

## The Ramp (and Friction) PhET Simulation Lab

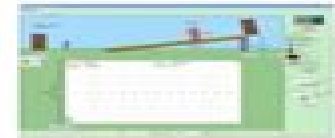
### Introduction:

When an object is dragged across a horizontal surface, the force of friction that must be overcome depends on the normal force as  $F_f = \mu F_n$  and the normal

force is given by  $F_n = W$ . When the surface becomes an inclined plane, the normal force changes and when the normal force changes, so does the friction.

In this lab, you will change the angle of an inclined plane and observe how weight is resolved into its components ( $F_n$  and  $F_{\parallel}$ ) using the basic trig functions.  $F_{\parallel}$  is the force parallel to the inclined plane.  $F_f$  is assumed to be going down the plane.

kg is a mass. To convert it to a weight you need to multiply it by the force of gravity ( $g$ ). Gravity is  $9.8 \text{ m/s}^2$ . The formula  $W = mg$  is weight equals mass times gravity.



The Ramp

- Be sure to stay in the **Introduction** part of the simulation. *More features* will be used later when we investigate energy. Start by playing with the cabinet some. Have fun, really... Now...back to work.

- Move the cabinet up and down the ramp by dragging it with your mouse.
- Move the ramp to an angle of zero (horizontal) and draw a free body diagram of the cabinet here:

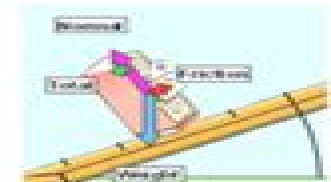
Horizontal plane

- On a horizontal plane, the normal force is \_\_\_\_\_ to the weight.
- The cabinet has a mass of 100kg. It therefore has a normal force of \_\_\_\_\_ N and a friction force (on the horizontal plane) of \_\_\_\_\_  $\mu = 0.30$

- Reset** the ramp and draw a free body diagram of the cabinet in the box here:

Inclined plane

- Before we add an applied force on the ramp, there is a force of \_\_\_\_\_ that acts against the force down the plane( Force parallel).
- When we apply a force to get the cabinet moving, the friction force acts in the \_\_\_\_\_ direction as movement of the cabinet.
- Slowly increase angle of the ramp until the cabinet starts to move on its own. What angle is this? \_\_\_\_\_ =  $\theta$



- At this point, the force down the plane is \_\_\_\_\_ than the force of friction.
- Since the ramp is now at an angle, the normal force is \_\_\_\_\_ than the weight.
- At the angle above, the normal force equals \_\_\_\_\_ N. (Hint: Trig function)
- At the angle above, the force down the plane equals \_\_\_\_\_ N.
- Using the formula for friction above, the force of friction is \_\_\_\_\_ N.

$$g = 9.8 \text{ m/s}^2$$

- If the plane-cabinet were frictionless, what angle would be required for the cabinet to move? \_\_\_\_\_ Calculate first, then test each object in the table below with the simulation on a horizontal plane.

# The Ramp And Friction Phet Simulation Lab Answers

**Lauren Gardner**



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