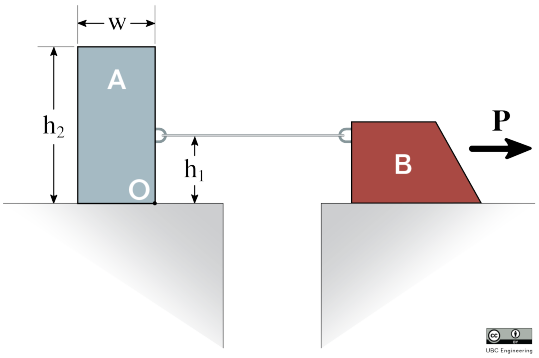
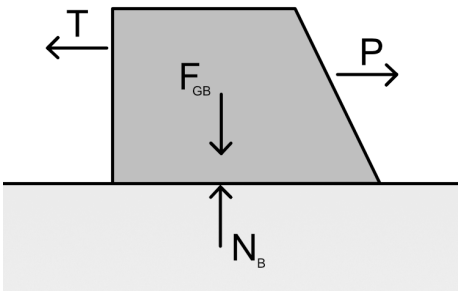
22-R-KIN-JL-13



You have set up the following block system such that blocks A and B are connected by a rope with tension T. You want to cause block A to either tip or slip first along the ground without touching it. So instead you decide to apply a force P on block B. Block A has a mass of 12 kg and block B has a mass of 8.5 kg. Block A has a height $h_2 = 0.8$ m and a width $w = 0.4$ m. The rope connects at a height $h_1 = 0.4$ m and the coefficients of static and kinetic friction for block A are given as $\mu_s = 0.35$ and $\mu_k = 0.3$. Block B sits on a smooth surface where friction is negligible. Find the force P required to move the blocks and whether block A slips or tips.

Solution

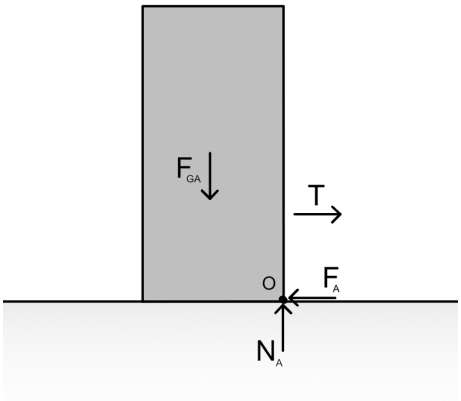
Begin by using the equations of motion for block B:



$\sum F_{Bx} : P - T = m_B(a_B)_x$
$\sum F_{By} : F_G - N_B = m_B(a_B)_y = 0 \quad \Longrightarrow \quad N_B = F_G = 83.4$ N

For block B to slip:
$P - T = 0 \quad \Longrightarrow \quad P = T$

Next use the equations of motion for block A:



$\sum F_{Ax} : T - F_A = m_A(a_A)_x$
$\sum F_{Ay} : F_G - N_A = m_A(a_A)_y = 0 \quad \Longrightarrow \quad N_A = F_G = 117.7$ N
$\sum M_O : T(h_1) - F_G(w/2) = T(0.4) - 117.7(0.2) = I\alpha$

For block A to slip:
$T - F_A = 0 \Longrightarrow T = \mu_s N_A = 41.2$ N

For block A to tip:
$T(h_1) - F_G(w/2) = 0 \Longrightarrow T = \frac{117.7(0.2)}{0.4} = 58.9$ N

Since the tension to cause block A to slip is less, it will slip before tipping.

$P = T = 41.2$ [N]

[Slip]