

Cambridge Technicals Engineering

Unit 3: Principles of mechanical engineering

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

Mark Scheme for June 2019

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

© OCR 2019

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
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.

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.

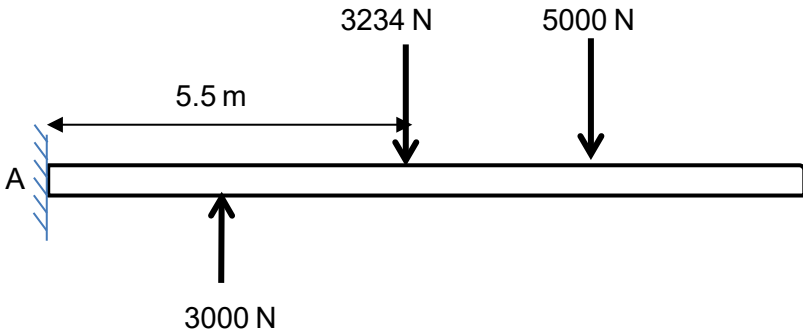
C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down 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/Indicative content	Mark	Guidance
For all questions, units shown in brackets are not required for full marks				
1	(i)	Horizontal: $700\cos 40$ (=536.23...) (N) Vertical: $700\sin 40$ (=449.95....) (N)	B1 B1	
			[2]	
	(ii)	Net vertical force = $500 + 700\sin 40 - 400 = 549.95\dots$ Magnitude = $\sqrt{549.95\dots^2 + 536.23\dots^2}$ = 768.1.. (N)	C1 C1 A1	Ecf their i) Ecf their i) OR their net vertical force. Ecf their i) OR their net vertical force.
			[3]	
	(iii)	(M(A)) = $700\sin 40 \times 1.3 + 700\cos 40 \times 0.6 - 400 \times 1.3$ = 386.675... (Nm)	C2 A1	Award C1 for each correct term (max 2) Accept - 386.675 (taking anticlockwise as +)
			[3]	
	(iv)	$500 \times d = 386.675$ (Distance =) 0.7733... (m) acting downwards	C1 A1	Ecf their part ii) and iii) Their (iii) divided by 500 scores 2 marks.
			[2]	

Question		Answer/Indicative content	Mark	Guidance																								
2	(i)	160 x 90 - 60x120 Or 20x90x2+120x30 Or 160x30 + 20x60x2 =7200 (mm ²) 7200/100 = 72 (cm ²)	C1	An attempt at compound area, allow one slip (eg omission of x 2)																								
		A1	7200 scores 1 mark.																									
			[2]																									
	(ii)	Use of moment of area method, may be seen in vector format, table format or other. <table border="1" data-bbox="360 624 1093 764"> <thead> <tr> <th>Shape</th> <th>Area</th> <th>x_i</th> <th>y_i</th> <th>a_ix_i</th> <th>a_iy_i</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>14400</td> <td>80</td> <td>45</td> <td>1152000</td> <td>648000</td> </tr> <tr> <td>2</td> <td>-7200</td> <td>80</td> <td>30</td> <td>-576000</td> <td>-216000</td> </tr> <tr> <td></td> <td>7200</td> <td></td> <td></td> <td>576000</td> <td>432000</td> </tr> </tbody> </table> $\bar{x} = \frac{576000}{7200} = 80(\text{mm})$ $\bar{y} = \frac{432000}{7200} = 60(\text{mm})$	Shape	Area	x _i	y _i	a _i x _i	a _i y _i	1	14400	80	45	1152000	648000	2	-7200	80	30	-576000	-216000		7200			576000	432000	C1	area and co-ordinates of centroid shown for 1 shape, condone one error
Shape	Area	x _i	y _i	a _i x _i	a _i y _i																							
1	14400	80	45	1152000	648000																							
2	-7200	80	30	-576000	-216000																							
	7200			576000	432000																							
			C1	Area and co-ordinates of centroid shown for second shape, condone one error																								
			C1	The sum of their a _i y _i (or a _i x _i) found and divided by their total area. (Using $\bar{x} = \frac{\sum a_i x_i}{\text{total area}}$ oe for \bar{y})																								
			A1	Both final answers correct																								
				Note candidates may show method only for y co-ordinate as x=80 from symmetry. As long as x=80 stated and y=60 has been calculated correctly award full marks.																								
				One answer correct scores 3 marks.																								
			[4]																									
	(iii)	Volume = 72 x 0.5 = 36 (cm ³) Mass = 36 x 1.05 = 37.8 (g) = 0.0378 (kg) Mass of 800 component = 800 x 0.0378 = 30.24 (kg) Cost = 30.24 x 14 = £423.36	C1	Ecf their area from i).																								
			C1	Ecf their volume																								
			A1																									
			C1	Ecf their mass but must have consistent units																								
			A1																									
			[5]																									

Question			Answer/Indicative content	Mark	Guidance
3	(a)	(i)		C1 A1	Allow 2 errors/omissions. Ignore labelling of Fulcrum. Diagram as shown. Ignore labelling of Fulcrum.
				[2]	
		(ii)	950 x 9.8 = 9310 (N)	A1	
				[1]	
		(iii)	Moments about fulcrum: Either $F_i \times 1.2$ or 9310×0.1 scores C1 mark $F_i = 775.83 \dots$ (N) Or Calculation of MA = $1.2/0.1 = 12$ Use of $F_i = F_o / MA = 9310/12$ $F_i = 775.83 \dots$ (N)	C1 A1 OR C1 A1	(no mark awarded here for calculation of MA as awarded in part iv)
				[2]	
		(iv)	$MA = 9310/775.83 = 12$ or $MA = 1.2/0.1 = 12$	A1	Award this mark if MA calculated correctly in part(iii)
				[1]	
	(b)		Teeth on output = MA x teeth on input = $1.25 \times 60 = 75$	A1	If alternative formula for MA used and answer of 48 seen award as long as formula stated as $MA = \text{teeth input}/\text{teeth output}$
				[1]	
	(c)		Wormgear and wormwheel	A1	Condone any reference to ‘worm’
				[1]	
	(d)		$\frac{x}{2x - 30} = 2 \text{ or } \frac{2x - 30}{x} = \frac{1}{2}$ $x = 4x - 60$ oe $x = 20$ (cm)	C1 C1 A1	Use of VR formula to set up an equation in x
				[3]	

