Science Friction

Adapted from an activity © 2014 Texas Instruments
Help: http://www.cemetech.net/forum or stemfriction@cemetech.net

Objectives

- Students will investigate the role of friction in the motion of a hero running across a concrete surface.
- Students will learn about Newton's second and third laws of motion and how they relate to the ability of the hero to run across a concrete surface.

Vocabulary

- Force
- Newton's second law
- Newton's third law
- Friction
- Static friction
- Kinetic friction
- Coefficient of friction

About the Lesson

- In this lesson, students will explore forces and friction and their effect on the motion of an individual running across a solid surface.
- As a result, students will understand that:
  - o Newton's second law states that force is a product of mass of an object and its acceleration.
  - o The force of friction is required for an individual to be able to walk or run across a concrete surface.

What Page Am I On?

When you see the **?** (question mark) symbol above GRAPH key, you can press it to find out what page you're on.

Tech Tips

- This activity includes screen captures taken using jsTIfied, a calculator emulator that runs in your browser (http://cemete.ch/emu)
- This lesson applies only to the TI-84 Plus C Silver Edition.
- The activity requires about 7KB of RAM to run. If students encounter ERR: MEMORY, they should use Doors CSE or the Mem menu to delete programs and variables or move them to the Archive.

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Lesson Files

- Student Activity: Science_Friction_Student.pdf
- Teacher Notes: Science_Friction_Teacher.pdf (this document)
- SCIFRICT.8xp and SFTD.8xv: Activity program files. Must be sent to handheld's Archive.
- Doors CSE 8.1, which provides necessary extra program functionality. *(Not included: download at http://dcs.cemetech.net).*

Send files to your TI-84 Plus C Silver Edition

Using TI-Connect 4.0 or higher, or a TI-84 Plus C Silver Edition calculator that already has this activity, send the program SCIFRICT (SCIFRICT.8xp) and the AppVar SFTD (SFTD.8xv) to your TI-84 Plus C Silver Edition. Both files should go to your calculator's Archive.

- **Using TI-Connect:** Open TI DeviceExplorer and select your calculator. Drag SCIFRICT.8xp into the item labeled "Flash/Archive" and wait for the transfer to complete. Drag SFTD.8xv into "Flash/Archive" as well.
- **From another calculator:** Put the receiving calculator in Receive mode by pressing `2nd` `XTθn` `▶` `ENTER`. On the sending calculator, go to the `Link` menu with `2nd` `XTθn`, choose `2: All-…`, then find "`SCIFRICT    PRGM`" and "`SFTD    AVAR`" and press `ENTER` next to each one. Each one should be marked with a square, indicating that it will be sent. Press `▶` `ENTER` to send the files over.

You will also need Doors CSE 8.1 or higher, which can be found at http://dcs.cemetech.net. The process of sending Doors CSE to your calculator is the same as above, and is also detailed in the Doors CSE readme document.

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Discussion Points and Possible Answers

Run the SCIFRICT program; move to pages 2-6 and read the background information.

1. Run Doors CSE 8 from the Apps menu of your calculator, select SCIFRICT, and run the program. You should see the Science Friction title screen. Throughout the Science Friction activity, you can press the arrow keys (◀ ▶) to move between pages, or ENT to advance to the next page.

2. On a text page, press the ▼ and ▲ arrows to scroll down and up, and ZOOM or ENTE to scroll down.

3. Have students move to pages 2 - 6 and read the background information on the student activity sheet. You may need to review forces and Newton's laws of motion with the class. They should have a solid understanding of the concept of force before moving forward with the activity. The coefficient of friction and its formula are introduced on page 4. Ask students to consider what information they can infer from the coefficient of friction. What does a higher coefficient of friction tell us about the relationship between the force of friction and the normal force?
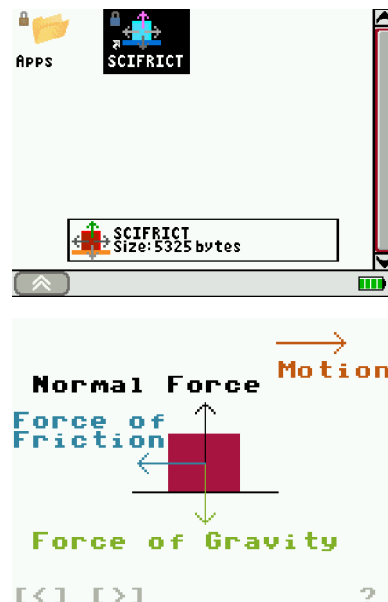
Move to pages 7-11.
Have students answer questions 1 - 2 on the activity sheet.

