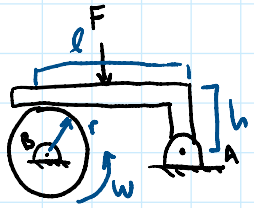
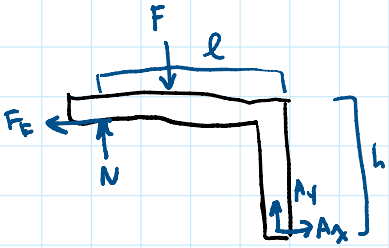
20-R-IM-DK-6

July 6, 2020 10:00 AM

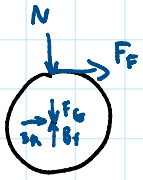
Intermediate Principle of Impulse and Momentum

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 2 seconds of operation is equal to $F = 10t$ and afterwards is equivalent to a constant force of $F = 20$ N. If the coefficient of kinetic friction is $\mu_k = 0.2$, determine the time needed for the wheel to come to a full stop. The braking arm has dimensions $\ell = 0.3$ m and $h = 0.12$ m, and the force of the servo motor is applied at $\frac{\ell}{2}$. Assume the wheel can be treated as a disk and the braking arm is massless.



Brake

$$\sum M_A = 0 = F\left(\frac{0.3}{2}\right) + F_F(0.12) - N(0.3)$$
$$= F(0.15) + 0.2N(0.12) - N(0.3)$$
$$0.8N(0.3) = F(0.15)$$
$$N = 0.625F$$

$$I_B\omega_1 + \sum\int_{t_1}^{t_2} M_B\,dt = I_B\omega_2$$

$$\frac{1}{2}mr^2\omega_1 + \int_0^t rF_F\,dt = 0$$

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

Two scenarios

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

Within 2 seconds

$$8 = \int_0^t 10t\,dt$$
$$8 = 5t^2$$
$$t = 1.264 \text{ s} < 2 \checkmark$$

After 2 seconds

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

250 t

125 t²

$$8 = 5(2)^2 + 20(t-2)$$
$$8 = 20 + 20t - 40$$
$$28 = 20t$$
$$t = 1.4 < 2 \times$$

Not greater than 2