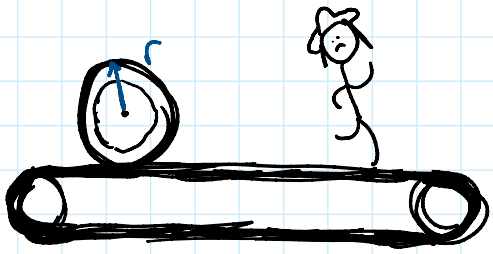
20-R-KIN-DK-34 Intermediate General Plane Motion

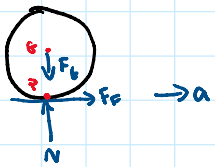
Inspiration: 17-10a Hibbeler



Mississippi Jane is at it again! She has found herself stuck on a conveyor belt with a rolling pipe - or so it seems. The pipe is actually not there and instead to be added in during post production for the actress' safety. It is up to you to calculate the proper physics of the pipe so that the CGI pipe may look as realistic as possible. If the pipe is meant to have a mass of ***500 kg*** and a mean radius of ***0.5 m***, determine the pipe's angular acceleration if the conveyor belt has an acceleration of ***3 m/s^2***. Assume the pipe does not slip on the conveyor belt, and neglect its thickness. Which way should the conveyor be rotating for the pipe to roll towards Mississippi if she is on the right of the pipe?

The conveyor should be rotating clockwise such that there is an acceleration to the right.

$$I_G = m r^2 = 500(0.5)^2 = 125 \text{ kg}\cdot\text{m}^2$$



$\sum F_x: ma_{Gx} = F_F$ $\quad 500\,a_{Gx} = F_F$

$\sum F_y: ma_{Gy} = 0 = N - F_G$ $\quad N = (500)(9.81) = 4905$

$\sum M_G: I_G\alpha = F_F r$ $\quad 125\alpha = F_F(0.5)$

Rolling without slipping $\Rightarrow F_F \leq \mu_s N$ and:

$$\vec{a}_G = \vec{a}_P + \vec{\alpha} \times \vec{r}_{G/P} - \omega^2 r_{G/P}$$

$$\vec{a}_G = 3\hat{i} + \alpha\hat{k} \times 0.5\hat{j} - \omega^2(0.5\hat{j})$$

$$\vec{a}_G = 3\hat{i} - 0.5\alpha\hat{i} - \omega^2(0.5)\hat{j}$$

$$a_{Gx} = 3 - 0.5\alpha$$

$500(3 - 0.5\alpha) = F_F \Rightarrow 1500 - 250\alpha = F_F$

$125\alpha = (1500 - 250\alpha)(0.5)$

$125\alpha = 750 - 125\alpha$ $\quad 250\alpha = 750$ $\quad \boxed{\alpha = 3 \text{ rad/s}^2}$

$F_F = 750$