

Cambridge Technicals Engineering

Unit 3: Principles of mechanical engineering

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

Mark Scheme for June 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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MARKING INSTRUCTIONS**PREPARATION FOR MARKING****TRADITIONAL**

Before the Standardisation meeting you must mark at least 10 scripts from several centres. For this preliminary marking you should use **pencil** and follow the **mark scheme**. Bring these **marked scripts** to the meeting.

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 traditional 40% Batch 1 and 100% Batch 2 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 or by email.
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.

Rubric Error Responses – Optional Questions

Where candidates have a choice of questions across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. (The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)

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 lined pages 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 an annotation to confirm that the work has been seen.
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 anyway 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 isn't an attempt at the questionNote: Award 0 marks - for an attempt that earns no credit (including copying out the question)
8. Assistant Examiners will email a brief report on the performance of candidates to your Team Leader (Supervisor) by the end of the marking period. Your 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

Annotation	Meaning
tick	Correct response worthy of a mark. Number of ticks = number of marks awarded.
cross	Incorrect response
Omission mark (carat)	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
POT	Power of ten error
RE	Rounding error (or reading/transcription error)
SF	Significant figure error

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.

10. Subject-specific marking instructions

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy/answer marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Question	Answer	Mark	Guidance					
1	(i) (Volume =) $215 \times 102.5 \times 65$ $=1432437.5 \text{ (mm}^3\text{)}$ $=1.432.. \times 10^{-3} \text{ (m}^3\text{)}$ (Mass =) $1.432 \times 10^{-3} \times 2100$ (Mass = $3.008 \text{ kg} =$) 3.0 (kg)	C1	Seen or implied. Ignore POT					
		C1	Seen or implied. Ignore POT					
		C1	Seen or implied. Ignore POT. Allow their volume x 2100					
		A1	Allow 3kg					
		[4]						
	(ii) $(F = \mu N =)$ $0.4 \times 3.0081 \times 9.8$ $(F = 11.8 =)$ 12 (N)	C1 A1	Using friction equation. Allow omission of g for C mark Allow ecf their mass from (i)					
		[2]	(synoptic Unit 2 2.3)					
	(iii)							
		Shape	Area	x_i	y_i	$a_i x_i$	$a_i y_i$	
		1	$1 \times 2 = 2$	1	0.5	2	1	
		2	$3 \times 2.5 = 7.5$	3.5	1.25	26.25	9.375	
			9.5			28.25	10.375	
		OR						
		Shape	Area	x_i	y_i	$a_i x_i$	$a_i y_i$	
		1	$5 \times 1 = 5$	2.5	0.5	12.5	2.5	
		2	$3 \times 1.5 = 4.5$	3.5	1.75	15.75	7.875	
	9.5			28.25	10.375			
	$\bar{x} (= \frac{28.25}{9.5}) = 2.97(368 \dots)(\text{m})$ $= 3.0(\text{m})$	C1 A1	Shape 1: 2 out of 3 of area, x_i , y_i correct Shape 2: 2 out of 3 of area, x_i , y_i correct Shape may be split up differently from the 2 arrangements shown here.					
	$\bar{y} (= \frac{10.375}{9.5}) = 1.09(210\dots)(\text{m})$ $= 1.1(\text{m})$	A1	Attempt to sum up their $a_i x_i$ or $a_i y_i$ values and divide by total area.					
		[5]						

Question			Answer	Mark	Guidance
2	(a)	(i)	Area = $450 \times 100 + 240 \times 160 + \frac{240 \times 140}{2} = 100200 \text{ (mm}^2\text{)}$	C1 A1	Appropriate separation of shape into rectangles/triangles (or trapezium) and attempt to calculate their areas
				[2]	
		(ii)	$(100200 \div 100) = 1002 \text{ cm}^2$	A1	ecf their answer to (a)(i)
				[1]	
	(b)	(i)	The Young modulus/ Young's modulus	B1	Accept stiffness
				[1]	
		(ii)	(Strain = stress / E =) $600 \times 10^6 \div 114 \times 10^9$ $= 5.3\% \text{ OR } 5.3 \times 10^{-3} \text{ (} 5.263\dots \times 10^{-3}\text{)}$	C1 A1	Use of formula, allow errors related to wrong powers of 10, e.g. 600/114
				[2]	
		(iii)	Force = Stress x area = $= 600 \times 10^6 \times (\pi \times 0.0061^2)$ (= 70139.19...N =) 70000 (or 70 if in kN) N / kN	C1 A1 A1	Use of correct formula, condone use of diameter not radius. Ignore POT errors.
				[3]	

