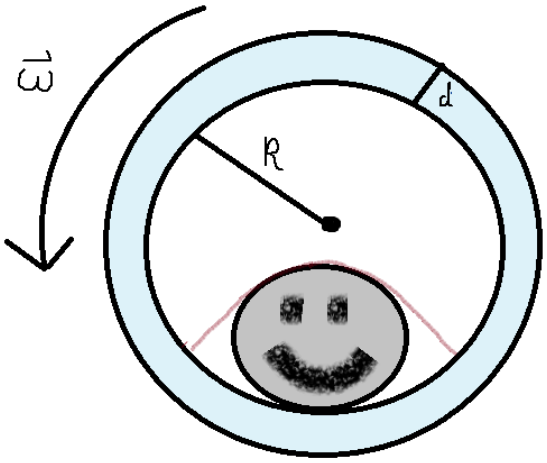
22-R-KIN-TW-8



Julie is taking her pet rock, Rocko, for a walk. Rocko is safely fastened to the side of a hollow cylinder with inner radius $R = 15$ cm, thickness $d = 0.5$ cm, and length 30 cm. If the cylinder has a density of $\rho = 100$ kg/m^3, what is the moment of inertia of the ball-rock system about the center of the cylinder? Assume the rock is perfectly spherical with a mass of 1 kg and a radius of 3.75 cm.

Solution:

$$I_{cylinder} = \frac{1}{2}mr^2$$
$$I_{cylinder} = I_{outside} - I_{inside}$$
$$m_{inside} = \rho V_{inside} = \rho\pi R^2 l = (100)\pi(0.15)^2(0.3) = 2.12 \text{ [kg]}$$
$$m_{outside} = \rho V_{outside} = \rho\pi(R+d)^2 l = (100)\pi(0.155)^2(0.3) = 2.26 \text{ [kg]}$$
$$I_{cylinder} = \frac{1}{2}(m_{out}r_{out}^2 - m_{in}r_{in}^2) = \frac{1}{2}((2.26)(0.155)^2 - (2.12)(0.15)^2) = 0.0033 \text{ [kg}\cdot\text{m}^2\text{]}$$
$$I_{rock} = I_G + mx^2$$
$$x = R - r = 0.15 - 0.0375 = 0.1125$$
$$I_{rock} = \frac{2}{5}m_{rock}r^2 + m_{rock}x^2 = \frac{2}{5}(1)(0.0375)^2 + (1)(0.1125)^2 = 0.0132 \text{ [kg}\cdot\text{m}^2\text{]}$$
$$I = I_{ball} + I_{rock} = 0.0166 \text{ [kg}\cdot\text{m}^2\text{]}$$