Cambridge Technicals

Engineering

Unit 23: Applied mathematics for engineering

Level 3 Cambridge Technical in Engineering

05823 - 05825 & 05873

Mark Scheme for January 2025

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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.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. 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.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **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.

Multiple-Choice Question Responses
When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space).

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. 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 the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 10.

7. There is a NR (**No Response**) option. Award NR (No Response):

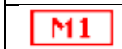
   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')
   - OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **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.**

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. **Annotations**

Annotation	Meaning
	Correct response
	Incorrect response
	Missing something
	Follow through
	Benefit of doubt
	Ignore subsequent working
	Method mark awarded 0
	Method mark awarded 1
	Accuracy mark awarded 0
	Accuracy mark awarded 1
	Independent mark awarded 0
	Independent mark awarded 1
	Special Case
	Transcription error

Mark scheme abbreviations

Other abbreviations in mark scheme	Meaning
oe	Or equivalent
Soi	Seen or implied
www	Without wrong working
ecf	Error carried forward
DM	Method mark dependent on previous M mark

11. **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.

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.

Question			Answer	Mark	Guidance
1	(a)		$m_{CD} = \frac{15-5}{25-0}\left[=\frac{10}{25}=\frac{2}{5}\right]$ $m_{AD} = \frac{5-20}{25-5}\left[=\frac{-15}{20}=-\frac{3}{4}\right]$	M1	Attempt both gradients CB and AD
			CB: $y=\frac{2}{5}x+c \rightarrow c=5 \rightarrow y=\frac{2}{5}x+5$ oe AD: $y=-\frac{3}{4}x+c$ and attempt to find c: eg $20=-\frac{3}{4}(5)+c \rightarrow c=\frac{95}{4}$ or 23.75 $\rightarrow y=-\frac{3}{4}x+23.75$ oe	M1 A1	Complete attempt to form equation of either line Equation of one line obtained. From correct working, with 3 terms present
			CB: $y=\frac{2}{5}x+5 \rightarrow 5Y=2X+25$ $\rightarrow \mathbf{2X-5Y=-25}$ **AG** AD: $y=-\frac{3}{4}x+23.75 \rightarrow 4Y=-3X+95$ $\rightarrow \mathbf{3X+4Y=95}$ **AG**	A1	Both lines correct in any form with sufficient working, and state the given answer for each line Allow with x, y rather than X, Y Accept any other valid method eg $\frac{Y-20}{X-5}=\frac{5-20}{25-5}=\frac{-15}{20}=\frac{-3}{4}$ $\frac{Y-5}{X-0}=\frac{15-5}{25-0}=\frac{10}{25}=\frac{2}{5}$ $4(Y-20)=-3(X-5)$ $4Y-80=-3X+15$ $3X+4Y=95$ $5(Y-5)=2(X)$ $5Y-25=2X$ $2X-5Y=-25$
				[4]	

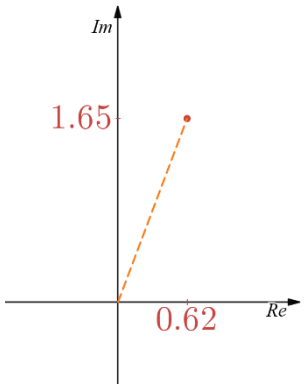
Question			Answer	Mark	Guidance
1	(b)		$\begin{bmatrix} 3 & 4 \\ 2 & -5 \end{bmatrix}\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} 95 \\ -25 \end{bmatrix}$	B1	Allow with x, y rather than X, Y Or with equations in other order $\begin{bmatrix} 2 & -5 \\ 3 & 4 \end{bmatrix}\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} -25 \\ 95 \end{bmatrix}$
				[1]	
1	(c)				Non-matrix methods cannot score here
			Det $\begin{bmatrix} 3 & 4 \\ 2 & -5 \end{bmatrix} = -15 - 8 = -23$	B1ft	soi ft from their 1b
			$\begin{bmatrix} -5 & -4 \\ -2 & 3 \end{bmatrix}$	B1ft	soi ft from their 1b
			$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} 3 & 4 \\ 2 & -5 \end{bmatrix}^{-1}\begin{bmatrix} 95 \\ -25 \end{bmatrix}$ or $\begin{bmatrix} X \\ Y \end{bmatrix} = -\frac{1}{23}\begin{bmatrix} -5 & -4 \\ -2 & 3 \end{bmatrix}\begin{bmatrix} 95 \\ -25 \end{bmatrix}$	M1 A1	
			$\begin{bmatrix} X \\ Y \end{bmatrix} = -\frac{1}{23}\begin{bmatrix} -475 + 100 \\ -190 - 75 \end{bmatrix}$ $X = \frac{375}{23}$ or 16.3 $\quad Y = \frac{265}{23}$ or 11.5	A1	
				[5]	
1	Total			[10]	