Question			Answer	Mark	Guidance
3	(a)	(i)	Class 3	B1	
				[1]	
		(ii)	$(F_{in} = F_{out}/MA =) 500/0.64$ $= 780 (781.25 \text{ N})$	C1 A1	
				[2]	
		(iii)	$500(x + 0.55) = 781.25 \times 0.55$ $(x =) 0.31 (0.30937.. \text{ m})$ OR $MA=0.64=0.55/(0.55 + x) \quad x=0.55/0.64-0.55$ $(x =) 0.31 (0.30937.. \text{ m})$	C1 A1 C1 A1	
				[2]	
	(b)	(i)	(Overall VR = product of drivers/product of driven) $\frac{40 \times 10}{20 \times 30}$ $= 2 \div 3 / 0.67 (0.6666....)$	C1 C1 A1	Use of appropriate VR formula seen or implied. Both VRs calculated but not multiplied together scores max 1 mark.
				[3]	
		(ii)	$(MA = 1/VR) = 1.5 \text{ or } 3 \div 2$	B1	ecf their answer to (b)(i).
				[1]	
		(iii)	Idler gear	B1	
				[1]	

Question		Answer	Mark	Guidance
4	(i)	$F = 0.2 \times 120 \times 9.8$ $= 240$ (235.2 N)	C1 A1	Allow incorrect mass (e.g. 80kg) but not omission of 9.8
			[2]	(synoptic Unit 1 4.3)
	(ii)	(Max. resistance is 450N so) $450 = 0.2R$ ($R = 2250$ N) (Total mass \Rightarrow) $2250 \div 9.8$ ($= 229.59..kg$) (Maximum load \Rightarrow) 190 (189.59.. kg)	C1 C1 A1	Correct equation OR calculated value Division of their normal force by 9.8 to find mass.
			[3]	(synoptic Unit 2 2.3)
	(iii)	$P - 235.2 = 120 \times 0.082$ ($P \Rightarrow$) 250 (245.04 N)	C1 C1 A1	Correct equation scores 2 x C1. Either side correct scores C1. Allow 80 instead of 120 for both C marks (maximum 2 marks) Allow ecf from (i)
			[3]	(synoptic Unit 2 2.1)
	(iv)	(Use of $v = u + at$) $0.65 = 0 + 0.082t$ ($t \Rightarrow$) 7.9 (7.9268.. s)	C1 A1	Allow correct alternative method eg $v^2 = u^2 + 2as$ and $s = 0.5(u+v) \times t$
			[2]	
	(v)	(Use of suvat to find distance e.g. $s = \frac{1}{2}(u + v)t$) $s = 0.5 \times 0.65 \times 7.9268..$ ($= 2.576...$) (Work = Force \times distance \Rightarrow) 245.04×2.576 $= 630$ (631.27...J)	C1 C1 A1	Valid approach to find distance, ecf their (a)(iii) Use of $W = Fd$ providing an attempt to find distance was made (using suvat) and allow Force from ii or iii. Allow ecf their values of P and t from (iii) and (iv) but not incorrectly found distance within this question
			[3]	

Question		Answer	Mark	Guidance
5	(i)	$AD = \sqrt{1.2^2 + 0.5^2}$ =1.3 (m)	C1 A1	
			[2]	
	(ii)	$200 \times 1.3 + 300 \times 1.2 - 150 \times 1.3$ 425 (Nm)	C1 C1 A1	1 or 2 components correct (ignore signs) All components consistent (all signs correct) ecf their (i). Ignore sign/ clockwise/anticlockwise.
			[3]	
	(iii)	Angle between 200N and vertical = $\tan^{-1}(0.5/1.2) = (22.619..)$ Net Vertical component = $300 + 200 \times \cos 22.619 = 484.615..$ Net horizontal component = $150 - 200 \times \sin 22.619 = 73.0769..$ Resultant = $\sqrt{484.615^2 + 73.0769^2}$ =490 (N)	C1 C1 C1 C1 A1	Allow angle with horizontal. allow incorrect angle but must be an attempt to resolve the 200N allow incorrect angle but must be an attempt to resolve the 200N ft their vertical and horizontal components ecf part(i) only
			[5]	

Question		Answer	Mark	Guidance
6	(a)	<u>Fixed</u> (joint/support)	B1	
			[1]	
	(b)	<u>Roller</u> (joint/support)	B1	rolling
			[1]	
	(c)	<p>Calculation of total distributed load = $2000 \times 12 = 24000\text{N}$ Vertical equilibrium: $R_A + R_B + 12000 = 15000 + 24000$ $(R_A + R_B = 27000)$</p> <p>Taking moments around end A: $R_B \times 12 + 12000 \times 3 - 15000 \times 7 - 24000 \times 6 = 0$</p> <p>$R_B = 18000$ (17750 N) $R_A = 9200$ (9250 N)</p>	<p>C1</p> <p>C1</p> <p>C1</p> <p>A1</p> <p>A1</p>	<p>May be seen as part of another calculation</p> <p>Vertical equilibrium attempted, allow error/omission of one term</p> <p>Moments around one end attempted, allow error/omission of one term, allow sign errors. If moments around both ends attempted and no vertical equilibrium seen then award 2 x C1.</p>
			[5]	

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