RAMP: FORCES AND MOTION

Mechanics

Unit 3

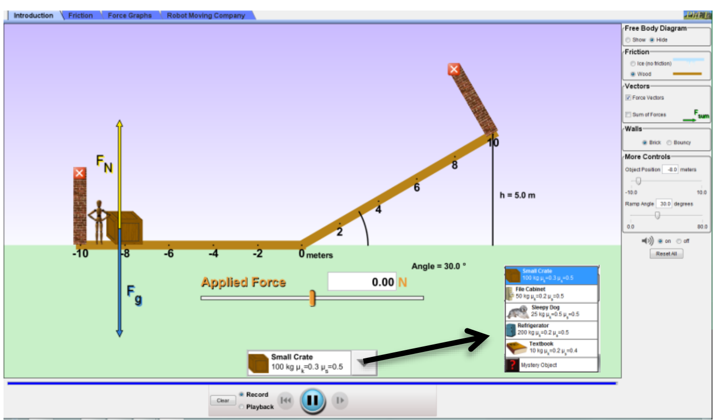
TA name: Due Date:

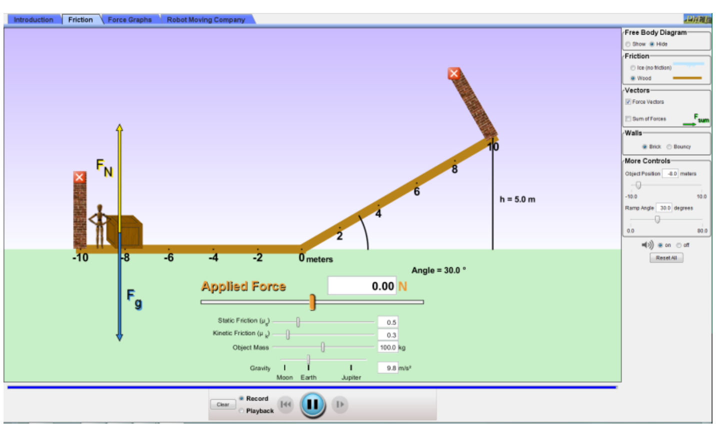
Student Name:

Student ID:

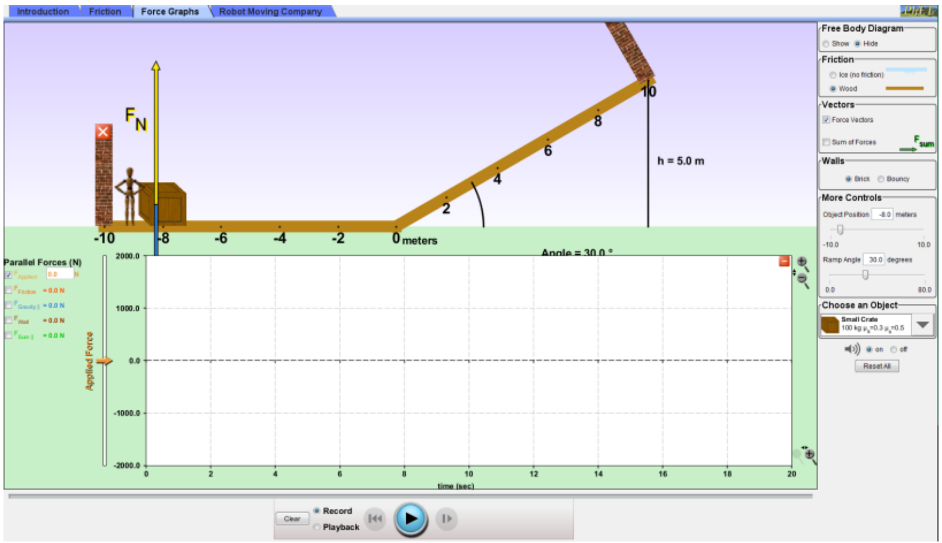
Simulation Activity #3: *Ramp: Forces and Motion*

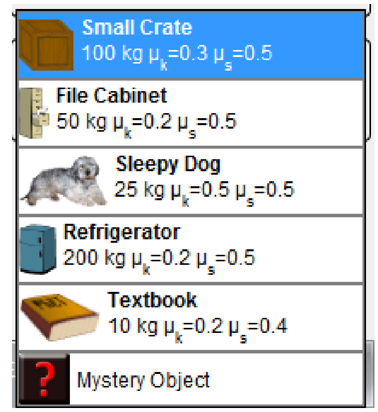
Simulation created by the Physics Education Technology Project (PhET) c/o The University of Colorado at Boulder http://phet.colorado.edu/