Question		Answer/Indicative content	Mark	Guidance
4	(a) (i)	<p>(A) Self-weight = $30 \times 11 \times 9.8 = 3234$ (N)</p> <p>(B)</p> 	B1 B1	<p>Arrow shown pointing downwards in centre of beam.</p> <p>Accept drawn in centre (by eye) – within 5mm - OR if shown 5.5m from either end or 2.5m away from the 5000N or 3.5m away from the 3000N.</p> <p>Allow marking up of diagram in (a)</p>
			[2]	
	(ii)	Fixed (joint)	A1	
			[1]	
	(iii)	<p>Accept any sensible answer eg</p> <p>Snow load on a roof</p> <p>Cars stood still in traffic on a bridge</p> <p>Wind loading on the side of a building/column</p>	A1	<p>What causes the load needs to be stated (not “objects” for example) AND what load is applied to needs to be stated.</p>
			[1]	
	(iv)	<p>$3234 + 5000 - 3000 = 5234$N</p> <p>upwards</p>	B1 B1	<p>Ecf <i>their</i> part (i)(A)</p> <p>Accept an arrow pointing up</p>
			[2]	

Question	Answer/Indicative content	Mark	Guidance
4 (b)	<p>Reaction at each end = 25000 (N) (symmetry)</p>	<p>C1 C1 A1</p>	<p>Accept if seen marked on diagram (NOT 250000)</p> <p>0 moment at both free ends and a linear diagram</p> <p>As drawn including 125000 correct. Points joined with approximately straight lines. Accept value marked either on y-axis or next to critical point. Condone no units given. If diagram shown is a reflection in x-axis of this award full marks.</p>
		[3]	

Question			Answer/Indicative content	Mark	Guidance
5	(a)	(i)	<p style="text-align: center;">R or N (OE)</p> <p style="text-align: center;">W or mg or $1800g$ or 1800×9.8 or 17640 (OE)</p>	C1 A1	<p>2 or more arrows correct.</p> <p>Arrows must have labels and arrowheads Condone no units indicated Condone appropriate alternative labels eg 'Normal Reaction' instead of N Candidate may draw object travelling left in which case D and the 200 and 300 should be switched round</p> <p>Allow a single arrow of 500 shown instead of 200 and 300 separately (ie can still score 2 marks max)</p>
				[2]	
		(ii)	<p>Use of $v = u + at$ $25 = 20a$ $a = 1.25 \text{ (m s}^{-2}\text{)}$</p>	C1 A1	<p>Correct suvat equation selected and numbers substituted correctly</p>
				[2]	
		(iii)	<p>$\Sigma F = ma$: $D - 200 - 300 = 1800 \times 1.25$ $D = 2750 \text{ (N)}$</p>	C1 C1 A1	<p>Use of $F = ma$ RHS correct LHS correct</p>
				[3]	
		(iv)	<p>Use of $s = \frac{1}{2}(u + v)t = \frac{1}{2}(0 + 25)20$ $s = 250 \text{ (m)}$</p>	C1 A1	<p>Correct suvat equation selected and numbers substituted correctly</p>
				[2]	
		(v)	<p>$F = \mu N : 300 = 1800 \times 9.8 \mu$ $\mu = 0.0170\dots$</p>	C1 A1	<p>Use of $F = \mu N$, accept omission of g for this mark. Allow 0.02</p>
				[2]	

Question			Answer/Indicative content	Mark	Guidance
6	(a)	(i)	$K.E = \frac{1}{2}mv^2 = \frac{1}{2} \times 14 \times 3^2 = 63 \text{ (J)}$	A1	
				[1]	
		(ii)	Momentum before collision = $14 \times 3 = 42$ Momentum after collision = $14 \times 2.25 + 2 \times v$ Momentum before collision = Momentum after collision $14 \times 2.25 + 2 \times v = 42$ $v = 5.25 \text{ (m/s)}$	C1 C1 A1	Either momentum before or momentum after correct scores C1 Correct equation with correct substitution (allow one error/omission) .
				[3]	
		(iii)	Kinetic energy after collision $= (14 \times 2.25^2)/2 + (2 \times 5.25^2)/2 = 63 \text{ (J)}$ Therefore the collision is elastic.	M1 A1	Allow ecf of v from part (ii) Reasonable but incorrect attempt to calculate KE and compare with a(i) can score max 1 mark. Answer must compare KE with their answer to (i) Conclusion must be stated and consistent with their calculations even if conclusion is not elastic
				[2]	
6	(b)		(Change in Kinetic energy =) $0.05 \times 10^2 / 2 - 0$ (Or = 2.5 J) $F \times 0.01 = 2.5$ $(F = 2.5 / 0.01) = 250 \text{ N}$	C1 A1	If KE calculated incorrectly but F = their KE/0.01 award C1
				[2]	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning

Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553

© OCR 2019

