Practice for Midterm 2:

INTERACTIONS

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

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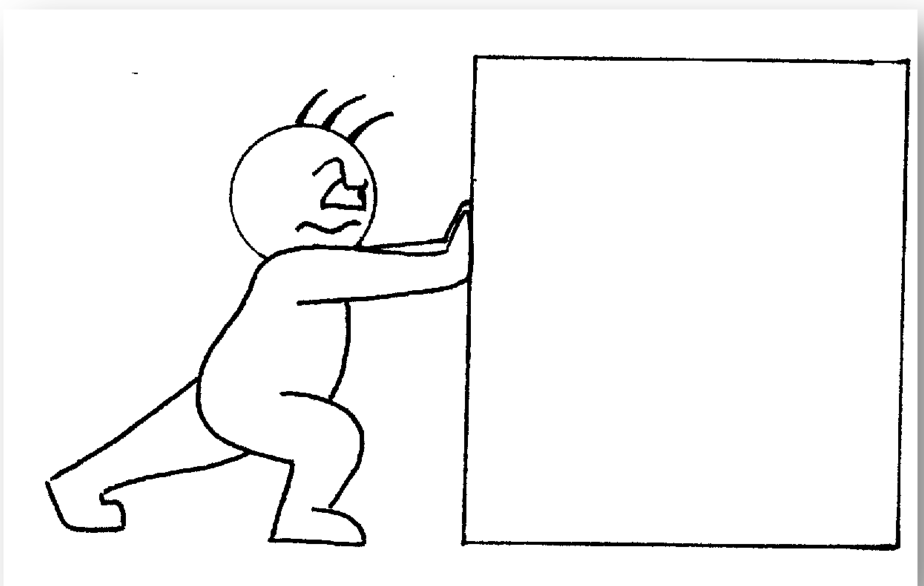
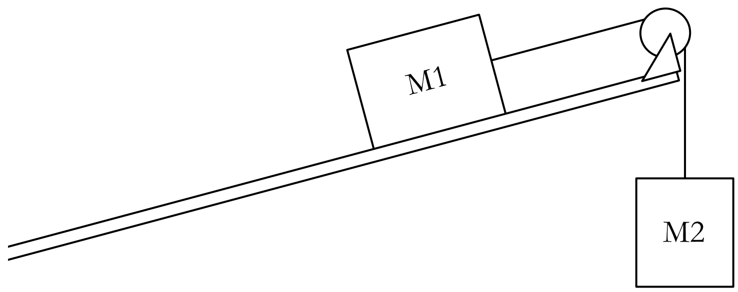


SOLUTIONS Part 3

1. Whacky Friction

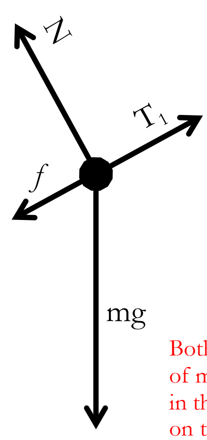
M1 sits on a slanted desktop and is attached by a string to M2, which hangs off the edge of the desk, as shown. The string runs over a pulley wheel at the edge of the table. The string is massless and the pulley wheel is massless & has zero friction at its axel—in other words, it changes the direction 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.



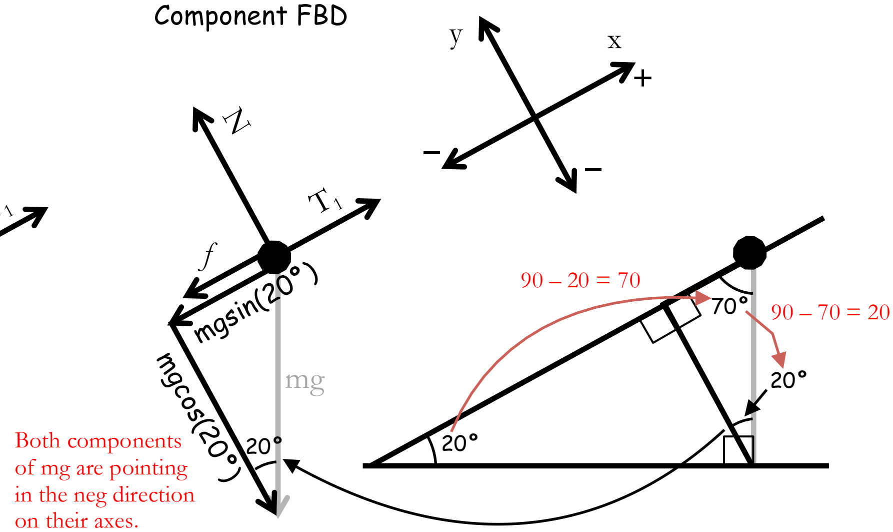
A. Draw your own pictorial diagram of this situation—it can look exactly like the one that's given, but it should contain ***all known and unknown quantities***.
B. Draw a system schema for this situation. (You need not include the string or the pulley wheel in your SS. Connect M1 directly to M2.)
C. Draw a pure & a component FBD of M1.
D. Compute the magnitude of the normal force on M1.
E. Compute f_s(max), the maximum force of static friction, between M1 and the desk.
F. Compute force with which gravity pulls M1 down the ramp.
G. Create an NII equation for M1 in the x direction, leaving a, f, and F_T as variables.
H. Draw an FBD for M2.
I. Create an NII equation for M2, leaving a and F_T as variables.
J. Assume the system starts at rest. Show that the force of tension on M1 will be enough to make it accelerate.
K. Calculate the force of kinetic friction on M1.
L. Solve the system of equations to find a_{sys} and tension on the string.

A&B.
[not provided.]

C. Pure FBD



Component FBD



C. Looking for N (fr desk), which is on the tilted y-axis.

$Fnet_y = ma_y$

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

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

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

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

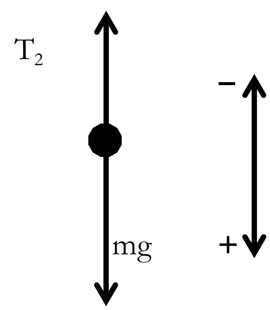
E. Looking for x-component of gravity: $-mg\sin(20°) = -(100\ n)(0.34) = -34n$ ← neg x direction

F. $Fnet_x = ma_x$

$T_1 - f - mg\sin(20°) = (10\ kg)a_x$

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

G. Only 2 forces on M2



We use a completely different coordinate system for M2. Both tilt & positive direction are different.

H. Fnet = ma ←All forces are on the y-axis.

$-T_2 + mg = ma_y$

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

I. 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 (pos x-direction) 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 D)

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_x for M1 = a_y for 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}:

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

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