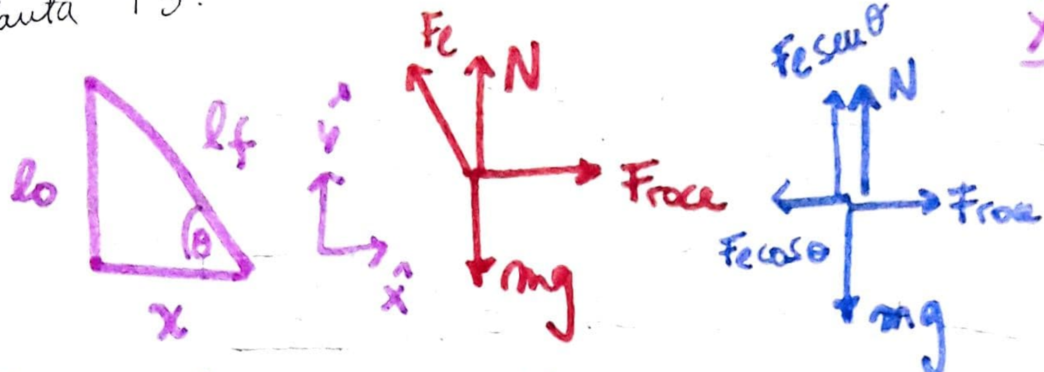
Pauta TS:

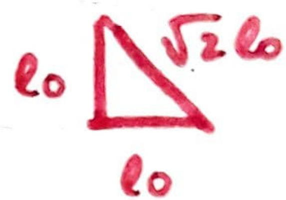


$\hat{y}|\ N + F_e \operatorname{sen}\theta = mg$

$\hat{x}|\ F_e \cos\theta = F_{roce}$

$\operatorname{sen}\theta = \frac{l_0}{l_f} \quad \cos\theta = \frac{x}{l_f} \quad x^2 + l_0^2 = l_f^2$

$t=0$



a)

$N = mg - F_e \operatorname{sen}\theta \quad ; \quad F_e = k(l_f - l_0)$

Condición: $N > 0$; El inicio es un mínimo, por lo que vale imponerla ahí.

$F_e(t=0) = k l_0(\sqrt{2}-1)$ y $\operatorname{sen}(\theta = 45) = \frac{\sqrt{2}}{2}$

$$N = mg - k l_0(\sqrt{2}-1)\cdot\frac{\sqrt{2}}{2}) > 0 \iff \boxed{mg > \frac{k l_0}{2}(2-\sqrt{2})}$$

b) $\Delta E_{MEC} = W_{tot}^{NC}$

$$W_{tot}^{NC} = \int_{l_0}^{-\frac{l_0}{2}} \vec{F}_{roce}\cdot dx\,\hat{x} \quad ; \quad F_{roce} = N\mu = \mu\left[mg - k[l_f - l_0]\cdot\frac{l_0}{l_f}\right]$$

$$= \mu\left[mg - k\left[\sqrt{x^2+l_0^2} - l_0\right]\cdot\frac{l_0}{\sqrt{x^2+l_0^2}}\right]$$

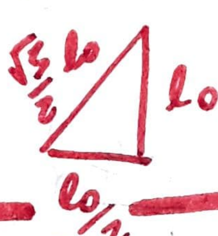
$$F_{roce} = \mu\left[mg - k\left\{1 - \frac{l_0}{\sqrt{x^2+l_0^2}}\right\} l_0\right]$$

$$W_{tot}^{NC} = \int_{l_0}^{-\frac{l_0}{2}} \mu\left[mg\, dx + k l_0 \int_{l_0}^{-\frac{l_0}{2}} \frac{1}{\sqrt{x^2+l_0^2}}\, dx \cdot - \int k l_0\, dx.\right]$$

$$= \mu\left[mg\left[-\frac{3}{2}l_0\right] + k l_0 \operatorname{arcsinh}\left(\frac{x}{l_0}\right)\Big|_{l_0}^{-l_0/2} + \frac{3}{2} k l_0^2\right]$$

$$W_{tot}^{NC} = \mu\left\{-\frac{3}{2}mg\, l_0 - \{k l_0\left[\operatorname{arcsinh}(1/2) + \operatorname{arcsinh}(1)\right] + \frac{3}{2} k l_0^2\right\}$$

$$W_{tot} = E_f - E_i$$



$$E_i = \frac{1}{2} k l_0^2 (\sqrt{2}-1)^2$$

$$E_f = \frac{1}{2} k l_0^2 \left(\frac{\sqrt{3}}{2}-1\right)^2$$

$$\boxed{\mu = \frac{\frac{1}{2} k l_0^2\left[\left(\frac{\sqrt{3}}{2}-1\right)^2 - (\sqrt{2}-1)^2\right]}{-\frac{3}{2} mg\, l_0 + \frac{3}{2} k l_0^2 - k l_0\left[\operatorname{arcsinh}(1/2) - \operatorname{arcsinh}(1)\right]}} \rightarrow \left(2\sqrt{2} - \sqrt{3} - 3/4\right).$$

c) Solo hacen trabajo F_r y F_e:

$$W_{Fr} = \int_{l_0}^{0} F_r\, dx \Rightarrow \boxed{W_{Fr} = \mu\left[-mg\, l_0 + k l_0^2 - k l_0 \operatorname{arcsinh}(1)\right]}$$

$$W_{Fe} = \int_{l_0}^{0} F_e \cdot \frac{x}{\sqrt{x^2+l_0^2}}\, dx \Rightarrow \boxed{W_{Fe} = -k l_0^2\left(\frac{1}{2} - \sqrt{2}\right)}$$

d) W_{tot}^{NC} será la energía liberada en forma de calor.

$$\boxed{Q = \frac{1}{2} k l_0^2 \left(\left(\frac{\sqrt{3}}{2}-1\right)^2 - (\sqrt{2}-1)^2\right)} = \frac{1}{2} k l_0 \left(2\sqrt{2} - \sqrt{3} - 3/4\right).$$