

Forces and Motion Basics Phet Simulation Lab

Purpose: To learn more about Newton's first and second law.

Procedure:

1. Open up a browser on a computer and type in phet.colorado.edu. Click on **Play with Sims**. Then click on **New Sims** on the left hand side of the screen and choose **Forces and Motion: Basics**. When the window for the simulation opens up, click on **Run Now**. If this doesn't start up the simulation, try downloading the simulation instead, or try a different browser. Your computer must be Java enabled.

Part 1: Motion (No Friction):

1. Click on the **Motion** tab at the top of the screen. Click on all the buttons in the box in the upper right of your screen: **Force Values, Masses, Speed**.
2. Put each item listed in the table below on the cart, one at a time. Type **20 N** in the Force Box.
3. Using a timing device, time how long it takes to for the object on the skateboard to reach the first major (bold) tick mark on the speed dial. Record the mass and time on the chart.
4. Calculate the acceleration of the object by using the equation $a = F/m$. Calculate the velocity of the object by using the equation $\Delta v = a\Delta t$. Since starting velocity = 0, the change in velocity will be the final velocity.
5. Replace the object you tested with the next object on the list. This should reset the speed, etc., but if it doesn't, click **Reset All** before you test the next object. This will clear all your buttons, so you will need to recheck those after every trial. Do this before plugging in 20 N each time.
6. Find the mass of the **mystery box** by comparing it's time to accelerate to the bold tick mark to the known masses. Fill in your guess for the mass of the box.
7. Pile as many objects onto the cart as possible. Write down in the last row the list of objects you chose, the total mass, find the time it takes to accelerate to the speed of the other objects, and calculate the acceleration and velocity.

Item	Mass (kg)	Force (N)	Time (s)	Acceleration (m/s ²)	Velocity (m/s)
Girl		20			
Trash can		20			
Man		20			
2 Boxes		20			
Refrigerator		20			
Mystery Box		20			
Most Mass Possible:		20			

Analysis for Part 1:

1. There are three different situations in which mass is doubled (40 → 80 kg, 50 → 100 kg, and 100 → 200 kg).
What happens to the time to reach the final velocity each time the mass is doubled?

What happens to the acceleration of the object each time the mass is doubled?

2. What is the best value and uncertainty for your calculated velocity?
3. List some errors that might account for the uncertainty you see.
4. What would it take for a 100 kg mass to have the same acceleration as a 50 kg mass, given the values you are allowed to change in the simulation?
5. Test your idea. Run a few trials to see if you can get the acceleration and average time of the 100 kg mass to be the same as the acceleration and time of your 50 kg mass in the chart above.

Item	Mass (kg)	Force (N)	Time (s) Trial 1	Time (s) Trial 2	Time (s) Trial 3	Best Value Time (s)	Acceleration (m/s ²)
2 Boxes	100						

Part II: Motion with Friction

1. Click on the **Friction** tab. Click on the **Forces**, **Sum of Forces**, **Values**, **Masses** and **Speed** buttons. Leave Friction at the mid-point. You will need to reselect all these every time you reset the simulation. Note that **Sum of Forces** is what we call **Net Force**.
2. Place 50 kg on the ground. Type in 50 N of force and hit Play. Fill in the values and direction for **Applied Force**, **Friction Force**, and **Sum of Forces into the chart below. Keep increasing Force by 50 N increments until you get to 300 N.**

Item	Mass (kg)	Applied Force (N) + Direction Arrow	Friction Force (N) + Direction Arrow	Sum of Forces (N) + Direction Arrow
1 Box	50	50		
1 Box	50	100		
1 Box	50	150		
1 Box	50	200		
1 Box	50	250		
1 Box	50	300		

3. Watch what happens when the maximum speed is reached. Fill in the chart for the forces after the maximum speed is reached and after the box comes to a stop. Make sure to include direction of the forces.

Item	Mass (kg)	Applied Force (N) + Direction Arrow	Friction Force (N) + Direction Arrow	Sum of Forces (N) + Direction Arrow
1 Moving Box after Maximum Speed is reached	50			
1 Box after coming to a stop	50			

Analysis for Part II:

- Based on your chart, what is the maximum value for Friction? _____
- Set the Applied Force to this value. What happens to the box? Why?
- Why is the friction force less than the maximum for low applied force situations?
- Which direction is the Net Force (Sum of Forces) after the maximum speed is reached? _____
- What other quantity is the Net Force (Sum of Forces) equal to after the max. speed is reached? Why?
- Why is Friction Force = 0 N after the box comes to a stop?
- Now use 2 boxes totaling 100 kg. Increase Applied Force this time in 100 N increments. Fill in the chart.

Item	Mass (kg)	Applied Force (N) + Direction Arrow	Friction Force (N) + Direction Arrow	Sum of Forces (N) + Direction Arrow
2 Boxes	100	100		
2 Boxes	100	200		
2 Boxes	100	300		
2 Boxes	100	400		

- What happens to the maximum value of friction at double the mass? Why?

Part III: Acceleration Lab

1. Click on the **Acceleration Lab** tab. Click on the **Forces, Sum of Forces, Values, Masses, Speed,** and **Acceleration** buttons. Leave Friction at the mid-point.
2. Put one box on the ground. Type in 200 N for the Force. Fill in the chart, estimating acceleration as best you can. Then figure out what value you need to double the **Net Force (Sum of Forces)** on the box. Hint: This will **not** be double the Applied force.
3. Let the speed reach the maximum allowed, then fill in the chart for when the box is slowing down, and after it comes to a stop. Be sure to pay attention to the value (+ or -) of the acceleration.

Item	Mass (kg)	Applied Force (N) + Direction Arrow	Friction Force (N) + Direction Arrow	Sum of Forces (N) + Direction Arrow	Acceleration (m/s ²)
1 Box	50	200			
1 Box at double the Net Force	50				
1 Box after max speed is reached (slowing down)	50				
1 Box after box comes to a stop	50				

Analysis Part III:

1. Why is the force to double acceleration not double the **Applied Force**?
2. When you doubled the **Net Force (Sum of Forces)**, by what factor did **acceleration** increase?
3. Turn off Friction. Put in 200 N of force and let the speed max out. What happens to the box after the man falls away? Why?
4. Reset all values, then click on all the buttons again. Place the glass of water in front of the man. Starting at 200 N, increase the force by 100 N increments until you get to 500 N. What happens to the water level in the glass? Why?