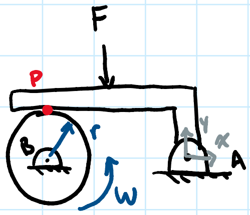
20-R-IM-DK-6

July 6, 2020 10:00 AM

Intermediate Principle of Impulse and Momentum

Inspiration: 19-4 Hibbeler

Your team is prototyping a simple braking system for your model car. The ***2 kg*** wheel with a radius of ***r = 0.1 m*** is rotating at ***omega = 10 rad/s***. A servo motor can apply a variable force F, which in its first two seconds of operation is equal to F = 10t N and afterwards is equivalent to a constant force of F = 20 N. If the coefficient of kinetic friction between the braking arm and the wheel is ***mu_k = 0.2***, determine the time needed for the wheel to come to a full stop. The point of contact P between the wheel and the arm is a distance ***r_P/A = (-0.3 i + 0.12 j) m*** from point A. The force of the servo motor is applied at exactly half of the horizontal distance to A from the point of contact. Assume the wheel can be treated as a disk and that the braking arm is massless.



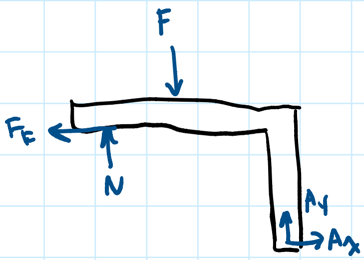
Brake

$$\Sigma M_A = 0 = F\left(\frac{0.3}{2}\right) + F_F(0.12) - N(0.3)$$

$$= F(0.15) + 0.2N(0.12) - N(0.3)$$

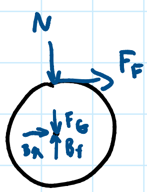
$$0.8N(0.3) = F(0.15)$$

$$N = 0.625F$$



$$I_B w_1 + \Sigma \int_{t_1}^{t_2} M_B \, dt = I_B w_2$$

$$\frac{1}{2} m r^2 w_1 + \int_0^t -r F_F \, dt = 0$$



$$\frac{1}{2}(2)(0.1^2)(10) = \int_0^t (0.1)(0.2)(0.625F) \, dt$$

Two scenarios

$$0.1 = 0.0125 \int_0^t F \, dt \qquad 8 = \int_0^t F \, dt$$

Within 2 seconds

$$8 = \int_0^t 10t \, dt$$

$$8 = 5t^2$$

$$\boxed{t = 1.2649} < 2 \checkmark$$

After 2 seconds

$$8 = \int_0^2 10t \, dt + \int_2^t 20$$

$$8 = 5(2)^2 + 20(t-2)$$

$$8 = 20 + 20t - 40$$

$$28 = 20t$$

$$t = 1.4 < 2 \times$$

Not greater than 2

250t

$125t^2$