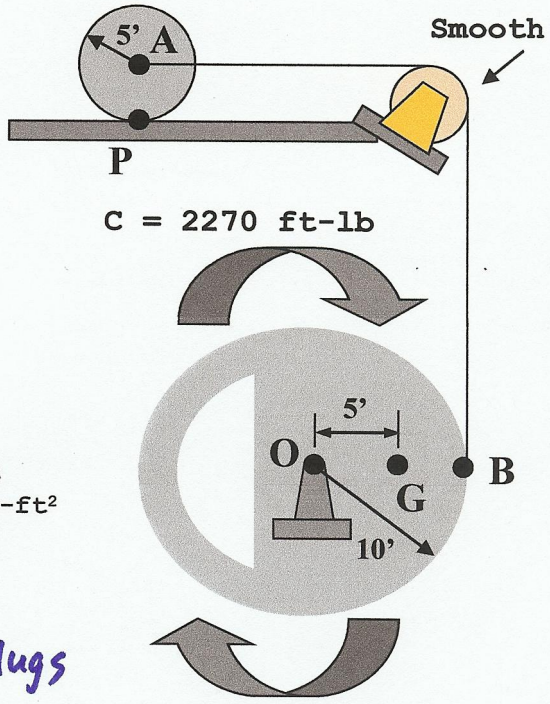
Force Acceleration II – Problem 3

The unbalanced flywheel is rotating clockwise with an angular velocity of 4 rad/sec. Does the wheel, AP, slip?

$\mu_s = 0.5$
$\mu_k = 0.3$
$W_{AP} = 161$ lbs
$I_{G\,AP} = 15$ slug-ft²

$m_{AP} = \frac{161}{32.2} = 5$ slugs



CLASSIFY MOTION

AP = GPM
OG = RAFA

$W_{OG} = 644$ lbs
$I_{G\,OG} = 800$ slug-ft²

$m_{OG} = \frac{644}{32.2} = 20$ slugs

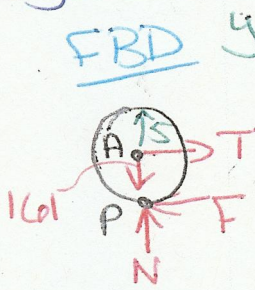
$\omega_{OG} = 4$ rps

Draw Diagrams

Wheel AP

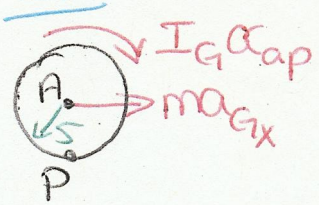
assume no slip:
$F < \mu_s N$
$a_{Gx} = 5\alpha_{ap}$

FBD



=

KD



① $\overset{+}{\rightarrow} \sum F_x = ma_{Gx} \Rightarrow T - F = 5(5\alpha_{ap})$

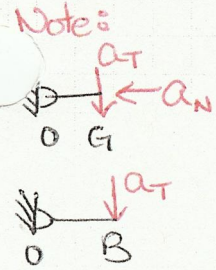
② $\overset{+}{\uparrow} \sum F_y = ma_{Gy} \Rightarrow N - 161 = 0$

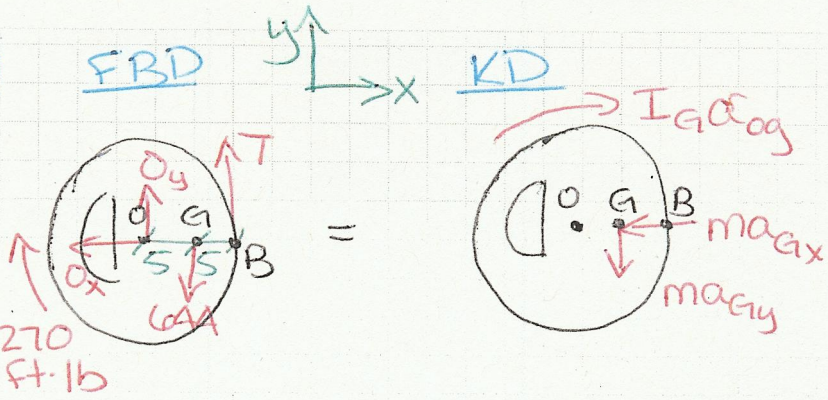
③ $\circlearrowleft \sum M_P = (\sum M_P)_{KD} \Rightarrow 5T = I_G\alpha_{ap} + (ma_{Gx})(\text{dist})$

$5T = 15(\alpha_{ap}) + (5(5\alpha_{ap}))(5)$

Wheel OG FBD KD

Note:





④ $\leftarrow +\sum F_x = ma_{Gx} \Rightarrow O_x = ma_{Gx} = m(\omega_{OG}^2 r) = 20(4^2(5))$

⑤ $+\uparrow \sum F_y = ma_{Gy} \Rightarrow 644 - O_y - T = 20(\alpha_{OG}\,5)$

⑥ $\circlearrowleft \sum M_O = (\sum M_O)_{KD} \Rightarrow 2270 + (644)(5) - (T)(10) = I_G\alpha_{OG} + (ma_{Gy})(d$

$5490 - T(10) = 800\alpha_{OG} + (20(5\alpha_{OG}))(5)$

NOTE: $a_{Gx_{AP}} = a_{B_T} \Rightarrow 5\alpha_{AP} = 10\alpha_{OG}$ ⑦

Summary of Eqns

AP mom	③	$5T - 140\alpha_{AP} = 0$
AP $\sum F_x$	①	$T - 25\alpha_{AP} - F = 0$
OG mom	⑥	$10T + 1300\alpha_{OG} = 5490$
OG $\sum F_y$	⑤	$T + 100\alpha_{OG} + O_y = 644$
Note	⑦	$5\alpha_{AP} - 10\alpha_{OG} = 0$

Matrix to Solve

$$\begin{bmatrix} 5 & -140 & 0 & 0 & 0 \\ 1 & -25 & -1 & 0 & 0 \\ 10 & 0 & 0 & 1300 & 0 \\ 1 & 0 & 0 & 100 & 1 \\ 0 & 5 & 0 & -10 & 0 \end{bmatrix} \begin{bmatrix} T \\ \alpha_{AP} \\ F \\ \alpha_{OG} \\ O_y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 5490 \\ 644 \\ 0 \end{bmatrix}$$

$T = 165.3$ lbs $\qquad \alpha_{AP} = 5.90$ rps^2 ↻

$F = 17.71$ lbs ← $\qquad \alpha_{OG} = 2.95$ rps^2 ↻

$O_y = 183.5$ lbs ↑

Check Assumption:

$F < \mu_s N$

$17.71 < (.5)(161)$

< 80.5 ✓ No Slip Assumption Valid