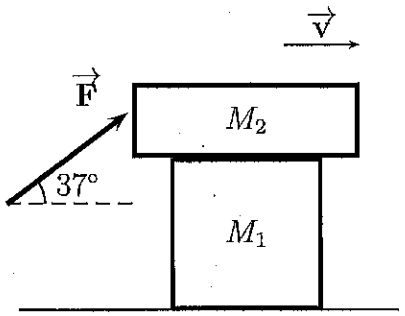
Physics 160 Makeup Question

Due Wednesday, March 21, 11:00AM

1. One day finds your physics instructor moving a $M_1 = 8.0\,kg$ crate of old books. On the way to the recycling bin, he finds a $M_2 = 6.0\,kg$ crate of old physics demos, so he places it on top of the first. By exerting a force, $\vec{\mathbf{F}} = 40\,N$ at 37° above the horizontal, to the upper crate, he gets the combination to slide to the right with constant speed.

   What is the minimum coefficient of friction between M_1 and the floor, as well as, between the two masses? Assume, as shown, that the crates remain horizontal and in contact with each other.



Let $\vec{n}_M$ be Normal Force on M_2 from M_1.

So on M_2, $\vec{n}_M$ is upward

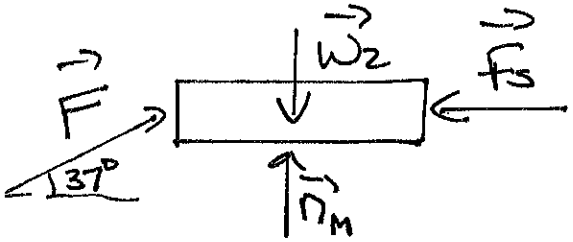
3rd Law $\Rightarrow$ $\vec{n}_M$ is downward on M_1

Between M_1 and M_2 is static friction, $\vec{f}_s$. Without it, M_2 would slide off M_1 ^ to right. $\Rightarrow$ $\vec{f}_s$ is to Left on M_2.

Since M_1 exerts this static friction, 3rd Law $\Rightarrow$ $\vec{f}_s$ to Right on M_1.

Between ground and M_1 is Normal Force $\vec{n}$ (upward on M_1) and kinetic friction, $\vec{f}_k$, M_1 sliding to right $\Rightarrow$ $\vec{f}_k$ to left

FBD FOR M_2:



$$\sum F_{2,x} = M_2 a_{2,x}$$

$$\sum F_{2,y} = M_2 a_{2,y}$$

M_2 HAS CONSTANT SPEED $\Rightarrow a_{2,x} = 0, a_{2,y} = 0$

$$\sum F_{2,x} = 0 \Rightarrow F_x - f_s = 0 \Rightarrow F\cos 37° - f_s = 0$$

$$\Rightarrow f_s = F\cos 37° = (40N)\cos 37° = 31.945N$$

$$\sum F_{2,y} = 0 \Rightarrow F_y + n_M - W_2 = 0 \Rightarrow F\sin 37° + n_M - M_2 g = 0$$

$$\Rightarrow n_M = M_2 g - F\sin 37° = (6kg)(9.8m/s^2) - (40N)\sin 37°$$

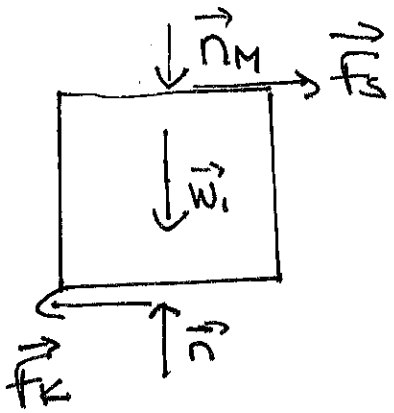
$$n_M = 58.8N - (40N)\sin 37° = 34.727N$$

MINIMUM COEFFICIENT $\Rightarrow$ COEFFICIENT IS STATIC FRICTION MAXIMIZED, i.e. $f_s = f_{s,MAX} = \mu_s n_M \Rightarrow \mu_s = \frac{f_s}{n_M}$

$$\mu_s = \frac{31.945}{34.727} \Rightarrow \boxed{\mu_s = .92}$$

$\hookrightarrow .919889$

FBD For M_1:



$$\sum F_{1,x} = M_1 a_{1,x}$$

$$\sum F_{1,y} = M_1 a_{1,y}$$

Likewise $a_{1,x} = 0$, $a_{1,y} = 0$

$$\sum F_{1,x} = 0 \Rightarrow f_s - f_K = 0 \Rightarrow f_K = f_s = 31.945N$$

$$\sum F_{1,y} = 0 \Rightarrow n - n_M - W_1 = 0 \Rightarrow n = n_M + W_1 = n_M + M_1 g$$

$$\Rightarrow n = 34.727N + (8kg)(9.8m/s^2) = 34.727N + 78.4N$$

$$\Rightarrow n = 113.127N$$

For Kinetic Friction, $f_K = \mu_K n \Rightarrow \mu_K = \frac{f_K}{n} = \frac{31.945N}{113.127N}$

$$\Rightarrow \mu_K = .282 = .28$$