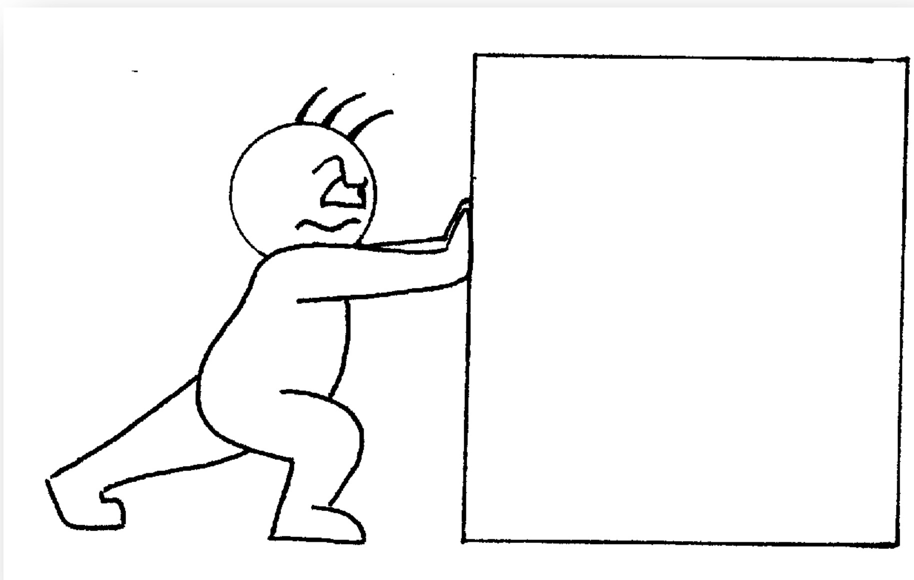
Practice for Midterm 2:

INTERACTIONS

Physics 203, Profs Yaverbaum, Song, Lu, & Bean

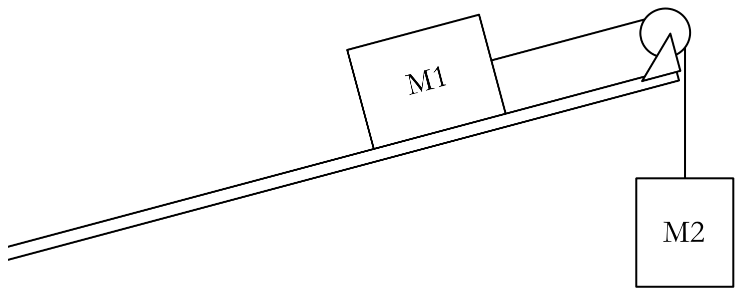
John Jay College of Criminal Justice, the CUNY



SOLUTIONS Part 3

1. Whacky Friction

M1 sits on a slanted desktop and is attached by a string to M2, which hangs off the edge of the desk, as shown. The string runs over a pulley wheel at the edge of the table. The string is massless and the pulley wheel is massless & has zero friction at its axel—in other words, it changes the direction of the string & thus of the force of tension, without absorbing any of that force. In short, the force of tension on M1 is equal & opposite to the force of tension on M2. The desk is angled 20 degrees from the horizontal. The coefficients of static and kinetic friction between M1 and the table are 0.6 and 0.4 respectively. M1 and M2 both have masses of 10kg.

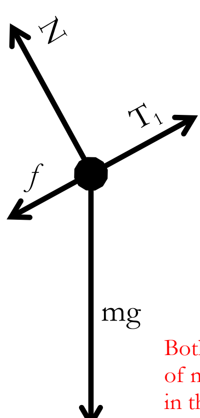


A. Draw your own pictorial diagram of this situation—it can look exactly like the one that's given, but it should contain ***all known and unknown quantities***.
B. Draw system schemata for each mass. (You need not include the string & pulley—you can connect M1 directly to M2.)
C. Draw a pure FBD & a component FBD of M1.
D. Write down Newton's 2nd Law. Apply it to M1 on the y-axis.
E. Compute the magnitude of the normal force between M1 and the desk.
F. Compute f_s(max), the maximum force of static friction between M1 and the desk.
G. Write down N's 2nd Law. Apply it to M1 on the x-axis. Leave ***a***, ***f***, and ***T*** as variables.
H. Draw an FBD for M2.
I. Write down N's 2nd Law. Apply it to M2. Leave ***a*** and ***T*** as variables.
J. Assume the system starts at rest. Show that it ***will*** begin to accelerate.

