left(\frac{1}{6}\right)^2 \left(\frac{5}{6}\right)^2 + 4 \left(\frac{1}{6}\right)^3 \left(\frac{5}{6}\right) + \left(\frac{1}{6}\right)^4$ $= 0.3858 + 0.1157 + 0.0154 + 0.0008$ $= 0.518$	B1 M1 A1	4 terms Correct powers and at least one coefficient of the first three term seen Awrt 0.518 or exact fraction
		[3]	

Question		Answer	Marks	Guidance
3		$ \begin{array}{r} x^2 + 2x + 3 \\ x+1 \overline{) x^3 + 3x^2 + 5x - 3} \\ \underline{x^3 + x^2} \\ 2x^2 + 5x \\ \underline{2x^2 + 2x} \\ 3x - 3 \\ \underline{3x + 3} \\ -6 \end{array} $	M1	Sight of correct process. x^2 in quotient and $x^3 + x^2$ in the working must be seen
		$\Rightarrow \text{Quotient is } x^2 + 2x + 3$	A1	Fully correct division
		$\text{Remainder is } -6$	A1	Remainder and quotient correctly identified N.B. Answer might be at bottom of page
			[3]	

Question		Answer	Marks	Guidance
4	(a)	$= \frac{5-x}{(x+1)(x-2)}$	B1 B1	Numerator; Like terms must be collected. Denominator. Allow correct quadratic Mark final answer
			[2]	
	(b)	$ \begin{aligned} &\text{DR} \\ &= \frac{2(5+\sqrt{2})+5-\sqrt{2}}{(5+\sqrt{2})(5-\sqrt{2})} \\ &= \frac{15+\sqrt{2}}{23} \end{aligned} $	B1 B1	Unsimplified numerator must be seen, possibly in two fractions with a common denominator oe Numerator Denominator
			[3]	

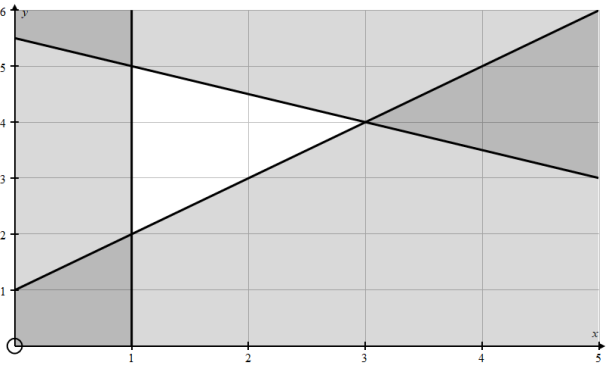
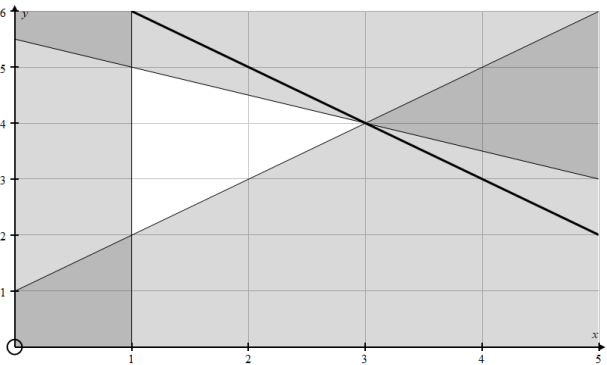
Question		Answer	Marks	Guidance
5	(a)	$\theta = \sin^{-1} 0.6 = (-36.9^\circ)$ $\Rightarrow \theta = 323$	M1	For sight of principal angle, soi
			A1	Answer wrt 323. Any extras is A0
			[2]	
	(b)	Adjacent side by Pythagoras $= 0.8$ oe $\tan \theta = (-) \frac{0.6}{0.8}$ $= -\frac{3}{4}$ oe	M1*	A value for the third side must be seen
			A1	Following from <i>their</i> sides
			DM1	
			A1	Beware – the correct value may be found on a calculator
		Alternative method for first two marks $\cos^2 \theta = 1 - \sin^2 \theta$ $\Rightarrow \cos \theta = \pm 0.8$	M1*	Use of identity to find $\cos \theta$
			A1	
			[4]	

