Name: ________________________________ Table: ___________ Section: _________

Lab 4: PhET Simulation – Friction
PhET simulations are simulations on all sorts of topics (not just physics) that come from the University of Colorado - Boulder

To find the simulation, either Google "Phet simulation ramp forces and motion" or go directly to this link: http://phet.colorado.edu/en/simulation/ramp-forces-and-motion

Click **"Run Now."** When the simulation opens:

- Click on the **"Force Graphs"** tab at the top.
- Set the ramp angle to zero degrees.
- Check the check boxes for the applied force and the force of friction at the bottom left.

We are going to examine the way friction behaves when you push an object on a flat surface. You can make the wooden stick-figure doll apply a force to the crate by clicking on the crate and dragging it along, **or** just slide the "Applied Force " slider up or down.

Introduction: Starting with the crate stationary, slowly increase the applied force on the crate without having the crate move quite yet. What is the acceleration? How does the frictional force compare to the applied force?

Do $F_{applied}$ and $F_{friction}$ (labeled F_a and F_f) constitute a Newton's third law pair? Why or why not?

Clear the scenario using the button at the bottom and now gradually increase the applied force until the block starts to move. At approximately what value of applied force does the block begin to move?

Describe in words what happens to the frictional force the instant the block begins moving. (Use specific evidence from the free-body diagram and/or the graph provided by the simulation.)

Click on the **"Friction"** tab at the top. Again, set the ramp angle to zero degrees.

Now double the mass of the crate using the appropriate slider or entering the value. Predict the value of the applied force necessary to get the crate moving.

Apply the force. What is the actual value needed to move the block? How does it compare to your prediction?

With the doubled mass, change to a different acceleration due to gravity, such as that on the Moon or on Jupiter. Enter the new value of g here: ___________

Again, make a prediction of the value of the applied force necessary to get the crate moving.

What is the actual value needed to move the block? How does it compare to your prediction?

Let's state the two important things about friction you have verified:

A. Friction behaves differently depending on whether an object is moving or stationary.

We call these different scenarios ____________ and ____________ friction, respectively.

B. Heavier objects experience _________ friction!

Kinetic Friction:
Click on the **"Force graphs"** tab at the top of the window, and set the ramp angle to 30°.

We will now examine the behavior of an object sliding down an inclined plane. Begin by drawing a free-body diagram, in the space to the right, of a crate that is accelerating down a ramp. Be sure to include friction and stipulate whether it is kinetic or static. Pay attention to the lengths of your vectors!

Use your free body diagram above and apply Newton's second law to express the normal force in terms of the mass of the crate, the gravitational constant, and the angle of inclination θ. Choose your coordinate system wisely!

Compare your free body diagram and expression for the normal force with other members of your group. Make any necessary corrections in the space below.

Let the crate slide down the ramp. How does the frictional force change when the object reaches the bottom of the ramp and goes onto the flat part of the track? Clearly explain why this change happens, using the relationship you derived above.

Static Friction:

Now let's examine the static case. Remain on the **"Force graphs"** tab at the top of the window. Make sure the box labeled "$F_{friction}$" is checked at the left of the screen, this will allow us to measure to force of friction experienced by an object as it slides down the ramp.

Draw a free body diagram for an object sitting on the incline at rest, assuming the incline is at the maximum angle BEFORE the object starts to move. Be sure to include friction and stipulate whether it is kinetic or static.

Recall from class that $F_{fs} \leq \mu_s F_N$. In your own words, explain why it is an inequality and not an equality. (Hint: Think about varying the angle of incline).

Select the refrigerator. Using the μ_s provided in the PhET, predict the angle at which the refrigerator will just begin to slide down the ramp when beginning at the top of the ramp at rest.

Now perform the experiment. Start with a low angle, put the fridge at the top of the ramp, and write down the frictional force and the angle in the table below. Slowly increase the angle and include angles both lower and higher than your predicted angle.

Angle	**Frictional Force**
0°	
Predicted: ________	

What trend do you see in the data for the frictional force as you increase the angle, before the object moves? How can you explain this trend?

Before the object slides, how does the frictional force compare to the component of the gravitational force acting down the slope? (Note that you can select to plot the F_g as well as the F_{SUM} on the graph.) Why must this be true?

Was your prediction of the angle correct? If not, fix your calculation in the space below.

Now select the mystery object. Using similar methods, determine the coefficient of static friction and show your work here.

Assessment:

The following two exercises will allow you to synthesize your knowledge of what we just learned about friction with what you already know about free body diagrams, Newton's second law, and kinematics equations:

1. You, with m =75 kg, have just come down a ski slope and are traveling at 18 m/s. You continue to slide on the flat terrain being slowed by frictional forces. It takes 7.3 s for you to come to a stop.

(a) Draw a scaled force diagram showing and naming all the forces acting on you as you slide.

(b) Calculate the value of your acceleration, and also determine, using variables, how the acceleration is connected to the coefficient of kinetic friction – then calculate the coefficient.

(c) Calculate the distance you slide before coming to a stop.

2. A young parent is dragging a 65 kg (640 N) sled (this includes the mass of two kids) across some snow on flat ground, by means of a rope attached to the sled. The rope is at an angle of 30 degrees with respect to the ground and the tension in the rope is 160 N. The sled is moving at a constant velocity of 1.5 m/s.

(a) Draw and label all forces acting on the kids + sled system. Indicate the relative size of each force by scaling the length of each force arrow appropriately.

(b) Calculate the normal force acting on the system.

(c) Calculate the force of friction acting on the system.

(d) Calculate the coefficient of friction between the sled and the snow.