Oxford Cambridge and RSA

Cambridge Technicals Engineering

Unit 1: Mathematics for Engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for January 2022

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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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Annotations

Annotation	**Meaning**
✓and ✖	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
DM1	Method mark dependent on previous M mark
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
λ	Omission sign
Other abbreviations in mark scheme	**Meaning**
oe	Or equivalent
Soi	Seen or implied
www	Without wrong working
ecf	Error carried forward

Subject-specific marking instructions

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. These annotations must be in the body of the work and **not** anywhere near the right hand margin of each page.
Mark using a red pen.

Put the mark for each subquestion near to and to the right of the mark for the question. Total all marks for the question and put this total in a ring at the bottom right of each question.

Transfer these marks to the box on the front page.

Total the marks for the paper. I suggest that all unringed marks are then totalled to make sure that the final mark is correct.

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.

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, e.g. 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.

DM
A method mark which is dependent on a previous method mark.

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.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

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. 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.

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.

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.

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 what appears to be the last (complete) attempt and ignore the others.

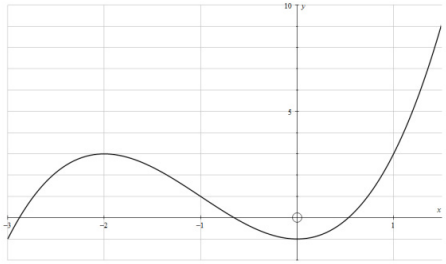
NB Follow these maths-specific instructions rather than those in the assessor handbook.

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	(a)		$(3x-1)-2(1-x)$ $=3x-1-2+2x$ $=5x-3$	B1 B1	Removal of brackets with correct signs soi
				[2]	
	(b)		$2x(2+3y)$	B1 B1	Either x or 2 correctly removed from bracket All correct
				[2]	
	(c)		$=\frac{3x}{6}+\frac{4x}{6}=\frac{7x}{6}$ **oe**	B1 B1	LCM of 6 seen (or multiple of 6) Accept only a single fraction but isw
				[2]	
	(d)		$2x-1=3+5x$ $\Rightarrow -3x=4$ $\Rightarrow x=-\frac{4}{3}$ **oe**	M1 A1	Collection of like terms i.e. ±4 or ±3x seen Accept −1.33 or better. It must be x = ...
				[2]	
	(e)		$s=vt-\frac{1}{2}at^2 \Rightarrow s+\frac{1}{2}at^2=vt$ $\Rightarrow v=\frac{s+\frac{1}{2}at^2}{t}$ **oe**	M1 M1 A1	Isolate vt term Divide by t
				[3]	
				[11]	

Question			Answer	Marks	Guidance
2	(a)		$(x=)\ \dfrac{-3\pm\sqrt{3^2-4.1.(-7)}}{2}\ \left(=\dfrac{-3\pm\sqrt{37}}{2}\right)$ $=1.54$ and -4.54	**M1** **A1** **A1**	Substitute correct numbers into correct formula, Condone missing± One correct root in any form (including 2 sf) Both roots correct to 3sf
			Alternative: $(x+1.5)^2$ $=9.25$ $\Rightarrow x=-1.5\pm\sqrt{9.25}$ $=1.54$ and -4.54	**M1** **A1** **A1**	Attempt to complete square – must have 1.5 One correct root in any form (including 2 sf) Both roots correct to 3sf
				[3]	
	(b)		$3a+4b=39$ **oe** $4a+3b=38$ **oe** By elimination: $12a+16b=156$ $12a+9b=114$ $\Rightarrow 7b=42$ $\Rightarrow b=6,\ a=5$ (i.e. cost of type A is £5 and type B is £6)	**B1** **B1** **M1** **A1** **A1**	(Condone use of £ signs) Attempt to find a value for one variable by any valid method One value Other answer SC Final answer with no equations www B3
				[5]	
				[8]	

Question			Answer	Marks	Guidance
3	(a)	(i)		**B1** **B1** **B1**	Right shape (i.e. approx cubic curve with two turning points) Through (0, -1) and (-2, 3) Roots in [-2, -3], [0, -1] and [1,0]
				[3]	
		(ii)	-2.9, -0.7, 0.5	**B1** **B1**	One out of 3 roots correct **ft** *their* cubic graph All 3 correct from their graph ±0.1 SC Three correct roots not from *their* graph B1
				[2]	
	(b)		Angle C $= 180-(55+80) = 45$ $\frac{AB}{Sin45} = \frac{8}{\sin 80} \Rightarrow AB = \frac{8\sin 45}{\sin 80} = 5.7(4...)$	**B1** **M1** **A1** **A1**	Sight of angle C Correct formula in correct triangle used in attempt to find either side AB as subject soi Correct to 1dp or better. Beware: 80sin45 = 5.7 **M0**
				[4]	
				[9]	

