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 2017

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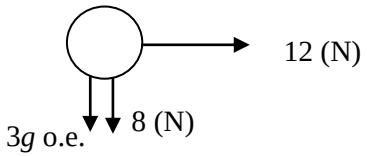
This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

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.

Question			Answer/Indicative content	Mark	Guidance
1		i)	$A = \pi \times 10^2 - \pi \times 7^2$ 160 (160.22 – 160.3)	C1 A1	Method mark for use of circle formula to calculate area of smaller and larger circle. Condone no explicit indication of subtraction. Ignore units
		ii)	$(160 \div 1000^2)$ $= 1.6 \times 10^{-4}$ (m^2) or 0.00016	 A1	Allow ECF part i) Ignore units
		iii)	14000 ÷ 0.00016 = 87000000 N/m^2 or Pa or equivalent OR 14000 ÷ 160.22 = 87.4 N/mm^2 or MPa	C1 A1	 Correct unit required for second mark. Allow 88000000 N/ m^2
		iv)	(Change in length =)50 – 49.978 (= 0.022) Strain = change in length ÷ original length = 0.0022/50 4.4×10^{-4} or 0.00044	C1 A1	Method mark calculation of change in length. Maximum 1 mark if unit shown Synoptic mark from Unit 2:LO4
		v)	$E = \frac{\sigma}{\varepsilon} = \frac{87390762}{0.00044} = 1.986 \times 10^{11}$ Pa or 199 GPa	C1 A1	Numbers substituted into formula. Allow ECF from parts iii & iv Correct calculation – correct unit required
		vi)	iii) smaller iv) smaller v) unchanged	A1	All must be correct for 1 mark.
2		i)	$v^2 = u^2 + 2as$ $0 = 13^2 + 2 \times (-9.8)s$ *or* $0 = 169 - 19.6s$ s = 8.6 m (8.62 for 9.8, 8.61 for 9.81)	 C1 A1	Selection of correct equation and input of correct values for u, v and a. Allow omission of negative sign in front of a for this mark. Ignore sign with BOD
		ii)		A2	Force arrows must have arrowheads. Allow Force arrows not connected to object. Accept any sensible object shape (eg box/rocket/dot etc). 12 N force must be horizontal, can point to left or right 3*g* force and 8 N must both be shown acting downwards. Acceptable equivalents for 3g include mg, 29.4, W, 3 × 9.8 Award 1 of 2 marks for 2 out of 3 forces correct. OR 1 mark for horizontal force drawn and labelled correctly and single vertical resultant drawn and labelled correctly.

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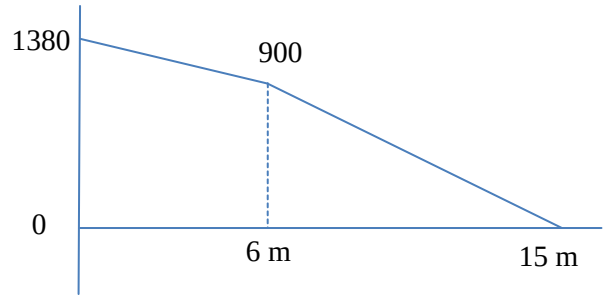
		iii)	$\Sigma F = ma$ $3g + 8 = 3a$ $a = 12.5(\text{m s}^{-2})$	C1 A1	Evidence of application of N2L. Allow ECF from ii) Allow use of mg or $3 \times 9.8 = 29.4$ Ignore unit, ignore sign. Allow ECF from ii)
		iv)	Resultant = $\sqrt{37.4^2 + 12^2}$ 39 (N) (39.28)	C1 A1	Calculation of resultant using 2 orthogonal forces. ECF diagram from part iii). Ignore unit
		v)	$\theta = tan^{-1}\left(\frac{12}{37.4}\right)$ 17.8 (degrees)	C1 A1	use of $\tan^{-1}$ with 2 components. ECF components from iii/iv. Allow ECF parts iii/iv. Allow 17.7 degrees. Synoptic mark from Unit 1:LO4
3	a)	i)	(0.51×8) 4.1 (4.08) (m^3)	 A1	
		ii)	(2400×4.08) 9792 (kg) (or 9840 if 4.1 used)	 A1	Allow ECF part i).
		iii)	$(W = mg = 9792 \times 9.8 =)$ 95961.6 (N)	A1	Allow ECF part i), accept sensible rounding. Synoptic mark from Unit 2:LO2
	b)	i)	34000 sin 30 or 17000 (N)	A1	Accept no mention of 17000 as long as calculation seen
		ii)	Roller (support)	A1	
		iii)	Self-weight of 95962 N correctly shown or implied. Correct expression taking moments about point A: $R_b \times 6 + 17000 \times 8 = 95962 \times 4$ $R_b = 41308$ N Vertical equilibrium: $R_a + R_b + 17000 = 95962$ $R_a = 37654$ N	C1 C1 A1 C1 A1	Can be shown on fig.2 or on own diagram or implied in subsequent working. Allow correct expression taking moments about B

