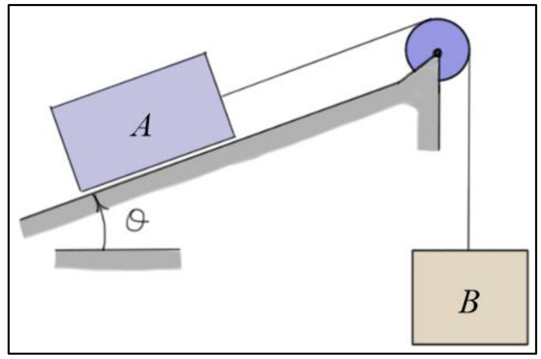
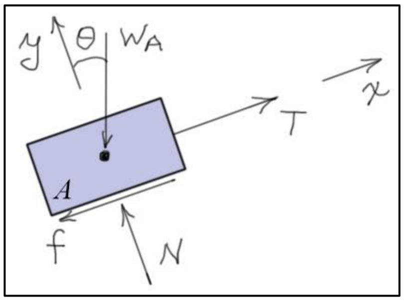
Elementary Dynamics Example #13: (Newton's Laws, Rectangular Components)

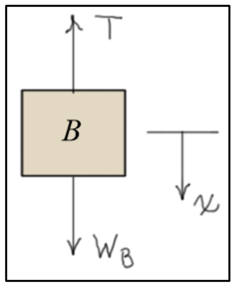


Given: $W_A = 100$ (lb), $\mu_s = 0.4$, $\mu_k = 0.3$, $\theta = 20$ (deg)
system is ***released from rest***

Find: a) $(W_B)_{\min}$, the ***minimum weight*** for block B to make block A move up the plane.
b) s, the distance moved by the blocks after $\frac{1}{2}$ (sec) of motion if $W_B = 1.5(W_B)_{\min}$.

Solution:





Free body diagrams for ***motion*** or ***motion impending up*** the plane

For motion impending of block A up the plane:

A: $\boxed{\sum F_y = N - W_A\cos(\theta) = 0} \Rightarrow \boxed{N = W_A\cos(\theta)}$

$\boxed{\sum F_x = T - W_A\sin(\theta) - \mu_s N = 0}$

$\Rightarrow \boxed{T = W_A\sin(\theta) + \mu_s N = W_A\sin(\theta) + \mu_s W_A\cos(\theta) \approx 71.7897 \approx 71.8 \text{ (lb)}}$

B: $\boxed{\sum F_x = (W_B)_{\min} - T = 0} \Rightarrow \boxed{(W_B)_{\min} \approx 71.8 \text{ (lb)}}$

For motion of the block up the plane, set $\boxed{W_B = 1.5(W_B)_{\min} \approx 107.685 \approx 108 \text{ (lb)}}$

A: $\boxed{\sum F_y = N - W_A\cos(\theta) = 0} \Rightarrow \boxed{N = W_A\cos(\theta) \approx 93.969 \approx 94.0 \text{ (lb)}}$

$\boxed{\sum F_x = T - W_A\sin(\theta) - \mu_k N = \left(\frac{W_A}{g}\right)a_A}$

B: $\boxed{\sum F_x = W_B - T = \left(\frac{W_B}{g}\right)a_B}$

$\boxed{a_A = a_B = a}$

Simultaneous equations:

$$\begin{aligned} T - \left(\frac{W_A}{g}\right)a &= W_A\sin(\theta) + \mu_k W_A\cos(\theta) \approx 62.3928 \\ T + \left(\frac{W_B}{g}\right)a &= W_B = 108 \end{aligned} \Rightarrow \begin{aligned} &T \approx 84.3 \text{ (lb)} \\ &a_A = a_B = a \approx 7.06 \text{ (ft/s}^2\text{)} \end{aligned}$$

For $\frac{1}{2}$ (sec) of constant acceleration of the blocks, we have

$$\boxed{s(t) = s_0 + v_0 t + \tfrac{1}{2}at^2 = \tfrac{1}{2}a\left(\tfrac{1}{2}\right)^2 \approx 0.8825 \approx 0.883 \text{ (ft)}}$$