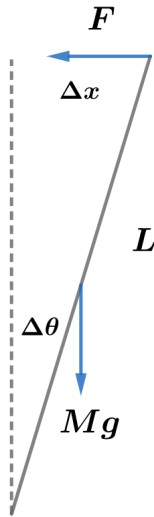


2019A F=ma Exam: Problem 20

Kevin S. Huang



Suppose the rod is displaced by $\Delta\theta$ from the vertical. We must have a restoring torque for it to be in stable equilibrium. We have

$$\Delta x = L\Delta\theta$$

so the total spring force is

$$F = 2k\Delta x = 2kL\Delta\theta$$

The restoring torque is

$$\begin{aligned}\tau &= FL \cos \Delta\theta - Mg \left(\frac{L}{2}\right) \sin \Delta\theta \\ &\approx FL - Mg \left(\frac{L}{2}\right) \Delta\theta \\ &= 2kL^2\Delta\theta - Mg \left(\frac{L}{2}\right) \Delta\theta > 0\end{aligned}$$

so

$$2kL > Mg \left(\frac{1}{2}\right)$$

$$\boxed{Mg < 4kL}$$