Question			Answer	Marks	Guidance
4		(i)	$RC = 1000 \times 500 \times 10^{-6} = \left(\frac{1}{2}\right)$ $\Rightarrow (V =) V_0 e^{-\frac{t}{RC}} = 12 \times e^{-2t}$ **oe**	**B1** **B1**	Values for R and C substituted. 10^{-6} might be missing
				[2]	
		(ii)	$V = 12e^{-2t} = 0.12$ $\Rightarrow e^{-2t} = 0.01$ $\Rightarrow -2t = \ln 0.01 = -4.605$ $\Rightarrow t = 2.3....$	**M1** **M1** **A1**	Set *their formula from (i)* $= 0.12$ Solve by taking logs soi by correct answer Allow www, 1dp or better
				[3]	
		(iii)	0	**B1**	Allow "tends to 0" or "close to 0"
				[1]	
		(iv)	$\frac{dV}{dt} = -24e^{-2t}$ **oe**	**B1** **B1**	-24 e^{-2t}
				[2]	
				[8]	

Question			Answer	Marks	Guidance
5		(i)	**AG**		
			$A=\int_0^2\left(\frac{1}{2}x^4-2x^3+2x^2\right)\mathrm{d}x$	**M1**	Integration . Ignore limits (i.e. All powers increased by 1 and all coefficients adjusted)
			$=\frac{x^5}{10}-\frac{x^4}{2}+\frac{2x^3}{3}$	**A1**	Ignore +*c*
			$=3.2-8+\frac{16}{3}=\frac{16}{3}-4.8\ \ (-0)$	**M1**	Use limits: at least one line of working must be seen ignore lack of lower limit value
			$=\frac{8}{15}$	**A1**	
				[4]	
		(ii)	$\frac{8}{15}\times 5$	**M1**	Multiply by 5. Allow working in cm.
			$=\frac{8}{3}\ \ \mathrm{m}^3$	**A1**	Allow 2.7 or better. Units required. Allow ans in cm^3
				[2]	
				[6]	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td></td><td>(i)</td><td>Cumulative frequency table below
<table>
<tr><th>Length (mm)</th><th>Frequency</th><th>Cumulative frequency</th></tr>
<tr><td>$l < 189$</td><td>0</td><td>0</td></tr>
<tr><td>$189 \leq l < 190$</td><td>10</td><td>10</td></tr>
<tr><td>$190 \leq l < 191$</td><td>12</td><td>22</td></tr>
<tr><td>$191 \leq l < 192$</td><td>17</td><td>39</td></tr>
<tr><td>$192 \leq l < 193$</td><td>24</td><td>63</td></tr>
<tr><td>$193 \leq l < 194$</td><td>26</td><td>89</td></tr>
<tr><td>$194 \leq l < 195$</td><td>25</td><td>114</td></tr>
<tr><td>$195 \leq l < 196$</td><td>20</td><td>134</td></tr>
<tr><td>$196 \leq l < 197$</td><td>11</td><td>145</td></tr>
<tr><td>$197 \leq l < 198$</td><td>5</td><td>150</td></tr>
</table></td><td>M1

