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 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.

Subject specific marking instructions

In all numerical calculation questions a correct response will gain all marks unless specified otherwise. You do not need to see all the workings if the answer is correct.

- In numerical calculation questions a correct response will gain all marks unless specified otherwise. You do not need to see all the workings if the answer is correct unless it is a 'show that' question.
- Numerical answers should be given to a minimum of 2 significant figures unless specified otherwise. There is usually no penalty for using more than 2 significant figures, but the answer given should equal the stated value when rounded to 2 significant figures.
- Numerical answers given as fractions will not be credited unless specified otherwise.
- Power of ten (POT) errors will lose a max of one mark per calculation.
- In calculation questions where one of the marks is awarded for substitution into the equation, POT errors can be ignored. There will be a penalty in subsequent marks for POT errors.
- Where there is a mark awarded for using a correct equation it can be seen or implied.

B marks: These are awarded as <u>independent</u> 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 <u>method</u> 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 <u>compensatory</u> 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.

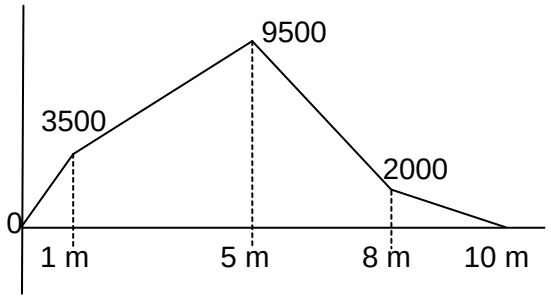
A marks: These are accuracy or <u>answer</u> marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Here is the mark scheme for this question paper.

Question			Answer/Indicative content	Mark	Guidance
1	(a)		Total area = 45500	C1	
			Application of second moment of area $45500\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = 15000\begin{pmatrix}25\\150\end{pmatrix} + 10500\begin{pmatrix}125\\265\end{pmatrix} + 20000\begin{pmatrix}175\\40\end{pmatrix}$ $45500\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = \begin{matrix}5187500\\5832500\end{matrix}$	C2	Correct substitution seen or implied for second moment of area method. Allow ecf for area. 1 compensation mark available for $\bar{x}$ and 1 compensation mark available for $\bar{y}$ Candidates may have split shape up differently and so areas and centroid values will need checking.
			$\bar{x} = 114.0(mm)$ $\bar{y} = 128.19(mm)$	A1 A1	Allow ecf for incorrect area only Allow ecf for incorrect area only
1	(b)	(i)	(FOS = 240÷110 =) 2.2 (2.18)	A1	
1		(ii)	There would be permanent/ plastic deformation (owtte).	A1	
1		(iii)	Area = π x 22.5^2 = 1590.4...mm^2 (or 0.00159 m^2)	C1	Calculation of area
			(Shear stress =) 120/1590.4	C1	Allow ecf for incorrect area
			= 0.07545 N/mm^2 (or MPa) UNIT REQUIRED (OR 75451 N/m^2 or Pa)	A1	Allow ecf for incorrect area Allow 0.076N/mm^2
2	(a)		• Non-reversible direction of transmission wanted • Much smaller than using spur gears or equivalents • Input and output axes at 90 degrees	A1	Accept any valid reason Reason must be specific to this type of gear arrangement.
2	(b)		E.g. pliers, crowbar, jack for a car	A1	Accept any valid application. Accept see saw balance.
2	(c)	(i)	(Effort = 392/1.95 =) 201(N)	A1	
2	(c)	(ii)	(B=1.2 ÷ 1.95 =) 0.615 (m)	A1	
2	(c)	(iii)	(Mass = weight/g = 392/9.8 =) 40(kg)	C1	Method mark for calculation of mass

