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 2016

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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. 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.

2. **Subject-specific marking instructions**

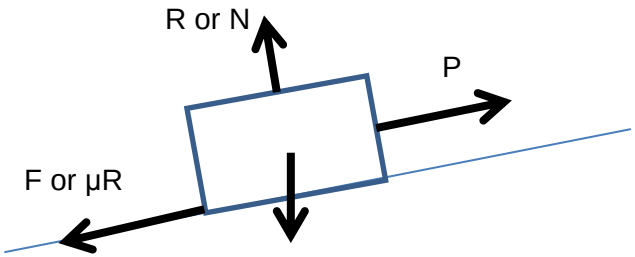
B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

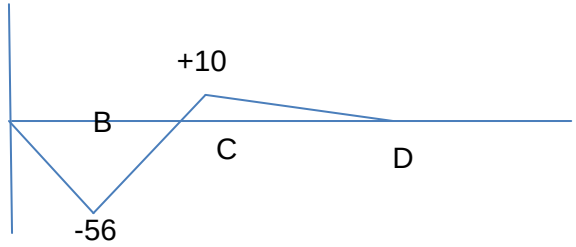
M marks: These are method marks upon which **A**-marks (accuracy/answer marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

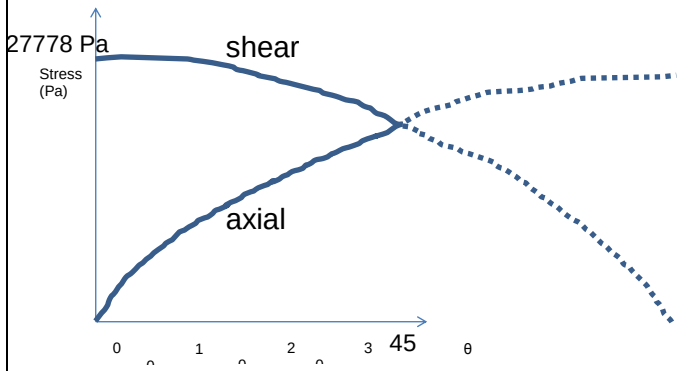
C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down 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	Marks	Guidance
1	(a)		Total area = 55x50 + $\frac{1}{2}(25 \times 50)$ = 3375 (mm^2)	C1	Award if 3375 used in later calculations
			First moment of area: 3375$\bar{x} = 625(2 * 25/3)$ + 2750(25+55/2) First moment of area: 3375$\bar{y} = 625(50/3)$ + 2750(25) $\bar{x} = 45.9(mm)$ $\bar{y} = 23.5(mm)$	C1 C1 A1 A1	Allow ecf for incorrect area Allow ecf for incorrect area Possible ecf for area Possible ecf for area
	(b)	(i)	Resolve horizontally F_H = 20cos40 + 12 or 27.3 (kN) Resolve vertically F_V = 20sin40 – 5 or 7.86 (kN) Magnitude = $\sqrt{27.32^2 + 7.856^2} = 28.4\,(kN)$	C1 C1 A1	Alternatively allow C1 for correct resolution of the 20kN force into <u>horizontal and vertical</u> components. Award 1 mark for correct calculation of magnitude using 2 incorrect components and 2 marks for 1 incorrect component.
		(ii)	Tanθ=7.8558/27.321 or 16.0 (°)	A1	Accept suitable rounding – expect answers between 15.9 and 16.1° Some candidates will correctly use sin/cos using values from bi
		(iii)	M = 12x50 + 5x80 or 1000 (Nm) (anticlockwise)	A1	

Question			Answer	Marks	Guidance
2	(a)	(i)	 1200g or equivalent Accept W or weight Don't accept gravity or g	A2	Arrowheads required on arrows Allow arrows not touching box Allow box drawn as car shape or any other sensible equivalent Car represented as point scores maximum 1 mark R must be at right angles to slope (by eye) mg must be vertically downwards (by eye) F can be shown anywhere on left edge of box Allow 1 mark for 3 of 4 forces drawn and labelled correctly OR for 4 forces drawn correctly without labels (ignore incorrect labels).
		(ii)	R / N = 1200gcos5 or 11715 (N) F (=μR) = 0.15 x 11715 or 1757 (N)	C1 A1	
		(iii)	3500 – 1757 -1200gsin5=1200a or 718.05 = 1200a a=0.598 (ms^{-2})	C2 A1	Award 1 of 2 for correct right hand side and minimum 2 of 3 terms on left hand side Possible ecf from (ii) Allow appropriate rounding.
	(b)	(i)	$v^2 = u^2+2as$ or $0^2=26.8^2 + 2 \times a \times 55$ a = (-) 6.53 (ms^{-2})	C1 A1	Accept positive or negative answer (Applying knowledge from Unit 2 LO2)
		(ii)	(Average) power (= work done/time) = 334 000/4.1 or 81463(W) or 81.5 (kW)	A1	(Applying knowledge from Unit 2 LO2)

