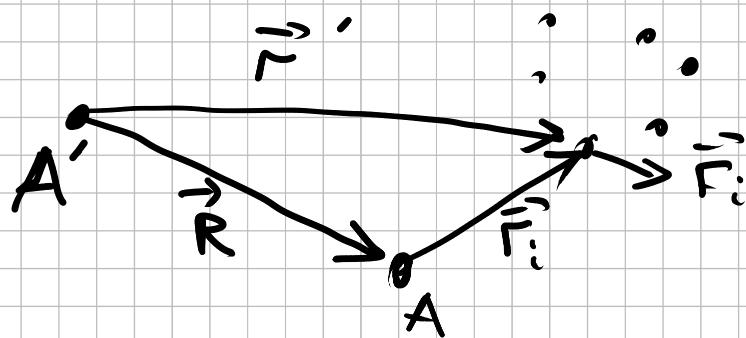
Static equilibrium

$$\boxed{\sum \vec{F}_i = 0 \quad , \quad \sum \vec{\tau}_i = 0 \ \text{with respect to any point}}$$



$$\sum_i \tau_i = \sum_i \vec{r}_i \times \vec{F}_i$$

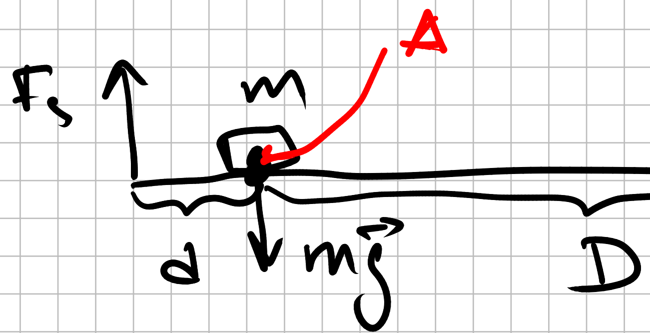
$$\vec{r}_i\,' = \vec{R} + \vec{r}_i$$

$$\sum_i \vec{\tau}_i\,' = \sum \vec{r}_i\,' \times \vec{F}_i =$$

$$= \sum (\vec{R} + \vec{r}_i) \times \vec{F}_i =$$

$$= \vec{R} \times \underbrace{\Big(\sum_i \vec{F}_i\Big)}_{0} + \underbrace{\sum_i \vec{r}_i \times \vec{F}_i}_{=0} = \vec{0}$$

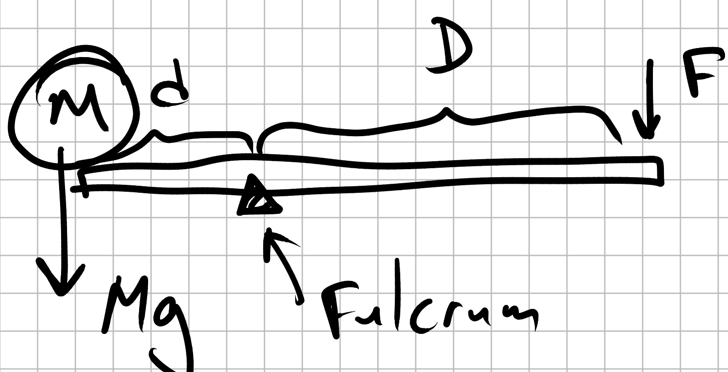
$$\vec{F_s} + m\vec{g} + \vec{F_p} = 0$$



