1	$V\sin\theta = \frac{2.4g}{2}$ or $48 = V\cos\theta \times 2.4$ $\tan\theta = \frac{12}{\frac{48}{2.4}}$ $\theta = 31(.0)^\circ$	B1 M1 A1	[3]	$-V\sin\theta = V\sin\theta - 2.4g$
2 (i)	$\frac{0.2\times10^2}{2} = \frac{64e^2}{2\times0.8}$ $AP = 1.3$	M1 A1 A1	[3]	KE loss = EE gain $e = 0.5$
(ii)	$\frac{0.2\times10^2}{2} = \frac{64\times0.2^2}{2\times0.8} + \frac{0.2v^2}{2}$ $v = 9.17\text{ms}^{-1}$	M1 A1 A1	[3]	KE / EEbalance
3 (i)	$mv\frac{\mathrm{d}v}{\mathrm{d}x} = -mg - 0.02mv$ $\frac{v+50g-50g}{50g+v}\frac{\mathrm{d}v}{\mathrm{d}x} = -0.02$ $\left(\frac{500}{500+v} - 1\right)\frac{\mathrm{d}v}{\mathrm{d}x} = 0.02$ AG	M1 DM1 A1	[3]	Newton's 2nd law, 2 resistive forces. $-mg - 0.02mv = -0.02(50g+v)$ used
(ii)	$\int\frac{500}{500+v} - 1\,\mathrm{d}v = \int 0.02\,\mathrm{d}x$ $\left[500\ln(500+v) - v\right]_{14}^{0} = 0.02H$ $H = 9.62\,\text{m}$	M1 DM1 A1	[3]	Attempts integration Appropriate use of v = 14, 0
4 (i)	$V\sin\theta = 50\sin30 - 4g$ $V^2 = (50\cos30)^2 + (-15)^2$ $V = 45.8\text{ms}^{-1}$ $15 = 50\sin30 - gt$ $t = 1$	B1 M1 A1 M1 A1	[5]	–15
(ii)	$OP^2 = (4\times50\cos30)^2 + \left(4\times50\sin30 - \frac{4^2g}{2}\right)^2$ $OP = 174\,\text{m}$	M1 A1	[2]	

5	**(i)**	$T = \frac{12(d-0.6)}{0.6} = \frac{21(d-0.7)}{0.7}$ $d = 0.9$ $T = \frac{12(0.2-0.6)}{0.6} = \frac{21(0.2-0.7)}{0.7}$ $W = 12$	M1 A1 M1 A1	[4]	Uses $T = \frac{\lambda \text{ ext}}{l}$ either string Must be total length, not extension Equation with both sides correct Finds either Tension (= 6)
	(ii)	$\text{PE} = 0.2 \times 12 \quad (= 2.4)$ $\frac{12 \times 0.1^2}{2 \times 0.6} + 12 \times 0.2 = \frac{\frac{12}{g}v^2}{2} + \frac{12 \times 0.3^2}{2 \times 0.6} + \frac{21 \times 0.2^2}{2 \times 0.7}$ $v = 1.29 \text{ ms}^{-1}$	B1√ M1 A1 A1	[4]	ft their value of d and their value of W PE / KE / EE balance
6	**(i)**	$\frac{0.2 \times 1.5^2}{0.5} = \text{Fr}$ $\mu\left(= \frac{\text{Fr}}{0.2g}\right) = 0.45$	M1 A1	[2]	Newton's 2nd law, $\text{acc} = \frac{v^2}{r}$ Fr = 0.9 N
	(ii)	$R = 0.2g - \frac{0.2g}{2}\sin 30$ $\text{Fr} = 0.45 \times 1.5$ $\frac{0.2g}{2}\cos 30 \pm 0.675 = 0.2\omega^2 0.5$ $\omega = 3.93$ (greatest) $\omega = 1.38$ (least)	M1 A1 M1 A1 A1	[5]	1.5 0.675 Either
	(iii)	$\frac{0.2g}{2}\cos 30 = 0.2\omega^2 0.5$ $\omega = 2.94$	M1 A1	[2]	

7	(i)	OG (sector) $= \dfrac{2\times 0.35\sin\frac{2\pi}{3}}{3\times\frac{2\pi}{3}}$	B1		0.096482…
		Area (sector) $= \dfrac{0.35^2\times\frac{4\pi}{3}}{2}$	B1		0.256563… 0.116666…
		OG (triangle) $= \dfrac{2\times 0.35\cos\frac{\pi}{3}}{3}$ and			
		Area (triangle) $= \dfrac{0.35^2\sin\frac{2\pi}{3}}{2}$	B1		0.053044…
		$0.096482...\times 0.256563...-$ $0.116666...\times 0.053044...$	M1		
		$= d(0.256563...+0.053044...)$	A1		
		$d = 0.06(00)$ m AG	A1	[6]	
	(ii) a	$F\times 0.35\cos\dfrac{\pi}{3} = 0.06\times 14$	M1		
		$F = 4.8$	A1	[2]	
	(ii) b	$F\sin\dfrac{\pi}{3}\times\left(0.35+0.35\sin\dfrac{\pi}{3}\right)$	M1		Moments about point of contact
		$+F\cos\dfrac{\pi}{3}\times 0.35\cos\dfrac{\pi}{3} = 14\times 0.06$	A1		
		$F = 1.29$ N	A1	[3]	
		OR			
		$F\times 0.35 + \text{Fr}\times 0.35 = 14\times 0.06$	(M1)		Moments about O
		$0.35F + 0.35F\sin\dfrac{\pi}{3} = 14\times 0.06$	(A1)		As $\text{Fr} = F\sin\dfrac{\pi}{3}$
		$F = 1.29$ N	(A1)		