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 January 2018

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

1. **Annotations**

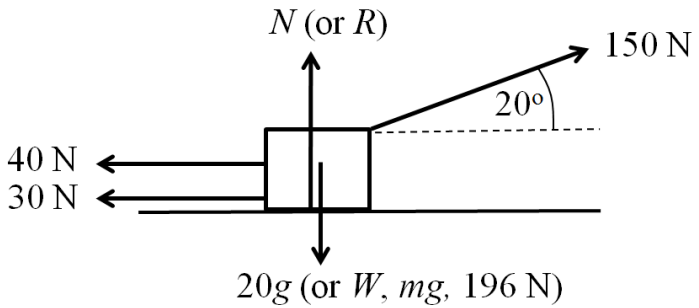
Annotation	**Meaning**
tick	Correct response worthy of a mark. **NB Number of ticks = number of marks awarded.**
cross	Incorrect response
Omission mark (carat)	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
POT	Power of ten error
CON	Contradiction
RE	Rounding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

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.

2. **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	(i)			A2	Award 1 mark if 3/5 arrows correct Arrows must have arrowheads and connect to box Allow 30N and 40N put as one arrow with label of 70N Allow tension resolved into vertical and horizontal components (as in part ii)) Allow any sensible labels used (eg normal reaction written instead of N, or friction instead of 30).
	(ii)		Horizontal component = 150cos20 (= 140.95) (N) Vertical component = 150sin20 (= 51.30) (N)	B1 B1	Allow correct expressions shown in 1i If answers wrong way around award 1 mark
	(iii)		Vertical Equilibrium: N+51.303=20*g* (N = 20×9.8-51.303 =) 144.69…(N)	C1 A1	Award attempt at equilibrium eg N=20*g* Accept answers rounding to 145N. Allow ECF from part ii)
	(iv)		Use of F = ma: 140.95-30-40 = 20a a=3.547.. ms^{-2}	C1 A1 B1	Award this mark for attempt using incorrect force. Accept answers in range 3.5-3.6.

Question			Answer/Indicative content	Mark	Guidance
2	(a)	(i)	(Overall VR=$\frac{product\ of\ drivers}{product\ of\ driven}$) or VR=$\frac{50x75}{20x25}(=7.5)$	C1	Correct method attempted
			(Rotational speed of D =) 120 x 7.5	C1	Allow ECF for calculated VR
			900 (rpm)	A1	
			Or		
			For A to B: VR= 50/20 = 2.5 or Speed of B = 120 x 2.5= 300 (Speed of C= 300rpm)	(C1)	For first velocity ratio
			For C to D: VR= 75/25 = 3 Speed of D = 3 x 300 = 900 (rpm)	(C1) (A1)	For 2nd VR
		(ii)	Use of Overall VR Formula $\frac{nx75}{20x25}=9$	C1	Allow alternative valid method
			N=60	A1	
	(b)		Any valid example, e.g.: • In a railway to allow trains to travel uphill • In the steering mechanism of a car • To open lock gates in canals • In a stairlift (the rack runs up the stairs and the pinion is on the lift part)	B1	Specific application must be clear do not allow one word answers such as car or train
	(c)	(i)	Class 2	A1	
		(ii)	(250x2.1=Load x 0.6) = 875 (N)	A1	Accept 89kg (or 89.3kg)
		(iii)	(MA = F_o/F_i=875/250 =) 3.5 **Or** (MA = a/b = 2.1/0.6 =) 3.5	A1	Allow ECF from c)ii)
	(d)		800/2.5 = 320 (mm)	B1	Accept answers of 0.32 (candidate converted units to m)
	(e)		The MA halves	B1	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>3</td><td>(a)</td><td>(i)</td><td>90sin30x5 + 20x10 - 40x5
=225 (clockwise)

Nm</td><td>C1
A1

B1</td><td>award C1 if 2 components correct
Allow answers of -225Nm (this is given answer if anti-clockwise take as positive).</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Resultant vertical force = 90cos30 + 20 (= 97.942…(N))
Resultant horizontal force = 90sin30 – 40 (= 5 (N))

Magnitude = $\sqrt{97.942^2 + 5^2} = 98.1\ (N)$</td><td>C1
C1

A1</td><td>

Allow ecf from component Force values</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>$F_C \times 5 = 225$ / $F_C = 45$ (N)
Horizontal force applied at corner C towards corner B</td><td>B1

B1</td><td>Allow Ecf from part i)

Accept “left”. Accept arrow pointing left</td></tr>
<tr><td>4</td><td>(a)</td><td>(i)</td><td>Use of second 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>21600</td><td>60</td><td>90</td><td>1296000</td><td>1944000</td></tr>
<tr><td>2</td><td>-400π</td><td>90</td><td>150</td><td>-113097</td><td>-188496</td></tr>
<tr><td></td><td>20343.36</td><td></td><td></td><td>1182903</td><td>1755504</td></tr>
</table>
$\bar{x} = \frac{1182903}{20343.36} = 58.14\ldots\ (mm)$
$\bar{y} = \frac{1755504}{20343.36} = 86.29$ ...(mm)</td><td>C1

C1

C1

A1
A1</td><td>Area and co-ordinates of centroid found for first shape (numbers 21600, 60, 90). Award if 2/3 correct.

