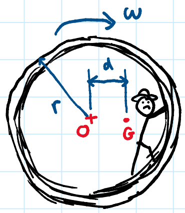
20-R-KIN-DK-29

July 22, 2020 9:38 AM

20-R-KIN-DK-29 Intermediate General Plane Motion

Inspiration: 17-112 Hibbeler



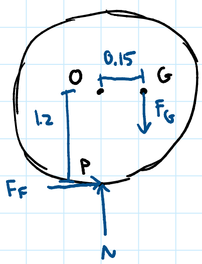
Montana James is at it again! He jumps into a pipe to escape from monkeys, rolling the pipe at an angular velocity of ***omega = 1 rad/s***. At this instant, the center of gravity of Montana and the pipe is at G, and their radius of gyration is ***k_G = 1.05 m***. Determine the angular acceleration of 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.

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

$$\Sigma M_P = m\vec{r}_{G/P}\times\vec{a}_G + I_G\vec{\alpha} = 220(0.15\hat{i}+1.2\hat{j})\times(a_{Gx}\hat{i}+a_{Gy}\hat{j}) + 242.55\alpha = -F_G(0.15)$$

$$= -220(1.2)a_{Gx}\hat{k} + 220(0.15)(a_{Gy})\hat{k} + 242.55\alpha = -220(9.81)(0.15)$$

$$-264a_{Gx} + 33a_{Gy} + 242.55\alpha = -323.73$$



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

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

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

$$-264(-1.2\alpha - 0.15) + 33(0.15\alpha) = -323.73$$

$$316.8\alpha + 39.6 + 4.95\alpha = -323.73$$

$$321.75\alpha = -363.33$$

$$\boxed{\alpha = -1.12923 \text{ rad/s}^2}$$