Practice Midterm 2:

INTERACTIONS

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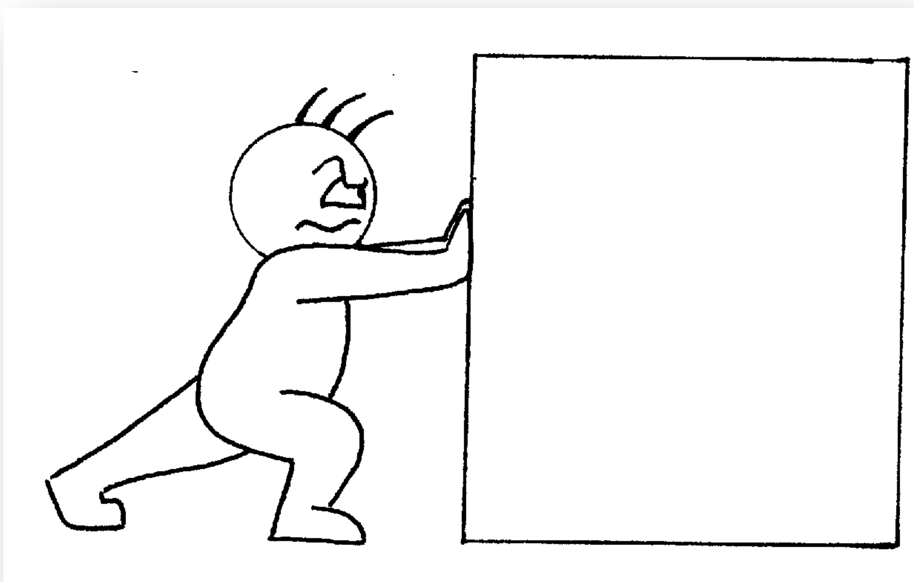


Name: ________________________________

Section: ________

Any/all of THE FOLLOWING RELATIONS underlie the material and are hereby

GIVEN* *(written out for you)* *below.

$\bar{v} \equiv \frac{x-x_0}{t-t_0}$	$W \equiv \int_{x_0}^{x} \vec{F} dx$
$v \equiv \lim_{(t-t_0)\to 0} (\bar{v})$	***if and only if*** $\vec{F}$ is constant, ***then:*** $W = \vec{F} \cdot \vec{d}$
$\bar{a} \equiv \frac{v-v_0}{t-t_0}$	$K = \frac{1}{2} m v^2$
$a \equiv \lim_{(t-t_0)\to 0} (\bar{a})$	$\sum W = \Delta K$
if and only if *a is constant,* ***then:*** $\bar{v} = \frac{v+v_0}{2}$	$\vec{p} \equiv m\vec{v}$
if and only if *a is constant,* ***then:*** $\Delta\vec{x} = \frac{1}{2}\vec{a}t^2 + \vec{v}_0 t$	$\vec{\imath} \equiv \int_{t_0}^{t} F dt$
$\vec{v}_{ab} + \vec{v}_{bc} = \vec{v}_{ac}$	$\sum \vec{\imath} = \Delta\vec{p}$
$\vec{v}_{ab} = -\vec{v}_{ba}$ and $\vec{v}_{aa} = 0$	***if and only if*** $\vec{F}$ is constant, ***then:*** $\vec{\imath} = \vec{F}\Delta t$
$sin^2\theta + cos^2\theta = 1$	$a_c = \frac{\mathrm{v}^2}{r}$
$\sum \vec{F} = m\vec{a}$	$F_s = -kx$
$f_k = \mu_k N$	$F_G = G\frac{m_1 m_2}{r^2}$
$f_s(\mathrm{max}) \leq \mu_s N$	$G = 6.67\times10^{-11}\ \mathrm{N}\frac{\mathrm{m}^2}{\mathrm{kg}^2}$
$g \approx 10\ m/s^2$ (on earth)	

Part I

1. A 15 kg dog is sitting on a 5kg stool. The stool is standing on the floor. None of them are moving with respect to each other.
    a. Draw a picture of the situation.
    b. Draw a system schema and an FBD of the stool.
    c. Write out a Newton's 3rd Law pair for each arrow in your FBD.
    d. Draw a system schema and an FBD treating the stool & dog as one system.
    e. Calculate the force with which the floor is pushes up on the stool. Show all work.