Question			Answer	Mark	Guidance
2	(a)		$\sin(\alpha) = \frac{4}{\sqrt{4^2+(1+2)^2}} = \frac{4}{5}$	B1	Or obtains angle 53(.13)
			$[T =] M_2 g$	B1	Tension in cable AB soi by $M_2 g$ or appropriate use of M_2
			Taking moments: $M_1 g(2) = M_2 g(2\sin\alpha)$	M1	Condone missing g for this mark Alt by resolving forces at point A $M_1 g = M_2 g \sin(\alpha)$
			5:4 or $\frac{M_2}{M_1} = \frac{5}{4}$ or 1.25	A1	Allow with g missing throughout
				[4]	
2	(b)		$PB^2 = 1^2 + 4^2 = 17$ $PB = 4.1(23)$	B1	Or $\sqrt{17}$
				[1]	
2	(c)		$AP_H = 2\cos 60 = 1$ and $AP_V = 2\sin 60 = \sqrt{3}$ oe	M1	Attempt horizontal and vertical distances from A to P
			$AB^2 = (AP_H)^2 + (AP_V)^2$ $= (2\cos 60 + 1)^2 + (4 - 2\sin 60)^2$ $\left[= \ 2^2 \ + \ \left(4-\sqrt{3}\right)^2\right]$	M1	Accept alternative solutions eg use of cosine rule $BPD = \tan^{-1}\frac{4}{1} = 75.96^o \rightarrow BPA = 44.0°$ M1 $AB^2 = PB^2 + 2^2 - 2 \times PB \times 2 \times \cos BPA$ M1
			$AB = \sqrt{2^2 \ + \ \left(4-\sqrt{3}\right)^2} = 3.024$ **AG**	A1	$AB = \sqrt{17 \ + 4 - 2 \times 4.123 \times 2 \times \cos(44.04)} \approx 3.024$ A1
				[3]	
2	(d)		$4.123^2 = 17 = 2^2 + 3.024^2 - 2\times 2\times 3.024\times\cos\alpha$	M1	Accept alternative solutions
			$\cos\alpha = \frac{4 + 3.024^2 - 17}{4\times 3.024} = -0.3187$	M1	Note: sin rule leading to 71.4 scores M1M1A0
			$\alpha = 108.6^o$	A1	Anything that rounds to 109
				[3]	

Question			Answer	Mark	Guidance
2	(e)		Taking moments about P: Type equation here. $50g(AP_H) = M_2g(AP\cos(\alpha - 90)$ $50g(2\cos 60) = M_2g(2\cos 18.6)$ $M_2 = \dfrac{50(2\cos 60)}{2\cos 18.6}$ $= 26.38$ $50g$ (	 **M1** **M1** **M1** **A1**	Accept solutions from resolving forces Condone missing g for method marks Allow with g missing throughout Anything that rounds to 26.4 eg Alt by resolving: Equate forces perpendicular to jib AP at point A $M_2g\cos(\alpha - 90)$ $M_1g\cos(60)$ $M_2 \times 0.9478 = M_1 \times 0.5$ $M_2 = \dfrac{25}{0.9478} = 26.38$
				[4]	
2	**Total**			**[15]**	

