OCR
Oxford Cambridge and RSA

Cambridge Technicals

Engineering

Unit **3**: Principles of mechanical engineering

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

Mark Scheme for June 2018

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.

Annotations

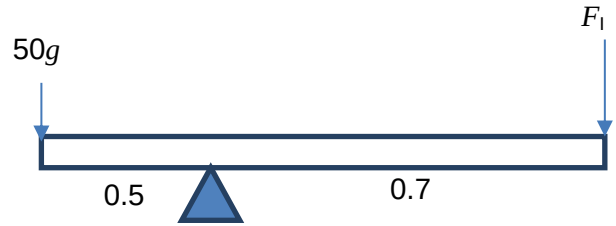
Annotation	**Meaning**
tick	Correct response worthy of a mark. Number of ticks = number of marks awarded.
cross	Incorrect response
Omission mark (carat)	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
POT	Power of ten error
RE	Rounding error
SF	Significant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

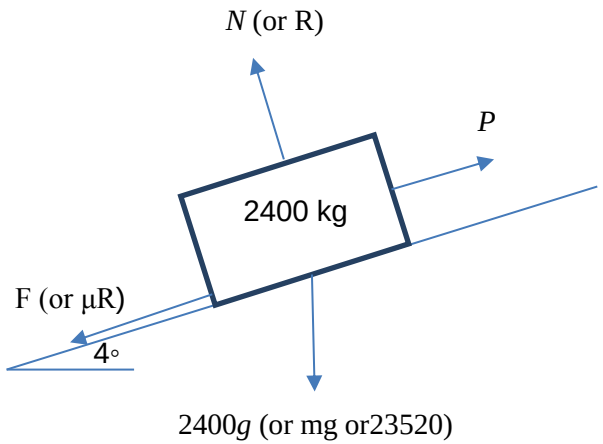
If the data given in a question is to 2 sf, then allow to 2 or more significant figures. If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Penalise a rounding error in the second significant figure once only in the paper.

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
1	(a)	(i)		C1 A1	As for A1 but allow one error or omission. Class 1 lever drawn with Input force and load shown and labelled. Allow sensible labels eg 50g, 50x9.8, 490(N) etc. Do not award if only mass shown. At least one distance labelled. Allow reaction force shown acting upwards instead of / in addition to fulcrum.
				[2]	
		(ii)	F_I x 0.7 = 490 x 0.5 F_I = 350 (N)	C1 A1	Award if 50 used instead of 490 (mass instead of weight) No ecf mass used. (Award 1 mark if 35.7(1) is seen)
				[2]	
		(iii)	(VR = b/a = 0.5/0.7 =) 0.714	A1	Allow 0.5/0.7 or 5/7
				[1]	
	(b)		Nutcracker, wheelbarrow, bottle-opener	A1	Accept any sensible answer
				[1]	
	(c)		Accept reasonable answers eg:When the direction of the input gear should not be reversed/Where a high MA is needed /It is more compact/smaller than spur gears/ 90 degree change in direction.	A1	eg rotation should only occur in one direction, or the output gear should not drive the input gear Accept reference to high ‘gear ratio’ or ‘force ratio’ Allow reference to higher (maximum) torque
				[1]	
	(d)		To allow greater torque /To prevent slippage (which can occur with a flat belt)	A1	Accept any sensible reference to slippage
				[1]	
	(e)	(i)	(VR=)product of drivers/product of driven / (40x60)/(60x30) = 1.3(3) OR VR A to B = 40/60 (= 2/3) AND/OR VR B to C = 60/30 (= 2) (Overall VR = 2/3 x 2 = 1.3(3))	C1 A1 (C1) (A1)	Use of formula for overall VR Allow 4/3
				[2]	
		(ii)	($V_i = V_O$/VR= 90/ (4/3))= 67.5 (rpm) Accept ECF from i	A1	VR = V_O/V_i (accept answers in range upto 69.23)
				[1]	

Question			Answer/Indicative content	Mark	Guidance
2.		(i)		C1 A1	Award 1 mark if maximum 1 mistakes/omissions All forces shown correctly with arrowheads and with sensible labels. Normal reaction approximately at right angles to slope (not vertically upward) Allow any sensible shape used for object (van, dot, circle etc) Labelling of angle is not required.
				[2]	
		(ii)	(*N* =) 2400*g*cos4 / 23463 (*F*=*μN* =) 0.3 x 23463 = 7038.8 (N)	C1 C1 A1	allow mass used instead of weight allow FT of calculated N
				[3]	
		(iii)	∑F=ma up slope (look for use of formula) allow ecf from ii 10000-7038.8 – 2400gsin4 = 2400a (soi) allow ecf from ii (a=) 0.55(ms^{-2})	C1 C1 A1	Award max 1 mark if weight omitted or incorrect. 1.16 scores 2 marks
				[3]	
		(iv)	($v^2 = u^2 + 2as$ =) 9.2^2 + 2 x 0.9 x 75 (=219.64) v = 14.8 (ms^{-1})	C1 A1	
				[2]	
		(v)	Initial KE = 101568 (J) OR Final KE = 262848(J) soi (Increase in K.E = $\frac{1}{2}mv^2 - \frac{1}{2}mu^2$ =$\frac{1}{2}2400 \times 14.82^2 - \frac{1}{2}2400 \times 9.2^2$) =16128 (J)	C1 A1	Allow ECF from iv Allow ECF from iv
				[2]	

