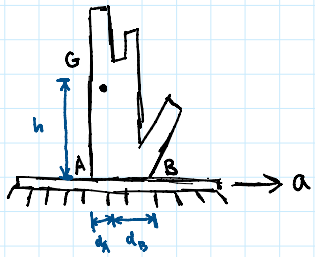
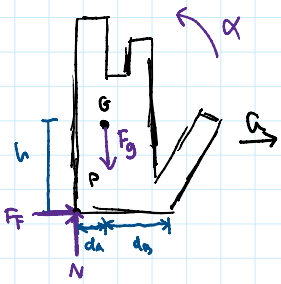
20-R-KIN-DK-28

July 22, 2020 9:38 AM

20-R-KIN-DK-28 Beginner General Plane Motion



Your friend is once again trying to their mom's modern art sculpture by dragging a rug underneath it. If they pull the rug such that it has an acceleration of ***1 m/s^2***, will the statue tip or slip? If it tips, determine the statue's angular acceleration, and if it slips, determine the statue's horizontal acceleration. The statue has a mass of ***m = 80 kg*** and has a radius of gyration ***k_G = 0.8***. The coefficient of static and kinetic friction is determined to be ***mu_s = 0.25*** and ***mu_k = 0.2*** respectively. Assume there is no friction between the rug and the ground.
The center of gravity G is found at a height ***h = 1.5 m*** and is a horizontal distance ***d_A = 0.1 m*** from point A. Point B is a horizontal distance ***d_B = 0.35 m*** away from the center of gravity.



No tip: $\vec{\alpha} = \vec{0}$ No slip: $F_F \leq \mu_s N$

$\sum F_x = F_F = ma_{Gx}$ $\sum F_y = N - mg = ma_{Gy} = 0$ $\sum M_G = F_F(1.5) - N(0.1) = I_G\alpha$

$N = mg$

$F_F \leq 0.25(80)(9.81)$

$F_F \leq 196.2\ N$ $F_F = ma_{Gx}$ $196.2 = 80\,a_{Gx}$ $\boxed{a_{Gx} = 2.4525}\ m/s^2$ for slipping

$\sum M_G = F_F(1.5) - N(0.1) = 0$ $F_F(1.5) = (80)(9.81)(0.1)$ $F_F = 52.32$

$52.32 = 80\,a_{Gx}$ $\boxed{a_{Gx} = 0.654}\ m/s^2$ for tipping The object will tip before slipping

$\sum F_x = F_F = ma_{Gx}$ $\sum F_y = N - mg = ma_{Gy}$ $\sum M_G = F_F h - N(d_A) = I_G\alpha$

$F_F \leq \mu_s N = 0.25N$ $N - (80)(9.81) = 80\,a_{Gy}$ $0.25N(1.5) - N(0.1) = (80)(0.8)^2\alpha$

$0.275N = 51.2\alpha$

$\vec{a}_G = \vec{a}_A + \vec{\alpha} \times \vec{r}_{G/A} - \omega^2 \vec{r}_{G/A}$ $\vec{a}_G = 1\hat{i} + \alpha\hat{k} \times (0.1\hat{i} + 1.5\hat{j}) - 0$

$= 1\hat{i} + 0.1\alpha\hat{j} - 1.5\alpha\hat{i}$

$a_{Gx} = 1 - 1.5\alpha$ $a_{Gy} = 0.1\alpha$

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$F_F = 80(1 - 1.5\alpha)$

$= 80 - 120\alpha$

$= -446.5367755$

$N - (80)(9.81) = 80(0.1\alpha)$

$\frac{2045}{11}\alpha - 8\alpha = 784.8$

$0.275N = 51.2\alpha$

$N = \frac{2045}{11}\alpha$

$\boxed{\alpha = 4.404448\ rad/s^2}$