$$\text{CW: } d \cdot F_s - D \cdot F_p + 0 \cdot mg = 0$$

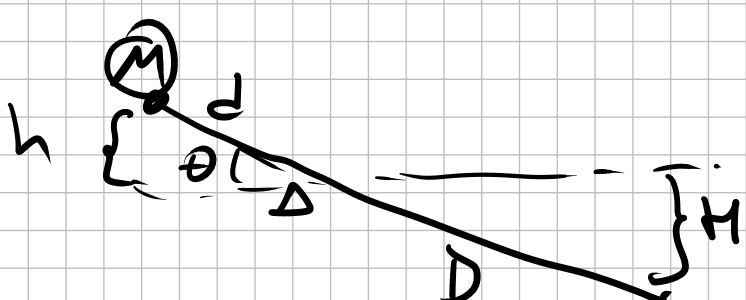
$$d \cdot F_s = D \cdot F_p$$

$$F_s = \frac{D}{d} \cdot F_p$$



Fulcrum: $\sum \vec{\tau_i}$

$$\Rightarrow \quad Mg = \frac{D}{d} F$$

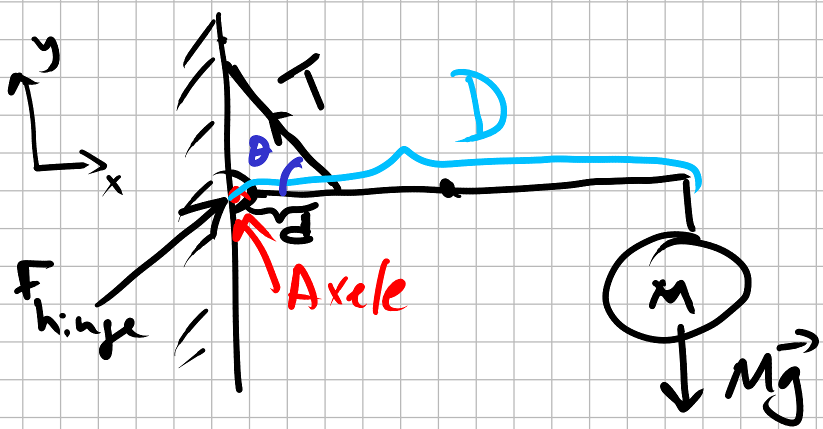


$$\text{Work}_{\text{gravity}} = hMg$$

work of gravity

$$\text{Work}_{\text{by human}} = F \cdot H = \underbrace{Mg\frac{d}{D}}_{F} \cdot \underbrace{h \cdot \frac{D}{d}}_{H} = hMg$$

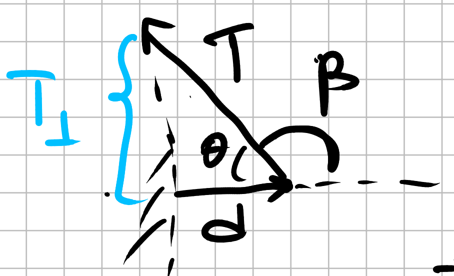
Forces acting on the rod:



$$\vec{F}_{net} = \vec{0} = \vec{T} + M\vec{g} + \vec{F}_H$$

$$\vec{\tau}_{net} = \vec{0}$$

$$= \vec{\tau}_T + \vec{\tau}_g + \vec{\tau}_H = 0$$



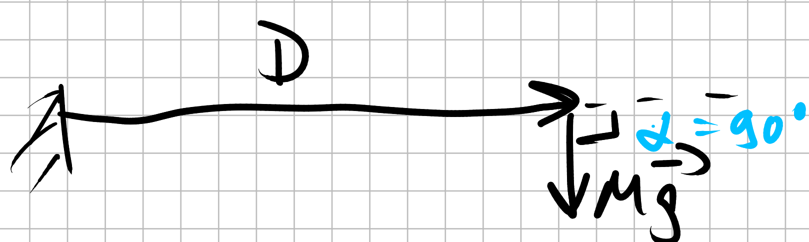
$$\tau_T = \vec{d} \times \vec{T} = d \cdot T_\perp$$

with respect to A : $\vec{\tau}_{net} \Rightarrow$

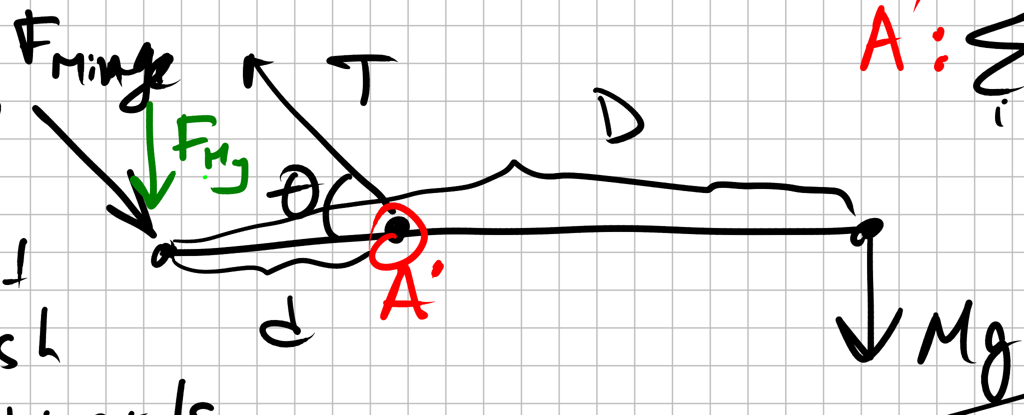
$$\text{cw}: \tau_{net} = -d \cdot T \sin \overbrace{\beta}^{180^\circ - \theta} + D \cdot Mg \cdot \sin 90^\circ + 0 \cdot F_H$$

$$= -dT \cdot \sin(180^\circ - \theta) + D \cdot Mg$$

$$= -d \cdot T \sin(\theta) + D \cdot Mg$$



$$\Rightarrow \boxed{T = \frac{D}{d \cdot \sin\theta} Mg}$$



must push downwards

A': $\sum_i \vec{\tau}_i = 0 \Rightarrow d \cdot F_{H_y} - (D-d)Mg$

$\sum \vec{F}_i = 0$

x: $F_{H_x} + T_x = 0$

y: $F_{H_y} + T_y + Mg_y = 0$

$$F_{H_y} = \frac{D-d}{d} \cdot Mg$$

$$F_{H_x} = T\cos\theta$$