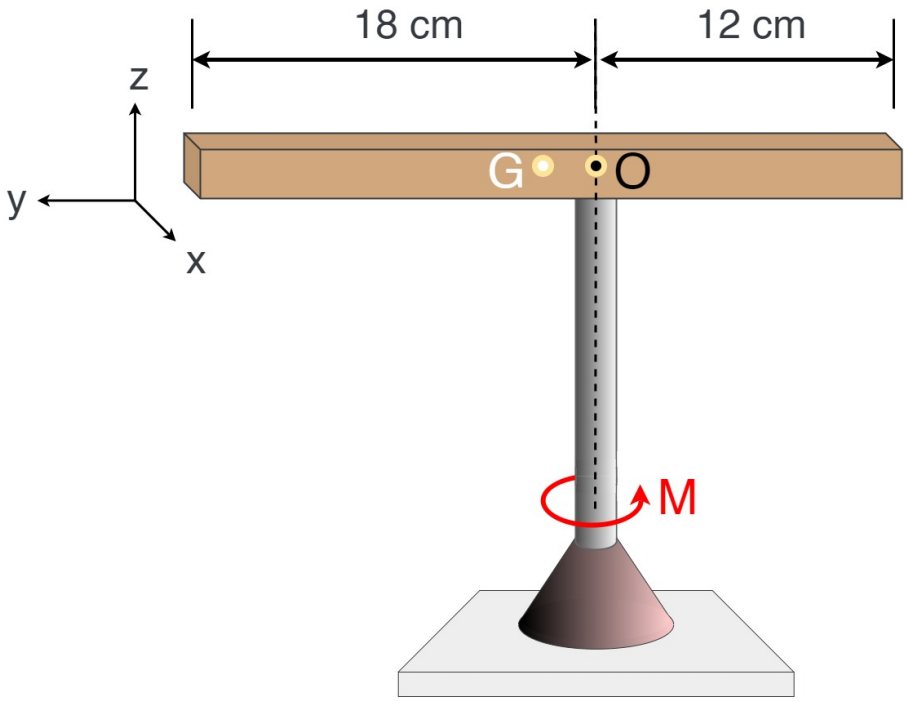
Unbalanced slender bar



The 30 cm slender bar weighs 100 kg and is mounted on a vertical shaft at **O**. If a torque $\mathbf{M} = 5\ Nm$ is applied to the bar through its shaft, calculate the magnitude of the horizontal force **R** on the bearing as the bar starts to rotate.

$$m = 100\ kg$$
$$M = 5\ Nm$$
$$L = 0.3\ m$$

The centre of mass G is located 15 cm from either end.
This means the distance d from O to G is 3 cm or 0.03 m.

Mass moment of inertia around O:

$$I = \frac{1}{12}mL^2 + md^2 = 0.84\ [kg \cdot m^2]$$

Angular acceleration:

$$\alpha = \frac{M}{I} = 5.952\ [rad/s^2]$$

The coordinate system is aligned such that as the bar starts to rotate, the acceleration of G points exactly in the positive x-direction.

Linear acceleration of G in the x-direction:

$$a_{G,x} = \alpha \cdot d = 0.1786\ [m/s^2]$$

Force in the x-direction on the bearing:

$$R = -m \cdot a_{G,x} = -17.86\ [N]$$

Note that the force on the bearing is in the **negative** x-direction, since the centre of mass of the bar accelerates in the **positive** x-direction and [**action = -reaction**].

Since the **magnitude** of the force is asked in the exercise, the answer is 17.86 N.