Question			Answer	Mark	Guidance
3	(a)		$v = \omega r$	B1	
				1	
3	(b)		ω= 2π/100 rad/min= v = ω×(6371+700) v = 444.3 (km min^{-1}) (26,657 kmh^{-1})	M1 A1	Accept answers without direct reference to ω e.g. 2π(6371+700)/100 Accept any answer that correctly rounds to 2sf in any units, other units must be shown eg $_{7405}\, ms^{-1}$
				2	
3	(c)		ω= 2π/12 rad/h $r = v/\omega$ r = 14000*12/2π=26738 distance above = 26738− 6371=20367 → 20000 (km)	M1 M1 A1	Other solutions without direct mention of ω accepted Oe $\frac{2\pi}{12\times3600}$ rad/s $= 1.45 \times 10^{-4}$ Accept any answer that rounds correctly to 2sf in any units, other units must be shown eg $= 2.0 \times 10^{7}$m
				[3]	
3	(d)		$ma = mg_h \qquad a = g_h$ $a = g \times 10^{-3}\left(\frac{r_e}{r_e+h}\right)^2 = \frac{v^2}{r_e+h} = \frac{\omega^2(r_e+h)^2}{r_e+h}$ $\omega^2(r_e+h) = g\times10^{-3}\left(\frac{r_e}{r_e+h}\right)^2$ $(r_e+h)^3 = g\times10^{-3}\left(\frac{r_e}{\omega}\right)^2$ $(r_e+h) = \sqrt[3]{g\times10^{-3}\left(\frac{r_e}{\omega}\right)^2}$ $h \approx \sqrt[3]{g\times10^{-3}\left(\frac{r_e}{\omega}\right)^2} - r_e$ **AG**	B1 M1* DM1 DM1 A1	$v = (r_e+h)\omega$ soi anywhere in solution Sets up equation and substitutes v for $r_e\omega$ or $(r_e+h)\omega$ at some point Progress in simplification Cube root from valid working
				[5]	
3	Total			[11]	

Question			Answer	Mark	Guidance
4	(a)		$\omega = 2\pi 50 = 314.16$ **AG**	**B1**	Accept more accurate decimal
				[1]	
4	(b)		$\frac{1}{Z_T} = \frac{1}{R} + \frac{1}{\omega Lj} \rightarrow \frac{1}{Z_T} = \frac{\omega Lj + R}{R\omega Lj}$	**M1**	Accept alternative methods Substitute and form a single fraction
			$Z_T = \frac{R\omega Lj}{\omega Lj + R} \times \frac{R - \omega Lj}{R - \omega Lj}$ oe	**M1**	(Invert and) setup correct process to rationalise Oe eg $Z_T = \frac{R\omega Lj}{\omega Lj + R} \times \frac{\omega Lj - R}{\omega Lj - R}$
			$= \frac{R\omega Lj(R - \omega Lj)}{R^2 + \omega^2 L^2}$	**M1**	Rational denominator for Z_T or rational numerator for $\frac{1}{Z_T}$ Oe eg $Z_T = \frac{R\omega Lj(\omega Lj - R)}{-(\omega L)^2 - R^2}$
			$Z_T = \frac{R\omega L(\omega L + Rj)}{(\omega L)^2 + R^2}$ **AG**	**A1**	AG from fully correct working Alternative solutions accepted eg $\frac{1}{Z_T} = \frac{\omega L - Rj}{R\omega L}$ $Z_T = \frac{R\omega L}{\omega L - Rj}$ $Z_T = \frac{R\omega L(\omega L + Rj)}{(\omega L - Rj)(\omega L + Rj)}$ $Z_T = \frac{R\omega L(\omega L + Rj)}{(\omega L)^2 + R^2}$
				[4]	

