

Cambridge Technicals

Engineering

Unit 3: Principles of mechanical engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825 & 05873

Mark Scheme for June 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.

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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. For answers marked by levels of response: Not applicable in F501

To determine the level – start at the highest level and work down until you reach the level that matches the answer

To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. Annotations

Annotation	Meaning
	Correct response worthy of a mark. Number of ticks = number of marks awarded.
	Incorrect response
	Missing something/incomplete response
	Error carried forward
	Benefit of doubt
	No benefit of the doubt
	Power of ten error
	Rounding error
	Significant figure error
	Transcription error
	Seen
	Blank page

Mark scheme abbreviations

Other abbreviations in mark scheme	Meaning
oe	Or equivalent
ecf	Error carried forward
wtte	Words to that effect
soi	Seen or implied
SC	Special case

In all numerical calculation questions a correct response to 2 sf will gain all marks unless specified otherwise. When an answer is given to more than 2 sf, if it rounds to the answer given in the mark scheme to 2 sf, the mark can be awarded.

If this is not the case for specific questions, this will be detailed in the mark scheme. You do not need to see all the workings if the answer is correct. Any answers or units in brackets do not need to be seen.

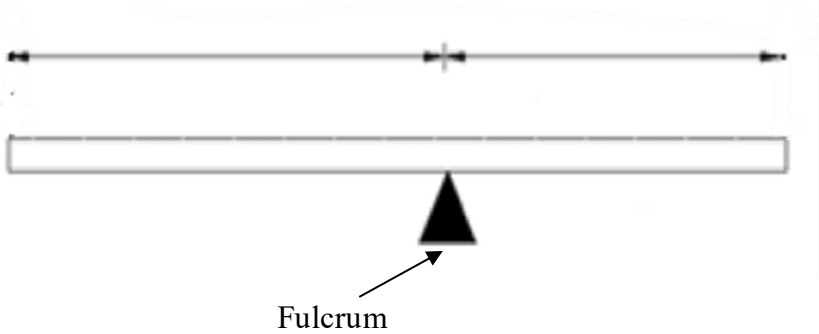
If the data given in a question is to 2 sf, then allow to 2 or more significant figures. If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.

Penalise a rounding error in the second significant figure once only in the paper.

Question			Answer	Mark	Guidance
1	(a)	(i)	(67.5, 100)	1 1	Synoptic assessment Unit 1 LO2.1 1 mark for each correct coordinate NB Must be 100, not rounded to 100. ALLOW coordinates the wrong way round with BOD.
				[2]	
		(ii)	$\text{Area} = 2(135 \times 6) + (188 \times 6) = 2748 \text{ mm}^2$ $\text{Volume} = 2000 \times 2748$ $5496000 \text{ (mm}^3\text{)} / 5.496 \times 10^6 \text{ (mm}^3\text{)}$	1 1 1	calculation of area can be in m^2 Substitution using <i>their</i> calculated area for 1 mark only. Allow 2m for length No final mark for volume in m^3 only ALLOW full marks if the correct answer in mm^{-3} is seen even if a subsequent attempt at conversion to m^{-3} is incorrect. Effectively ISW
				[3]	
		(iii)	$5496000 \text{ mm}^3 = 0.005496 \text{ m}^3$ $\text{Density} = 43.14 / 0.005496$ $= 7849 \text{ (kg m}^{-3}\text{)}$	1 1	ALLOW ecf from 1(a) (ii) throughout conversion of units Accept 7844 kg m^{-3} if 0.0055 is used POT error can score 1 mark
				[2]	