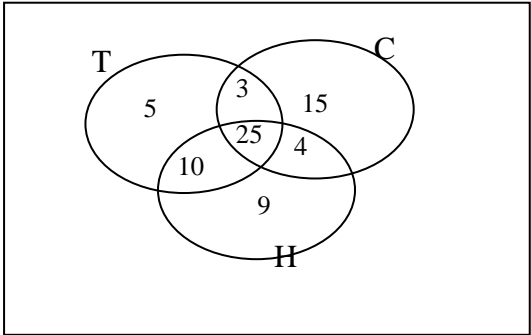
Question		Answer	Marks	Guidance
6	(a)	15, 17.5, 18.75 oe	B2	B1 for 2 correct
			[2]	
	(b)	$= \frac{18.75 - 15}{4} (= 0.9375) \approx 0.94 \text{ ms}^{-2}$	M1 A1	Use of Central estimate SC B1 for 1.25 or 0.63 from upper and lower estimates N.B. Use of suvat formula or calculus (implied by answer of 0.87) is M0
			[2]	
	(c)	e.g. smaller intervals	B1	If UE or LE is given in part(b) then allow use of central estimate. N.B. not use of calculus
			[1]	

Question		Answer	Marks	Guidance										
7	(a)	$x = 0 \Rightarrow y = 1$ $x = 1 \Rightarrow y = -1$ Sign change	B1 B1	Both Or e.g. change in sign or different signs Or reference to graph Use of inequalities rather than words is acceptable. ft their values providing there is a change of sign.										
			[2]											
	(b)	<table border="1" style="display: inline-table; vertical-align: top;"> <tbody> <tr> <td>0.5</td> <td>0.732051</td> </tr> <tr> <td>0.6</td> <td>0.493182</td> </tr> <tr> <td>0.7</td> <td>0.197669</td> </tr> <tr> <td>0.8</td> <td>-0.15178</td> </tr> <tr> <td>0.9</td> <td>-0.55212</td> </tr> </tbody> </table> So root is in range [0.7,0.8] When $x = 0.75$, $y = 0.0295 > 0$ So correct to 1 dp $\beta = 0.8$	0.5	0.732051	0.6	0.493182	0.7	0.197669	0.8	-0.15178	0.9	-0.55212	M1 A1 A1	Choose at least one value that narrows the range of sign change. Accept range [0.7,0.85] or better Test in range [0.75,0.85] or better and conclusion. e.g. Could be a series of values for step size 0.01
0.5	0.732051													
0.6	0.493182													
0.7	0.197669													
0.8	-0.15178													
0.9	-0.55212													
		Alternative method: $x_{n+1} = \sqrt{\frac{3^{x_n}}{4}}$ e.g $x_0 = 1$ $\Rightarrow \beta = 0.758388$	M1 A1 A1	Use of iterative formula which must be correct. Any starting value in range [0,1] Final value										
			[3]											

Question		Answer	Marks	Guidance
8	(a)	$\frac{\sin C}{12} = \frac{\sin 50}{10}$	M1	Correct use of sin rule
		$\Rightarrow \sin C = 12 \times \frac{\sin 50}{10} = 0.919\dots$	M1	Correct rearrangement of <i>their</i> equation to obtain SinC
		$\Rightarrow C = 66.8^\circ$	A1	Principal angle awrt 66.8
		and $C = 113.2^\circ$	A1	2 nd quadrant . awrt 113
			[4]	
	(b)	<ul style="list-style-type: none"> • $BC > 12 \text{ cm}$ or $BC > AB$ or BC is 2nd longest side • $BC = 12\sin 50$ (= 9.19 cm) or BC is perpendicular to AC 	B1	
			B1	Do not allow : the angle at $C = 90^\circ$ Should be smaller than one sde Should be larger than one side
			[2]	

