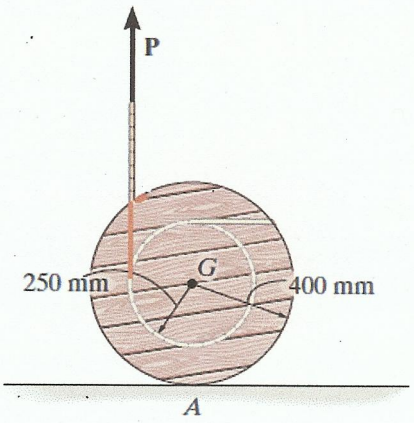
Force Acceleration III – Problem 1



The spool has a mass of 10 kg and a radius of gyration of $k_G = 0.3$ m. If the coefficients of static and kinetic friction at A are $\mu_s = 0.2$ and $\mu_k = 0.15$, respectively, determine the angular acceleration of the spool if P = 50 N.

CLASSIFY MOTION

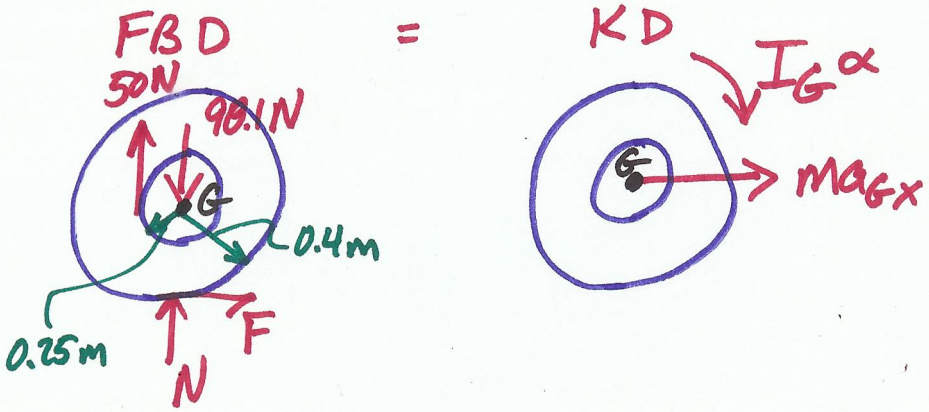
GPM

PROPERTIES

$W = 10(9.81) = 98.1\,N$

$I_G = mk^2 = 10(.3)^2 = 0.9\,kg\,m^2$

FBD = KD



WRITE EQNS

① $\uparrow \Sigma F_y \Rightarrow \quad 50 - 98.1 + N = 0 \qquad N = 48.1$

② $\rightarrow \Sigma F_x \Rightarrow \quad F = ma_{Gx} = 10\,a_{Gx} \qquad = 10(0.4\alpha)$

③ $\circlearrowleft \Sigma M_G \Rightarrow \quad -50(.25) + F(0.4) = -0.9\alpha$

ASSUME NO SLIP

$a_{Gx} = \alpha r = 0.4\alpha$

SOLVE ② + ③

$F = 4\alpha$

$-50(.25) + (4\alpha)(0.4) = -0.9\alpha \qquad \alpha = 5.0\ rps^2\ \circlearrowleft$

Force Acceleration III – Problem 1 continued

So IF $\alpha = 5.0 \text{ rps}^2$

THEN $a_{Gx} = 0.4\alpha = 2.0 \text{ m/s}^2$

$F = 10 a_{Gx} = 20.0 \text{ N}$

CHECK NO SLIP ASSUMPTION

$F_{MAX} = \mu_S N = 0.2(48.1 \text{ N}) = 9.62 \text{ N}$

$F > F_{MAX}$ ∴ SLIPPING!

RECALCULATE a_{Gx} USING $F = \mu_K N$

$F = \mu_K N = 0.15(48.1 \text{ N}) = 7.21 \text{ N}$

FROM EQN 3

$-50(.25) + F(0.4) = -0.9\alpha$

$-50(.25) + 7.21(0.4) = -0.9\alpha$

$\alpha = 10.68 \text{ rps}^2$ ↙