Cambridge Technicals
Engineering

Unit 3: Principles of mechanical engineering

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

Mark Scheme for January 2022

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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.

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.

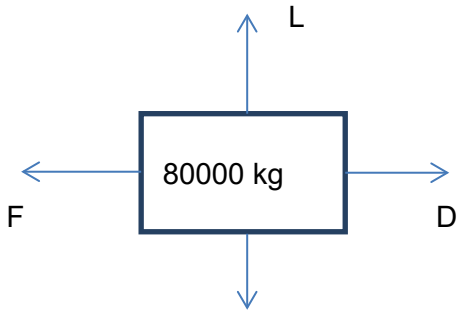
C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down 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.

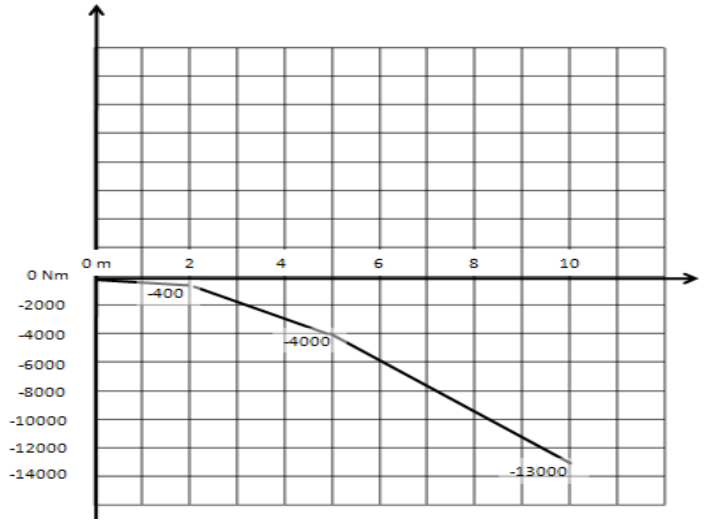
Question			Answer/Indicative content	Mark	Guidance
1	(a)	(i)	Horizontal: 400cos40 or 310 (306.4 N) Vertical: 400sin40 or 260 (257.1 N)	A1 A1	If vertical and horizontal components given in wrong order (swapped) then award C1. If both expression seen in incorrect equations award 1 mark.
				[2]	
		(ii)	M(A) = 200x5 – 250 x9 – 400cos40x5 + 400sin40x9 = (-) 468 Nm (clockwise)	C1 C1 A1	At least 3 correct terms, ignore signs All terms correct and signs consistent Ignore +/-. No/incorrect units scores max 2 marks.
				[3]	
		(iii)	At point C the forces are all concurrent or The forces all meet at/ pass through a single point/ C or The forces all point directly to/away from the pivot /C or Correct statement using resultant (force).	A1	Allow each force.
				[1]	
	(b)		P= 300sin50 or Q + 180 = 300cos50 P = 229.8 (N) Q = 12.8 (N)	C1 A1 A1	Allow any valid equation for horizontal forces ignore sin/cos error.
				[3]	

Question			Answer/Indicative content	Mark	Guidance
2	(a)		Any 3 of: spur gears, compound spur gears, chain-driven sprockets, bevel gears, rack and pinion, worm(gear) and (worm)wheel	B3	1 mark each Allow Belt and Pulley
				[3]	
	(b)		(MA = 1/VR = 1/0.4 =) 2.5	A1	
				[1]	
	(c)	(i)	Class 2	A1	
				[1]	
		(ii)	(F_{out} = MA x F_{in} =) 2.5 x 2000 or 5000(N) Mass = 5000/9.8 = 510.0 (kg)	C1 A1	If 10 used for g, max 1 mark OR ecf their Fout max 1 mark
				[2]	
		(iii)	(MA = a/b so) b = 2.5 x 0.6 or 1.5 (m) x = 0.9 (m)	C1 A1	
				[2]	
	(d)		(Arc length = rθ) r = 80 / (π/3) (= 76.39...(mm)) d = 152.78.. (mm) VR = 120/152.78.. = 0.785	 C1 A1 A1	 Use of arc length formula ecf their diameter. Accept answers rounding to 0.8.
				[3]	