Area and co-ordinates of centroid found for second shape (numbers -400π, 90, 150). Award if 2/3 correct.

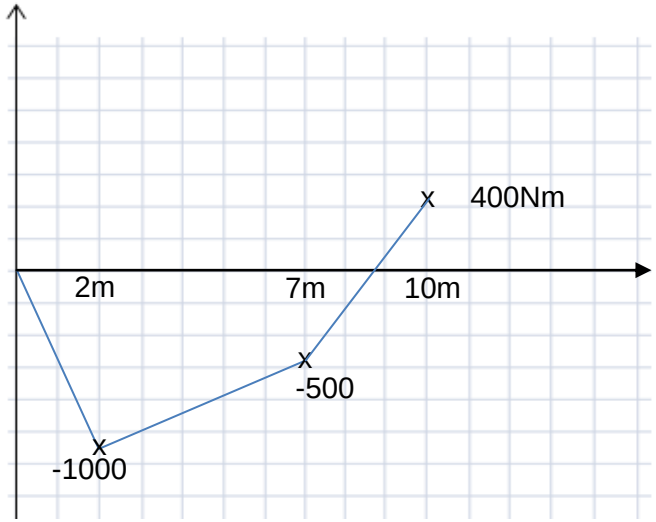
The sum of their a_ix_i (or a_iy_i) found and divided by their total area. (Using $\bar{x} = \frac{\sum a_ix_i}{total\ area}$ oe for $\bar{y}$)

Correct answers for $\bar{x}$ and $\bar{y}$ rounding to 58 and 86 respectively to 2 s.f.</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Calculating moment of weight of plate about C
80x58.1= 4648 (Nmm)
Force = 4648/120 = 38.7 (N)</td><td>C1

A1</td><td>Allow Ecf from part i).</td></tr>
<tr><td></td><td>(b)</td><td></td><td>Use of formula change in length = strain x original length
=0.002 x 1.8
Change in length = 0.0036 (m)</td><td>C1

A1</td><td>Allow strain = 0.02</td></tr>
</table>

Question			Answer/Indicative content	Mark	Guidance
5	(a)		Vol = $\pi r^2 h = \pi$ x 0.07^2 x 0.8 (= 0.012315) Density = mass/volume = 105/0.012315 = 8526 kg/m^3	C1 A1 B1	Allow ECF of their value of volume.
	(b)	(i)	Use of SUVAT with u=0, a=9.8, v=7.5 and equation $v^2=u^2+2as$ $7.5^2 = 0 + 2x9.8s$ s=2.869…(m) **or** use of result v=$\sqrt{2gh}$ and rearranging to get h=2.869…(m)	C1 A1 (C1) (A1)	Allow one error (eg a=-9.8)
		(ii)	(Kinetic Energy = $\frac{1}{2}mv^2 = \frac{1}{2} \times 100 \times 7.5^2 =) 2812.5\ (J)$	A1	
		(iii)	(Potential Energy = $mgh = 100 \times 9.8 \times 0.3 =) 294\ (J)$	A1	
		(iv)	Work done = (change in energy = 2812.5+294 =) 3106.5 (J) (Force = work/distance = 3106.5/0.3 =) 10355 (N)	C1 A1	Allow ECF of their value of work done.
	(c)	(i)	Area = 30x25 - $4\pi x2^2$ = 699.7… (mm^2)	C1 A1	Allow 1 error (eg using given diameter of 4 instead of radius or forgetting to multiply area of circle by 4)
		(ii)	(15, 12.5)	A1	Accept centroid of plate

Question			Answer/Indicative content	Mark	Guidance
6	(a)		Encastre	A1	Allow reasonable spelling errors
	(b)	(i)	300 (N) (downwards)	A1	
		(ii)	Attempt to calculate moment = 200x3 + 600x8 – 500x10 = 400 (Nm)	C1 A1	Allow max 2 errors in sign or distance Allow -400
		(iii)		C1 C1 C1 A1	0 moment at free end (0m along beam from LHS) AND non-zero value at wall end AND no curves. Calculation of moment at 2m (-500x2=-1000) ignoring signs. This can be stated or shown on diagram. Calculation of moment at 7m (-500x7+600x5=-500) ignoring signs. This can be stated or shown on diagram. Diagram as shown. Allow opposite sign convention so that diagram is reflected about x-axis. Allow values marked on axes or at critical values
	(c)		Attempt at conservation of momentum 3x2.4 - 5x1.8 = -3x0.5 + 5v (-1.8 = -1.5 + 5v) v= 0.06 (ms^{-1}) in same direction as initial velocity (may be shown as arrow).	C1 C1 A1	Allow max 2 errors in sign or terms. Award this mark for a single sign error followed through correctly No ECF

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