



OBJECTIVES

- Measure kinetic friction data.
- Determine the coefficient of kinetic friction.
- Make observations and predictions about shoes.
- Measure the force needed to pull different shoes across a surface.
- Calculate the coefficient of friction, μ .

MATERIALS

- TI-Nspire™ CX II
- Calculator Connection Cable (Mini-A to Micro-B USB)
- Vernier GDX Force & Acceleration Sensor
- Sneaker, loafer, and dress shoe, all the same size
- Copy of student worksheet
- 3 loops of string
- Pen or pencil



Figure 1.

PROCEDURE

1. Make a data table on a separate sheet of paper to record the type of shoe, weight of the shoe (N), average force (N), predicted ranking of friction for each shoe, and finally the coefficient of friction (μ) calculated for each shoe.
2. List each type of shoe in the data table. Make a prediction of how each shoe will rank in their amount of friction and record the ranking in the data table.
3. Turn on the TI-Nspire CX II.
4. Connect the GDX Force & Acceleration Sensor to the TI-Nspire CX II Handheld with the cable provided. (or using the Bluetooth Adapter for wireless connectivity) The Vernier DataQuest App will automatically open.
5. Click Mode, choose Time Based, click OK.
6. For the Force Sensor to be ready to collect data, the sensor must be zeroed.
7. Hold the Force Sensor, with the hook pointing towards the ground.



Friction: Your Friend or Your Enemy?

Student Activity

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8. Look at the force value on the screen.
9. When the value stabilizes (stays the same), click the Force meter and choose Zero in the lower left corner of the dialog box. The reading should be very close to zero.
10. Attach a loop of string to the shoes in such a way that will allow you to drag it across the table (see *Figure 1*).
11. Measure the weight of each of the shoes by hanging them from the Force Sensor and record their weights in the Data Table.
12. Hook the Force Sensor to the string attached to the shoe and practice using the Force Sensor to drag the shoe across the table. **When you drag the shoe, be sure to pull so the Force Sensor remains horizontal to the table top. Practice a few runs to make sure you can pull the shoe slowly and steadily.**
13. Begin slowly and steadily pulling the shoe across the table.
14. Once the shoe is moving steadily, have another person in the team click or tap Collect to start data collection.
15. If you reach the end of the table before data collection is over, repeat the run. You want to have a relatively steady force value for the five-second run.
16. When you have successfully collected data, click Menu, Analyze, Statistics.
17. Record the mean (average) force in the Data Table.
18. Repeat Steps 7-17 for each of the remaining shoes.

DATA ANALYSIS

The weight of the shoe in newtons is the Force Normal, F_N . The force of friction of the shoe is F_F . To calculate the coefficient of friction for each shoe, the formula is $\mu = F_F / F_N$. Calculate the coefficient of friction for each shoe to three decimal places and record in your data table.

QUESTIONS

1. How did your prediction of the amount of friction for each shoe compare to the data you collected?
2. How do you explain the difference between the force of friction for each of the shoes?
3. How would the force of friction be affected by dragging the shoes over a layer of ice?
4. How would the force of friction be affected by dragging the shoes over a rough-sawn board?
5. Why are cinders scattered on icy roads?



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6. Why does the coefficient of friction have no units?
7. If there were no friction, would you be able to walk? Why or why not?
8. Summarize what you have learned about friction from this experiment.

EXTENSION

Repeat this experiment on two different surfaces and compare the results with the data from the table top.