20-R-IM-DK-8

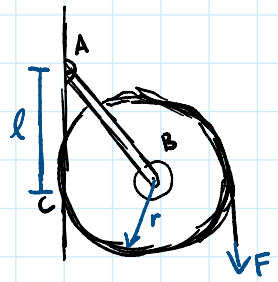
July 7, 2020 9:12 AM

Intermediate Principle of Impulse and Momentum

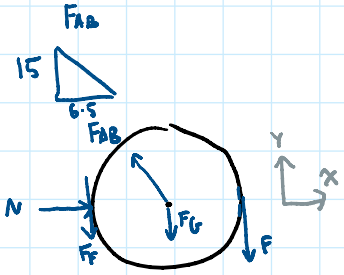
Inspiration: 19-12 Hibbeler

Check: Answer (Magnitude larger than expected but could be because F is comparitively large and time is relatively long)

(Similar scenario as 20-R-KIN-DK-23)



You were able to obtain a roll of toilet paper during quarantine and put it to good use. If the roll rests against a wall where its coefficient of friction is $\mu_k = 0.2$ and you apply a vertical force $F = 10\ N$ downwards, determine the magnitude of the angular velocity of the roll after $t = 5\ s$. Point B and point C are located a vertical distance $\ell = 0.15\ m$ under point A. Assume the roll can be treated as a cylinder with a mass of $m = 0.25\ kg$, a width of $w = 0.115\ m$, and a radius of $r = 0.065\ m$. Neglect the mass of the unraveled toilet paper and make sure to wash your hands after.



$$I_B = \frac{1}{2}mr^2 = \frac{1}{2}(0.25)(0.065)^2 = \frac{169}{320000}$$

x: $m v_{Bx_1} + \sum \int_{t_1}^{t_2} F_x\, dt = m v_{Bx_2}$

$$0 + \int_0^5 N - F_{AB}\frac{6.5}{\sqrt{15^2+6.5^2}} = 0$$

$$5N = 5(0.3976)F_{AB}$$

$$N = 0.3976\, F_{AB}$$

y: $m v_{By_1} + \sum \int_{t_1}^{t_2} F_y\, dt = m v_{By_2}$

$$0 + \int_0^5 -F_F + F_{AB}\frac{15}{\sqrt{15^2+6.5^2}} - F_G - F\, dt = 0$$

$$-5(0.2N) + 5\left(\frac{15}{\sqrt{15^2+6.5^2}}F_{AB}\right) - 5(0.25)(9.81) - 5(10) = 0$$

$$0.917556\, F_{AB} - 0.2N = 12.4525$$

$$0.838036\, F_{AB} = 12.4525$$

$$F_{AB} = 14.8591\ N$$

$$N = 5.9084\ N$$

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

$$0 + \int_0^5 -Fr + F_F r\, dt = I_B w_2$$

$$-10(0.065)(5) + 0.2(5.908)(0.065)(5) = \frac{169}{320000} W_2$$

$$\vec{W_2} = -5426.707692 \text{ rad/s}$$

$$W_2 = 5426.708 \text{ rad/s}$$