Name ___________________________________ Date __________________

Experiment
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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

LabPro or CBL 2 interface
TI Graphing Calculator
DataMate program
Vernier Force Sensor
wooden block (with a hook)
paper clip
wood with smooth surface
wood with rough surface
sandpaper

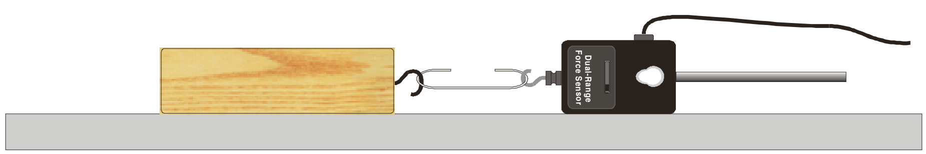

Figure 1

PROCEDURE

Part I Smooth and Rough Surfaces

1. Plug the Force Sensor into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends. If you are using a Dual-Range Force Sensor, set the range switch to 10N.

2. Turn on the calculator and start the DATAMATE program. Press CLEAR to reset the program.

3. Set up the calculator and interface for the Force Sensor.
   a. Select SETUP from the main screen.
   b. If the calculator displays a Force Probe in CH 1, proceed directly to Step 4. If it does not, continue with this step to set up your sensor manually.
   c. Press ENTER to select CH 1.
   d. Select FORCE from the SELECT SENSOR menu.
   e. Select the correct Force Sensor and setting from the FORCE menu.

4. Set up the calculator and interface for data collection.
   a. Use ▲ and ▼ to select MODE and press ENTER.
   b. Select TIME GRAPH from the SELECT MODE menu.
   c. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
   d. Enter "0.05" as the time between samples in seconds.
   e. Enter "60" as the number of samples. Data collection will last 3 seconds.
   f. Select OK to return to the setup screen.

5. Zero the Force Sensor.
   a. Lay the Force Sensor on the tabletop in the position shown in Figure 1.
   b. Select ZERO from the SETUP menu.
   c. Select CH1-FORCE (N) from the SELECT CHANNEL menu.
   d. Press ENTER to zero the Force Sensor.

6. 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.

7. 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.

8. Determine and record the force used to pull the block.
   a. After data collection stops, press ENTER to return to the main screen.
   b. Select ANALYZE from the main screen.
   c. Select STATISTICS from the ANALYZE OPTIONS menu.
   d. Press ENTER before moving the cursor.
   e. Use ► to move the cursor to the right side of the screen and press ENTER.
   f. Record the MEAN (average) force (in N).

9. Repeat Steps 7-8 as you pull the block over a piece of wood with a rough surface.

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Part II Predicting Friction

10. 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.

11. Repeat Steps 7-8 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. 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.

2. Scrap pieces of wood obtained at a wood shop, building materials store, or a lumberyard can be used as surfaces for Part I.

3. This experiment can be done with either of two types of force sensors, the newer Dual-Range Force Sensor, with a black plastic sensor box, and the older Student Force Sensor, made of gray metal. The student procedure and accompanying figures are written primarily for the Dual-Range Force Sensor.

   Newer Dual-Range Force Sensors (DFS-BTA versions) are equipped with auto-ID capability when used with LabPro or CBL 2. Remind students that the Dual-Range Force Sensor has a switch setting which should be set to 10 N for this experiment.[1]

   Student Force Sensors are not auto-ID, so students will need to perform the manual setup described in the procedure. The Student Force Sensor has only one range, hence no switch setting. When using this sensor, students will choose Setup on the main screen of DataMate, select Force from the list of sensors, and then select STUDENT FORCE (N).

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)	0.62	0.98	0.67	0.92	2.21

ANSWERS TO QUESTIONS

1. Surface roughness increases friction.

2. Answers will vary.

3. Answers will vary.

[1] Some earlier versions of the Dual-Range Force Sensor have a lower setting of 5 N instead of 10 N. If you have one of these sensors, students can load an appropriate calibration by choosing Setup from on the main screen, selecting Force from the list of sensors, and then selecting DUAL R FORCE 5(N).

4. Some examples of where friction is helpful are when it keeps you from slipping and sliding, between the brake lining and brake pads of a car, between a car's tires and the road during acceleration, snow tires, and a baseball player's use of rosin.

5. Some examples of where it is best to reduce friction are the bottoms of racing skis, between wheels and axles, between internal parts of a lock, between the cylinder walls and pistons of a car, and on a bicycle chain.

6. Friction depends on the nature of the materials in contact and the smoothness of their surfaces. Rough surfaces cause more friction than smooth surfaces.