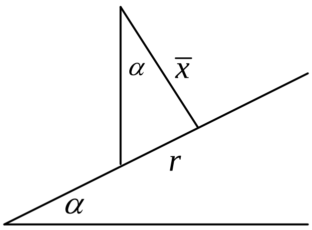
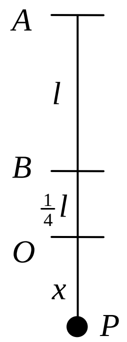
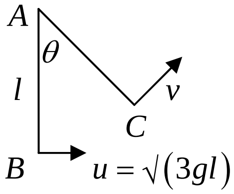
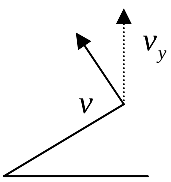
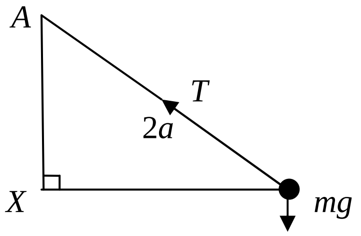
Question Number	Scheme	Marks
1.	(a) $\rightarrow$ $F = T\sin 60°$ $\quad\uparrow$ $T\cos 60° = 0.8g$ both	M1
	[or Z $F\cos 60° = 0.8g\cos 30°$]	(M2)
	$F = 0.8g\tan 60° \approx 14$ (N) accept 13.6	M1 A1
		(3)
	(b) $T = \dfrac{0.8g}{\sin 30°}(=15.68)$ allow in (a)	M1
	HL $15.68 = \dfrac{24\times x}{1.2} \Rightarrow x \approx 0.78$ (cm) accept 0.784	M1 A1
		(3)
	(c) $E = \dfrac{24\times x^2}{2\times 1.2} \approx 6.1(\text{J})$ accept 6.15	M1 A1ft
		(2)
		Total 8 marks
2.	(a) $\dfrac{dv}{dt} = 2\sin\frac{1}{2}t \Rightarrow v = A - 4\cos\frac{1}{2}t$	M1 A1
	$v = 4, t = 0 \Rightarrow 4 = A - 4 \Rightarrow A = 8$	M1
	$v = 8 - 4\cos\frac{1}{2}t$	A1
		(4)
	(b) $\int_{\dots}^{\dots}\left(8 - 4\cos\frac{1}{2}t\right)dt = 8t - 8\sin\frac{1}{2}t$ ft constants	M1 A1ft
	$[\dots]_0^{\pi/2} = 4\left(\pi - \sqrt{2}\right)$ awrt 6.9	M1 A1
		(4)
		Total 8 marks

Question Number	Scheme	Marks
3.	(a) N2L $ma = -\frac{cm}{x^2}$	B1
	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{2}v^2\right) = -\frac{c}{x^2} \Rightarrow \frac{1}{2}v^2 = A + \frac{c}{m}$ ignore A	M1 A1
	$v^2 = B + \frac{2c}{m}$	
	$x = R, v = U \Rightarrow B = U^2 - \frac{2c}{R}$	M1
	Leading to $v^2 = U^2 + 2c\left(\frac{1}{x} - \frac{1}{R}\right)$ ∗ cso	A1
		(5)
	(b) $\frac{1}{2}\left[\frac{1}{2}mU^2\right] = \frac{1}{2}m\left[U^2 + 2c\left(\frac{1}{2R} - \frac{1}{R}\right)\right]$	M1 A1
	Leading to $c = \frac{1}{2}RU^2$	A1
		(3)
		Total 8 marks
4.	(a) $5M\bar{x} = 3M \times \frac{h}{2} + 2M\left(h + \frac{3}{8}r\right)$	M1 A2(1,0)
	$5\bar{x} = \frac{3h}{2} + 2h + \frac{3}{4}r = \frac{7h}{2} + \frac{3}{4}r$	
	$\bar{x} = \frac{14h + 3r}{20}$ ∗ cso	M1 A1
		(5)
	(b) 	
	$\tan\alpha = \frac{20r}{14h + 3r} = \frac{4}{3}$	M1 A1
	Leading to $h = \frac{6}{7}r$	M1 A1
		(4)
		Total 9 marks

