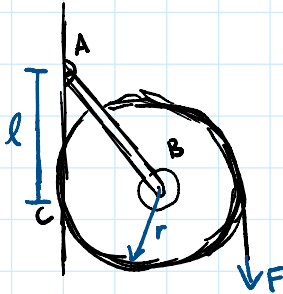


# Intermediate Principle of Impulse and Momentum

Inspiration: 19-12 Hibbeler

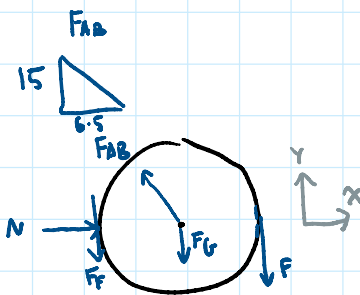
(Similar scenario as 20-R-KIN-DK-23)



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  $F = 10 \text{ N}$  downwards, determine the magnitude of the angular velocity of the roll after  $t = 5 \text{ seconds}$ . Point B and point C are located a vertical distance  $l = 0.15 \text{ m}$  under point A. Assume the roll can be treated as a cylinder with a mass of  $m = 0.25 \text{ kg}$ , a width of  $w = 0.115 \text{ m}$ , and a radius of  $r = 0.065 \text{ m}$ . Neglect the mass of the unraveled toilet paper and make sure to wash your hands after.

For Webwork, decrease  $F$  and  $t$  variables to lower the magnitude of the final answer

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



$$x: m v_{Bx1} + \sum \int_{t_1}^{t_2} F_x dt = m v_{Bx2}$$

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

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

$$N = 0.3976 F_{AB}$$

$$y: m v_{By1} + \sum \int_{t_1}^{t_2} F_y dt = m v_{By2}$$

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

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

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

$$0.438036 F_{AB} = 12.4525$$

$$F_{AB} = 14.45915 \text{ N}$$

$$N = 5.908 \text{ N}$$

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

$$0 + \int_0^5 -Fr + F_f r dt = I_B \omega_2$$

$$-10(0.065)(5) + 0.2(5.908)(0.065)(5) = \frac{169}{320000} \omega_2$$

→

$$-10(0.065)(5) + 0.2(5.908)(0.065)(5) = \frac{-10}{320000} \omega_2$$

$$\vec{\omega}_2 = -5426.707692 \text{ rad/s}$$

$$\omega_2 = 5426.708 \text{ rad/s}$$