Question	Answer	Marks	Guidance
9	Points on line equidistant from A and B $\Rightarrow (x-3)^2 + (y-7)^2 = (x-7)^2 + (y-1)^2$ $\Rightarrow -6x + 9 - 14y + 49 = -14x + 49 - 2y + 1$ $\Rightarrow 8x - 12y + 8 = 0$ $\Rightarrow 3y = 2x + 2$ oe	M1 M1 A1 B1 A1	Equidistant from A and B Finding distance for one length Correct unsimplified expansion Reduction to linear form 3 term equation
	Alternative method $\left(\text{Gradient}_{AB} = \frac{7-1}{3-7} = -\frac{3}{2} \right)$ $\Rightarrow \text{Gradient perp bisector} = \frac{2}{3}$ Midpoint of AB = (5, 4) $\Rightarrow y - 4 = \frac{2}{3}(x - 5)$ $\Rightarrow 3y - 12 = 2x - 10$ $\Rightarrow 3y = 2x + 2$ oe	 M1 A1 B1 M1 A1	 Find gradient of perp bisector Soi by use (i.e. can be used to find equation without being stated) Use of standard forms for line using <i>their</i> midpoint and <i>their</i> perpendicular gradient. 3 term equation
		[5]	

Question	Answer	Marks	Guidance
<p>10 (a)</p>		<p>B1 B1 B1 B1</p>	<p>$y = x + 1$ through (1,2) and (3,4) $x = 1$ through (1,2) and (1,5) $x + 2y = 11$ through (1,5) and (3,4)</p> <p>Shading correct (i.e. lines must be correct.)</p>
<p>(b)</p>	 <p>Max $x + y = 7$ (at (3, 4))</p>	<p>[4]</p> <p>M1 A1</p>	<p>Any line seen of form $x + y = a$ soi</p> <p>Correct answer is full marks</p>
	<p>Alternative Method: Sight of check for at least two of <i>their</i> points (Max $x + y = 7$ (at (3, 4))</p>	<p>M1 A1</p>	<p>“sight of check” may be points on the graph. So the graph on 10(a) needs to be checked May be embedded in calculations. ft their acceptable region</p> <p>Correct answer is full marks</p>
		<p>[2]</p>	

Question		Answer	Marks	Guidance
11	(a)		<p>B1</p> <p>B1</p> <p>B1</p>	<p>3 overlapping labelled ovals</p> <p>Sight of 25, 3, 4 and 5</p> <p>All 7 regions correct</p> <p>Do not accept probabilities, such as $\frac{5}{80}$ 5/80</p> <p>N.B the rectangle does not have to be drawn.</p>
			[3]	
	(b)	$= (80 -) 71$ $= 9$	<p>M1</p> <p>A1</p>	<p>Sum of all 7 regions and take from 80soi</p> <p>SC Answer given as a probability $\frac{9}{80}$ B1</p>
			[2]	

Question		Answer	Marks	Guidance
12	(a)	$(x-4)^2 + (y-5)^2$ $=13$	B1	
			B1	
			[2]	
	(b)	(7,7)	M1 A1	Use of vector to find point soi
			[2]	
	(c)	Grad $AD = \frac{8-3}{2-1} = 5$ Grad $BD = \frac{8-7}{2-7} = -\frac{1}{5}$ Since $5 \times -\frac{1}{5} = -1$ the lines are perpendicular	B1	Must see either “Gradient AD” or the fraction showing change in y /change in x
B1			Must see either “Gradient BD” or the fraction showing change in y /change in x	
B1			“Perpendicular” must be seen	
			[3]	
	(d)	e.g. D is on the circle D is on the circumference	B1	
			[1]	

