Cambridge Technicals
Engineering

Unit 3: Principles of mechanical engineering

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

Mark Scheme for June 2023

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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 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 posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

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

   YOU MUST MARK 5 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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 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 isn't 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.**
   If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

9. 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.

10. **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

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.

11. **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.

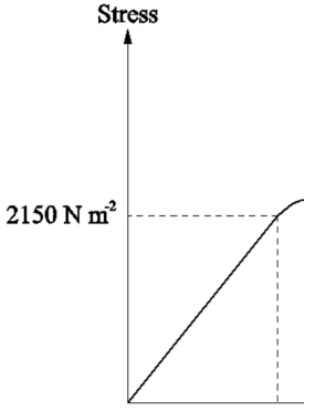
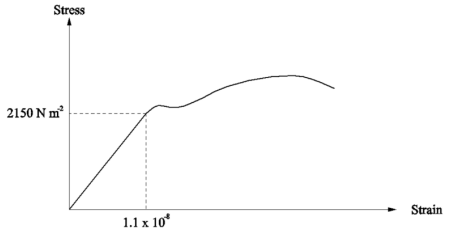
A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

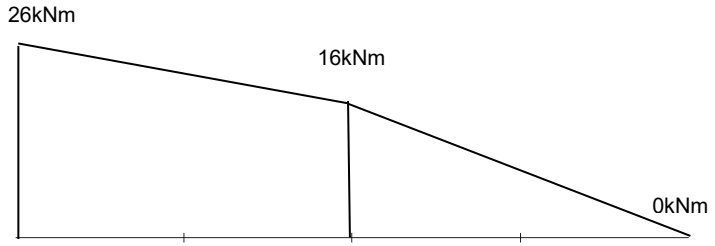
Question			Answer	Marks	Guidance
1		(i)	(70x90) – (40x40)/2	C1	Allow other acceptable method of calculating area. 1 area correct scores 1 mark.
			= 5500 (mm^2)	A1	Allow answer in m^2 (5.5×10^{-3})
				[2]	
		(ii)	$\bar{x}$= (3500x25)+(1200x70)+(800x63.33) = 40 (40.39 mm) 5500 $\bar{y}$= (3500x35)+(1200x15)+(800x43.33) = 32 (31.85 mm) 5500	C1 C1	Allow ecf from 1(i) for Total Area only. Calculates $\bar{x}$ and $\bar{y}$ for one defined area. Multiplies one defined area by their $\bar{x}$ or $\bar{y}$
			Or alternatives below: $\bar{x}$= (2700x45)+(2000x25)+(800x63.33) = 40 (40.39 mm) 5500 $\bar{y}$= (2700x15)+(2000x50)+(800x43.33) = 32 (31.85 mm) 5500	C1 A1 A1	Substitutes their values (either direction) into $\bar{y} = \frac{\sum A_i y_i}{\sum A_i}$ Allow other appropriate figures when splitting into regular 2D shapes Award 4 marks if either A mark is scored.
			$\bar{x}$ =(6300x45)-(800x76.67) = 40 (40.39 mm) 5500 $\bar{y}$ = (6300x35)-(800x56.67) = 32 (31.85 mm) 5500		
				[5]	

Question			Answer	Marks	Guidance
		(iii)	The centroid represents the centre of mass/gravity.	B1	Accept "point where weight acts from" or "point where mass is considered to be"
				[1]	
		(iv)	Angle = $\tan^{-1}$(*their x/ their y*) $\tan^{-1}$(40.39/31.85) = 51° (or 52° or 128° or 129°)	C1 A1	Accept correct calculation of angle to horizontal i.e. $\tan^{-1}$ 32/40 (or $\tan^{-1}$ their y divided by their x) Accept 51° 52° 128° 129°. (for applying knowledge from Unit 1 LO 4.3)
				[2]	

Question			Answer	Marks	Guidance
2	(a)		Concurrent forces – lines of action/ forces all meet at a single point.	B1	In same/opposite direction(s) scores 0.
				[1]	
	(b)		22-10 (= 12) $\sqrt{(7^2+12^2)}$ seen or implied = 13.9 (N)	C1 C1 A1	Allow their value of x component or 22 or 10 in otherwise correct expression for max 1 mark. (For applying knowledge from Unit 1 LO 4.3 - Pythagoras)
				[3]	
	(c)	(i)	2500/5500 = 0.45 (0.4545) (or 450000 or 45.45) N/mm^2 (or N/m^2 or N/cm^2)	C1 A1 A1	Seen or implied. Ignore POT errors. Unit must be consistent with value **IF** shown. (For applying knowledge from Unit 2 LO 1.1)
				[3]	
		(ii)	Substitution of values into strain=stress/E (any rearrangement) (Strain =) 2.27×10^{-6} (Change in length =) $3000\times2.27\times10^{-6}$ $= 6.82\times10^{-3}$mm (or other correct units)	C1 C1 C1 A1	Allow ecf from 2(c)(i) throughout. Seen or implied. Allow POT errors. Seen or implied. Allow POT errors. Seen or implied. Allow FT from their strain for this C mark and correct working in other units. Allow POT errors. 6.75×10^{-3} mm if 0.45 used from (c)(i)
				[4]	

