1		$X = 2V\cos 30$ $Y = 2V\sin 30 - g\frac{2^2}{2}$ $\tan 15 = \frac{\left(2V\sin 30 - g\frac{2^2}{2}\right)}{2V\cos 30}$ $V = 37.3$	B1 B1 M1 A1 [4]	$1.731V$ V–20
2	**(i)**	Horizontal distance $= 0.8 \times \frac{3}{4} \times \sin 30$ *OR* $0.8\tan 30\cos 30 - \frac{0.8}{4}\sin 30$ Mom. = (0.6sin30 × 20 =) 6 Nm AG *OR* Mom = $20\cos 30 \times 0.8\tan 30 - 20\sin 30 \times \frac{0.8}{4}$ Mom = 6 Nm AG	M1 A1 [2] M1 A1	P to centre of mass (= 0.3 m) Resolves Wt // and perp axis and finds moments of both components
	(ii)	$6 = F \times 0.8\tan 30$ $F = 13(.0)$	M1 A1 [2]	Takes moments about P
3		$\frac{28e}{1.6} = 0.35g$ $e = 0.2$ $\frac{0.35v^2}{2} = 28 \times \frac{0.2^2}{2} \times 1.6 + 0.35 \times \frac{1.8^2}{2} - 0.35g \times 0.2$ $v = 1.11$ m s^{-1}	M1 A1 M1 A1 A1 [5]	Equates λext/l and weight OP = 1.8 m EE/KE/PE balance All correct terms with candidate's value of e
4	**(i)**	$ABCF$ area = 0.64 and CDE = 0.36 $(0.64 + 0.36)d = 0.64 \times \frac{0.4}{2} + 0.36 \times (0.4 + \frac{1.8}{3})$ $d = 0.488$ m AG	B1 M1 A1 A1 [4]	Both areas correct Table of moments idea All terms correct
	(ii)	$0.488 \times 100 = 1.6T$ $T = 30.5$ N $(0.488 - 0.4) \times 100 = 1.6T$ $T = 5.5$	M1 A1 A1 [3]	Either limiting case (no turning about A) (no turning about F)

5 (i)	$x\tan\alpha = 0$ so $\alpha = 0$	B1	Justification needed
	$\frac{gx^2}{2V^2\cos^2 0} = 0.05x^2$	M1	Comparison with standard eqn
	$V = 10$ m s^{-1}	A1 [3]	
(ii)	$\frac{dy}{dx} = -0.1x$	M1	
	$-0.1x = -\tan 60$	M1	
	$y\ (= -0.05(10\tan 60)^2) = -15$	A1	
	$v^2 =$	M1	Uses Pythagoras
	$10^2 + 2g15$	A1√	ft candidate's value (V(i), y)
	$v = 20$ m s^{-1}	A1	
	OR	[6]	
	$y' = 10\tan 60$	M1	y' = B's downward velocity $=10\sqrt{3}$
	$(10\sqrt{3})^2 = 2gh$	M1	
	$y = -15$	A1	Negative, $y = -h$
	$v^2 =$	M1	Uses Pythagoras
	$10^2 + (10\sqrt{3})^2$	A1√	ft candidate's value (V(i))
	$v = 20$ m s^{-1}	A1	
	OR		
	$v\cos 60 = 10$	M1	
	$v = 20$ m s^{-1}	A1	
	$10\sqrt{3} = 10t$	M1	
	$t = \sqrt{3}$	A1	
	$y = 10\sqrt{3} \times \frac{\sqrt{3}}{2}$	M1	
	$y = 15$ (below) or -15	A1	
6 (i)	$0.6v\frac{dv}{dx} = 0.4v^{1/2}$	M1	Newton's 2nd law, $a = v\frac{dv}{dx}$
	$3v^{1/2}\frac{dv}{dx} = 2$ AG	A1 [2]	
(ii)	$3\int v^{\frac{1}{2}}dv = 2\int dx$	M1	Integrates
	$\frac{3v^{\frac{3}{2}}}{\frac{3}{2}} = 2x$ (+c)	A1	Accept omission of +c Evaluates c (=0)
	$3 \times 1^{\frac{3}{2}} \times \frac{2}{3} = 2 + c$	M1	
	$v = x^{\frac{2}{3}}$	A1 [4]	

(iii)	$\int x^{\frac{-2}{3}}\,dx = \int dt$ $\left[\dfrac{x^{\frac{1}{3}}}{\frac{1}{3}}\right]_1^8 = t$ $t = 3$	M1 A1 A1 [3]	Integrates using $v = \dfrac{dx}{dt}$
7 (i)	$T = \dfrac{15\left(\dfrac{0.4}{\cos\theta}\right)}{2}$ $T = \dfrac{3}{\cos\theta}$ AG $T\cos\theta = mg$ $m = 0.3$	M1 A1 M1 A1 [4]	Uses $T = \dfrac{\lambda \text{ext}}{2}$ Resolves vertically for P
(ii)	$r = 0.4\tan\theta$ $\dfrac{0.3v^2}{r} = T\sin\theta$ *OR* $0.3\omega^2 r = T\sin\theta$ $0.3\omega^2(0.4\tan\theta) = \dfrac{3}{\cos\theta} \times \sin\theta$ $\omega = 5$ **SC** Candidates who choose at least two specific values of θ: Calculation of r twice Both calculations give $\omega = 5$	B1 M1 A1√ A1 [4] B1 B1	 Newton's 2nd law with correct expression for radial accn, ft cv(m(i))
(iii)	EPE $= \dfrac{15\left(\dfrac{0.4}{\cos\theta}\right)^2}{2\times 2}$ KE $= \dfrac{0.3\left(5\times 0.4\tan\theta\right)^2}{2}$ $\dfrac{15\left(\dfrac{0.4}{\cos\theta}\right)^2}{2\times 2} = \left(\dfrac{0.3(2\tan\theta)^2}{2}\right)\times 2$ $\cos^2\theta\tan^2\theta = 0.5$ *OR* $\sin^2\theta = 0.5$ $\theta = 45$	B1 B1√ M1 A1 [4]	 ft candidate's value of ω Award if × 2 is with wrong term www