2. A mover is trying to push a 120kg piano across a rough floor. The coefficients of friction between the piano and the floor are given as $\mu_s = 0.4$ and $\mu_k = 0.3$.
    a. Draw a picture of the situation.
    b. Draw a system schema and an FBD of the piano.
    c. Write out a Newton's 3rd Law pair for each arrow in your FBD.
    d. Calculate the minimum force the mover must push with if he wants to move the piano at all.

3. A hand is pushing a flower pot across a table. The coefficients of friction between the pot and the table are given as $\mu_s = 0.4$ and $\mu_k = 0.3$. The hand pushes with a force of 10N and the flower pot moves with an acceleration of 2 m/s^2.
    a. Draw a picture of the situation.
    b. Draw a system schema and an FBD of the flower pot.
    c. Write out a Newton's 3rd Law pair for each arrow in your FBD.
    d. Calculate the mass of the flower pot.

4. Someone has shoved a large ceramic plate so that it slides across a cafeteria table. The plate has a mass of 3 kg. It starts out with a velocity of 4 m/s and takes 2 seconds to come to a complete stop.
    a. Draw a picture of the situation.
    b. Draw a system schema & an FBD of plate.
    c. Calculate the acceleration of the plate as it slides.
    d. Calculate the coefficient of kinetic friction between the plate and the table.

Part II

1. Darn Cat's on Top of the Elevator Again!

A cat stands on a digital scale that is attached to the roof of an elevator. The elevator is accelerating upwards at a constant rate of 20 m/s^2. At a certain moment, the instantaneous velocity of the elevator is 40 m/s upwards relative to the ground. The scale reads 135N. (Scales measure normal force—that's what they do.)

A. Draw a diagram of the situation, including ***all known and unknown quantities***.
B. Draw a system schema of this situation.
C. Draw an FBD of the cat.
D. Compute the mass of the cat.

At this exact moment, the elevator stops accelerating.

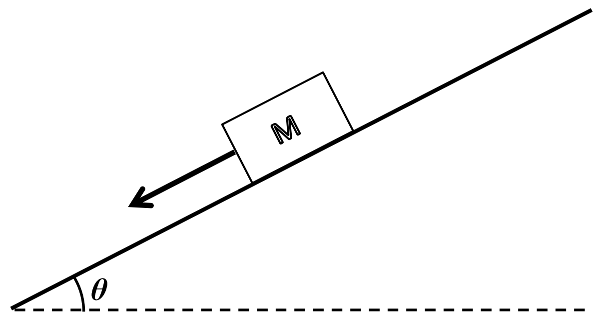
E. Compute the reading on the scale.
F. If it continues in this state of 5 seconds, how far will the elevator travel in those 5 seconds (from the perspective of the ground)?
G. How far will the cat travel in those 5 seconds (from the perspective of the ground)?

Suddenly, the elevator begins accelerating downwards at a rate of 12 m/s^2.

H. Compute the reading on the scale.
I. From the perspective of the ground, how far will the elevator travel in 5 seconds?
J. From the perspective of the ground, how far will the cat travel in 5 seconds?

3. Slippy Slide

Mass M is ***sliding*** down a ***rough*** track. The track forms an angle $\boldsymbol{\theta}$ with the horizontal. The mass has a coefficient of kinetic friction with the track of $\boldsymbol{\mu_k}$.



Your goal: find an expression for ***a***, the acceleration of the mass, in terms of the ***given variables***.

