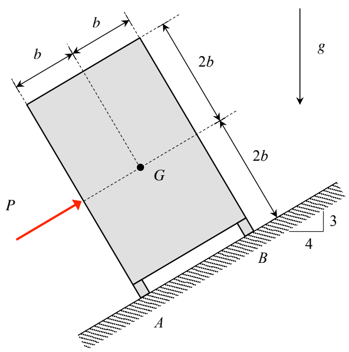
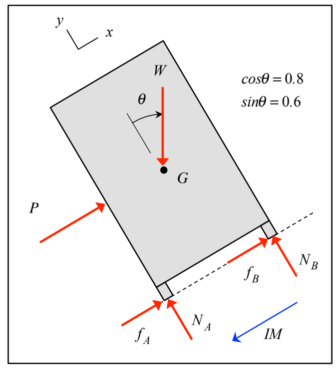
Example 6.C.3 - Solved

Given: A crate weighing W rests on a rough incline, with the coefficient of static friction between the crate and the incline being $\mu_S = 0.6$. A force P acts on the crate in a direction that is parallel with the incline.

Find: Determine the minimum force P required to hold the crate in equilibrium. Does this loading correspond to impending tipping or slipping of the crate?





FBD

Since we are looking for the *smallest* force P to hold the crate in position, the impending motion of the crate will be *down the incline* (either sliding or tipping). For impending motion down the incline, the friction forces at A and B must point up the incline to oppose the impending motion, as shown in the above FBD.

Equilibrium:

$$\sum F_x = P + f_A + f_B - W\sin\theta = 0 \qquad (1)$$

$$\sum F_y = N_A + N_B - W\cos\theta = 0 \qquad (2)$$

$$\sum M_A = N_B(2b) - P(2b) + W\sin\theta(2b) - W\cos\theta(b) = 0 \qquad (3)$$

Assume tipping (about corner A): $N_B = 0 \quad (f_A \neq \mu_S N_A)$ (4)

$$(3),(4) \Rightarrow P_{tip} = \frac{W}{2}(2\sin\theta - \cos\theta) = 0.2W \qquad (5)$$

Assume slipping: $f_A = \mu_S N_A$ and $f_B = \mu_S N_B \quad (N_B \neq 0)$ (6)

$$(1),(2),(6) \Rightarrow P_{slip} = W\sin\theta - \mu_S(N_A + N_B) = W(\sin\theta - \mu_S\cos\theta) = 0.12W \qquad (7)$$

Conclusion:
We want to prevent BOTH slipping and tipping. Therefore, we choose the LARGEST of the two values for *P*: $P_{min} = P_{tip} = 0.2W$. The impending motion is tipping.