Question			Answer	Marks	Guidance
3	(a)	(i)	A = 102x7x2 + 240x6 or 2868 (mm^2) 2.868 x 10^{-3} m^2 or 0.002868m^2	C1 A1	If incorrect area calculation in mm^2 award max 1 mark for correct conversion to m^2 or if all linear dimensions correctly converted (Applying knowledge from Unit 2 LO2)
		(ii)	Volume (= area x length) = 2.868 x 10^{-3} x 12 or 0.034416 Mass (= density x volume) = 0.034416 x 8000 =275.33kg	C1 C1 A1	 Allow (0.034x8000 =) 272kg
	(b)		M(B) = 14 x 4 or 56 (kN) M(C) = 25x6 – 14x10 or 10 (kN) M(A) = 0 M(D) = 0 Correct B.M.D showing values at B and C  	C1 C1 C1 C1 A1	Allow -56 Allow -10 but must be opposite to M(B) Allow shown on diagram Allow shown on diagram Allow. reflection of correct diagram in x-axis Allow values not on diagram

Question			Answer	Marks	Guidance
4	(a)	(i)	Parallel component = 2000sin30 or 1000 (N) Perpendicular component = 2000cos30 or 1732 (N)	A1 A1	(Applying knowledge from Unit 1 LO4)
		(ii)	M (= 1732 x 3.5) = 6062 Nm	A1	Must include correct unit Possible ecf from **4(a)(i)** relating to perpendicular component
	(b)	(i)	A= 400x500 – 400x320 = 72000 (mm^2) Shear stress (= shear force ÷ area = 2000÷0.072) = 27778 Pa or N/m^2	C1 A1	Allow ecf for incorrect area. Question says "state units" so apply POT error if unit not correct or if no unit given.
		(ii)		M1 A1	Award 1 mark for shear stress starting at answer to (b) (i) and decreasing, and axial stress starting at 0 and increasing For 2 marks lines must also have approximate shape of sin/cos graphs, crossing when $\theta = 45$.
	(c)	(i)	Attempt to calculate gradient of straight line section of graph or picking two suitable values and using formula to calculate Young's Modulus using values upto $240x10^6 \div 0.0012$ $= 2 \times 10^{11}$ Pa Equivalent answers e.g. 200 GPa or 200 000 MPa	C1 A1	Accept 2×10^{11} with no units. Otherwise apply POT error if unit not consistent with value or if no unit given (Applying knowledge from Unit 2 LO4)

Question			Answer	Marks	Guidance
		(ii)	Elastic deformation	B1	Any reasonable reference to elasticity acceptable (Applying knowledge from Unit 2 LO4)
5	(a)		Gear changing system on a bike Other possibilities: gear systems in other motor vehicles eg motorcycles caterpillar tracks in some tanks or diggers/construction vehicles	B1	Any sensible answer Needs to be a specific application e.g. chain saw drive, bicycle gears, transmitting rotary motion, gear changing system, do not allow one-word answers e.g. car, chain-saw, bicycle.
	(b)		A: Bevel Gear	B1	
	(c)	(i)	Class 1 Lever	B1	
		(ii)	F_{in} x 3 = 360 x 0.5 F_{in}= 60(N) MA (=F_O/F_I = 360/60) = 6	C1 A1 A1	Allow ecf for F_{IN}
	(d)	(i)	B: Anti-clockwise C: Anti-clockwise D: Clockwise	A1	All 3 directions must be correct
		(ii)	Velocity of B (= Velocity of C = 800 x 32/16) = 1600 (rpm) Velocity of D (= 1600 x 42/12) = 5600 (rpm)	C1 A1	
		(iii)	5600/800 or 7	A1	Allow ecf from d(ii) Allow 1:7

Question			Answer	Marks	Guidance
6	(a)	(i)	Loss in P.E. = mgh =80 x 9.8 x 8 or 6272(J)	A1	
		(ii)	increase in K.E (= ∆gpe – work done) = 4272 (J) = = ½ x 80 x v^2 v=10.3 (ms^{-1})	C1 C1 A1	Award 1 if 2 of 3 terms correct (ecf from ai) Award both marks here if only error is error carried forward from part (a)(i) (Common incorrect answer ignoring delta gpe gives 7.07 m/s – award 1 mark)
		(iii)	horizontal component u=10.3cos25 or 9.335ms^{-1} (or 9.375 if using v = 10.344) s (= ut = 9.063 x1.8) = 16.9 (m)	C1 A1	Allow ecf from (ii) (Applying knowledge from Unit 1 LO4) Allow 16.8. No ecf for horizontal component u. (11.534 if 7.07 is used)
	b)	i)	($m_1u_1+m_2u_2=(m_1+m_2)v$) 300 x0.8 = (300+80)v v = 0.632 (ms^{-1})	 C1 A1	
		ii)	Total loading = 1.8x2100 + 2000 or 5780 (N) (2T=5780) T=2890 (N)	C1 A1	

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