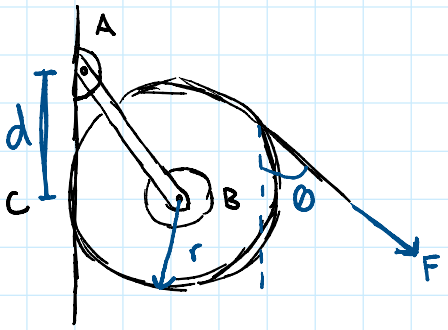
20-R-KIN-DK-23

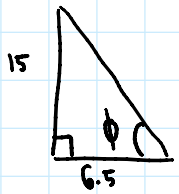
June 2, 2020 9:25 AM

20-R-KIN-DK-23 Intermediate Rotation

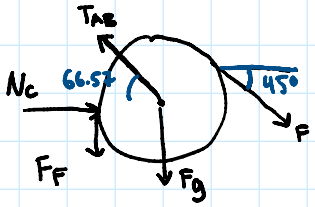
Inspiration: 17-69 Hibbeler



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 $\mu_k = 0.18$ and you apply a force of 5 N at an angle of 45° tangent to the roll, determine the angular acceleration of the precious toilet paper. Assume the roll can be treated as a cylinder with a mass of 0.25 kg, a width of 11.5 cm, and a radius of 6.5 cm. Point B is a vertical distance $d = 15$ cm from point A.



$$\phi = \tan^{-1}\frac{15}{6.5} = 66.5713^\circ$$



$$\sum F_x: \; ma_{Gx} = 0 = N_C + F\cos\theta - T_{AB}\cos\phi$$

$$\sum F_y: \; ma_{Gy} = 0 = T_{AB}\sin\phi - F_g - F_F - F\sin\theta$$

$$\sum M_B: \; F_F r - Fr = I_G\alpha$$

$$F_F = \mu_K N_C = 0.18 N_C$$

$$N_C + 1\cos 45 - T_{AB}\cos 66.57 = 0 \qquad N_C = T_{AB}\cos 66.57 - 1\cos 45$$

$$T_{AB}\sin 66.57 - 0.25(9.81) - 0.18N_C - 1\sin 45 = 0$$

$$0.18N_C(0.065) - 1(0.065) = \tfrac{1}{2}(0.25)(0.065)^2\alpha$$

$$T_{AB}\sin 66.57 - 2.4525 - 0.18T_{AB}\cos 66.57 + 0.18(\cos 45) - \sin 45 = 0$$

$$T_{AB}\sin 66.57 - 0.18T_{AB}\cos 66.57 = 3.0323$$

$$\boxed{T_{AB} = 3.5644 \text{ N}} \qquad \boxed{N_C = 0.7181619}$$

$$\boxed{\alpha = -107.16607 \text{ rad/s}^2}$$