

Force Acceleration I – Problem 4

A drum having a radius of 5 ft and weighing 161 lbs has a radius of gyration with respect to an axis perpendicular to the paper through the center of mass, G, of 2 ft. A couple of magnitude $C = 400$ ft-lbs is applied as shown.

- Determine the acceleration of the center of mass, G.
- Determine the magnitude and direction of the friction force.

CLASSIFY MOTION
GPM

PROPERTIES

$$W = 161 \text{ lbs}$$

$$m = \frac{161}{32.2} = 5 \text{ slug}$$

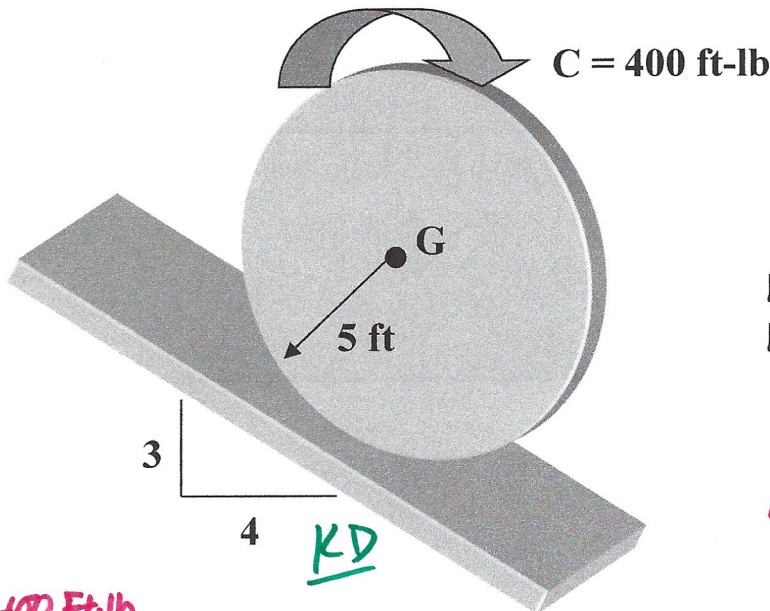
$$\mu_s = 0.3$$

$$\mu_k = 0.2$$

$$I_G = mK^2 = 5(2)^2 = 20 \text{ slug-ft}^2$$

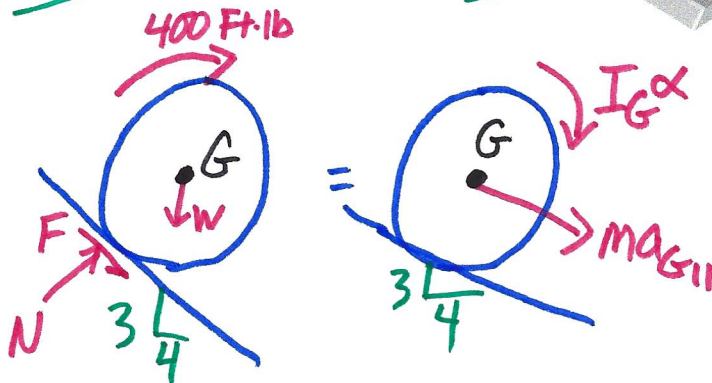
ASSUME NO SLIP WHEEL

$$a_{G_{||}} = \alpha r = 5\alpha$$



FBD

KD



$$\text{I } \rightarrow \sum F_{||} = ma_{G_{||}} \Rightarrow \frac{3}{5}(161) + F = 5(5\alpha)$$

$$\text{II } \nearrow \sum F_{\perp} = ma_{G_{\perp}} \Rightarrow N - \frac{4}{5}(161) = 0 \quad N = 128.8 \text{ lb}$$

$$\text{III } \curvearrowright \sum M_G = I_G \alpha \Rightarrow 400 - 5F = 20\alpha$$

SOLVE I + III

$$\alpha = 6.09 \text{ rad/s}^2 \quad F = 55.4 \text{ lbs}$$

Force Acceleration I – Problem 4 continued

BUT WAIT!

IF NO SLIP $F = \mu_s N = 0.3(128.8) = 38.6 < 55.4$

\therefore NO SLIP WHEEL ASSUMPTION NO GOOD, DRUM SLIPS

THEREFORE $F = \mu_k N$ AND $a_{G11} \neq \alpha r$

$F = 0.2(128.8) = 25.8$

EQU I AGAIN

$\Rightarrow \sum F_{11} = ma_{G11} \Rightarrow \frac{3}{5}(161) + 25.8 = 5a_{G11}$

$a_{G11} = 24.5 \text{ ft/s}^2 \rightarrow$

CAN SOLVE BY $\sum M$ OTHER THAN G! TRY POC WITH GROUND

$\uparrow \sum M_{POC} = \sum M_{ic} \Rightarrow 400 + \frac{3}{5}(161)5 = 20\alpha + (5(5\alpha))5$

$\Rightarrow \sum F_{11} = ma_{G11} \Rightarrow \frac{3}{5}(161) + F = 5(5\alpha)$

SOLVE $\alpha = 6.09 \text{ rps}^2 \downarrow F = 55.4 \text{ lbs}$

SAME AS BEFORE