Question			Answer	Mark	Guidance
4	(c)		$Z_T = \frac{R\omega L(\omega L + Rj)}{(\omega L)^2 + R^2} =$ $= \frac{5 \times 314.16 \times 6 \times 10^{-3}(314.16 \times 6 \times 10^{-3} + 5\sqrt{-1})}{(314.16 \times 6 \times 10^{-3})^2 + 5^2}$ $a = \frac{17.765..}{28.553..} = 0.6222$ $b = \frac{47.124....}{28.553..} = 1.6504$ $[Z_T = 0.62 + 1.65j]$	**M1** **M1** **A1** **A1**	Numerator substitutions correct soi (j may still be present) Denominator substitutions correct soi Note: $R(\omega L)^2 = 17.765...$ $R^2\omega L = 47.124..$ $(\omega L)^2 + R^2 = 28.553..$ Answers which round correctly to 1dp without wrong working
				[4]	
4	(d)			**B1** **B1FT**	Real and imaginary axes indicated Correct labelled position for their Z_T from 4c, by indicating values on axes, or coordinates given
				[2]	

Question			Answer	Mark	Guidance
4	(e)		$r(\cos\theta + \text{j}\sin\theta)$		
			$r = \sqrt{1.6504^2 + 0.6222^2} = 1.764$	B1ft	Anything which rounds to 1.8
			$\theta = \tan^{-1}\frac{1.6504}{0.6222} = 69.4\,(^\circ)$	B1ft	Anything which rounds to 69, 70, 71
				[2]	
4	Total			[13]	

Question			Answer	Mark	Guidance
5	(a)		Speed $= \frac{dy}{dt}$ $\frac{dy}{dt} = e^{-2t}(-2A\sin 2t + 2B\cos 2t) - 2e^{-2t}(A\cos 2t + B\sin 2t)$	**M1** **A1**	Derivative of the form $uv' + vu'$ Accept alternative forms
				[2]	
5	(b)		$y = 1, t = 0$ $1 = e^0(A\cos 0 + B\sin 0) \Rightarrow A = 1$ $y = e^{-2t}(\cos 2t + B\sin 2t)$ $\frac{dy}{dt} = 0, t = 0$ $\frac{dy}{dt} = 0 = e^{-2t}(-2\sin 2t + 2B\cos 2t) - 2e^{-2t}(\cos 2t + B\sin 2t)$ $0 = e^0(-2\sin 0 + 2B\cos 0) - 2e^0(\cos 0 + B\sin 0)$ $0 = 2B - 2 \Rightarrow B = 1$	**B1** **M1** **A1**	 Use of $\frac{dy}{dt} = 0, t = 0$ and their A in their answer from 5a
				[3]	
5	(c)		$\frac{dy}{dt} = e^{-2t}(-2\sin 2t + 2\cos 2t) - 2e^{-2t}(\cos 2t + \sin 2t)$ $= -e^{-2t}4\sin 2t$ $\frac{dy^2}{dt^2} = e^{-2t}(-8\cos 2t) - 2e^{-2t}(-4\sin 2t)$ $= e^{-2t}(8\sin 2t - 8\cos 2t)$ Substitute terms and evaluate $e^{-2t}(8\sin 2t - 8\cos 2t) + 4e^{-2t}(-4\sin 2t) + 8e^{-2t}(\cos 2t + \sin 2t)$ $e^{-2t}((8 - 16 + 8)\sin 2t + (-8 + 8)\cos 2t) = 0$ **AG**	**M1** **A1** **B1**	 2nd derivative of the form $uv' + vu'$ aef, but with correct A and correct B substituted Validly confirm = 0
				[3]	

Question			Answer	Mark	Guidance
5	(d)		$\frac{dy}{dt} = e^{-2t}(-4\,sin\,2\,t) = 0$ For minimum $e^{-2t}(-4\sin 2t) = 0 \Rightarrow t = n\pi/2$ $y = e^{-\pi}(\cos\pi + \sin\pi) = -0.04321$	M1 M1 A1	Equate their first derivative from 5a to zero Solve $\sin 2t = 0$ to obtain any correct t eg $t = 0, \frac{\pi}{2}, \pi$ From $t = \frac{\pi}{2}$
				[3]	
5	(e)		The damping effect is very high because the mass moves very little below the *y* origin on the first and therefore subsequent oscillations	B1	
				[1]	
5	Total			[12]	

