

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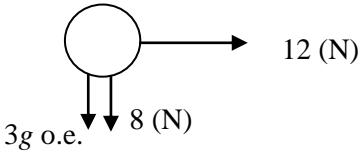
This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

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.

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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 \div 0.00016 = 87000000 N/m ² or Pa or equivalent OR 14000 \div 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 \div original length = 0.0022/50 4.4 x 10 ⁻⁴ or 0.00044	C1 A1	Method mark calculation of change in length. Maximum 1 mark if unit shown <i>Synoptic mark from Unit 2:LO4</i>
	v)	$E = \frac{\sigma}{\epsilon} = \frac{87390762}{0.00044} = 1.986 \times 10^{11}$ 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 3g force and 8 N must both be shown acting downwards. Acceptable equivalents for 3g include mg, 29.4, W, 3 \times 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.

Question		Answer/Indicative content	Mark	Guidance	
	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: $R_b \times 6 + 17000 \times 8 = 95962 \times 4$ $R_b = 41308 \text{ N}$ Vertical equilibrium: $R_a + R_b + 17000 = 95962$ $R_a = 37654 \text{ N}$	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 × 6 1380 Nm	C1 A1	Ignore sign
	iii)		C1 C1 A1	Values of 1380 (Nm) at 0(m) and/or 0 (Nm) at <u>only</u> 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.: <ul style="list-style-type: none"> • 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.

Question		Answer/Indicative content	Mark	Guidance
		One mark for one disadvantage e.g.: <ul style="list-style-type: none"> 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 $r = 7.85 \div (\pi/6) = 15$ cm Diameter = $2r = 30$ cm VR = input diameter \div 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 =) $80 \times 9.8 \times 25 \sin 6$ ≈ 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

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

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning

Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

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