Question			Answer/Indicative content	Mark	Guidance
4	a)		19.1 (19.09859), 45	A2	1 per co-ordinate. Award 1 mark if correct co-ordinates found but not indicated which is which, or written wrong way around.
	b)		$\theta = tan^{-1}\left(\frac{200}{75}\right)$ = 69.4(°) or 110.6(°)	C1 A1	
	c)	i)	80 (N) (downwards)	A1	Do not allow 80 N upwards
		ii)	(M =) 100 ×15 – 20 x 6 1380 Nm	C1 A1	 Ignore sign
		iii)		C1 C1 A1	Values of 1380 (Nm) at 0(m) and/or 0 (Nm) at only 15(m) indicated. Calculation of 900 (Nm) at 6 (m) seen or indicated on diagram. Diagram correctly drawn as shown (All values indicated on diagram all in the same quadrant. Straight lines connecting values. (allow hand-drawn as long as intention of straight line is clear). Condone all values in the negative quadrant.
5	a)	i)	(VR = V_o/V_i : V_i = 36/2.4) = 15 rpm	A1	
		ii)	(1 ÷ 2.4) = 0.42 (0.417)	A1	Note that 0.41 is a rounding error (see 9 above) Accept 1/2.4 seen
	b)		One mark for one advantage e.g.: • Simple/easy to install • Relatively cheap • Axis of shafts need not be aligned • No lubrication needed • Minimal maintenance required	A1	Accept any alternative correct response.

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			One mark for one disadvantage e.g.: • Belt can slip • Belt can stretch • Angular-velocity ratio may not be constant	A1	Accept any alternative correct response.
	c)		Arc length = $r\theta$ so r = 7.85÷ (π/6) = 15 cm Diameter = 2r = 30 cm VR = input diameter ÷ output diameter = 30/40 = 0.75	C1 C1 A1	 Allow ecf of incorrect radius. Synoptic mark from Unit 1:LO4
	d)	i)	Class 2	A1	
		ii)	A: Effort or F_{in} or Input Force B: Load or F_{out} or Output Force C: Fulcrum	A2	Award 1 mark if 2 of 3 correct. Allow pivot for C
6		i)	($E = \frac{1}{2}mv^2 = \frac{80}{2} \times 2.7^2$) = 291.6 (J)	 A1	Synoptic mark from Unit 2:LO2
		ii)	(P.E = mgh =) 80 × 9.8 × 25sin 6 ≈ 2049 J	C1 A1	 Accept answers between 2038 and 2051. Ignore sign. Unit must be seen for second mark in either i or ii
		iii)	Increase in K.E = answer to 6ii Final K.E = 291.6 + 2049 = 2340 J $2340 = \frac{1}{2}mv^2$ v = 7.64 (m s^{-1})	C1 C1 A1	Seen or implied Calculation of final K.E. ecf part i) and part ii). Allow ECF from parts ii) and iii) only. Accept answers between 7.63 and 7.65 m s^{-1}. Allow alternative method using N2L and SUVAT, C1 for correct acceleration and C1 for correct use of suvat

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		iv)	$R = mg = 80 \times 9.8 = 784$ $(F_{max} = \mu R = 784 \times 0.15) = 117.6$ (N)	C1 A1	Calculation of reaction force. May be implied in later working.
		v)	Work = force × distance where force =117.6 × 50 (constant speed means equilibrium) 5880 J	C1 A1	ECF answer to part iv). Unit required

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