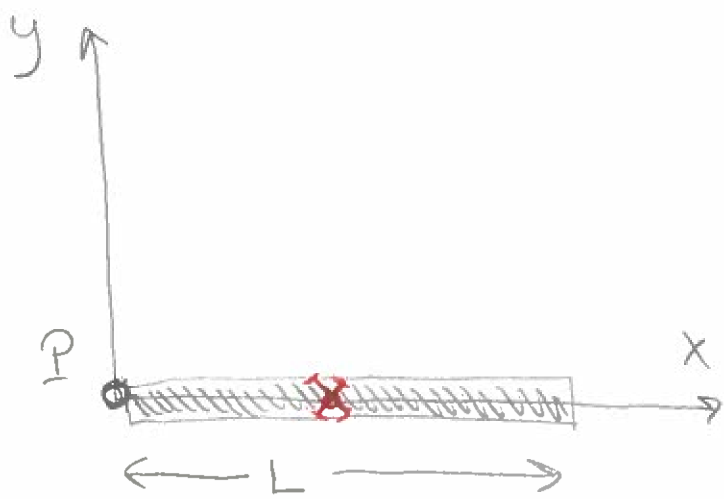


Long thin rod of uniform density has

mass $M = 2.35$ kg

length $L = 1.6$ m

The rod can pivot around point $P = (0,0)$.

Moment of inertia of rod around pivot is

$$I = \frac{1}{3} M L^2 = 2.005 \text{ kg}\cdot\text{m}^2$$

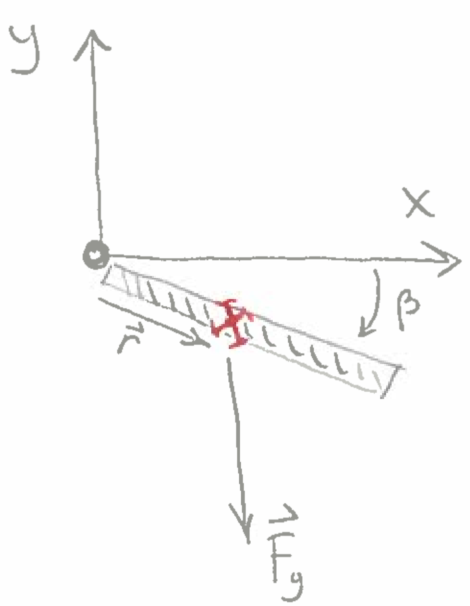
Center of mass is at the geometric center of the rod, marked "x" in picture above

$$\text{CoM} = \frac{L}{2}\hat{\imath} + 0\hat{\jmath} = 0.8 \text{ m}\,\hat{\imath} + 0 \text{ m}\,\hat{\jmath}$$

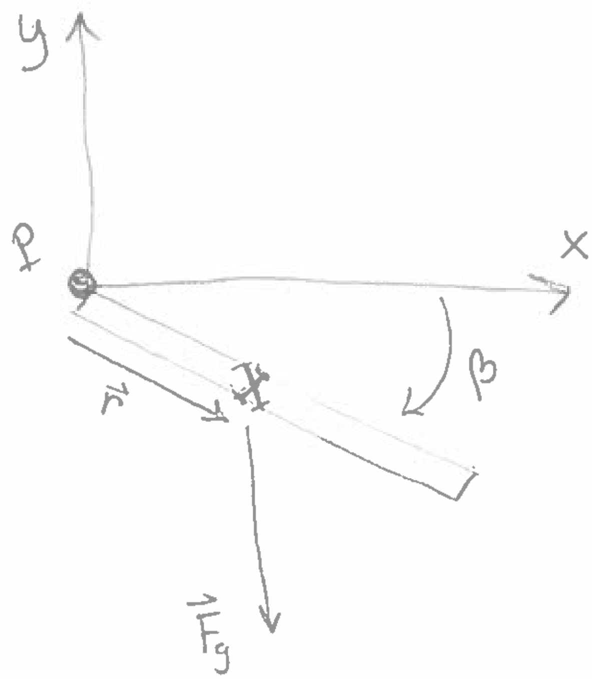
Gravity pulls on the rod at its center of mass, so the torque on rod around point P is

$$\tau = \vec{r} \times \vec{F_g} = (0.8 \text{ m}\,\hat{\imath} + 0 \text{ m}\,\hat{\jmath}) \times (-23.03 \text{ N}\,\hat{\jmath})$$

$$= -18.4 \text{ N}\cdot\text{m}\,\hat{k}$$ into page



The rod is released, and begins to swing down. After a short time, it has rotated by angle $\beta = 20°$.



The center of mass is now at

$$x = r\cos\beta = \frac{L}{2}\cos\beta$$
$$= 0.752\ m$$
$$y = -r\sin\beta = -\frac{L}{2}\sin\beta$$
$$= -0.274\ m$$

The change in GPE from initial state is

$$\Delta GPE = GPE_f - GPE_i$$
$$= mgy_f - mgy_i$$
$$= (2.35\ kg)(9.8\ \tfrac{m}{s^2})(-0.274\ m) - 0$$
$$= -6.30\ J$$

The Kinetic energy of the rod is equal in size to this

$$KE_i + GPE_i = KE_f + GPE_f$$
$$0 + 0 = \tfrac{1}{2} I\omega_f^2 + (-6.30\ J)$$
$$\Rightarrow \tfrac{1}{2} I\omega_f^2 = 6.30\ J$$

So the angular velocity is

$$\omega_f = \sqrt{\frac{6.30\ J}{\frac{1}{2}(2.005\ kg\cdot m^2)}} = 2.51\ \tfrac{rad}{s}$$