

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

$$\underbrace{(L_1)_x}_{\text{zero}} + \sum (\text{Imp})_x = (L_2)_x \quad \underbrace{(H_G)_1}_{\text{zero}} + \sum \int M_G dt = (H_G)_2$$

$$\overset{+}{\rightarrow} I = m(v_G)_{2x} \Rightarrow (v_G)_{2x} = \frac{I}{m} \approx 0.266 \text{ (m/s)}$$

$$\overset{\curvearrowright}{\circlearrowleft} 0.25 I = I_G \omega_2 = \frac{1}{12} m(3r^2 + h^2) \omega_2$$

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

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

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