Question			Answer	Marks	Guidance
3	(a)		Bevel (Gear) Worm (Wheel and Worm Gear)	B1 B1	1 mark for each correct response.
				[2]	
	(b)	(i)	Gear B – Idler gear Gear C – Output gear	B1 B1	Responses must be this way around. If reversed scores 0
				[2]	
		(ii)	25/20 = 1.25	C1 A1	Apply VR = input teeth/output teeth Allow 1.3
				[2]	
		(iii)	Two from: • So that input and output gears rotate in the same direction. • To provide additional support for gear train. • To increase/set distance between input and output shafts/gears.	B1 B1	Change direction of output gear. Needs to refer to either output gear or both gears. Accept to increase length
				[2]	

Question			Answer	Marks	Guidance
4	(a)	(i)		B1 B1	Award one mark for a straight line (judge critically by eye) from (0, 0) through ($1.1x10^{-8}$, 2150) Award 2nd mark for curved line beyond elastic limit as shown. Allow curved line that reaches a maximum providing end point of line is not below 2150. Straight line that clearly stops at elastic limit should also receive 2 marks. Allow rough approximation to (all of) diagram below for special case of mild steel only for 2nd mark. (Gradient is negative at failure.) 
				[2]	
		(ii)	$2150/1.1x10^{-8}$ or $195.5x10^{9}$ Answer = steel	M1 A1	(For applying of knowledge from Unit 2 LO 4.9/10) Comparison with table of data
				[2]	
	(b)		8/3 = 50/F or F x 8 = 50 x 3 F = 50x3/8 = 18.8 (18.75)(N)	C1 C1 A1	Application of principle of moments or use of MA = a/b= F_o/F_I If 2.7 used for 8/3, answer is 18.52
				[3]	

Question			Answer	Marks	Guidance
5	(a)	(i)	Continuously (Supported beam)	B1	
				[1]	
		(ii)	Suitable correct response, for example: • (Self-weight of) Girder on a surface • (Self-weight of) layer of snow on a roof	B1	Correct responses will refer to both the item (girder or layer of snow) providing the load and the item (horizontal surface or flat roof) that is resisting the load. Allow a queue of cars on bridge but not just cars.
				[1]	
	(b)	(i)	8-3 = 5kN	C1 A1	
				[2]	
		(ii)	 Straight line from centre to one extreme at 0 Straight line from centre to maximum magnitude at other extreme 26 kNm shown correctly on diagram or calculated. 16 kNm shown correctly on diagram or calculated. Diagram as shown including labels (ignore axis labels)	B1 C1 C1 C1 C1 A5	Accept diagram correctly drawn above **or** below line. Accept ecf from 5(b)(i)
				[5]	

Question			Answer	Marks	Guidance
6	(a)	(i)	(2600x15.6)+(1600x13) = (2600x9.4)+(1600xV_2) 36920 = 1600V_2 = 23 (23.1) (ms^{-1})	C1 C1 A1	Equation completely correct scores 2. 2 terms correct scores 1 (ignore sign)
				[3]	
		(ii)	$v^2 = u^2 + 2as$ s = $\underline{9.4^2}$ / (2 x -4) s = 11.0 (m) (11.045)	C1 C1 A1	Identifying appropriate equation Rearrangement and substitution
				[3]	
		(iii)	(f = ma =) 2600 x 4 = 10400 (N)	C1 A1	(For applying knowledge from Unit 2 LO 2.3)
				[2]	
		(iv)	(W = fd =) 10400 x 11.0 = 114400 (J) (or 114868)	C1 A1	Application of W = Force × distance ecf 6(a)(ii) and 6(a)(iii) Accept answers rounding to 114000 and 115000
				[2]	
	(b)	(i)	(150000/9.8)x9.8x8.4 (OR 150000 x 8.4) = 1260000 (J)	C1 A1	Accept 150 instead of 150000/9.8 leading to 12348 (J) for max 2 marks. 1260 scores 1 mark Accept 150000 instead of 150000/9.8 leading to 12348000 (J) for max 2 marks
				[2]	

Question			Answer	Marks	Guidance
		(ii)	Correct equation(s) seen or implied and values: $8.4 = 0.5 \times 9.8 \times t^2$ (or $v^2 = 2 \times 9.8 \times 8.4$ and $v = 9.8 \times t$)	C1	If candidate uses kinetic energy award 1 mark for calculation of velocity. Expect 12.8m/s. Allow ecf b(i)
			Correct rearrangement for t^2 (or t): $t^2 = 8.4 \times 2 / 9.8$ (or $t = \sqrt{(2 \times 9.8 \times 8.4)} / 9.8$)	C1	Allow $t = v/9.8$ using correct calculation of v from KE.
			1.3 seconds (1.31)	A1	Allow ecf from b(i) throughout. t = 1.71 scores 2 marks
				[3]	

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