1	(a)	(iv)	Strain = $0.05 / 2000 = 0.000025 / 2.5 \times 10^{-5}$ $210 \text{ GPa} = 210 \times 10^9 \text{ N m}^{-2} / 210000 \text{ N mm}^{-2}$ $210 \times 10^9 = \text{Stress} / 0.000025$ $\therefore \text{Stress} = 5250000 \text{ N m}^{-2} / 5250 \text{ N mm}^{-2}$ $5250000 = \text{force} / 2748 \times 10^{-6} \text{ or } 5250 = \text{force} / 2748$ $\therefore \text{Force} = 14427 \text{ (N) or } 14.43 \text{ k(N)}$	1	ALLOW ecf from 1(a)(ii) throughout
				1	calculation of strain soi
				1	Unit conversion soi Synoptic assessment Unit 2 LO 1.1
				1	Appropriate prefix must be given if not in N
					Deduct one mark for POT error(s) only
			Alternative solution $YM = \frac{Fl}{Ae}$ $210 \times 10^9 = \frac{Fx2000}{2748 \times 10^{-6} \times 0.05}$ $F = 210 \times 10^9 \times \frac{2748 \times 10^{-6} \times 0.05}{2000}$ $\therefore \text{Force} = 14427 \text{ (N) or } 14.43 \text{ kN}$	1	Substitution
				1	Rearrangement
				1	Appropriate units must be given if not in N
					Deduct one mark for POT error(s) only
				[3]	
	(b)		$(4 \times 40 / 3\pi) = 16.98/17$ $\bar{x} = 40 - (4 \times 40 / 3\pi)$ $\bar{x} = 23.02 \quad \bar{y} = 40$ or $(23.02, 40.00) / (23.40)$	1	Substitution
				1	Both values in the correct order required for mark
				[2]	

2	(a)	(i)	$1.84 = 290 / F$ $F = 290 / 1.84 = 157.6 \text{ (N)}$	1 1	Substitution
				[2]	
		(ii)	Input distance / 1.4 = 1.84 Input distance = 2.58 m $1.4 + 2.58 = 3.98 \text{ (m)}$	1 1	Substitution and rearrangement 1.4 + <i>their</i> calculated input distance
			Alternative solution $290 \times 1.4 = F_O \times \text{input distance}$ Input distance = $(290 \times 1.4) / 157.6 = 2.58 \text{ m}$ $1.4 + 2.58 = 3.98 \text{ (m)}$	1 1	ALLOW ecf from 2 (a) (i) Substitution and rearrangement 1.4 + <i>their</i> calculated input distance
				[2]	

2	(a)	(iii)	Effort 157.6N 2.58m  Load 290N	1	ALLOW ecf from 2 (a) (i) and 2 (a) (ii) throughout Effort and load labelled and shown either side of the fulcrum ALLOW their numerical values instead of labels
				1	Fulcrum labelled between effort and load.
				1	Correctly labelled distances shown or the fulcrum should be closer to the load if correct distances have been calculated. Look for ecf here. If the fulcrum is in the middle due to ecf, the values of a and b must be shown to be equal.
				[3]	

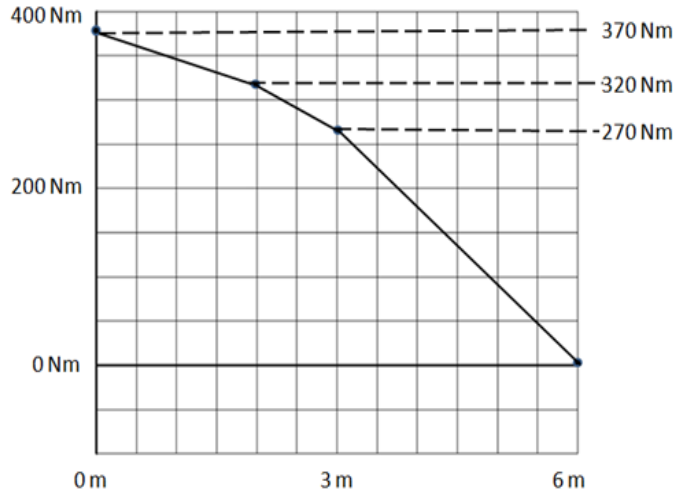
Question			Answer				Mark	Guidance
2	(b)			Axis of rotation changes 90°	Converts rotational movement to linear movement	Direction of transmission can be reversed	1 1 1	1 mark for each correct row
			Bevel gear	✓		✓		
			Rack and pinion		✓	✓		
			Wormgear and wormwheel	✓				
							[3]	
	(c)		- To allow the gears to rotate in the same direction - To keep the rotation the same direction - To keep the rotational movement the same - To reverse the rotation of the output/driven (gear) - To change the direction of the output/driven (gear) - To increase the total size of the gear train. - To allow the size of the two gears to be reduced while retaining the same total distance between them.				1	Accept any other appropriate answer but ignore move Ignore reference to MA or VR If several reasons are given award no marks if one or more is incorrect even if others are correct.
							[1]	

