Cambridge Technicals
Engineering

Unit 3: Principles of mechanical engineering

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

Mark Scheme for January 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 RM Assessor 50% 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 using 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 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. Award No Response (NR) if:
   - if there is nothing written at all in the answer space

   Award zero (0) if:
   - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

   Team leaders must confirm the correct use of NR with markers before live marking commences and should check this when reviewing scripts.

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 RM Assessor messaging system.

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 (updated for RM assessor marking)**

Annotation	Meaning
✓	correct response worthy of a mark. **number of ticks = no of marks awarded**
✗	incorrect
^	missing something
ECF	error carried forward
BOD	benefit of doubt
NBOD	benefit of doubt not given
POT	power of ten error
CON	contradiction
RE	rounding error
SF	significant figure error
BP	blank page (to be used on the additional pages if nothing is written there.
SEEN	to indicate that an examiner has seen a response or page

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.

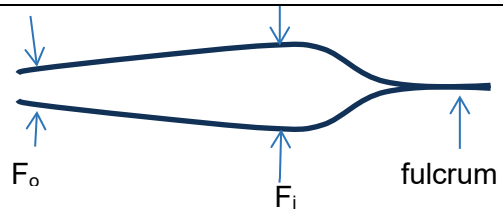
M marks: These are method marks upon which **A**-marks (accuracy/answer marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

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.

In all numerical calculation questions a correct response will gain all marks unless specified otherwise.
You do not need to see all the workings if the answer is correct. If an incorrect or no answer is seen then the workings must be marked.
Numerical answers are expected to be given to 2 SF unless otherwise specified. Answers given to more than 2 SF but which round correctly to 2 SF gain full credit.

Question			Answer	Marks	Guidance
1	(a)	(i)	Torque: C Shear Force: A Tension Force: B	A2	Award 1 mark for 1 correct.
				[2]	
		(ii)	(Shear Stress $= \frac{\text{Shear Force}}{\text{Area}} =) \frac{250}{\pi \times 0.008^2}$ $= 1240000$ (1243398) OR 1.24 Pa OR N/m^2 for use of m (or MPa or N/mm2 for use of mm)	C1 A1 B1	Correct substitution. Ignore POT errors and allow use of diameter in correct expression for C1. Accept equivalents
				[3]	
	(b)	(i)	X marked approximately on curve between (0.09, -) and (0.11, -).	A1	
				[1]	
		(ii)	• Value(s) used (for stress and/or strain) are outside the elastic region (or in the inelastic or plastic region or above the elastic limit) oe • % strain is used in the calculation oe	B1 B1	Ignore answers referring to a single point or single value of a pair of values. Allow strain value should be converted (from % to a decimal) OR divided by 100 oe for 2nd B mark. Don't allow "wrong" value of strain.
				[2]	
		(iii)	Attempt to use graph to find strain for 140MPa (Change in length = Strain × original length =) 0.0006 ×1.2 ($= 7.2 \times 10^{-4}$) = 0.72 (mm)	C1 C1 A1	Must see evidence on graph OR 0.06 OR 0.0006 Use of correct formula with their strain value. Allow value as % Allow alternative method using values from graph to find Young's Modulus if correct answer calculated.
				[3]	
				[11]	

Question			Answer	Marks	Guidance
2	(a)		A gear system would be more durable or hardwearing OR No slippage would occur with the gear system OR can transmit higher torque.	A1	Any acceptable advantage
				[1]	
	(b)		Any 2 from: • spur (gears) • idler (gears) • chain driven sprockets • bevel (gears) • rack and/or pinion • worm(gear) and/or (worm)wheel	A2	Award A1 for each correct answer Not just compound (gears) Not chains or sprockets Worm variants alone score maximum 1 mark. Accept other correct responses
				[2]	
	(c)	(i)		B1 B1	Fulcrum position correct Input and output force correct (input must be closer to fulcrum). Allow single arrows used. Force arrows should be approximately vertical or at 90 degrees to surface. judge by eye – look for intent and don't be too harsh.
				[2]	
		(ii)	Class 3	A1	
				[1]	
	(d)		$VR_{A\ to\ B} = 20/30\ (= 2/3)$ OR $MA = 30/20$ $V_B = 75 \times 2/3\ (= 50)$ (rpm) $VR_{C\ to\ D} = 40/100\ (= 0.4)$ OR $MA = 100/40$ $(V_D = 50 \times 0.4 =)\ 20$ (rpm)	C1 C1 C1 A1	
				[4]	
				[10]	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>3</td><td>(i)</td><td></td><td>
<table>
<tr><td>Shape</td><td>Area</td><td>x_i</td><td>y_i</td><td>a_ix_i</td><td>a_iy_i</td></tr>
<tr><td>Rectangle</td><td>600</td><td>5</td><td>30</td><td>3000</td><td>18000</td></tr>
<tr><td>Triangle</td><td>900</td><td>20</td><td>20</td><td>18000</td><td>18000</td></tr>
<tr><td></td><td>1500</td><td></td><td></td><td>21000</td><td>36000</td></tr>
</table>
$\bar{x} = \frac{21000}{1500} = 14\ (mm)$
$\bar{y} = \frac{36000}{1500} = 24$ (mm)
</td><td>C1
C1
C1