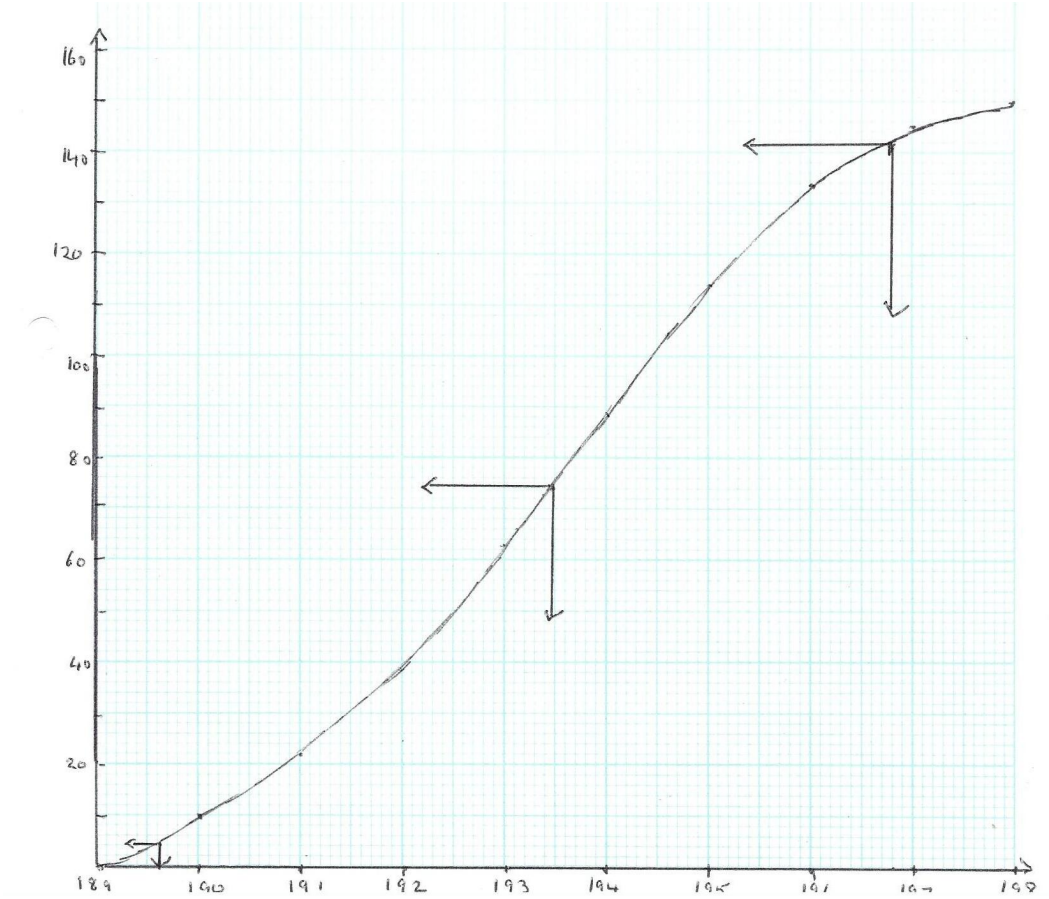
A1</td><td>Adding numbers cumulatively

All correct</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Curve complete as below</td><td>B1
B1</td><td>Their points plotted at end points. Allow one error in plotting points
Smooth curve through their plotted points</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>Read off at 75
Giving 193.4</td><td>M1
A1</td><td>Soi by answer within range
± 0.1 ft their graph
Answer must be a single value</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td></tr>
<tr><td></td><td></td><td>(iv)</td><td>Range is 189.6 – 196.8
From graph:
4 at lower end and 8 at upper end
So 12 are outside the acceptable range.</td><td>B1

M1
A1</td><td>

Taking readings from graph for their range soi
Allow 10 – 14
SC value in range with no working B1</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[3]</td><td></td></tr>
<tr><td colspan="3"></td><td></td><td>[9]</td><td></td></tr>
</table>

Cumulative frequency curve.



Question			Answer	Marks	Guidance
7		(i)	$(x-10)^2+(y-13)^2=25$ $(x-20)^2+(y-8)^2=25$	B1 B1	Sight of 5^2 or 25 in an equation (or correct use of one centre in correct form) Both correct (5^2 allowed)
				[2]	
		(ii)	Volume of plate $=30\times20\times2=1200\,\text{cm}^3$ Volume of each circle $=25\pi\times2\,\text{cm}^3$ Volume remaining $=1200-2\times25\pi\times2\,\text{cm}^3$ $=886\ (\text{cm}^3)$	B1 B1 M1 A1	First two marks can be areas (78.54 or 157.08) The thickness must be included here.
			Alternative: Area of plate $=30\times20=600\,\text{cm}^2$ Area of each circle $=25\pi\,\text{cm}^2$ Area remaining $=600-25\pi\times2\,\text{cm}^2=443$ $\Rightarrow$ Volume $=443\times2$ $=886\ (\text{cm}^3)$	B1 B1 M1 A1	 Attempt to find remaining area and multiply by 2 Awrt 886
				[4]	
		(iii)	DE $=\sqrt{(20-10)^2+(8-13)^2}=\sqrt{100+25}$ $=\sqrt{125}$ $\Rightarrow$ Smallest distance $=1.2\ (\text{cm})$	M1 A1 A1	Attempt to find DE using Pythagoras Allow 11.1 or 11.2 or better soi 1.2 or better
				[3]	
				[9]	

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