20-R-IM-DK-10

July 7, 2020 10:34 AM

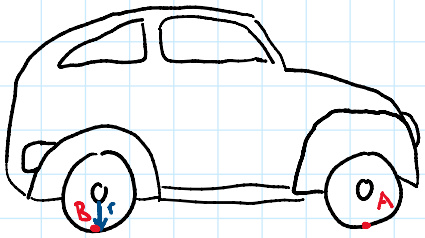
Intermediate Principle of Impulse and Momentum

Inspiration: 19-16 Hibbeler

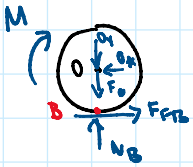
$k: 0.3 - 0.5$ $m_{wheel}: 6 - 9.5$

$m_{tot}: 700 - 900$ kg

$M = 400 - 600$



A punch buggy has a total mass of ***m_tot = 840 kg***, including the mass of its passengers and its four wheels. Each wheel has a mass ***m_wheel = 7 kg*** and a radius of gyration about its axle of ***k = 0.4 m*** and a radius of gyration about its axle of ***k = 0.4 m***. You are just learning to drive the punch buggy and accidentally step on the accelerometer. If this causes the motor to apply a moment of ***M = 200 Nm*** to the two rear wheels, determine the speed of your car and your panicked instructor after ***t = 3 seconds***. Each wheel has a radius ***r = 0.3 m*** and can be treated as if it were pinned on the axle. Assume the car rolls without slipping and starts from rest. Neglect the screams of your instructor while you do this calculation.



Rear wheels

$$(H_B)_1 + \sum \int_{t_1}^{t_2} M_B \, dt = (H_B)_2$$

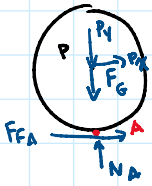
$$\circlearrowright + \quad 0 + \int_0^3 M - O_x r \, dt = 2(I_O w + r(mv)) \qquad \vec{L}$$

$$200(3) - O_x(0.3)(3) = 2\left(7(0.4)^2 w + 0.3(7)v\right)$$

Rolling without slipping $\Rightarrow v = wr$

$$600 - 0.9\,O_x = 2.24\left(\frac{1}{0.3}\right)v + 4.2v$$

$$O_x = -\frac{350}{27}v + \frac{2000}{9}$$

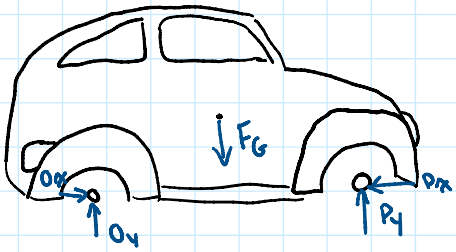


Front wheels

$$(H_A)_1 + \sum \int_{t_1}^{t_2} M_A \, dt = (H_A)_2$$

$$0 + P_x(0.3)(3) = 2\left(7(0.4)^2 w + 0.3(7)v\right)$$

$$P_x = \frac{350}{27}v$$



Car frame + Passengers: $m = 840 - 4(7) = 812$

x: $$m v_{Gx_1} + \sum \int_{t_1}^{t_2} F_x \, dt = m v_{Gx_2}$$

$$0 + O_x(3) - P_x(3) = 812v$$

$$-\frac{350}{27}(3)v + 2000 - \frac{350}{27}(3)v = 812v$$

$$2000 = \frac{8005}{9}v$$

$$\boxed{v = 2.24775 \text{ m/s}}$$