Q1. What is force?

Answer: A push or a pull.

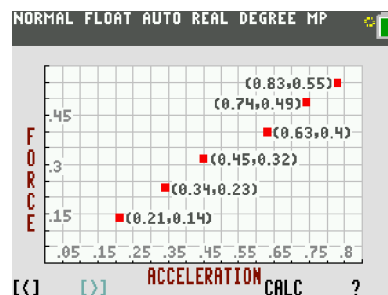Q2. If the object on page 8 has a mass of 1.02 kg, what is its acceleration in m/s^2?

Answer: a = F/m = 10 N / 1.02 kg = 9.8 m/s^2

Move to pages 12-13.
Have students use the graph on page 12 to answer question 3.

Q3. What is the mass of the cart from page 12?
    Answer: Students may average the measurements or use linear regression to find the answer. A precise answer using linear regression is 0.64762 kg.

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Move to pages 14 – 18.

Have students answer the following questions on the activity sheet.

Q4. Newton's third law of motion states that _____.

Answer: C. for every action force, there is an equal and opposite reaction force

Q5. If the sum of all the forces acting on a moving object is zero, the object will _____.

Answer: D. continue moving with constant velocity

Q6. A box is pushed toward the right across a classroom floor. The force of friction on the box is directed toward the _____.

Answer: A. left

Q7. A girl is pulling a box across the floor. The normal force acting on the box is 160 N. Calculate the frictional force on the box if the coefficient of friction between the box and floor is 0.25.

Answer: F_n = 160 N and μ = 0.25. F_f = μ × F_n = (0.25) × (160 N) = 40 N

Q8. When a 12 N horizontal force is applied to a box on a horizontal tabletop, the box remains at rest. The force of static friction acting on the box is _____.

Answer: C. 12 N

Move to pages 19-24.

4. Students will read about the villain's plan and the role he wants them to play. Ask them to consider the substances and how they might affect the hero's ability to run across a concrete surface.
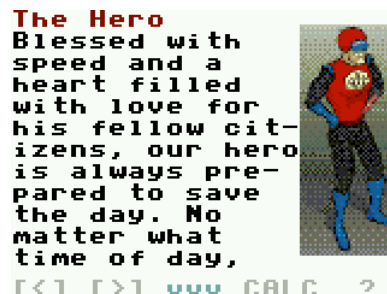
Move to pages 25.

Have students answer the following question on the activity sheet.

Q9. Which of the three substances do you think will be most effective at stopping or slowing the hero? Why do you think this is the best option?

Sample Answer: Ice will be most effective because there will not be enough friction between the hero's shoes and the ice. This will cause the hero to slip when running.

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Move to pages 26.

