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Crash Course in Physics: Exploring Motion and Force Phenomena for Middle School

Experiments

Investigation Friction

- Go Direct® Sensor Cart

Getting Faster

- Go Direct Sensor Cart

Workshop Presenter

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Investigating Friction

Friction is a force that resists motion. It involves objects in contact with each other, and it can be 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 the force sensor built into a Go Direct Sensor Cart to measure frictional force as you pull a block across different surfaces.

OBJECTIVES

- 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

Chromebook, computer, **or** mobile device
Graphical Analysis app
Go Direct Sensor Cart
wooden block (with a hook)
loop of string or paper clip
wood with smooth surface
wood with rough surface
sandpaper

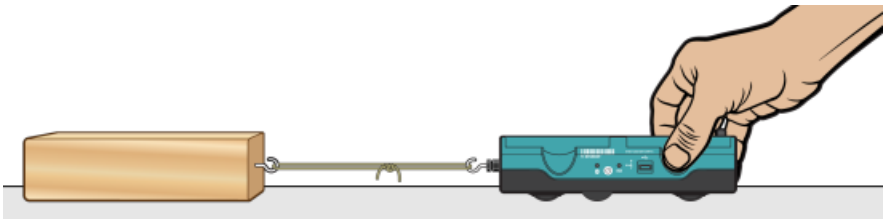

Figure 1

PROCEDURE

Part I Smooth and rough surfaces

1. Launch Graphical Analysis. Connect the Go Direct Sensor Cart to your Chromebook, computer, or mobile device. Click or tap Sensor Channels, deselect Position, and select Force. Click or tap Done.

2. Click or tap Mode to open Data Collection Settings. Change End Collection to 3 seconds. Click or tap Done.

3. Set the Sensor Cart on the tabletop in the position shown in Figure 1. Making sure nothing is touching the hook, click or tap the Force meter and choose Zero to zero the force sensor.

4. Get a wooden block that has a hook on one end. Connect the wooden block to the Sensor Cart using the loop of string (see Figure 1). Use a paper clip if you do not have a loop of string.

5. Slowly pull the wooden block across a piece of wood with a smooth surface. Hold the cart by its sides and pull it toward you (see Figure 1). Once the wooden block is moving at a steady rate, click or tap Collect to start data collection. Continue pulling the wooden block until data collection is complete.

6. Determine the mean (average) force (in N).

   a. After data collection is complete, click or tap Graph Tools, , and choose View Statistics.

   b. Record the mean force.

7. Repeat Steps 5–6 as you pull the block over a piece of wood with a rough surface.

Part II Predicting friction

8. You will measure friction as the block is pulled across your desk top, the floor, and sandpaper. In the blanks supplied in the data table, predict the order of friction for these surfaces, from least to most.

9. Repeat Steps 5–6 for each of the surfaces.

DATA

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

Predicted order of friction values for the desk top, the floor, and sandpaper:		
_____	_____	_____
least friction		most friction

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 either the relationship between frictional force and contact area or frictional force and mass.
3. Design an experiment to test methods of reducing friction.

Getting Faster

You may have noticed that an object rolling down a hill starts out slowly and then speeds up. In this activity, you will measure the maximum speed of a cart or toy car as it rolls down a ramp from different starting positions. You will use Graphical Analysis to measure the speed of a Sensor Cart.

OBJECTIVES

- Measure speed.
- Record data.
- Graph results.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis app
Go Direct Sensor Cart
1.5 m board
meter stick
books, bricks, or box to support ramp
large book

Figure 1

PROCEDURE

1. Connect to the Go Direct Sensor Cart and set up the data-collection settings.

    a. Launch Graphical Analysis.

    b. Connect the Sensor Cart to your Chromebook, computer, or mobile device.

    c. Click or tap Done.

    d. Click or tap Mode to open Data Collection Settings. Change End Collection to 3 s. Click or tap Done.

2. Set up the ramp.
   a. Set up the ramp as shown in Figure 1. The high end of the ramp should be no more than 30 cm from the floor.
   b. Place a large book on the floor about 50 cm from the bottom end of ramp. This book will stop your car after it comes off the ramp.
   c. If necessary, use tape or chalk to mark lines on the ramp at 40 cm from the bottom of the ramp, 60 cm from the bottom of the ramp, and 80 cm from the bottom of the ramp.
3. Position the cart at the top and center of the track as shown in Figure 1 with the **+x** arrow pointing towards the bottom of the track.
4. Collect data.
   a. Place your cart on the ramp so the front edge of the cart is at the 40 cm line.
   b. Click or tap Collect to start data collection, then release the cart.
   c. Examine the graphs. Are the graphs smooth, with no abrupt changes? If not, make adjustments and repeat data collection until you have smooth graphs.
5. Click or tap Graph Tools, , for the velocity *vs*. time graph, and choose View Statistics. Record the maximum speed in your data table.
6. Repeat Steps 4–5 two more times.
7. Repeat Steps 4–6 with the front of the car at the 60 cm position and again with the front of the car at the 80 cm position.

DATA

Table 1: Maximum Speed (m/s)			
Trial	40 cm	60 cm	80 cm
1			
2			
3			

Table 2	
Release position (cm)	Average maximum speed (m/s)

PROCESSING THE DATA

1. Calculate the average maximum speed for each release position. Show your work, and write the average values in Table 2.

2. Graph the results

   a. Disconnect the sensor cart from Graphical Analysis.

   b. Click or tap File, , and choose New Experiment. Click or tap Manual Entry.

   c. Enter the Release Position values in the first (X) column and enter the Average Maximum Speed in the second (Y) column.

   d. Change the column headings to Release Position (cm) and Average Maximum Speed (m/s).

   e. Describe the shape of the graph.

3. What happened to the maximum speed as you released the cart from higher points?

4. Explain two ways to make the cart's maximum speed greater, and explain why you think they would be successful.

EXTENSIONS

1. Repeat the experiment with a ramp with a different height.

2. Redo the experiment with different amounts of mass on the cart. Summarize your results in a few sentences.