Physics Lab 3 (Online Simulation)





Objective:

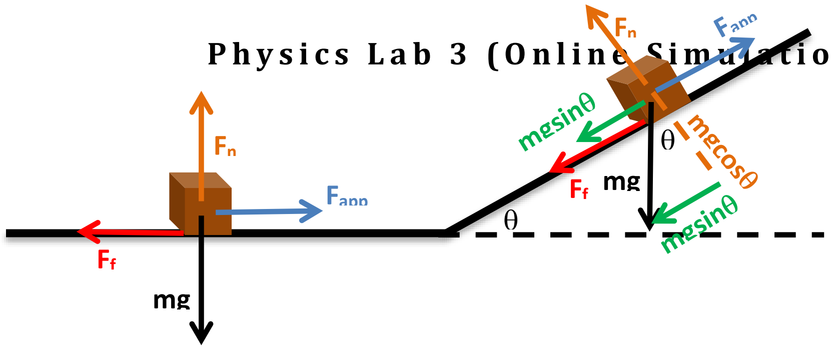
This activity is intended to enhance your physics education. We offer it as a virtual lab online. We think it will help you make connections between predictions and conclusions, concepts and actions, equations and practical activities. We also think that if you give this activity a chance, it will be fun! This is an opportunity to learn a great deal. Answer all questions as you follow the procedure in running the simulation.

Familiarize yourself with The Ramp: Forces and Motion simulation using different scenario as shown in the figure above. Click a tab at the top to view a scenario. For example, click the Introduction tab, to view the first figure above. In this figure, you can select object from the drop down menu at the center bottom. You can also drag the box or insert the value in the space provided for the applied force to move the box. If you want to see the effect of friction and mass of an object on the force applied click the next tab, friction. You can also change gravity using the sliding bar just below the object mass. If you want to observe graphs which represent what you are doing on the box, check the force graphs tab. In doing all of these, you need to understand the controls to the right of the simulations. These controls help you where you can hide or show the free body diagram, to use the ice or wood surface, to display force vectors and/or sum of forces, and more controls to specify the object's position and to define the angle of the ramp. Once you understand how to operate the simulation, you can predict the results based on the theoretical background (for example, the basics explained in the introduction below) and verify it using the simulation.

Introduction:

When an object is dragged across a horizontal (or inclined) surface, the force of friction that must be overcome by any parallel (to the surface) force (F_{II}) depends on the **normal force (Fn)** and the **coefficient of friction (μ).** Depending on the situation the normal force can be expressed in different ways. For example, if the force applied is parallel to the surface as shown below, the normal force is equal to the weight in the case where the object is on the horizontal surface, and the normal force is equal to the weight times the cosine of the angle of the inclined in the case of inclined surface. Note that the friction changes as the normal force expression changes.

Physics Lab 3 (Online Simulation)



If the box moves with constant velocity, the net force is zero. Note the general equation and the subsequent two equations in relation to the state of motion described and figure above.

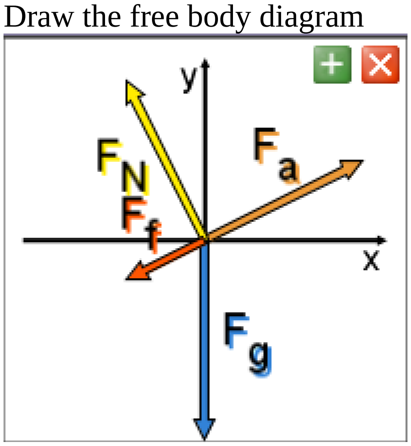
$F_f = \mu F_n$ (1)

Horizontal surface: $F_f = \mu mg$ (2)

Inclined surface: $F_f = \mu mg\cos\theta$ (3)

Procedure: *Open Ramp: Force and Motion*
http://phet.colorado.edu/en/simulation/ramp-forces-and-motion

1. Click the Introduction tab
   a. Select the small crate from the drop down option
   b. Change the values of the ramp angle to zero so that the surface is horizontal
   c. Adjust the object position to be at 8.0
   d. Now, slowly increase the ramp angle until you reach an angle when the small crate is about to move. Angle = 26.6 degree
   e. Keeping the same angle, what minimum applied force do you need to move the crate up the inclined plane? Drag the small crate along the direction of the inclined plane and observe the changing values of the applied force. . Applied force = 870N to start moving and 700N to continue.
   f. Draw the free body diagram



   g. Switch small crate with File cabinet and repeat steps b through f. compare the angle and the applied forces you found for small crate. Which quantity didn't change its value? If so why? The ramp angle stayed the same because everything scales with mass and the coefficient of static friction is the same.