Students will use the simulation on page 26 to explore the results of each of the following scenarios: no substance sprayed on the concrete, water sprayed on the concrete, oil sprayed on the concrete, and the ice ray spraying a layer of ice on the concrete. Based on the images in the simulation, the students will see that the hero is able to run across the concrete and water successfully and that he will slip and fall on both oil and ice.
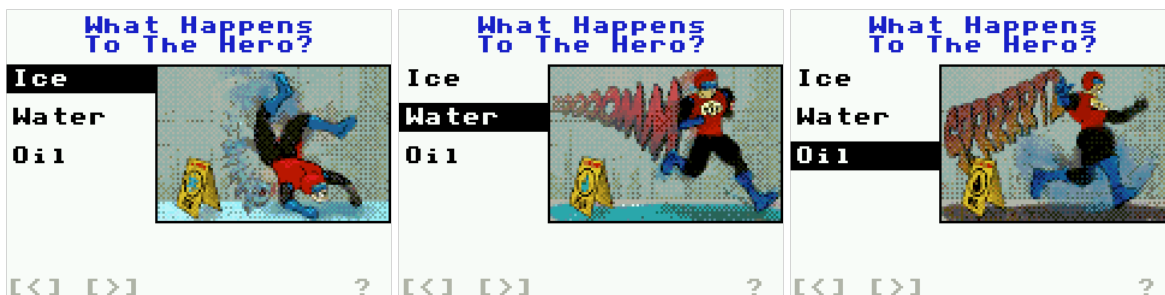
Move to pages 27-28. Answer the following questions here, in the space provided.

Q10.   What do you think caused the hero to slip and fall when you sprayed the concrete with oil and the ice ray?

Sample Answer: The oil and ice reduced the friction between the hero's boot and the surface, causing him to slip.

Q11.   The water, oil, and ice changed the magnitude of the _____.

Answer: C. coefficient of friction

Move to pages 29-30.

After the students have answered questions 10 and 11, have them discuss their answers. What role does friction play in the hero's ability to run across a solid surface? What forces are acting on the hero's foot when he makes contact with the concrete or the material that is coating the concrete? This is a good opportunity to discuss why friction isn't always a bad thing, even though we usually think of it as a force that slows the motion of an object.

Students will read more about the coefficient of friction on page 29 and the values for the coefficients of kinetic friction between different surfaces in the table on page 30. Ask them what they can infer from these values if they know that the hero was wearing rubber soled boots.

Move to pages 31-36.
Have students answer the following questions on the activity sheet.

Q12.   Rank the surfaces in order of the maximum possible static friction force each is able to apply to the hero's foot while he is running.

Answer: A. dry concrete, wet concrete, ice

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Q13. If the hero has a mass of 90 kg, find the maximum static friction force for dry concrete (use the maximum value for coefficient of static friction from the table on page 30).

Answer: F_n = 90 kg * 9.8 m/s^2 = 882 N

$F_{s,max}$ = (0.85) * (882 N) = 749.7 N

Q14. If the hero has a mass of 90 kg, find the maximum static friction force for an iced surface.

Answer: F_n = 90 kg * 9.8 m/s^2 = 882 N

$F_{s,max}$ = (0.15) * (882 N) = 132.3 N

Q15. How does Newton's third law apply to an individual running on a surface?

Sample Answer: Newton's third law states that for each force, there is an equal and opposite reaction force. When you run on a surface, you exert a force onto the surface, and it exerts a force back on you.

Q16. Use your own words to describe why friction is necessary for the hero to be able to walk or run across a solid surface.

Sample Answer: Friction is necessary in order for anyone to walk or run. When walking on a surface, an individual's foot applies a force that pushes backwards on the surface. The friction between the person's foot and the surface produces an equal and opposite force back on the foot, causing the person to move forward. Without friction, the foot pushes backwards against a surface and slips.

Move to pages 37-38.
Have students answer the following question on the activity sheet.

Q17. Using your tool belt loaded with oil or an ice ray, you were able to halt the hero's progress and accomplish the villain's dastardly mission. Can you think of a strategy the hero could use to defeat the oil or ice obstacle?

Sample Answer: One option for the hero is to attempt to slide across the ice rather than trying to run. By using this option, he would be able to use the reduced coefficient of friction as an advantage. He could use his arms to steer him as he slides across the ice.

On page 38, students will read more about civil engineering. This would provide a good starting point for a class discussion about engineering careers and the types of courses that engineers would take to prepare them to solve problems in everyday life.

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Assessment

- Formative assessment will consist of questions answered on the activity sheet.
- Summative assessment could consist of questions/problems on the chapter test or a performance assessment involving students diagramming the forces acting on a stationary or moving object or determining the speed of an object using the slope from a graph.

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