Question Number	Scheme	Marks
5.		
	(a) HL $T = mg = \frac{\lambda \times \frac{1}{4}l}{l} \Rightarrow \lambda = 4mg$	M1 A1
		(2)
	(b) N2L $mg - T = m\ddot{x}$	M1
	$mg - \frac{4mg\left(\frac{1}{4}l + x\right)}{l} = m\ddot{x}$	M1 A1
	$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\frac{4g}{l}x$ ∗ cso	M1 A1
		(5)
	(c) $v^2 = \omega^2\left(a^2 - x^2\right) = \frac{4g}{l}\left(\frac{l^2}{4} - \frac{l^2}{16}\right)$	M1 A1
	Leading to $v = \frac{1}{2}\sqrt{(3gl)}$	M1 A1
		(4)
	or energy, $\frac{1}{2}\frac{4mg.\,{}^{gl^2}\!/_{16}}{l} = \frac{1}{2}mv^2 + mg.\frac{3l}{4}$ for the first M1 A1 in (c)	
	(d) P first moves freely under gravity, then (part) SHM.	B1 B1
		(2)
		Total 13 marks

Question Number	Scheme	Marks
6.	(a) 	
	Energy $\frac{1}{2}m\left(u^2 - v^2\right) = mgl\left(1-\cos\theta\right)$	M1 A1
	$\left[v^2 = gl + 2gl\cos\theta\right]$	
	N2L $T - mg\cos\theta = \frac{mv^2}{l}$	M1 A1
	$= \frac{mg\cancel{l}\left(1+2\cos\theta\right)}{\cancel{l}}$	M1
	$T = mg\left(1+3\cos\theta\right)$ * cso	A1
		(6)
	(b) $T = 0 \Rightarrow \cos\theta = -\frac{1}{3}$	B1
	$v^2 = gl - \frac{2}{3}gl \Rightarrow v = \left(\frac{gl}{3}\right)^{1/2}$	M1 A1
		(3)
	(c) $\uparrow\ v_y = \left(\frac{gl}{3}\right)^{1/2}\sin\theta \quad \left[= \left(\frac{gl}{3}\right)^{1/2} \cdot \frac{2\sqrt{2}}{3}\right]$	M1
	 $v^2 = u^2 - 2gh \Rightarrow 2gh = \frac{gl}{3}\cdot\frac{8}{9} \Rightarrow h = \frac{4l}{27}$	M1 A1
	$H = l\left(1-\cos\theta\right) + \frac{4l}{27} = \frac{40l}{27}$	M1 A1
		(5)
		Total 14 marks

Question Number	Scheme	Marks
7.	(a) N2L $\leftarrow$ $T\cos 30° = m(2a\cos 30°)\left(\dfrac{kg}{3a}\right)$	M1 A1
	$T = \dfrac{2kmg}{3}$ ∗ cso	A1
		(3)
	(b) $\uparrow$ $R = mg - T\sin 30°$	M1 A1
	$= mg\left(1 - \dfrac{k}{3}\right)$	A1
		(3)
	(c) (R □ 0) $\Rightarrow$ k □ 3 ignore $k > 0$, accept $k < 3$	M1 A1
		(2)
	(d) 	
	N2L $\leftarrow$ $T\cos\theta = m(2a\cos\theta)\left(\dfrac{2g}{a}\right)$	M1 A1
	$(T = 4mg)$	
	$\uparrow$ $T\sin\theta = mg$	M1
	Eliminating T	M1
	$AX = 2a\sin\theta = \dfrac{1}{2}a$	A1
	$AO = 2a\sin 30° = a$ $\Rightarrow$ $AX = \dfrac{1}{2}AO$, as required ∗ cso	B1, A1
		(7)
		Total 15 marks