Question			Answer	Mark	Guidance
6	(a)		$[y =] \int \frac{(e^{-(x-3)} - e^{(x-3)})}{2} dx$ oe	B1	soi Must include the factor of $\frac{1}{2}$ here or later
			$[y =] \frac{-e^{(x-3)} - e^{-(x-3)}}{2} + C$	M1	at least one of the two terms in correct form
			$y = \frac{-1-1}{2} + C = 10$ $C = 11$	M1	Uses $x = 3$, y =10 in attempt to find their c following integration
			$y = \frac{-e^{-(x-3)} - e^{(x-3)}}{2} + 11$ oe	A1	
				[4]	
6	(b)		Substitute $x = 0$ or $x = 6$ eg $y = 11 - \frac{e^{-3} + e^{3}}{2}$ Plinth height ≈ 0.9323 m	M1 A1	Substitution into their equation from 6a which must have contained exponential terms in x Answer which is correct to 2sf
				[2]	

Question			Answer	Mark	Guidance
6	(c)		$11-\frac{e^{x-3}+e^{-(x-3)}}{2}=5$	M1	Substitutes $y=5$ into their formula from 6a which must have contained exponential terms in x
			$e^{x-3}+e^{-(x-3)}=12$ oe	B1	Correct equation in any equivalent form
			Substitute $X = e^{x-3}$		
			$X+\frac{1}{X}=12$		
			$X^2+1=12X$	M1*	Change of variable to obtain a 3 term quadratic
			$X^2-12X+1=0$		
			$X=\frac{12\pm\sqrt{144-4}}{2}$	DM1	Solve 3 term quadratic
			$X = 0.08392, 11.91608$		
			$x-3=\ln(0.08392)$		
			$x=\ln(0.08392)+3\approx 0.5221$		
			$x=6-0.5221\cong 5.4779$	A1	Both required, answers that round correctly to 2sf Accept correct answers from use of calculator at any stage
				[5]	
6	Total			[11]	

Question			Answer	Mark	Guidance
7	(a)		$u = x \quad u' = 1$ $v' = \cos ax \quad v = \frac{\sin ax}{a}$	M1	Sets up integration by parts
			$\int x\cos ax = x\frac{\sin ax}{a} - \int \frac{\sin ax}{a} 1 \mathrm{d}x$	M1	Correct structure $\int uv' = uv - \int u'v$
			$x\frac{\sin ax}{a} + \frac{\cos ax}{a^2} + C$ **AG**	M1 A1	Completes the cycle Obtains given answer (allow with c missing)
				[4]	
7	(b)		$\int r\cos\left(\frac{r}{A}\right) dr \quad \rightarrow \frac{r\sin\left(\frac{r}{A}\right)}{\frac{1}{A}} + \frac{\cos\left(\frac{r}{A}\right)}{\left(\frac{1}{A}\right)^2}$	M1*	Attempt integral, by using given result in 7a with $x = r$ and $a = \frac{1}{A}$
			$V = 2\pi H\left[rA\sin\left(\frac{r}{A}\right) + A^2\cos\left(\frac{r}{A}\right)\right]_0^R$ $V = 240\pi\left[150r\sin\left(\frac{r}{150}\right) + 150^2\cos\left(\frac{r}{150}\right)\right]_0^R$	B1	All correct with H = 120, A = 150 substituted
			$V = 240\pi\left(150^2\sin\left(\frac{150}{150}\right) + 150^2\cos\left(\frac{150}{150}\right) - 150^2\right)$ $V = 240\pi \times 150^2(\sin(1) + \cos(1) - 1) = 6476631$	DM1	Correct process to apply limits 0 to 150
			6476631 mm^3 = 0.006476631 $\mathrm{m}^3 \approx 6.48$ L	A1	Answer in litres, which rounds correctly to 2sf Accept correct answers from use of calculator at any stage
				[4]	
7	**Total**			[8]	

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