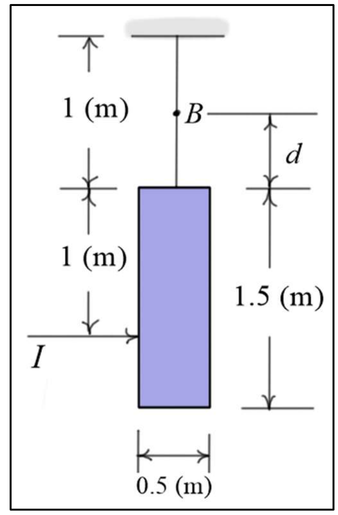
Elementary Dynamics Example #48: (Rigid Body Kinetics – Impulse & Momentum #2)



Given: uniform cylindrical bag with mass $m_{\text{bag}} = m = 100$ (kg)

applied Impulse, $I = 20$ (N-s)

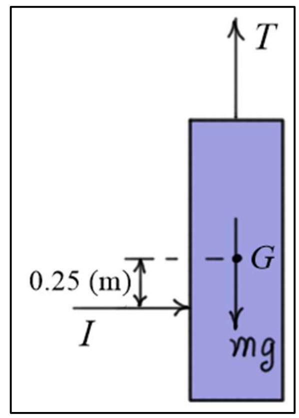
bag is at rest when the impulse is applied

Find: ω, the angular velocity of bag just after impulse is applied

d, the distance from top of bag to the instantaneous center

Solution:

The bag is at ***rest*** when the impulse I is applied. The tension and weight forces are in the y-direction only. Applying the principles of linear and angular impulse and momentum to the free body diagram gives



$$\underbrace{(L_1)_x}_{\text{zero}} + \sum (\text{Imp})_x = (L_2)_x \qquad \underbrace{(\underset{\sim}{H}_G)_1}_{\text{zero}} + \sum \int \underset{\sim}{M}_G \, dt = (\underset{\sim}{H}_G)_2$$

$$\overset{+}{\rightarrow} \; I = m(v_G)_{2x} \quad \Rightarrow \quad (v_G)_{2x} = \frac{I}{m} \approx 0.2\overline{66} \text{ (m/s)}$$

$$\circlearrowleft{+} \; 0.25 I = I_G \, \omega_2 = \tfrac{1}{12} m \left(3r^2 + h^2\right) \omega_2$$

$$\Rightarrow \omega_2 = \frac{0.25 I}{\tfrac{1}{12} m \left(3r^2 + h^2\right)} \approx 0.328205 \approx 0.328 \text{ (rad/s)} \quad \text{(counterclockwise)}$$

If B is the instantaneous center, then just after the impulse

$$(d + 0.75)\omega_2 = (v_G)_{2x} \quad \Rightarrow \quad d = \left(\frac{(v_G)_{2x}}{\omega_2}\right) - 0.75 \approx 0.0625 \text{ (m)}$$