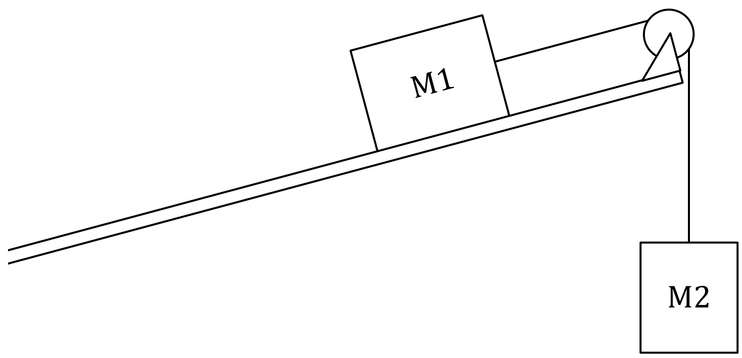
A. Create a system schema of the mass.
B. Create a ***pure*** FBD of the mass.
C. Create a coordinate system ***in which the x-axis lines up with the direction of acceleration***.
D. Create a ***component*** FBD of the mass.
E. Write down Newton's 2nd Law. apply it to the mass on the y-axis.
F. What is the acceleration of the mass on the y-axis?
G. Solve for the magnitude of the normal force between the track and the mass, in terms of ***m***, ***g***, and $\boldsymbol{\theta}$.
H. Write down Newton's 2nd Law. apply it to the mass on the x-axis.
I. Solve for ***a***, in terms of the ***given variables***.

PART III:

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—in other words, it changes the direction of tension, without changing its magnitude. So tension on M1 is equal in magnitude (but not opposite in direction) 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 desk 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 $\boldsymbol{a}$, $\boldsymbol{f}$, and $\boldsymbol{T}$ as variables.
H. Draw an FBD for M2.
I. Write down N's 2nd Law. Apply it to M2. Leave $\boldsymbol{a}$ and $\boldsymbol{T}$ as variables.
J. Assume the system starts at rest. Show that it ***will*** begin to accelerate.
Step 1: If the system is at rest, what is $\boldsymbol{a}$?
Step 2: Look at M2. Find $\boldsymbol{T}$.
Step 3: Look at M1. Find $\boldsymbol{f}$.
Step 4: Explain why this scenario is or is not possible.
K. Calculate the force of kinetic friction on M1.
L. Solve the system of equations to find $\boldsymbol{a}$ and $\boldsymbol{T}$.

NOTE: in addition to the version of this problem that you see here, you should be prepared for "find the limiting case" type questions like the one you saw in the block-and-string problem on the NII.3 homework (problem II, part L). You should know how to solve BOTH that problem and this one.

2. The Inclined Plane is Moving!

A child seated in a car places a quarter on a clipboard. The coefficient of static friction between the clipboard and the quarter is 0.1. The car begins to accelerate forwards at a constant rate of 2 m/s^2. At the same time, the child tilts the clipboard forward (i.e. front end down, back end up).

GOAL: Find the range of angles (measured from the horizontal) that the child can tilt the clipboard if she wants the quarter not to move?

A. Draw a pictorial diagram of the situation, including ***all known and unknown quantities***.

B. If we are looking at the ***minimum*** angle, what direction will friction have to point to keep the quarter in place?
C. If we are looking at the ***maximum*** angle, what direction will friction have to point to keep the quarter in place?
D. If the angle goes below the minimum angle, what will happen to static friction and what will happen to the quarter?
E. If the angle goes above the minimum angle, what will happen to static friction and what will happen to the quarter?

F. Draw a system schema of the quarter.

Find the ***minimum*** angle
G. Draw a ***pure*** FBD of the quarter for this scenario (minimum angle).
H. Choose a coordinate system in which the x-axis is parallel to the direction of acceleration (assuming that the quarter does ***not*** slide).
I. Draw a ***component*** FBD of the quarter.
J. Write NII equations for the quarter on both axes.
K. Express $\boldsymbol{f}_{s(max)}$ in terms of **N**.
L. Solve for **N** in terms of other variables in both equations.
Hint 1: The quarter is ***not*** sliding.
Hint 2: ***Do*** plug in 10 for $\boldsymbol{g}$.
M. Solve to find $\boldsymbol{\theta}_{min}$.

Find the ***maximum*** angle.
N. Solve to find $\boldsymbol{\theta}_{max}$, using the same steps (G-M) that you used to find $\boldsymbol{\theta}_{min}$.

NOTE: In addition to the version of this problem that you see here, you should be prepared for the “Rough Accelerating Plane” problem from the NII.3 homework (problem IV). You should know how to solve BOTH that problem and this one.