h. Now, change the object to mysterious object and try to find the angle of the ramp in which the mysteries object about to move. Angle = 16.6 degree
i. What is the mass of the mysterious object? Hint: find the applied force by dragging up the inclined plane with constant velocity. Mass = 122.8 Kg
j. What will be the minimum applied force needed to for the mysterious object to move along the horizontal plane? To start movement, it needs to be 361.03N but afterwards it can be 240.69N. I calculated this by first calculating that μ_s= .3 μ_k=.2
k. Check your answers in steps d and e theoretically: The answers check out. The calculated results are off by a slight amount but with rounding applied they are the same.

2. Click the friction tab
   a. Adjust the static and kinetic coefficients of frictions to 0.4 and 0.3 respectively for a 100 kg object located on Earth
   b. Let the ramp angle to be 30 degrees
   c. If the object starts sliding down the inclined plane from the 8.0 m position, how far can it travel along the horizontal plane? Δx = -6.3 m
   d. If you want the object to cover 1.0 m on a horizontal plane after slides down the inclined plane from 8.0 m position, you would adjust the coefficient of friction or the angle of the ramp.
      i. Keeping the angle at 30 degrees, find the static and kinetic coefficients of friction
      μ_k=.505. As long as the static friction doesn't prevent the box from moving in the first place. It doesn't matter since the box is in motion.

      ii. Keeping the static and kinetic coefficients of friction to 0.4 and 0.3, find the ramp angle
      Not possible. The angle would be 18.757 degrees but at that angle static friction keeps the box in place.

   e. Repeat steps a through d. Did you find a different answer? If not, why? No. The same conditions produced the same results. The static friction for d.i could be anything from .505 to .577 but kinetic friction must be .505.

3. Click Force graphs tab
   a. Check the $F_{Friction}$, $F_{Gravity}$, and F_{Sum} boxes
   b. Using the steps a, b, and c of procedure 1, and the ramp angle found in step d run the simulation
   c. What are the values of forces you read from the graphs
      i. On inclined plane: $F_{Friction}$=315.82N, $F_{Gravity}$=-315.82N, F_{Sum}=0N
      ii. On a horizontal suface: $F_{Friction}$=N/A, $F_{Gravity}$=N/A, F_{Sum}=N/A
   d. Repeat c using the setups a and b of procedure 2. Unable to change friction coefficients.
      i. On inclined plane: $F_{Friction}$=255.021N, $F_{Gravity}$=-487.628N, F_{Sum}=-232.607N
      ii. On a horizontal suface: $F_{Friction}$=294N, $F_{Gravity}$=0N, F_{Sum}=294N

iii. Using distances along the inclined plane and horizontal planes and the respective times from the graph, calculate the average speeds of the crate
   1. on the inclined plane: v_{avg}=3m/s
   2. on the horizontal surface: v_{avg}=0m/s

e. Adjust the ramp angle to 30 degree, select sleepy dog, and run the simulation with wood then with ice using the friction control. Using the time information from the graph, and acceleration along the inclined plane, find the speed at the bottom of the inclined plane
   i. Wood: v=3.24m/s, Ice: v=8.85m/s

Follow up Questions:

1. As the angle of the ramp is increased, the normal force increases **/decreases** / remains the same and the friction force increases /**decreases** / remains the same
2. As the angle of the ramp is increased, the force parallel **increases** /decreases / remains the same.
3. The angle at which the force down the plane was equal to the force of friction (for the cabinet) was 26.6 degrees.
4. Consider a very low (zero) friction, 5.0 kg skateboard on a ramp at an angle of 15o to the horizontal. What would be the **net force** that would cause acceleration when the skateboard is allowed to move? 12.68N
5. What would the skatebord's acceleration down the plane? 2.54 m/s^2
6. Now consider the same no-friction 5.0 kg skateboard on the same 15^o ramp. If a 45kg teenager jumps on, what would be her acceleration down the ramp? 2.54 m/s^2
7. Imagine you are pushing a 15 kg cart full of 25 kg of bottled water up a 10^o ramp. If the coefficient of friction is 0.02, what is the friction force you must overcome to push the cart up the ramp? 7.72N
8. Realizing that there is also a force parallel (as a component of weight) you must ALSO overcome, what is the TOTAL force you must apply to push the cart up the ramp at a constant speed? 75.79 N