Question			Answer/Indicative content	Mark	Guidance
3	**(a)**	**(i)**	Area = 300 x 50 + 300 x 80 + 60 x 300 OR Area= 300 x 430 – 2 x 300 x 120 =57000 (mm^2) = 0.057 (m^2)	C1 C1 A1	Allow conversion to m
				[3]	
		(ii)	(Volume =) 0.057x14 = (0.798m^3). (0.057 x 14 x 8000) = 6384 (kg)	C1 A1	Allow ecf from (i)
				[2]	
		(iii)	(Change in length = strain x original length = 8 x 10^{-4} x 14 =) 0.0112 (m)	 A1	
				[1]	
		(iv)	The material would undergo permanent / plastic deformation	B1	
				[1]	
	(b)		Area = Force/stress = 120x10^3/200x10^6 =0.0006 (m^2) / 600 (mm^2)	C1 A1	Correct use of formula. Allow errors in units (eg 120/200)
				[2]	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td></td><td>(Vertical equilibrium:) Psin40+20sin60
(P=) 50.8(N)
(Horizontal Equilibrium:) Pcos40=Q + 20cos60
(Q=)28.9(N)</td><td>C1
A1
C1
A1</td><td>

Allow FT from their P (or Q)</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>Use of 1st moment of area method, may be seen in vector format, table format or other.

<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>1</td><td>1.92</td><td>0.6</td><td>0.8</td><td>1.152</td><td>1.536</td></tr>
<tr><td>2</td><td>1.2</td><td>1.7</td><td>0.6</td><td>2.04</td><td>0.72</td></tr>
<tr><td></td><td>3.12</td><td></td><td></td><td>3.192</td><td>2.256</td></tr>
</table>
OR
<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>1</td><td>2.64</td><td>1.1</td><td>0.6</td><td>2.904</td><td>1.584</td></tr>
<tr><td>2</td><td>0.48</td><td>0.6</td><td>1.4</td><td>0.288</td><td>0.672</td></tr>
<tr><td></td><td>3.12</td><td></td><td></td><td>3.192</td><td>2.256</td></tr>
</table>
$\bar{x} = \frac{3.192}{3.12} = 1.023(m)$
$\bar{y} = \frac{2.256}{3.12} = 0.723$(m)</td><td>C1

C1

A1

A1</td><td>Area and co-ordinates of centroid shown for any 1 shape,

The sum of their a_ix_i (or a_iy_i) found and divided by their total area. (Using $\bar{x} = \frac{\sum a_i x_i}{total\ area}$ oe for $\bar{y}$)</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>Net horizontal force = 15-12cos30 (=4.607…)
Net vertical force = 10-12sin30 (=4)

Magnitude = $\sqrt{4.607..^2 + 4^2}$

= 6.1 (N)</td><td>C1
C1

C1

A1</td><td>Attempt to find net horizontal force
Attempt to find net vertical force

Allow FT. Pythagoras used with their horizontal and vertical components
Allow FT</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Moment = 15x0.8 + 10x0.2
=14 (Nm) (anticlockwise)</td><td>C1
A1</td><td>Allow one error in distance</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td></tr>
</table>

Question			Answer/Indicative content	Mark	Guidance
5		(i)	(Work = average power x time =) 5000 x 30 =150 000 **J** / 150 **kJ**	C1 A1	Use of equation – ignore POT errors Maximum 1 mark if unit not stated.
				[2]	
		(ii)	(Force = Work/distance =150 000/600) = 250 (N)	 A1	 Allow ecf from (i)
				[1]	
		(iii)	(Increase in K.E = $\frac{1}{2}250 \times (28^2 - 5^2)$) = 94875 (J) ($Work_{engine}$ – $Work_{resistance}$ = Increase in K.E) 150 000 – W = 94875 W=55125 (J)	C1 C1 A1	Calculating increase in K.E Allow FT from iii. Ignore sign errors. Award 2 marks for correct answer from use of F=ma and suvat
				[3]	
6	(a)	(i)	(Self-weight = 350 x 8 =) 2800N (acting at centre of beam) soi $\sum M(A)=0$; R_b x 8 - 800 x 1 - 600 x 6 – 2800 x 4 = 0 R_b= 1950(N) (upwards) $\sum M(B)=0$; OR Vertical equilibrium: $R_a + R_b = 800 + 600 + 2800$ R_a = 2250 (N) (upwards)	C1 C1 A1 C1 (C1) A1	Total self-weight calculated and evidence of point load acting at centre of beam (may be implied by later working) Attempting moments about A and equating to 0. Allow one missing or incorrect term. Attempting moments about B and equating to 0. Allow one missing or incorrect term. Allow ecf of their R_a or R_b. ALLOW FT OF SELF WEIGHT THROUGHOUT
				[5]	
		(ii)	Pin-joint or Pin-support	A1	
				[1]	
		(iii)	200 (N), to the left, at support B	A1	
				[1]	
	(b)		A column being supported by a beam A counterweight on a crane-arm Vehicle on bridge	A1	Allow sensible examples but must be acting on a structure that can be modelled as a beam.
				[1]	

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