

# Friction

Friction is a force that resists motion. It involves objects in contact with each other, and it can be either useful or harmful. Friction helps when you want to slow or stop a bicycle, but it is harmful when it causes wear on the parts of a machine. In this activity, you will study the effects of surface smoothness and the nature of materials in contact on sliding friction. You will use a Force Sensor to measure frictional force, in Newtons (N), as you pull a block across different surfaces.

## OBJECTIVES

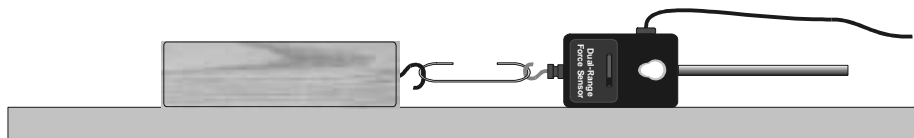
In this experiment, you will

- Measure sliding friction.
- Measure friction between a wooden block and smooth-surface wood.
- Measure friction between a wooden block and rough-surface wood.
- Make predictions about other surfaces.
- Test your predictions.

## MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator  
EasyData application  
data-collection interface  
Vernier Force Sensor  
wooden block (with a hook)

paper clip  
wood with smooth surface  
wood with rough surface  
sandpaper



*Figure 1*

## PROCEDURE

### Part I Smooth and Rough Surfaces

1. Set up the Force Sensor.
  - a. Turn on the calculator.
  - b. Set the Force Sensor range switch to 10 N.
  - c. Connect the Force Sensor, data-collection interface, and calculator.

2. Set up EasyData for data collection.
  - a. Start the EasyData application, if it is not already running.
  - b. Select **(File)** from the Main screen, and then select **New** to reset the application.
  - c. Select **(Setup)** from the Main screen, then select **Time Graph...**
  - d. Select **(Edit)** on the Time Graph Settings screen.
  - e. Enter **0.05** as the time between samples in seconds.
  - f. Select **(Next)**.
  - g. Enter **60** as the number of samples and select **(Next)**. Data collection will last 3 seconds.
  - h. Select **(OK)** to return to the Main screen.
3. Zero the Force Sensor.
  - a. Lay the Force Sensor on the tabletop in the position shown in Figure 1.
  - b. Select **(Setup)** from the Main screen, and then select **Zero...**
  - c. Select **(Zero)** to zero the Force Sensor Sensor.
4. Get a wooden block (with a hook on one end). Partly straighten a paper clip—leaving a hook at each end. Use the paper clip to attach the wooden block to the Force Sensor.
5. Slowly pull the wooden block across a piece of wood with a smooth surface. Hold the Force Sensor by its handle and pull it to you, as demonstrated by your teacher. The Force Sensor should be held parallel to and about 1 cm above the surface. Once the wooden block is moving at a steady rate, select **(Start)** to begin data collection.
6. Determine and record the force used to pull the block.
  - a. When data collection is complete, a graph of force *vs.* time will be displayed. Select **(Anlyz)**, and then select **Statistics...**
  - b. Before moving the cursor, select **(OK)** to set the left bound at 0 s.
  - c. The cursor will move to the right edge of the graph. Ensure it is on the last point and select **(OK)** to set the right bound.
  - d. Record the mean (average) force (in N).
  - e. Select **(OK)** to return to the graph.
  - f. Select **(Main)** to return to the Main screen.
7. Repeat Steps 5–6 as you pull the block over a piece of wood with a rough surface. Note: After selecting **(Start)**, select **(OK)** to start data collection.

## Part II Predicting Friction

8. You will measure friction as the block is pulled across your desktop, the floor, and sandpaper. In the space provided in the data table below, predict the order of friction for these surfaces—from lowest to highest.
9. Repeat Steps 5–6 for each of the surfaces.

**DATA**

Part I Smooth and rough surfaces		
Surface	Smooth wood	Rough wood
Force (N)		

Part II Predicting friction			
Predicted order of values for desktop, floor, and sandpaper			
(Lowest)			(Highest)
Surface	Desktop	Floor	Sandpaper
Force (N)			

**PROCESSING THE DATA**

1. What is the effect of surface roughness on friction?
2. How did you decide the order of your predictions in Part II?
3. How good were your predictions? Explain.
4. Give two examples of situations where friction is helpful.
5. Give two examples of situations where it is best to reduce friction.

6. Summarize the results of this experiment.

## **EXTENSIONS**

1. Test the friction of other surfaces, such as glass, metals, rubber, and different fabrics.
2. Investigate how frictional force varies with contact area and mass.
3. Design an experiment to test methods of reducing friction.

**TEACHER INFORMATION****Friction**

1. There are several different combinations of equipment that will work for measuring force. The most common method, which uses the USB port on TI-84 Plus calculators, is to connect a Force Sensor to an EasyLink. For more information on EasyLink refer to *Appendix G*.

The other method, which works for both the TI-83 Plus and TI-84 Plus families of calculators, is to use a Force Sensor attached to a LabPro or CBL 2.

2. A 15 cm (6 in) long wooden block cut from a 5 cm by 10 cm (2 in by 4 in) piece of wood works well. Insert a hook in the center of one end. Use a paper clip or a piece of string to attach it to the Force Sensor. Other flat-surface objects can be substituted.
3. Scrap pieces of wood obtained at a wood shop, building materials store, or a lumberyard can be used as surfaces for Part I.
4. Illustrate proper technique for pulling a wooden block across a surface with the Force Sensor before the experiment.
5. Remind your students not to pull the block too fast.
6. Your students should get better results using the Force Sensor and average force values than they would with spring scales.

**SAMPLE RESULTS**

Surface	Smooth wood	Rough wood	Desktop	Floor	Sandpaper
Force (N)	xxxx	xxxx	xxxx	xxxx	xxxx

**ANSWERS TO QUESTIONS**

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.