Question	Answer	Marks	Guidance
1(i)	$T\cos\theta\left(=T\times\frac{0.15}{0.8}\right)=0.3g$	M1	Resolve vertically. θ is the angle between the string and the vertical
	$T = 16\ N$ **AG**	A1	
		2	
1(ii)	$r^2 = 0.8^2 - 0.15^2$	B1	$r = 0.78581...$
	$16\sin\theta\left(=16\times\frac{0.78581...}{0.8}\right)=\frac{0.3v^2}{0.78581...}$	M1	Use Newton's Second Law horizontally
	$v = 6.416$	A1	
		3	

Question	Answer	Marks	Guidance
2	$V\cos\theta = 16\cos 30\left(=8\sqrt{3}=13.856...\right)$	B1	Use horizontal motion
	$V\sin\theta = 16\sin 30 + 4g\left(=48\right)$	B1	Use vertical motion
	$V^2 = \left(16\cos 30\right)^2 + \left(16\sin 30 + 4g\right)^2$ **OR** $\tan\theta = \frac{\left(16\sin 30 + 4g\right)}{16\cos 30}$	M1	Use Pythagoras's theorem or trigonometry of a right angled triangle
	$V = 50(.0)$	A1	
	$\theta = 73.9°$	A1	
		5	

Question	Answer	Marks	Guidance
3	Volume of cylinder $= \pi \times 0.22 \times 0.7\ (= 0.028\pi)$ **AND** Volume of hemisphere $= 2\pi \times \frac{0.2^3}{3} (= 0.0053333\pi)$	**B1**	Both volumes required for **B1**
	Distance of centre of mass from object base $= 0.7 - 3 \times \frac{0.2}{8} (= 0.625)$	**B1**	
	$x\left(\pi \times 0.2^2 \times 0.7 - 2\pi \times \frac{0.2^3}{3}\right) + \left(0.7 - 3 \times \frac{0.2}{8}\right) \times 2\pi \times \frac{0.2^3}{3} = 0.35 \times 0.028\pi$	**M1A1**	Take moments about the plane face
	$x = 0.285$ m	**A1**	
		5	

Question	Answer	Marks	Guidance
4(i)	$x = 25\cos 30t$	**B1**	Use horizontal motion
	$y = 25\sin 30t - \frac{gt^2}{2}$	**B1**	Use vertical motion
	$y = 25\sin 30\left(\frac{x}{25\cos 30}\right) - \frac{g\left(\frac{x}{25\cos 30}\right)^2}{2}$	**M1**	Eliminate t
	$y = \frac{x}{\sqrt{3}} - \frac{4x^2}{375}$ or $y = 0.577x - 0.0107x^2$	**A1**	
		4	

Question	Answer	Marks	Guidance
4(ii)	$\frac{dy}{dx} = \frac{1}{\sqrt{3}} - \frac{8x}{375}$ or $\frac{dy}{dx} = 0.577 - 0.0214x$	M1A1	Differentiate the equation from part **(i)** to find the gradient
	$-\tan 15 = \frac{1}{\sqrt{3}} - \frac{8x}{375}$ or $-\tan 15 = 0.577 - 0.0214x$	M1	Attempt to solve
	$x = 39.6$ or $x = 39.5$	A1	
		4	
	Alternative method for question 4(ii)		
	$\tan 15 = \frac{v_y}{v_x} = \frac{v_y}{12.5\sqrt{3}}$	M1	
	$v_y = 12.5\sqrt{3}\tan 15\ (= 5.8)$ downwards	A1	
	$-5.8 = 12.5 - 10t$ leading to $t = 1.83$	M1	Vertical motion using $v = u + at$
	$X = 1.83 \times \frac{25\sqrt{3}}{2} = 39.6$	A1	
		4	

Question	Answer	Marks	Guidance
5(i)	$0.4g(0.5+x)=\dfrac{6x^2}{(2\times 0.5)}$	M1	Set up an energy equation
	$6x^2-4x-2=0$ or $3x^2-2x-1=0$	M1	Attempt to solve a 3 term quadratic equation
	$x=1$ (ignore $-\dfrac{1}{3}$ if seen)	A1	
		3	
5(ii)	$0.4g=\dfrac{6e}{0.5}$	M1	Use $T=\dfrac{\lambda x}{l}$ to find the extension at the equilibrium position
	$e=\dfrac{1}{3}$	A1	
	PE change $=0.4g\left(0.5+\dfrac{1}{3}\right)$	B1ft	Ft for candidate's e
	$\dfrac{0.4V^2}{2}=0.4g\left(0.5+\dfrac{1}{3}\right)-\dfrac{6\left(\dfrac{1}{3}\right)^2}{(2\times 0.5)}$	M1	Set up a three term energy equation
	$V=3.65\ \mathrm{ms^{-1}}$	A1	
		5	

Question	Answer	Marks	Guidance
6(i)	From $AB = 0.2$	**B1**	
	From $BC = 0.1$	**B1**	
		2	
6(ii)	$\tan\theta = \frac{0.1}{0.2}$	**M1**	θ is the angle between AB and the horizontal
	$\theta = 26.6°$	**A1**	
		2	
6(iii)	$12\cos 26.6 \times 0.3 = W \times 0.2$	**M1A1**	Take moments about B. (W is the weight of the lamina)
	$W = 16.1\ N$	**A1**	
		3	

Question	Answer	Marks	Guidance
7(i)	$0.5v\frac{dv}{dx} = -0.5g - 0.1x^2$	**M1**	Use Newton's Second Law vertically
	$v\frac{dv}{dx} = -10 - 0.2x^2$ **AG**	**A1**	
		2	

Question	Answer	Marks	Guidance
7(ii)	$\int v\mathrm{d}v = \int\left(-10-0.2x^2\right)\mathrm{d}x$	M1	Attempt to integrate the expression in part **(i)**
	$\frac{v^2}{2} - 10\times\frac{-0.2x^3}{3} + c$	A1	
	$\left[\frac{v2}{2} = -10 - \frac{0.2}{3} + 18\right]$	M1	Either use limits or find c and put $x = 1$
	$v = 3.98\ (329\ldots)\ \text{m}s^{-1}$		
7(iii)	$0.5v\frac{\mathrm{d}v}{\mathrm{d}x} = -0.5g - 0.1x^2 - \frac{16(x-1)}{1}$	M1	Use Newton's Second Law vertically when string becomes taut
	$v\frac{\mathrm{d}v}{\mathrm{d}x} = -10 - 0.2x^2 - 32x + 32 = 22 - 32x - 0.2x^2$	A1	
		2	
7(iv)	$\int v\mathrm{d}v = \int\left(22-32x-0.2x^2\right)\mathrm{d}x$	M1	Attempt to integrate after the string becomes taut
	$\frac{v^2}{2} = 22x - \frac{32x^2}{2} - \frac{0.2x^3}{3} + k$	A1	
	$x = 1$, $v = 3.98\ (329\ldots)$ hence $k = 2$. Now put $x = 1.5$ $22\times 1.5 - 32\times\frac{1.5^2}{2} - 0.2\times\frac{1.5^3}{3} + 2 = -1.225$	M1	Either use limits or find k and put $x = 1.5$
	As $\frac{v^2}{2}$ cannot be negative, P comes to rest before the extension of the string is 0.5.	A1	
		4	