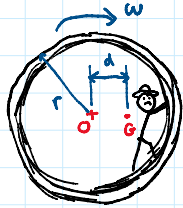


20-R-KIN-DK-29

Intermediate General Plane Motion

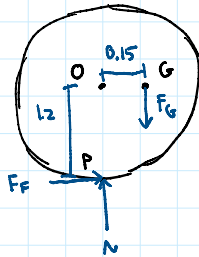
Inspiration: 17-112 Hibbeler



Montana James is at it again! He jumps into a pipe to escape from monkeys, rolling the pipe at an angular velocity of $\omega = 1 \text{ rad/s}$. At this instant, the center of gravity of Montana and the pipe is at G, and their radius of gyration is $k_G = 1.05 \text{ m}$. Determine the angular acceleration of the pipe if the combined mass of Montana James and the pipe is 220 kg . Assume Montana does not move within the pipe and that the pipe rolls without slipping. The radius of the pipe is 1.2 m and G is a horizontal distance of 0.15 m away from O.

$$I_G = mk_G^2 = (220)(1.05)^2 = 242.55$$

$$\begin{aligned} \sum M_P &= m \vec{r}_{G/P} \times \vec{a}_G + I_G \ddot{\alpha} = 220(0.15\hat{i} + 1.2\hat{j}) \times (a_{Gx}\hat{i} + a_{Gy}\hat{j}) + 242.55\ddot{\alpha} = -F_G(0.15) \\ &= -220(1.2)a_{Gx}\hat{k} + 220(0.15)(a_{Gy})\hat{k} + 242.55\ddot{\alpha} = -220(9.81)(0.15) \\ -264a_{Gx} + 33a_{Gy} + 242.55\ddot{\alpha} &= -323.73 \end{aligned}$$



Rolling without slipping: $a_o = \ddot{\alpha} \times \vec{r}_{O/P} = \ddot{\alpha} \hat{k} \times (1.2\hat{j}) = -1.2\ddot{\alpha} \hat{i}$

$$\vec{a}_G = \vec{a}_o + \ddot{\alpha} \times \vec{r}_{G/O} - \omega^2 \vec{r}_{G/O} = -1.2\ddot{\alpha} \hat{i} + \ddot{\alpha} \hat{k} \times (0.15\hat{i}) - (1^2)(0.15\hat{i})$$

$$\vec{a}_G = -1.2\ddot{\alpha} \hat{i} - 0.15\ddot{\alpha} \hat{i} + 0.15\ddot{\alpha} \hat{j} \quad a_{Gx} = -1.2\ddot{\alpha} - 0.15 \quad a_{Gy} = 0.15\ddot{\alpha}$$

$$-264(-1.2\ddot{\alpha} - 0.15) + 33(0.15\ddot{\alpha}) + 242.55\ddot{\alpha} = -323.73$$

$$316.8\ddot{\alpha} + 39.6 + 4.95\ddot{\alpha} + 242.55\ddot{\alpha} = -323.73$$

$$564.3\ddot{\alpha} = -363.33$$

$$\ddot{\alpha} = -0.6436596 \text{ rad/s}^2$$