Name:_____

The Ramp (and Friction) PhET Simulation Lab

Introduction:


The Ramp

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 $F_{//}$) using the basic trig functions.

Procedure: *Play with the Sims → Motion → The Ramp* Run Now!

- 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:

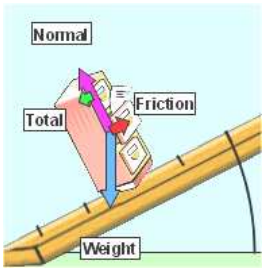
Horizontal plane

1. On a horizontal plane, the normal force is _____ to the weight.
2. The cabinet has a mass of 100kg. It therefore has a normal force of _____ N and a friction force (on the horizontal plane) of _____ **μ = 0.30**

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

Inclined plane

3. The force down the plane and normal force are components of _____.
4. Before we add an applied force on the ramp, there is a force of _____ that acts against the force down the plane (Force parallel).
5. When we apply a force to get the cabinet moving, the friction force acts in the _____ direction as movement of the cabinet.
6. **Slowly** increase angle (0.1 degrees at a time) of the ramp until the cabinet starts to move on its own. What angle is this? _____ = θ



7. At this point, the force down the plane is _____ than the force of friction.
8. Since the ramp is now at an angle, the normal force is _____ than the weight.
9. At the angle above, the normal force equals _____N. (hint: what trig function?)
10. At the angle above, the force down the plane equals _____N. (trig function?)
11. Using the formula for friction above, the force of friction is _____N.
12. If the plane-cabinet were frictionless, what angle would be required for the cabinet to move? _____
13. Why? _____

Calculate first, then test each object in the table below with the simulation on a horizontal plane.

g = 9.8m/s^2

Object	Mass	Weight	Normal Force	μ, Coef of Friction	Friction Force to Overcome
Dog				0.10	
Crate				0.70	
Piano				0.40	
Refrigerator				0.50	

Conclusion Calculations:

Back to the cabinet (Reset). **μ = 0.30**

Complete the table below. You may check your answers in the simulation.

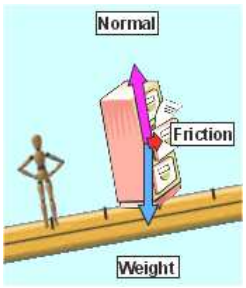
Force Applied is the force required (by you for instance) to make the cabinet move at a constant velocity in either direction *or keep it from accelerating (if applicable)*.

Recall…constant velocity = _____ net force.

Also note: force applied may change direction as the angle increases!

Angle, θ	Mass	Weight g = 9.8m/s²	Normal Force, F_n	Force parallel $F_{//}$	Friction Force F_f	Force Applied, F_a
0.00°	100. kg			0.00 N		1.
10.0°	100. kg				2.	
20.0°	100. kg			3.		
30.0°	100. kg		4.			
40.0°	100. kg			5.		
50.0°	100. kg				6.	
60.0°	100. kg					7.
70.0°	100. kg				8.	
80.0°	100. kg			9.		
90.0°	100. kg		0.00 N		10.	

Conclusion Questions:



1. On a horizontal plane, the _____force equals the _____.
2. 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*.
3. As the angle of the ramp is increased, the force parallel *increases / decreases / remains the same.*
4. The angle at which the force down the plane was equal to the force of friction (for the cabinet) was _____.
5. Consider a very low (zero) friction, 5.0 kg skateboard on a ramp at an angle of 15° to the horizontal. What would be the **net force** that would cause acceleration when the skateboard is allowed to move? _____ N
6. What would be the skateboard's acceleration down the plane? _____ m/s^2
7. Now consider the same no-friction 5.0 kg skateboard on the same 15° ramp. If a 45kg teenager jumps on, what would be her acceleration down the ramp? _____ m/s^2
8. Imagine you are pushing a 15 kg cart full of 25 kg of bottled water up a 10° ramp.
9. If the coefficient of friction is 0.02, what is the friction force you must overcome to push the cart up the ramp? _____ N
10. 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? _____ N