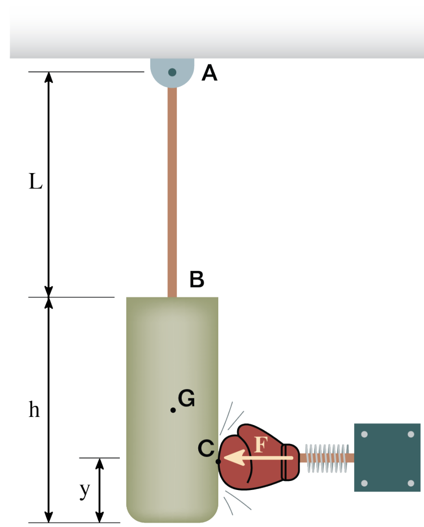
22-R-KIN-JL-10

An engineer decides to go to the gym to show off how strong the new punching machine that he built is. The punching bag can be approximated by a cylinder with height $h = 12$m and a radius of 0.5 m. The punching bag has a constant density of $\rho = 650$ kg/m^3 and is attached to the pin at A by a rigid member of length $L = 6$ m. The member is rigidly attached to the bag and has a negligible mass. Find the radius of gyration about the point A.



Solution

The mass moment of inertia at the point A is:

$$I_A = I_{bag}$$

$$I_A = (I_G)_{bag} + md^2$$

$$I_A = \frac{1}{12}m(3r^2 + h^2) + m(L + \frac{h}{2})^2$$

$$I_A = m\left(\frac{1}{12}(3r^2 + h^2) + (L + \frac{h}{2})^2\right)$$

The radius of gyration about point A is:

$$k_A = \sqrt{\frac{I_A}{m}} \quad \Longrightarrow \quad I_A = mk_A^2$$

Equating the values for I_A gives:

$$mk_A^2 = m\left(\frac{1}{12}(3r^2 + h^2) + (L + \frac{h}{2})^2\right)$$

$$k_A = \sqrt{\frac{1}{12}(3r^2 + h^2) + (L + \frac{h}{2})^2}$$

$$= \sqrt{\frac{1}{12}(3 \cdot 0.5^2 + 12^2) + (6 + \frac{12}{2})^2} = 12.492 \quad \text{[m]}$$