Online Lab: Newton's Laws and Friction

Name: Date:

Instructor: Section:

Objective:

The purpose of this lab is to develop a basic understanding of Newton's Law and Friction.

Theory:

To predict the type of motion an object will experience due to forces acting on it, a net force needs to be calculated. A net force is a vector sum of all the forces that act on the object. **Newton's First Law** states that an object will be at rest or will maintain constant velocity motion until a non-zero net external force acts on it. In other words, if the vector sum of all the forces applied to an object (or net force) is zero, the object stays at rest or is moving with constant velocity. The system of reference where this fact holds true is called an inertial system of reference.

The sum of the forces, F, acting upon a mass, m causes the mass to accelerate with acceleration a, where F and a are vectors. Since our system is one dimensional and there is only one force (the vertical forces cancel out), this reduces to

$$\vec{F} = m\vec{a} \tag{1}$$

This equation is known as **Newton's Second Law**.

Newton's Third Law states that for every force (the action) there is an equal and opposite force (the reaction). To elaborate: If Body A exerts a force on Body B, Body B exerts an equal and opposite force on Body A. $\vec{F}_{AB}$ = -$\vec{F}_{BA}$

An object which is in motion across a surface encounters a force of friction. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together. The friction force can be calculated using the equation:

$$F_f = \mu F_N \tag{2}$$

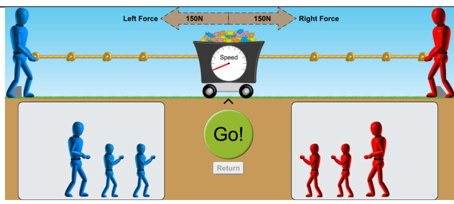
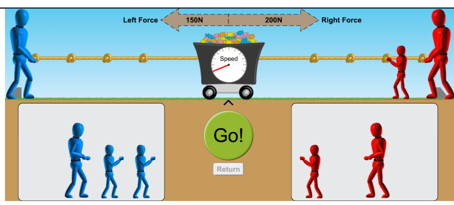
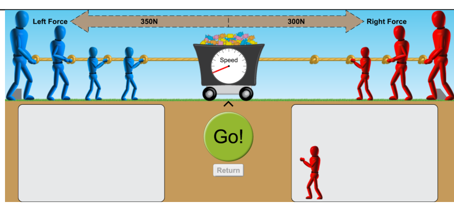
Where F_N is the normal force, F_f is the frictional force and the symbol μ (pronounced "mew") represents of the coefficient of friction and will be different for different surfaces. If an object is **NOT MOVING**, it is a static force and we must use the static coefficient (μ_s) and if it is **MOVING**, it is a kinetic force and we must use the dynamic coefficient (μ_k).

Tug of War

Here we are going to investigate how if the Blue People exert a force on the Red People, the Red People exert an equal and opposite force on the Blue People.

1. Go to the following website:
   https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html
2. Click the **Net Force** tab on the PHeT simulation.
3. Make sure all of the boxes in the upper right hand corner are checked.
4. Create each setup scenario in Table 1. Click the green “Go!” button
5. Observe and Record your results in Table 1. For the Winner: Enter (Blue, Red, Tie).
6. Click the **Return** button to return the cart to start.

Table 1: Net Force

Setup	F_{Left} **(N)**	F_{Right} **(N)**	F_{Sum} **(N)**	**Winner**
				
				
				

Observations:

1. When the cart was in motion, were the forces equal or unequal? Explain.

2. Does the cart always move in the direction of the sum of the force?

Friction

1. Click the "Friction" tab at the top of the window.
2. Make sure all of the boxes in the upper right hand corner are checked.
3. Place each item or combination of items listed in Table 2 on the screen. Set the Applied Force to the value given in Table 2. These are the values needed to start the objects moving. Click PLAY. Read and Record the Friction Force, F_{fk} just after it starts moving.
4. Calculate and Record the Normal Force, F_N. ***Recall:*** $F_N = \boldsymbol{mg}$ *and* $g = 9.8\ m/s^2$.
5. Calculate the coefficient of kinetic friction μ_k for each item. Record in Column 6.

Table 2: Data: Friction

Item(s)	**Mass** m (kg)	**Applied Force (N)**	**Normal Force** F_N **(N)**	**Kinetic Friction** F_{fk} **(N)**	μ_k
Child	40 kg	150 N			
Crate	50 kg	200 N			
Man	80 kg	250 N			
Trash Can	100 kg	300 N			
Box, Trash Can	150 kg	400 N			

Observations and Analysis:

1. Describe how the force of friction changes as the applied force is increased.
2. What do you observe about the Friction and Applied forces before the objects start moving? (Are the FORCES BALANCED or UNBALANCED?)
3. **Create a graph of F_{fk} versus F_N and upload it with this Lab Report in D2L.** Measure the slope of the line using any method you are comfortable with. Record the slope here. What is the physical meaning of the slope?

Newton's Second Law

Part A: Constant Force with varying Mass

1. Click the "Acceleration" tab at the top of the window.
2. Make sure all of the boxes in the upper right hand corner are checked.
3. Set the Applied Force to 300 N.
4. Place each item listed in Table 2 on the screen.
5. Click Play. Observe and Pause after 2-3 seconds.
6. Record the acceleration a, Sum of the Forces F_{Sum} and Friction Force F_f in Table 3.

Table 3: Data: Constant Force with varying Mass

Item	**Mass (kg)**	**Acceleration** a (m/s^2)	**Sum of Forces** F_{Sum} **(N)**	**Friction Force** F_f **(N)**
Child	40 kg			
Box	50 kg			
Man	80 kg			
Water pail	100 kg			
Refrigerator	200 kg			

Observations and Analysis:

Fill in the blank by selecting one of the given options for Question 1.

1. At constant force, acceleration varies (directly / inversely) with mass. When subjected to the same amount of net external force, a heavier object will experience (less / greater) acceleration than a lighter one.
2. What do you observe as the mass increases?

Part B: Constant Mass with varying Force

1. Now set the mass to 100 kg. Start the applied force at 300 N.
2. Click Play. Pause after 2-3 seconds. Observe and Record the acceleration a, Sum of the Forces F_{Sum} and Friction Force F_f in Table 1.
3. Slowly increment in intervals of 50 N, pausing after 2-3 seconds to record your results.

Table 4: Data: Constant Mass with varying Force

Applied Force (N)	**Acceleration** a (m/s^2)	**Friction Force** F_f **(N)**	**Sum of Forces** F_{Sum} **(N)**
300 N			
350 N			
400 N			
450 N			
500 N			

Observations and Analysis:

Fill in the blank by selecting one of the given options for Question 1.

1. With constant mass, an objects acceleration varies (directly / inversely) with the net external force applied. This means that the acceleration of an object increases as the force applied is (decreased / increased) , but its acceleration decreases if the force applied is (decreased / increased) .
2. What do you observe about the external force applied and the object's acceleration?
3. **Create a graph of F_{Sum} versus a and upload it with this Lab Report in D2L.** Measure the slope of the line using any method you are comfortable with. Record the slope here. What is the physical meaning of the slope? Hint: What are the units of the slope?
4. **Take a photo or scan a copy showing ALL calculations performed during this lab and upload it with this Lab Report in D2L.**