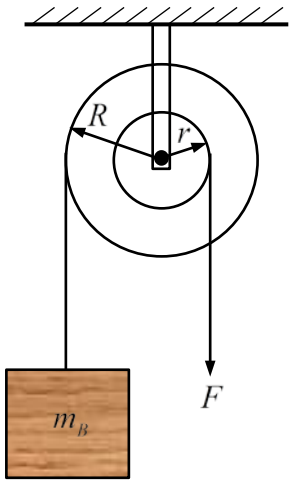
4-13. Two wheels are welded together and they turn at the same rate. The double wheel has a total mass of $m = 10$ kg and a radius of gyration $k_O = 80$ mm. The radiuses of the two wheels are $R = 0.2$ m and $r = 0.1$ m, respectively. A normally distributed force $F \sim N(1500, 150^2)$ N is applied to the inner wheel to hoist the 45 kg block that is attached to the outer wheel. If the block is originally at rest and the mass of the rope is negligible, determine the probability that the velocity of the block is smaller than 10 m/s after 2 seconds.



$$(H_O)_1 + \Sigma \int M_O dt = (H_O)_2$$

$$0 + Frt - m_B gRt = mk_O^2 \omega + m_B R^2 \omega$$

$$\omega = \frac{(Fr - m_B gR)t}{mk_O^2 + m_B R^2}$$

$$v_B = \omega R = \frac{(Fr - m_B gR)tR}{mk_O^2 + m_B R^2}$$

$$\mu_{v_B} = \frac{(\mu_F r - m_B gR)tR}{mk_O^2 + m_B R^2} = \frac{(1500(0.1) - 45(9.81)(0.2))(2)(0.2)}{10(0.08)^2 + 45(0.2)^2} = 13.24 \text{ m/s}$$

$$\sigma_{v_B} = \frac{rtR\sigma_F}{mk_O^2 + m_B R^2} = \frac{0.1(2)(0.2)(150)}{10(0.08)^2 + 45(0.2)^2} = 3.22 \text{ m/s}$$

$$\Pr\{v_B < 10\} = \Phi\left(\frac{10 - \mu_{v_B}}{\sigma_{v_B}}\right) = \Phi\left(\frac{10 - 13.24}{3.22}\right) = 0.16$$