# Lab 3: Simulation of Friction and Newton's Laws

Our goal in this lab is to explore how frictional forces work, and use what we learn to understand how forces affect motion. To do this we will use a computer simulation, [Force and Motion](https://phet.colorado.edu/en/simulation/legacy/forces-and-motion).

## Running the Simulation

The simulation requires either Java or the use of ChirpJ as instructed at the link above. However, some machines still may not run the simulation. If you cannot get the simulation to run on your device, you can access it by using [VMWare Horizon to access the Learning Center computers.](https://smccd.instructure.com/courses/35406/quizzes/%24CANVAS_COURSE_REFERENCE%24/file_ref/g714baab831be758296fbee5917cc9848/download?download_frd=1) Use the Learning Center computers, open Chrome, and search for "phet Forces and Motion". Make sure you are using the "Forces and Motion" simulation, NOT the "Forces and Motion Basics" one.

## Motion with no Friction

After starting the simulation, arrows show the forces acting on the box: you can see that gravity (Fg) is pulling the box downwards, while a normal force from the ground (FN) is pushing the box upwards. These two forces balance so the box doesn’t move.

We will now remove the effects of friction by clicking the “ice’ button on the right-hand side of the screen.

1. *Predict* the motion of the box you expect to see if you apply a 200 N force to the box now. Will it be constant velocity? Constant acceleration? Stationary? None of the above?

Next, type in “200” into the “Applied force” box use the simulation to apply 200 N to the box. Then press the “play” button.

1. Was your prediction correct? If not discuss why not.

Click “reset all” and then “yes” to reset the setup. Again make the surface ice.

1. Predict the motion of the box you expect to see if you apply a 1 N force to the box. Will it move? If so, how will its motion compare to the motion with a 200 N force?

Now use the simulation to apply 1 N to the box on ice and describe the motion you see. (Don’t forget to press the “play” button- and wait for a while after you press the button).

1. Was your prediction correct? Watch carefully to see if there are any changes in speed. If your prediction was not correct, discuss why not.
2. According to your observations, would it be more accurate to say that when on ice, the force directly controls the velocity, or that it directly controls the acceleration? That is, if you were told that the force was 200N at a particular time, would that information help you determine the acceleration or the velocity of the box? Explain your answer.

## Introduction to Static Friction

Now click on the “Friction” tab in the upper left. In this simulation, there will be friction. Type in “200” into the “Applied force” box. Notice that the little person is now pushing on the box.

1. What new force shows up on the diagram? What do you suppose this new forces is?
2. Click the “play” button. Does the box move? Why or why not? What does this tell you about the magnitude of the new force you mentioned above?
3. Reset the simulation again. Type in “400” into the “Applied force” box, but do not press “play”. How do the forces that arise compare to those when the force was 200 N?
4. Click the “play” button. Does the box move? Why or why not? What happened to the frictional force when you increased the applied force?
5. Click the “pause” button. Now change the “Applied force” box to 700 N. What do you notice about the applied and frictional forces now?
6. Click “play” and observe the box’s motion. Does the box appear to move with constant velocity or constant acceleration?
7. What does the box’s behavior with forces of 200 N, 400 N, and 700 N tell us about the frictional force on the box?

## Changing Mass and Friction

Reset the simulation and change the object’s mass to 50 kg using the controls near the bottom of the screen. Apply 400 N of force to the box and press “play”.

1. Does the box move? What accounts for the difference between the effects of the 400 N force on the 100 kg and 50 kg objects?
2. A student makes the statement: “A small force is not enough to accelerate a very massive object”. In what ways is the student correct? In what ways are they incorrect?

## Measuring Maximum Friction

Use trial and error to determine the minimum force needed to start the 50 kg crate moving. Be sure that the box is fully stopped before each test. Repeat with 100 kg and 150 kg crates.

1. Report your results in a table. Use your results to predict how much force is needed to start at 25kg crate moving, showing your work. Test your results and report on whether they were correct or not.
2. Using your results from the previous question, write an equation for the force needed to start a box of mass m moving on this particular floor.

## Static and Kinetic Friction

The friction we’ve been looking at so far is friction between two objects that aren’t moving relative to each other (in this case, the box and the floor). We call this “static friction”. A second type of friction acts on sliding objects: this is called “kinetic friction”. We can see this in the simulation: reset the simulation and apply 700 N to a 100 kg crate. As you hit play, watch the arrow representing the frictional force carefully.

1. What happens when the crate starts moving? What does this tell you about the relationship between the sizes of the maximum static friction and the kinetic friction?

Reset the simulation. Now hover your mouse over the box, click and hold down the button, and then drag the mouse to the right. This should cause the person to push the box. Get a feel for how this works, then reset the setup again. Finally, have the person push the box till it starts moving, then release the mouse button so the person stops pushing the box.

1. Describe the motion of the box after the person stops pushing the box. Why does the box move in this way?

Click on the “Force Graphs” tab. Reset the simulation. Click on the Ffriction box in on the left-hand side to graph the frictional forces.

1. In a minute, you will have the person push the box and then let it slide, as you did above. But, BEFORE you do this, predict what the graph of the frictional force vs. time will look like and show your prediction in GradeScope.

Now have the person push the box fairly gently so that it slides, but not too fast. (If the person pushes too hard, some of the interesting effects will not be captured by the graph). Repeat this several times to make sure you are capturing the correct graph.

1. Sketch the graph the frictional force you see on your piece of paper below your prediction graph, and discuss any differences between what you saw and what you predicted.
2. If you wanted to move an initially stationary box at a constant velocity on a surface with friction, what would you have to do?