



Science Objectives

- Students will determine what factors affect the friction between two surfaces.
- Students will relate the forces needed to drag different shoes across a table at a constant speed.

Vocabulary

- acceleration
- force
- normal force
- kinetic friction
- mass
- Newton's Laws
- coefficient of friction, μ

About the Lesson

- This lesson measures kinetic friction of different shoes being dragged across a table top.
- As a result, students will:
 - a) Manipulate values for force dragging different shoes.
 - b) Measure kinetic friction data.
 - c) Determine the coefficient of kinetic friction.

TI-Nspire™ Navigator™

- Monitor student progress using Screen Capture.

Activity Materials

- *Friction_Your_Friend_or_Your_Enemy* word document
- TI-Nspire™ CX II
- Vernier GDX Force & Acceleration sensor
- TI-Bluetooth adapter
- Sneaker, loafer, and dress shoe, all same size
- copy of student worksheet
- three pieces of string
- pen or pencil

TI-Nspire™ Technology Skills:

- Capture data with probes

Tech Tips:

Access free tutorials at

<http://education.ti.com/calculator/spd/US/Online-Learning/Tutorials>

Lesson Files:

Student Activity

- Friction_Your_Friend_or_Your_Enemy_Student.doc
- Friction_Your_Friend_or_Your_Enemy_Student.pdf



Activity Overview

- Please print the student worksheet and make available to students before beginning the lab.
- Students will need to make a data table on a separate sheet of paper before starting the activity.
- Lab background information as well as lab procedures are included only in the student worksheet.
- Always remember to review any safety precautions thoroughly with your students prior to starting the lab.
- Vernier GoDirect (GDX) probes and sensors can be either directly connected to the TI-Nspire CX II with Calculator Connection Cable (Mini-A to Micro-B USB) or through TI's Bluetooth Adapter.
- The directions in the student experiment are for using the connecting cable to directly connect the CX II directly to the sensor. ****For this experiment, it would be better to use the TI-Bluetooth Adapter following the steps provided below.**
- *Optional procedure* for the Bluetooth Adapter (instead of the USB cable), follow these pairing directions:
 - Turn the TI-Nspire™ CX II on.
 - Turn on the GDX Probe or Sensor of choice.
 - Plug the Mini-A end of the cable into the Npsire CX II and the Micro-B into the Bluetooth Adapter.
 - Press **[Menu]** on the TI-Nspire unit and choose **Add Vernier DataQuest**.
 - Select **Add Bluetooth Sensor** on the Handheld screen.
 - On the next screen, > **Connect for the Probe or Sensor** that you wish to add.
 - Choose OK on that screen and OK on the following screen.
 - The Probe or Sensor is now ready for use wirelessly.
 - *For more information on Go Direct Sensors, and TI Technology visit*
<https://education.ti.com/en/product-resources/go-direct>

Note: TI-Nspire CX II's Vernier DataQuest app can also support many of the newer Vernier GoDirect sensors, while also continues to support some of Vernier's older sensors and probes

- We estimate this experiment can be completed in a 45-60 minute class period.

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.

Answer: The coefficient of friction will be greatest for the sneaker and least for the dress shoe. Actual values will vary by the size and tread of the shoe.

QUESTIONS

1. How did your prediction of the amount of friction for each shoe compare to the data you collected?

Answer: Answers will vary.



2. How do you explain the difference between the force of friction for each of the shoes?

Answer: Shoes with rougher soles (greater grip) will have a greater force of friction.

3. How would the force of friction be affected by dragging the shoes over a layer of ice?

Answer: Dragging the shoes across a layer of ice would greatly reduce friction.

4. How would the force of friction be affected by dragging the shoes over a rough-sawn board?

Answer: The force of friction would increase due to the rougher surface.

5. Why are cinders scattered on icy roads?

Answer: The cinders increase the friction (grip) between the car tires and the road surface.

6. Why does the coefficient of friction have no units?

Answer: Since the coefficient of friction is a ratio of the force of friction and the normal force, the units cancel out. It is therefore a dimensionless quantity.

7. If there were no friction, would you be able to walk? Why or why not?

Answer: Without friction you would not be able to walk since your shoes would not be able to grip the surface and propel you forward.

8. Summarize what you have learned about friction from this experiment.

Answer: Students should refer to the fact that rougher surfaces produce greater friction.

TI-Nspire Navigator Opportunity

Use TI-Nspire Navigator to capture screen shots of student progress.