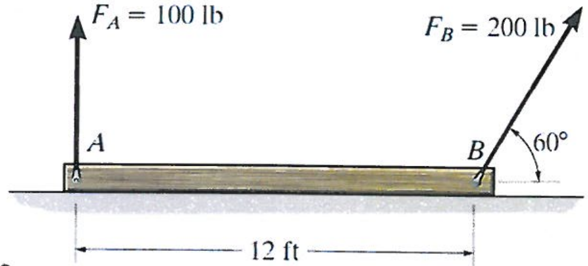
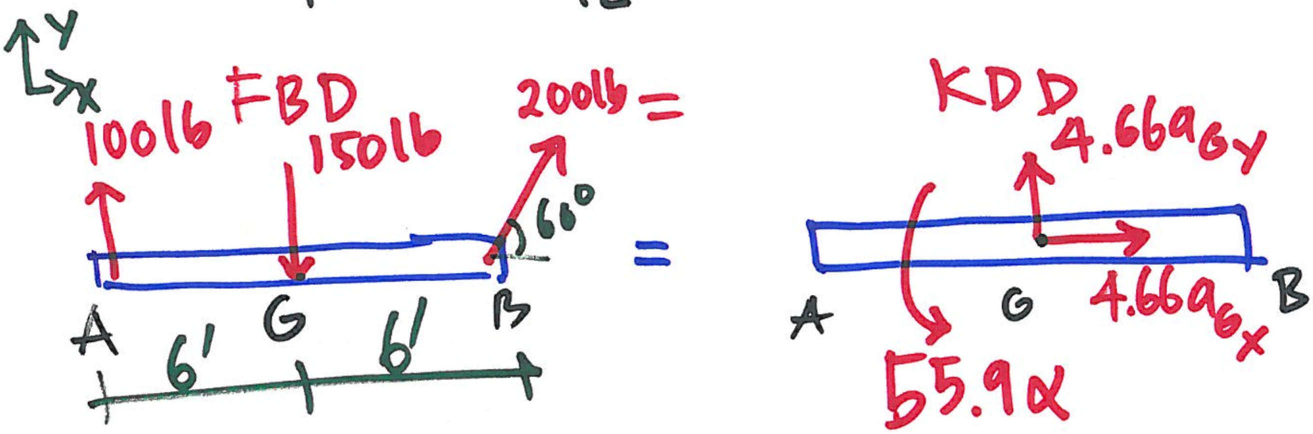
17-92

The uniform 150-lb beam is initially at rest when the forces are applied to the cables. Determine the magnitude of the acceleration of the mass center and the angular acceleration of the beam at this instant.



$W = 150\,lb \Rightarrow mass = \frac{150}{32.2} = 4.66$ slugs.

$I_G = \frac{1}{12} m l^2 = \frac{1}{12} 4.66\,(12^2) = 55.9$ slug-ft^2



$\xrightarrow{+} \Sigma F_x = m a_{Gx}$: $200 \cos 60° = 4.66\, a_{Gx}$

$a_{Gx} = 21.46$ ft/s^2

$+\uparrow \Sigma F_y = m a_{Gy}$: $100 - 150 + 200 \sin 60° = 4.66\, a_{Gy}$

$a_{Gy} = 26.43$ ft/s^2

$a_G = \sqrt{a_{Gx}^2 + a_{Gy}^2} = \sqrt{21.46^2 + 26.43^2} = \underline{\underline{34.0}}$ ft/s^2

Ans.

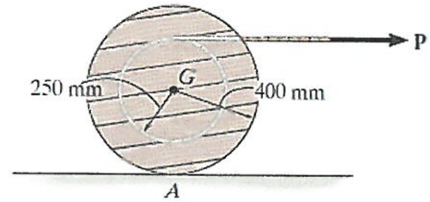
$\circlearrowleft + \Sigma M_G = I_G \alpha$: $-100(6) + 200 \sin 60° (6) = 55.9\alpha$

$\alpha = \underline{\underline{7.86 \text{ rad/s}^2}} \circlearrowleft$

Ans.

*17–96.

The spool has a mass of 100 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.