Question	Answer	Marks	Guidance
13 (a)	$\frac{dy}{dx} = 8 - 2x$ <p style="text-align: right;">DR</p> <p>When $x = 2, m = 4$</p> <p>\Rightarrow equation of tangent is $y - 12 = 4(x - 2)$</p> <p>$\Rightarrow y = 4x + 4$</p> <p>\Rightarrow Coordinates of R are $(0, 4)$</p>	M1* A1 A1 DM1 A1	Diffn: At least one power reduced by 1 but beware division by x grad fn m Eqn of line using <i>their</i> m or use of vector. Beware setting their gradient fn to 0 and using this as m
		[5]	
(b)	<p>Area of trapezium = $2 \times \left(\frac{4+12}{2} \right) = 16$ DR</p> <p>Area under curve = $\int_0^2 (8x - x^2) dx$</p> <p>$= \left[4x^2 - \frac{x^3}{3} \right]_0^2 = \left(16 - \frac{8}{3} \right) - 0 = \frac{40}{3}$</p> <p>Area OPR = $16 - \frac{40}{3} = \frac{8}{3}$</p>	M1 A1 M1 A1 M1 A1	Area of trapezium or by integration Area Integration. Ignore limits. At least one power raised by 1. Beware of just multiplying by x Area Subtract. Can be awarded even if M0 M0 above
	<p>Alternative method DR</p> <p>Area = $\int_0^2 ((4x + 4) - (8x - x^2)) dx$</p> <p>$= \int_0^2 (4x + 4 - 8x + x^2) dx = \int_0^2 (x^2 - 4x + 4) dx$</p> <p>$= \left[\frac{x^3}{3} - 2x^2 + 4x \right]_0^2 = \left(\frac{8}{3} - 8 + 8 \right) - 0$</p> <p>$= \frac{8}{3}$</p>	M1 A1 M1 A1 M1 A1	Subtracting Correct integrand (could be other way round) Integration. Ignore limits Correctly integrated Correct limits applied in the correct order, Ignore lower limit
		[6]	

Question		Answer	Marks	Guidance																				
14	(a)	(i)	e.g. As t increases, RHS tends to 0, so 20 is the long term temperature, e.g the room temperature	B1																				
				[1]																				
	(a)	(ii)	$100 - 20 = A \times 2^{\frac{0}{b}}$ $\Rightarrow A = 80$	M1 A1	Substitute $t = 0$ and $T = 100$																			
				[2]																				
	(b)	$T - 20 = A \times 2^{-\frac{t}{b}}$ $\Rightarrow \log(T - 20) = \log\left(A \times 2^{-\frac{t}{b}}\right)$ $= \log A + \log\left(2^{-\frac{t}{b}}\right) = \log A - \frac{\log 2}{b}t$ oe Interpretation of a correct equation as a straight line	M1 A1 A1	Use of both log laws in rhs Correct equation. NB. Lhs must be correct i.e. is of form $Y = mX + c$. (no ft)																				
				[3]																				
	(c)	<table border="1"> <tbody> <tr> <td>Time (t minutes)</td> <td>0</td> <td>10</td> <td>20</td> <td>30</td> </tr> <tr> <td>Temperature ($T^\circ\text{C}$)</td> <td>100</td> <td>60</td> <td>40</td> <td>30</td> </tr> <tr> <td>$T - 20$</td> <td>80</td> <td>40</td> <td>20</td> <td>10</td> </tr> <tr> <td>$\log_{10}(T - 20)$</td> <td>1.90</td> <td>1.60</td> <td>1.30</td> <td>1</td> </tr> </tbody> </table>	Time (t minutes)	0	10	20	30	Temperature ($T^\circ\text{C}$)	100	60	40	30	$T - 20$	80	40	20	10	$\log_{10}(T - 20)$	1.90	1.60	1.30	1	B2	All correct to 1dp B1 one error
Time (t minutes)	0	10	20	30																				
Temperature ($T^\circ\text{C}$)	100	60	40	30																				
$T - 20$	80	40	20	10																				
$\log_{10}(T - 20)$	1.90	1.60	1.30	1																				
				[2]																				