Question			Answer/Indicative content	Mark	Guidance
3	(a)		x = 70 (mm) y= (4 x 70 / 3π =) 29.7 (mm)	B1 B1	If x and y transposed or if only the 2 values are seen award C1. (70, 29.7) scores 2 marks.
				[2]	
	(b)		x=20 (mm) y=25 (mm)	B1 B1	If x and y transposed or if only the 2 values are seen award C1. (20, 25) scores 2 marks.
				[2]	
	(c)	(i)	Area = 50 x 240 + 30 x 240 + 200 x 40 Calculated value consistent with their workings = 0.0272 (m^2)	C1 C1 A1	Allow one error. Allow conversion to m. May be split up differently. allow their area in mm. Award max 2 marks for <u>any</u> POT error (including 27200).
				[3]	
		(ii)	Vol = 0.0272 x 9 or 0.2448 (m^3) Mass = (0.2448 x 8000 =) 1958.4 (kg)	C1 A1	ecf their area ecf their area and volume
				[2]	
		(iii)	F = Stress x Area =150 x 10^6 x 0.0272 = 4080000 (N)	C1 A1	ecf their area, allow incorrect units eg 150 used
				[2]	

Question			Answer/Indicative content	Mark	Guidance
4	(i)		 80000g or W or mg or 800000x9.8	C1 A1	Award C1 for 3 forces correct Diagram correct Plane may be shown travelling to the right, so F and D reversed All arrows must have arrowheads and labels Allow forces written in words instead of letters, eg Lift instead of L, as long as terms in question stem used Allow arrows on opposite faces correct direction and labelling.
				[2]	
	(ii)		Vertical equilibrium: L = 80000 x 9.8 L = 784,000 (N)	C1 A1	attempting vertical equilibrium eg L = 80000 or 80000x10
				[2]	
	(iii)		144 kmh^{-1} = 144 x 1000/3600 (= 40 (ms^{-1})) Use of suvat with a=0.3, s=2000 (or 2), u = 40 (or 144) and equation $s=ut + ½ at^2$ $2000 = 40t + 0.15t^2$ or $0.15t^2 + 40t – 2000 = 0$ t = 43.1 (s)	C1 C1 C1 A1	Converting speed to appropriate units Correct suvat equation chosen/seen and values of a, s and u stated/seen. Allow u = 144 and s = 2. Correct substitution (allow correct rearrangement). Do not award if negative solution (-309.7) not discounted MAX 2 marks if 144 used.
				[4]	

Question			Answer/Indicative content	Mark	Guidance
	(iv)		F=ma used F – 70000 = 80000 x 0.3 F = 94000(N)	C1 C1 A1	Attempt to use F=ma with values for m and a substituted correctly. Correct elements and signs in equation
				[3]	
	(v)		P =Fv = 94000 x 40 OR 3,760,000 (W)	A1	ecf their F (from (iv) and allow 144 for v.
				[1]	
5	**(a)**		i) UDL ii) UDL iii) Point Load	A1	All 3 must be correct
				[1]	
	(b)	**(i)**	Cantilever	A1	Allow minor spelling error
				[1]	
		(ii)	(200 + 1000 + 600) = 1800 (N)	B1	
				[1]	
		(iii)	(-) [200 x 10 + 1000 x 8 + 600 x 5] = (-) 13000 (Nm)	C1 A1	2 out of 3 terms correct. Ignore signs. Accept +/-
				[2]	

Question			Answer/Indicative content	Mark	Guidance
		(iv)		C1 C1 C1 A1	Zero bending moment at 0m, non-zero value at 10m, and linear diagram Moment at 2m (= (-)200 x 2) = (-) 400 (Nm) Moment at 5m (= (-) [200 x 5 + 1000 x 3]) = (-) 4000 (Nm) All values correct, signs consistent (all positive or all negative), points connected with straight lines (award for intent), ecf their iii). If opposite sign convention used diagram will be reflected in x-axis, award full marks for this. Allow diagram not to scale for 10m point only.
				[4]	
6	**(i)**		Conservation of momentum formula with at least 3 correct terms. Ignore incorrect directions. $1.5 \times 4 + 0.5 \times -2 = 1.5 \times 1 + 0.5v_B$ $v_B = 7$ (ms^{-1}) same direction as A (or opposite to initial motion)	C1 C1 A1 A1	Allow momenta shown on diagram before and after collision. All 4 terms correct, with consistent signs. Allow correct diagram showing direction.
				[4]	
	(ii)		Initial K.E = $0.5 \times 1.5 \times 4^2 + 0.5 \times 0.5 \times 2^2 = 13$ (J) Final K.E = $0.5 \times 1.5 \times 1^2 + 0.5 \times 0.5 \times 7^2 = 13$ (J) collision is elastic (or inelastic if consistent with calculations.)	C1 C1 A1	Must see evidence to support statement. NO CALCULATIONS – NO MARKS.
				[3]	

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