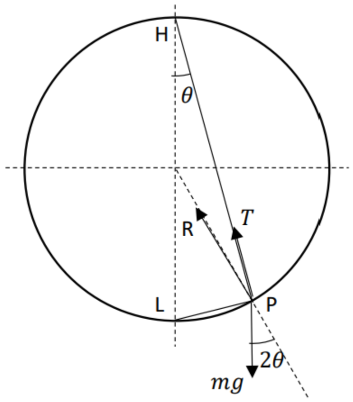
STEP II, 2020, Q10 MS

10(i)	
	Diagram showing necessary forces and angles
	$T = \frac{\lambda(2a\cos\alpha - l)}{l}$
	Resolving tangentially: $T\sin\alpha - mg\sin 2\alpha = 0$
	Therefore $\sin\alpha\left(\frac{\lambda}{l}(2a\cos\alpha - l) - 2mg\cos\alpha\right) = 0$
	Since $\sin\alpha > 0$, $2a\lambda\cos\alpha - \lambda l - 2mgl\cos\alpha = 0$ $\cos\alpha = \frac{\lambda l}{2(a\lambda - mgl)}$
	$\cos\alpha < 1$, so $\lambda l < 2(a\lambda - mgl)$ Therefore $\lambda(2a - l) > 2mgl$
	Since $2a - l > 0$, $\lambda > \frac{2mgl}{2a-l}$
10(ii)	Energy: $\frac{1}{2}mv^2 - mga\cos 2\theta + \frac{\lambda}{2l}(2a\cos\theta - l)^2 = \frac{1}{2}mu^2 - mga + \frac{\lambda}{2l}(2a - l)^2$
	If the particle comes to rest when $\theta = \beta$: $-mga\,(2\cos^2\beta - 1) + \frac{\lambda}{2l}(2a\cos\beta - l)^2 = \frac{1}{2}mu^2 - mga + \frac{\lambda}{2l}(2a - l)^2$
	$a\lambda\cos^2\beta\left(\frac{2(a\lambda - mgl)}{\lambda l}\right) - 2a\lambda\cos\beta = \frac{1}{2}mu^2 - 2mga + \frac{2\lambda a^2}{l} - 2a\lambda$
	Therefore, $\cos^2\beta - 2\cos\alpha\cos\beta = \frac{mu^2}{2a\lambda}\cos\alpha + 1 - 2\cos\alpha$
	Adding $\cos^2\alpha$ to both sides: $(\cos\alpha - \cos\beta)^2 = (1 - \cos\alpha)^2 + \frac{mu^2}{2a\lambda}\cos\alpha$
	For this to occur, $\cos\beta > 0$:
	$\cos^2\alpha > (1 - \cos\alpha)^2 + \frac{mu^2}{2a\lambda}\cos\alpha$
	And so, $u^2 < \frac{2a\lambda}{m}(2 - \sec\alpha)$