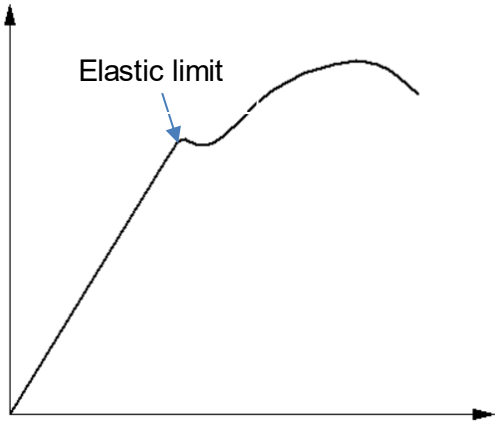
Question			Answer	Mark	Guidance
3	(a)		Horizontal resultant = $25 - 15(\cos 30) - 10(\cos 45) = \mathbf{4.939}$ Vertical resultant = $10 + 15(\sin 30) - 10(\sin 45) = \mathbf{10.429}$ $\sqrt{(4.939^2 + 10.429^2)}$ $= 11.54 \text{ (N)}$	1	Unit 2 LO 2.1 Calculation of horizontal resultant soi
				1	Calculation of vertical resultant soi
				1	Use of Pythagoras with <i>their</i> values
				1	
				[4]	
	(b)		$a = 11.54 / 2.5$	1	ALLOW ecf from part (a) throughout
			$= 4.616 \text{ (ms}^{-2}\text{)}$	1	Substitution
				[2]	

3	(c)		$s = 6 = at^2/2 = 4.616 \ t^2/2$ $t = \sqrt{(60/4.616)} = 1.612 \text{ seconds}$ $v = 1.612 \times 4.616 = 7.44 \text{ (ms}^{-1}\text{)}$	1 1 1	ALLOW ecf from part (b) throughout substitution calculation of t Synoptic assessment Unit 1 LO 1.3
			Alternative solution 1: $v^2 = u^2 + 2 \text{ as}$ $v^2 = 0^2 + 2 \times 4.616 \times 6$ $v^2 = 55.392$ $v = 7.44 \text{ (ms}^{-1}\text{)}$	1 1 1	ALLOW ecf from part (b) throughout Substitution Re-arrangement (Synoptic assessment Unit 1 LO 1.3)
			Alternative solution 2 Work done = ke $F \times d = \frac{1}{2} mv^2$ $11.54 \times 6 = \frac{1}{2} \times 2.5 \times v^2$ $v^2 = 55.392$ $v = 7.44 \text{ (ms}^{-1}\text{)}$	1 1 1	ALLOW ecf from part (a) throughout Substitution Re-arrangement (Synoptic assessment Unit 1 LO 1.3)
				[3]	