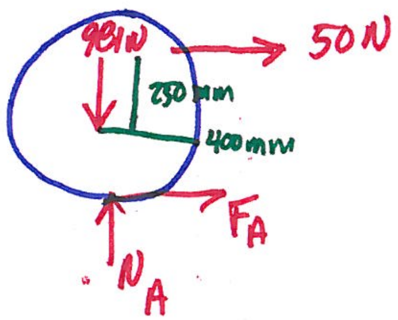
CLASSIFY MOTION

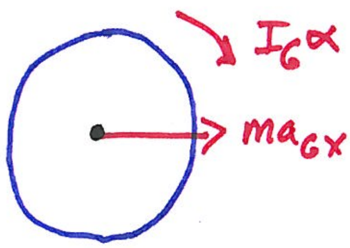
GPM

$I_G = mk^2 = 100(.3)^2 = 9 \text{ Kg m}^2$

$W = 100(9.81) = 981 \text{ N}$

FBD = KD





① $\rightarrow \Sigma F_x = 50 + \underline{F_A} = 100\, \underline{a_{Gx}}$

② $\uparrow \Sigma F_y = \underline{N_A} - 981 = 0$ $\quad N_A = 981 \text{ N} \uparrow$

③ $\circlearrowright \Sigma M_G = .25(50) - .4\underline{F_A} = 9\underline{\alpha}$

3 EQNS
4 UNKS

ASSUME NO SLIP

$a_G = \alpha_w r_w = \alpha_w (0.4)$

① $F_A - 100(.4\alpha) = -50$

③ $-.4F_A - 9\alpha = -12.5$ } SOLVE

$$\begin{bmatrix} 1 & -40 \\ -.4 & -9 \end{bmatrix} \begin{Bmatrix} F_A \\ \alpha \end{Bmatrix} = \begin{Bmatrix} -50 \\ -12.5 \end{Bmatrix}$$

$F_A = 2.0 \text{ N}$

$\alpha = 1.3 \text{ rad/s}^2$

CHECK ASSUMPTION

$F_{max} = \mu_s N = 0.2(981) = 196.2 \text{ N} > F_a = 2.0 \text{ N}$

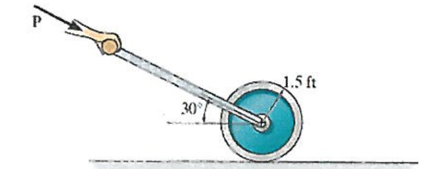
YES!

$\therefore$ NO SLIP

SO $\underline{\alpha = 1.3 \text{ rad/s}^2 \circlearrowright}$

17–105.

If the coefficient of static friction between the 50-lb roller and the ground is $\mu_s = 0.25$, determine the maximum force P that can be applied to the handle, so that roller rolls on the ground without slipping. Also, find the angular acceleration of the roller. Assume the roller to be a uniform cylinder.



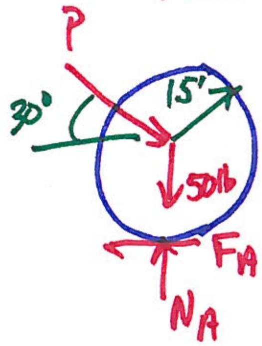
CLASSIFY MOTION

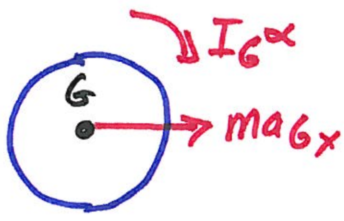
GPM

$W = 50\text{lb} \qquad m = \frac{50}{32.2} = 1.553 \text{ SLUG}$

$I_G = \frac{1}{2} m r^2 = \frac{1}{2}(1.553)(1.5)^2 = 1.747 \text{ Kg-m}^2$

FBD = KD





① $\rightarrow \Sigma F_x = P\cos 30 - F_A = m a_{Gx} = 1.553\, a_{Gx}$

② $\uparrow \Sigma F_y = N_A - 50 - P\sin 30 = 0$

③ $\circlearrowright \Sigma M_G = 1.5 F_A = 1.747\alpha$

MAX FORCE W/O SLIPPING MEANS $F_A = F_{MAX} = \mu_s N_A = 0.25 N_A$

NO SLIP MEANS $a_{Gx} = \alpha_w r_w = 1.5\alpha$

SUBSTITUTE

① $P\cos 30 - 0.25 N_A - 1.553(1.5\alpha) = 0$

② $-P\sin 30 + N_A = 50$

③ $1.5(.25 N_A) - 1.747\alpha = 0$

SOLVE

$$\begin{bmatrix} .866 & -.25 & -2.33 \\ -.5 & 1 & 0 \\ 0 & .375 & -1.747 \end{bmatrix} \begin{Bmatrix} P \\ N_A \\ \alpha \end{Bmatrix} = \begin{Bmatrix} 0 \\ 50 \\ 0 \end{Bmatrix}$$

$P = 76.4 \text{ lb}$ 30°

$N_A = 88.2 \text{ lb} \uparrow$

$\alpha = 18.93 \text{ Ft/s}^2 \circlearrowright$