Question			Answer/Indicative content	Mark	Guidance
			(Volume= mass/density = 40/7000 =) 5.714... x 10^{-3} (m^3)	A1	Award 1 if volume calculated correctly using weight instead of mass (Answer of 0.056 seen) and previous mark not already awarded
2	**(c)**	**(iv)**	Area = volume/length = 0.01632... Radius = $\sqrt{\frac{Area}{\pi}}$ = 0.0721.. m (Diameter =) 0.1441 (m)	C1 A1	Allow ecf part iii) Accept answers between 0.07208 and 0.07211. Allow ecf part iii) only
2	**(d)**	**(i)**	(VR = (teeth in)/(teeth out) = 1.5) (teeth out = 24/1.5 =) 16	A1	
2	**(d)**	**(ii)**	Idler gear	A1	
2	**(d)**	**(iii)**	VR = (24/48)(48/T_C) =1.5 (T_C = 24/1.5 =) 16	C1 A1	
2	**(d)**	**(iv)**	One mark from e.g.: • Less maintenance • No slipping (if compared with non-toothed belts) • Greater maximum torque transmission	A1	Accept suitable alternative answers. Accept higher efficiency or higher accuracy. Advantage must be specific to this gear arrangement.
3	**(a)**	**(i)**	($P = Fv$ = 20 × 5 =) 100 (W)	A1	
3	**(a)**	**(ii)**	(E_k = (19.5 × 3^2)/2=) 87.75 (J)	A1	
3	**(a)**	**(iii)**	19.5×3 + 17.5×0 = 19.5v + 17.5×1 (v = (58.5–17.5)/19.5 =) 2.1026 (m s^{-1})	C1 A1	
3	**(b)**	**(i)**	Weight (of the ball)	A1	NOT mass of the ball. NOT gravity. Accept other reasonable answers e.g. mass of ball × g OR mg if seen force acting on the ball due to gravity etc
3	**(b)**	**(ii)**	(Net) horizontal force = 0.6-0.5cos10 / 0.1076	C1	

Question			Answer/Indicative content	Mark	Guidance
			(Net) vertical force = 0.5sin10 + 2.9 / 2.9896 Res = $\sqrt{0.1076^2 + 2.9868^2}$ Res = 2.99 (N)	C1 C1 A1	 Accept reasonable rounding (expect answers between 2.95 and 3.2)
3	**(b)**	**(iii)**	(A=ΣF/m = 2.99/0.3 =) 9.96 (m s^{-2})	A1	Allow ecf part ii) Accept reasonable rounding [9.8,…. 10.2]
4	**(i)**		v=u + at 24.5 = 0 + 14a (a =) 1.75 (ms^{-2})	 C1 A1	 Correct equation and correct substitution
	(ii)		R=4000x9.8 / R=39200 (F_{max}=μR=0.22 x 39200 =) 8624 (N)	C1 A1	
	(iii)		ΣF=ma = 4000x1.75 F – 8624 = 4000 x 1.75 (F=) 15624 (N)	C1 C1 A1	Attempt to apply N2L with at least 'ma' calculation shown All elements of calculation correct including signs Allow ecf from part i) and ii)
5	**(a)**	**(i)**	E.g. wind loading on wall, cars bumper to bumper on a bridge, snow load on a roof	A1	Accept any sensible answer – must state what structure loading is acting upon (eg wall, bridge roof etc –)
5	**(a)**	**(ii)**	E.g. individual car or truck on a bridge, main load carried by a crane	A1	Accept any sensible answer – must state what structure the load is acting upon
5	**(b)**	**(i)**	2000 x 1 + 4000x5 = 1500x8 +10R_b OR 10R_a + 1500x2=4000x5 + 2000x9 OR R_a + R_b = 4500 R_b=1000(N) R_a=3500(N)	 C1 A1 A1	
5	**(b)**	**(ii)**	1000 x5 + 1500x3 = 9500 Nm Or 3500x5 - 2000x4 = 9500 Nm	A1	Allow -9500

Question			Answer/Indicative content	Mark	Guidance
5	**(b)**	**(iii)**		C1 C1 C1 A1	Values of 0 (Nm) at 0m and 10m (or A and B shown) – only award for a BENDING MOMENT diagram. Value of 9500 (or ecf) seen at correct point on diagram (may be negative) Values of 3500 and 2000 shown at correct points on diagram (must have same sign as 9500). Diagram drawn and labelled correctly as shown
6	**(a)**		Horizontal equilibrium: Qsin35=210 Q=366.1(N) Vertical equilibrium: P=Qcos35 P=299.9 (N)	C1 A1 C1 A1	.
6	**(b)**		(For vertical equilibrium) F=10 + 20 F = 30 (N) Correct moments equation (e.g. F *x* + 8x3 – 20x10=0) (x =276/30 =) 5.87 (m)	C1 A1 C3 A1	 Award 1 mark for correct equation Award 3 marks for correct moments equation about any corner. Deduct 1 mark for each mistake.

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