	(d)		B1	All correct. The straight line is not required
			[1]	
	(e)	<p>Gradient = -0.03</p> $-\frac{\log 2}{b} = -0.03$ $\Rightarrow b = \frac{\log 2}{0.03} \approx 10$	M1 A1	Correct attempt. (N.B. +ve value means an incorrect attempt) Correct answer www B2
		<p>Alternative Method</p> <p>Substitute any set of values into equation e.g. $T - 20 = 10$, $t = 30$, $A = 80$</p> $\log 10 = \log 80 - \frac{30 \log 2}{b}$ $\Rightarrow \frac{30 \log 2}{b} = \log 80 - \log 10 = \log 8 = 3 \log 2$ $\Rightarrow b = 10$	M1 A1	Use any set other than $t = 0$
			[2]	

Question		Answer	Marks	Guidance																
15	(a) (i)	$y = 2x^3 + 3x^2 - 12x + 8$ $\Rightarrow \frac{dy}{dx} = 6x^2 + 6x - 12$ $= 0$ when $x^2 + x - 2 = 0$ $\Rightarrow x = 1, -2$ So when $x = 1, y = 2 + 3 - 12 + 8 = 1$	DR M1 A1 M1 A1	Diffn. At least one power reduced by 1 but beware division by x Set = 0 and attempt to solve or substitute $x = 1$ to obtain derivative = $6 + 6 - 12 = 0$ AG. Values must be seen																
			[4]																	
	(a) (ii)	<table border="1" style="display: inline-table; vertical-align: top;"> <tr> <td>x</td> <td>0.9</td> <td>1</td> <td>1.1</td> </tr> <tr> <td>$\frac{dy}{dx}$</td> <td>-1.74</td> <td>0</td> <td>1.86</td> </tr> </table> Or <table border="1" style="display: inline-table; vertical-align: top;"> <tr> <td>x</td> <td>0.9</td> <td>1</td> <td>1.1</td> </tr> <tr> <td>y</td> <td>1.08</td> <td>1</td> <td>1.09</td> </tr> </table> So minimum.	x	0.9	1	1.1	$\frac{dy}{dx}$	-1.74	0	1.86	x	0.9	1	1.1	y	1.08	1	1.09	DR M1 A1	Either method using a suitable range Values seen and conclusion Values in these tables can be given to 1dp
x	0.9	1	1.1																	
$\frac{dy}{dx}$	-1.74	0	1.86																	
x	0.9	1	1.1																	
y	1.08	1	1.09																	
		Alternative method $\frac{d^2y}{dx^2} = 12x + 6$ When $x = 1, \frac{d^2y}{dx^2} = 18 (> 0)$ So minimum	DR M1 A1																	
		Alternative method Nature of cubic curve is such that the coefficient of $x^3 > 0$ so minimum point is to the right of maximum point	M1 A1																	
			[2]																	
	(b)	Other turning point is when $x = -2$ Then $y = 28$	DR B1 B1	Ft From other value in (i) For $y = 28$																
			[2]																	

Question	Answer	Marks	Guidance
16 (a)	Speed= $\frac{\text{distance}}{\text{time}}$ oe boat speed = my speed – current = $4 - r$ $\Rightarrow \left(4 - r = \frac{9}{t}\right) \Rightarrow t = \frac{9}{4 - r}$	B1 B1	Must see evidence of relationship Must see reasoning for $4 - r$ AG
		[2]	
	$(t =) \frac{9}{4 + r}$	B1	
		[1]	
(c)	$\frac{9}{4 - r} - \frac{9}{4 + r} = 1.2$ $\Rightarrow 9((4 + r) - (4 - r)) = 1.2(4 + r)(4 - r)$ $\Rightarrow 18r = 1.2(16 - r^2) \Rightarrow 15r = 16 - r^2$ $\Rightarrow r^2 + 15r - 16 (= 0)$	B1 M1 A1 A1	Sight of difference of <i>their</i> times oe Accept fractions either way round Eliminate fractions from equation involving r only Correct (Unsimplified) equation AG www
		[4]	
(d)	$\Rightarrow (r - 1)(r + 16) (= 0)$ $\Rightarrow r = 1$ (possibly including $r = -16$) Speed of current is 1 kmhr^{-1}	M1 A1 A1	Factorisation by sight of $(r \pm 1)(r \pm 16) = 0$ soi If by formula then correct substitutions into correct formula required, allowing one sign error
		[3]	

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