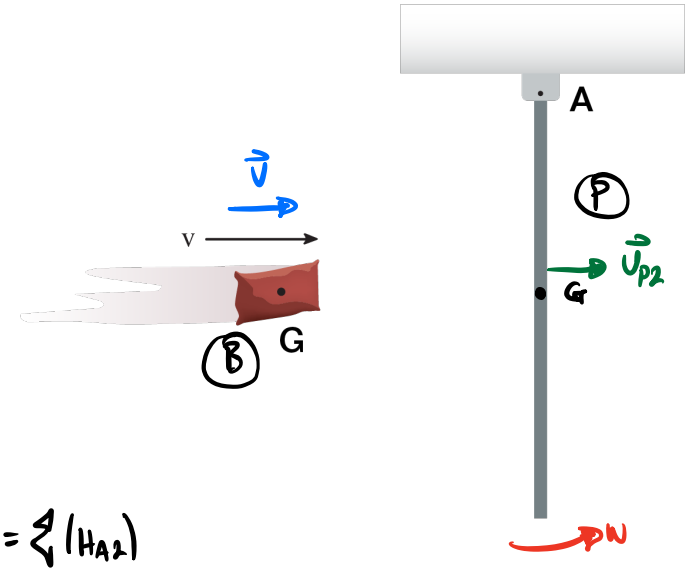
A 1 m x 1 m plate is used as target practice at a firing range. This time a bean bag cannon is being used. If a bean bag has a mass of $m_{bag} = 2\ kg$ and a radius of gyration $k_G = 0.1\ m$, determine the angular velocity of the plate right after the bean bag strikes it in the center with a velocity of $v = 20\ m/s$. The plate has a mass $m_{plate} = 20\ kg$ and the coefficient of restitution is $e = 0.4$.



$$\Sigma(H_{A_1}) = \Sigma(H_{A_2})$$

$$H_B = \cancel{H_G}^{\,0} + r_{G/A}\, m v_B$$

$$\frac{\ell}{2} m_B v_{B_1} = \frac{\ell}{2} m_B v_{B_2} + \frac{\ell}{2} m_P v_{P_2} + I_{GP}\, \omega_2$$

$$\frac{(1m)}{2}(2kg)(20m/s) = \frac{(1m)}{2}(2kg)\, v_{B_2} + \frac{(1m)}{2}(20kg)\, v_{P_2} + \overbrace{\tfrac{1}{12} m \ell^2}^{\frac{1}{12}(20kg)(1m)^2}\omega_2 \quad (*)$$

$$v_{P_2} = \frac{\ell}{2}\omega_2 = \frac{(1m)}{2}\omega_2 = \frac{\omega_2}{2} \qquad (\vec{v} = \vec{\omega} \times \vec{r})$$

$$e = \frac{v_{P_2} - v_{B_2}}{v_{B_1} - \cancel{v_{B_1}}^{\,0}} \qquad 0.4 = \frac{\frac{\omega_2}{2} - v_{B_2}}{20m/s - 0}$$

$$8 = \frac{w_2}{2} - v_{B2} \quad \Rightarrow \quad v_{B2} = \frac{w_2}{2} - 8 \quad [m/s]$$

$$(+) \circlearrowleft \quad 20 = v_{B2} + 5w_2 + \frac{20}{12} w_2 = v_{B2} + \frac{20}{3} w_2$$

$$20 = \frac{w_2}{2} - 8 + \frac{20}{3} w_2$$

$$\boxed{w_2 = 3.91 \text{ rad/s}}$$