Question			Answer	Mark	Guidance
4	(a)		$P = Fv$ $50000 = F \times 16$ $F = 50000 / 16 = 3125 \text{ (N)} / 3.125 \text{ k(N)}$	1 1	Substitution POT error can score 1 mark Appropriate prefix must be given if not in N
				[2]	
	(b)		$v^2 = u^2 + 2as$ $0 = 30^2 + (2 \times -9.8s)$ $900 = 19.6s$ $s = 45.92 \text{ (m)} (45.87 \text{ if } 9.81 \text{ is used})$	1 1 1	Substitution Synoptic assessment Unit 2 LO2.2 rearrangement
			Alternative solution $mgh = \frac{1}{2}mv^2$ $9.8 \times h = \frac{1}{2}v^2$ $h = \frac{0.5 \times 30^2}{9.8}$ $h = 45.92 \text{ (m)} (45.87 \text{ if } 9.81 \text{ is used})$	1 1 1	Substitution Synoptic assessment Unit 2 LO2.2 rearrangement
				[3]	
	(c)		$(2 \times 80) + (3 \times 125) = 535$ $535 / 3 = 178.33 \text{ (N)}$	1 1	substitution ALLOW <i>their</i> value / 3
				[2]	

Question			Answer	Mark	Guidance
5	(a)	(i)	load X – Uniform(ly) Distributed (load) or UDL	1	1 mark for each correct response
			load Y – (Single) Point (load)	1	DO NOT ALLOW Single load
				[2]	
		(ii)	Z – (Normal) Reaction (force)	1	ALLOW Reactant/Reactive/Contact
				[1]	
	(b)	(i)	$90 - 40 - 25 = 25$ (kN) or $90000 - 40000 - 25000 = 2500$ (N)	1	substitution and evaluation
			Up	1	direction. Can be shown as an upwards arrow (on the diagram)
				[2]	
		(ii)	$(90 \times 6) - (40 \times 3) - (25 \times 2)$ $= 370$ (kNm) (CW)	1 1 1	Substitution identify -ve moments or forces ALLOW -370 (kNm) Incorrect negative moments can result in ± 710 kNm, ± 610 Nm, ± 470 kNm
				[3]	

Question			Answer	Mark	Guidance		
5	(b)	(iii)	0 kNm at free end of cantilever and 370 kNm at fixed end of cantilever shown on diagram	1	ALLOW ecf from part (b) (ii) throughout		
			At 3m, $3 \times 90 = 270$ kNm shown on diagram	1			
			At 2m, $(4 \times 90) - 40 = 320$ kNm shown on diagram	1		SC If 270 and 320 are seen without (correct) distances, in working or on diagram award 1 mark	
			Y axis should be kNm	1			Appropriate scale for diagram must be evident. Award 1 mark if appropriate scale and labelled axes with quantities ((bending) moments and distance or units (kNm/Nm and m) are evident without bending moment diagram.
							
				[4]			

Question			Answer	Mark	Guidance
6	(a)	(i)		1	Accept others forms of labelling, for example a cross or circle. The point indicated must be at the top of the linear section of the graph and no further to the right than the top of the peak of the first curve.
				[1]	
		(ii)	Any change in shape will be permanent. Atoms/separation/bonds don't return to original form Material starts to plastically/permanently deform Material will (eventually) fracture/snap/break.	1	Accept any appropriate answer.
				[1]	
		(iii)	550 / 1.75 = 314.3 (Nmm⁻²) / 3.14 x 10⁻⁴ (Nm⁻²)	1 1	Selection of formula POT error can score 1 mark ALLOW full marks if the correct answer in Nmm⁻² is seen even if a subsequent attempt at conversion to Nm⁻² is incorrect. Effectively ISW
				[2]	

6	(b)	(i)	$mgh = 8700 \times 9.8 \times 24$ $= 2046240 \text{ J} / 2.046 \times 10^6 \text{ J}$ (9.81 gives 2048328 J) or 2046 kJ or 2.046 MJ	1 1	Substitution Correct units must be given ALLOW Nm, kgm ² s ⁻² DO NOT ALLOW j
				[2]	

		(ii)	$2046240 = \frac{1}{2} mv^2$ $(2 \times 2046240) / 8700 = v^2$ $v^2 = 470.4$ $v = 21.69 \text{ (ms}^{-1}\text{)}$	1 1 1	ALLOW ecf from part (b) (i) throughout Substitution. Allow ecf from 6(b)(i) Rearrangement Synoptic assessment Unit 1 LO 1.3 NB If suvat has been used, award 1 mark only for the correct answer.
				[3]	

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