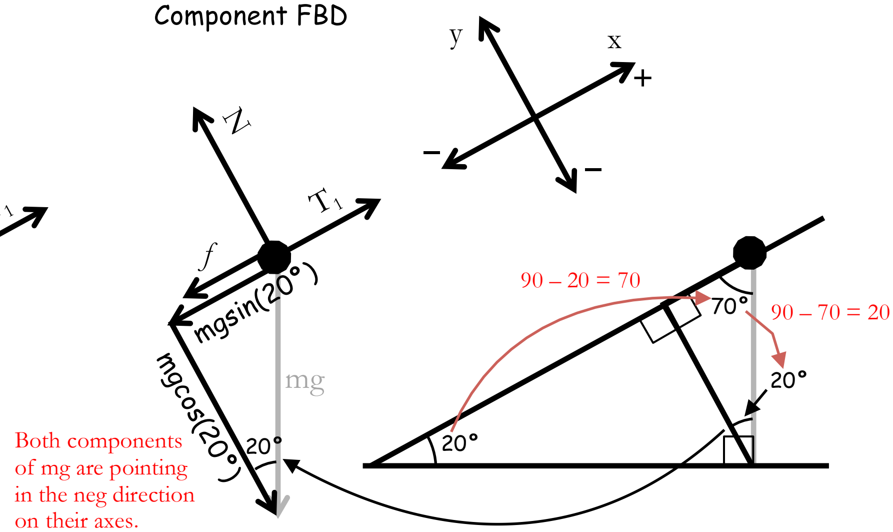
K. Calculate the force of kinetic friction on M1.
L. Solve the system of equations to find ***a*** and ***T***.

A&B.
[not provided.]

C. Pure FBD



Component FBD



D. $\sum \vec{F}_y = ma_y$

$N - mg\cos(20°) = 0$ ← M2 stays on surface of ramp, so ***no movement on y-axis, so $a_y=0$***

E. $N = mg\cos(20°) = (100N)(0.94) = 94n$

F. $|f_s(\max)| = \mu_s N$

$|f_s(\max)| = 0.6(94\ n) = 56.4\ n$ ← but f_s is in the neg x direction (see diagram)

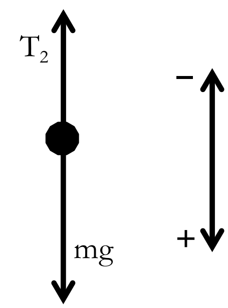
G. $\sum \vec{F}_x = ma_x$

$T_1 - f - mg\sin(20°) = (10)a_x$

$T_1 - f - (10)(10)(0.34) = (10)a_x$

$T_1 - f - 34 = (10)a_x$

H. Only 2 forces on M2



NOTE: we define a completely different coordinate system for M2. Both tilt & positive direction are different.

I. $\sum \vec{F} = ma$ ←only one axis.

$-T_2 + mg = ma_y$

$-T_2 + 100n = (10\ kg)a_y$

J. If sys is at rest, then a = 0, and friction is static.

For M2, we have: $-T_2 + 100\ n = (10\ kg)a_x$

$-T_2 + 100\ n = 0$

$T_2 = 100\ n$

Upward tension on M2 = upward diagonal tension on M1

So for M1, we have: $T_1 - f - 34\ n = (10\ kg)a_x$

$100\ n - f_s - 34\ n = 0$

Solve for f_s: $f_s = 100\ n - 34\ n = 66\ n$

But, $|f_s(\max)| = 56.4\ n$ (from step F)

So, f_s cannot be 66 n.

So, f_s is broken & system will accelerate.

J. Looking for f_k $|f_k| = \mu_k N = (0.4)(94\ n) = 37.6\ n$

K. for M1, we have: $T_1 - f_k - 34\ n = (10\ kg)a_x$

$T_1 - 37.6\ n - 34\ n = (10\ kg)a_x$

$T_1 - 71.6\ n = (10\ kg)a_x$

for M2, we have: $-T_2 + 100\ n = (10\ kg)a$

$a_{M1} = a_{M2} = a_{sys}$ and $T_1 = T_2 = T$

So, we have $T - 71.6\ n = (10\ kg)a_{sys}$ and $-T + 100\ n = (10\ kg)a_{sys}$

Set them equal: $T - 71.6\ n = -T + 100\ n$

$2T = 171.6\ n$

$T = 171.6/2 = 85.8\ n$

Plug in & solve for a_{sys}:

$-85.8\ n + 100\ n = (10\ kg)a_{sys}$

$a_{sys} = 14.2/10 = 1.42\ m/s^2$

But notice this comes out so simple because of how we defined our signs & directions. If we'd made down negative for M2, then a_{M1} would equal $-a_{M2}$, and we would have to substitute before we solved the system.