



The 30 cm slender bar weighs 100 kg and is mounted on a vertical shaft at O . If a torque $M = 5 \text{ Nm}$ 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.

$$m = 100 \text{ kg}$$

$$M = 5 \text{ Nm}$$

$$L = 0.3 \text{ m}$$

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 :

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

Angular acceleration:

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

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:

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

Force in the x -direction on the bearing:

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

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.