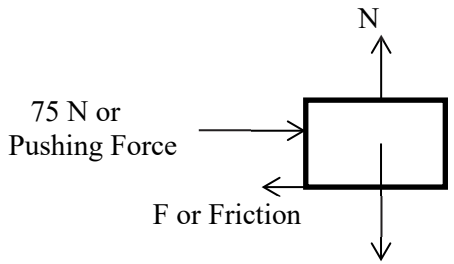
A1
A1</td><td>2 out of 3 correct for Area, x and y for rectangle
2 out of 3 correct for Area, x and y for triangle
Dividing their sum of a_ix_i by their total area, seen for either x or y</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[5]</td><td></td></tr>
<tr><td></td><td>(ii)</td><td></td><td>The forces are not concurrent (because) they do not pass through a single point</td><td>A1</td><td>Accept any equivalent correct statement regarding concurrent.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[1]</td><td></td></tr>
<tr><td></td><td>(iii)</td><td></td><td>Net vertical force = 30 – 60sin20 (=9.47879..)
Net horizontal force = 60cos20 – 50 (=6.381…)

Resultant force = $\sqrt{9.47879..^2 + 6.381..^2}$

= 11 (11.4) (N)</td><td>C1
C1

C1
A1</td><td>Ignore sign but do not condone adding forces
Ignore sign but do not condone adding forces
If only error in components is sin/cos swap award 1 C mark here.
Using Pythagoras with their 2 components
Allow 12 (11.5) if components rounded to 2SF.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>[10]</td><td></td></tr>
</table>

Question			Answer	Marks	Guidance
4	(i)		$(\sum F = ma \quad \rightarrow) \quad 3000 - 600 = 1800a$ a= 1.3 (1.33..) (ms^{-2})	C1 C1 A1	RHS or LHS correct (seen or implied) award C1 All correct award 2 x C1 Synoptic content from Unit 2: 2.3
				[3]	
	(ii)		(Power = Force × velocity = 3000 × 10 =) 30000 W	A1 B1	
				[2]	
	(iii)		$v^2 = u^2 + 2as$ $26^2 = 10^2 + 2 \times 0.8s$ s = 360 (m)	C1 C1 A1	Correct choice of SUVAT equation Values substituted correctly,
				[3]	
	(iv)		(Increase in K.E = $\frac{1}{2}m(v^2 - u^2)$) = $\frac{1}{2}1800(26^2 - 10^2)$ (Final KE =) $\frac{1}{2}1800.26^2$ $(= 608400)$ OR (Initial KE =) $\frac{1}{2}1800(10^2)(= 90000)$ (Increase = 608400 – 90000) = 518400 (J)	C1 A1	Correct calculation for final or initial KE Synoptic content from Unit 2: *2*.4
				[2]	
				[10]	

Question			Answer	Marks	Guidance
5	(a)	(i)		**B2**	B1 if 2 out of 4 forces correct. B2 for all 4 forces correct. Accept horizontal forces going in opposite directions, but friction force must point in opposite sense to the 75N. Arrows must have arrowheads and labels, accept any sensible alternative labels.
				[2]	
		(ii)	(Maximum Friction = μN = 0.27×30×9.8 =) 79N (79.38) Not successful / box does not move.	 **M1** **A1**	
				[2]	
	(b)	**(i)**	Density = $\frac{Mass}{Volume} = \frac{0.160}{\frac{4}{3}\times\pi\times 0.0286^3}$ 1600 (1632.801…) (kgm^{-3})	**C1** **C1** **C1** **A1**	Correct expression for density seen or implied Correct expression for volume seen or implied. Correct substitution seen or implied. Ignore POT for all 3 C marks Question requires answer in kgm^{-3}
				[4]	
		(ii)	(Conservation of momentum → Initial total momentum = Final total momentum 170 × 0.9 (+0) = 170 × 0.027 + 160v *(note that 160g is mass of red ball)* v = 0.93 (0.928) (ms^{-1})	 **C1** **C1** **A1**	C1 for either RHS or LHS correct (seen or implied) Correct statement Consistent use of grams or kg accepted for both C marks. Synoptic content from Unit 1: 1.3
				[3]	
				[11]	

Question			Answer	Marks	Guidance
6	(a)		(Vertical Equilibrium) $R + 10000 = 8000 + 15000 + 300 \times 10.5$ $(R =)$ 16000 (16150) (N)	 **C1** **C1** **A1**	 Statement of vertical equilibrium ignoring self-weight. Self-weight seen in statement or calculated separately (3150N)
				[3]	
	(b)	**(i)**	$R_A = 2200$ (N) $x = 2$ (m)	**A1** **A1**	 Accept 1SF for x in this question. Award 1 mark if both answers incorrect but either $R_A \times 3 = 6600$ OR $3800 \times x = 7600$ seen
				[2]	
		(ii)	Evidence of correct method using force diagram or BM diagram to find either P or y. $(P =)$ 4000 (N) ($2200(3+y) - 2000y = 7600$ or $3800(2+y) - 4000y = 6600$) $(y =)$ 5 (m)	**C1** **A1** **A1**	e.g. Vertical equilibrium equation set up correctly to find P OR taking moments about appropriate point correctly to find x.
				[3]	
				[8]	

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