# Science Friction

Adapted from an activity © 2014 Texas Instruments

Background

Have you ever dreamed of having a superpower such as heroic strength or the ability to fly? Or, would you rather play the role of the bad guy and use your wits to try to outsmart the hero? In this activity, you will explore how friction affects the motion and speed of a superhero running across a concrete surface. You will also learn about civil engineering and some of the various disciplines in this career field.
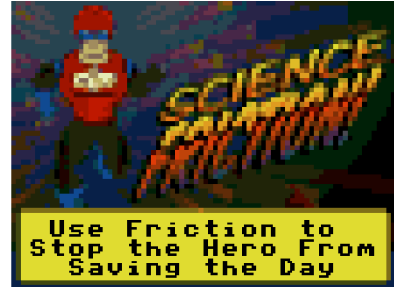
What Page Am I On?

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

Send files to your TI-84 Plus C Silver Edition

Using TI-Connect 4.0 or higher, or a classmate's calculator, 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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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. **Friction** is a force that opposes motion when two surfaces are in contact with one another. Friction depends on the texture of both surfaces. It is also dependent on the force that pushes the two surfaces together. This force is called the **normal force**.

4. The friction force that exists between two surfaces is proportional to the coefficient of friction (μ). The coefficient of friction is essentially a measure of how "sticky" the surfaces are. A higher coefficient means the surfaces are more stick and leads to relatively larger friction forces. The coefficient of friction can be calculated using the formula shown below, where F_f is the force of friction opposing the motion of an object and F_n is the normal force acting on the object.
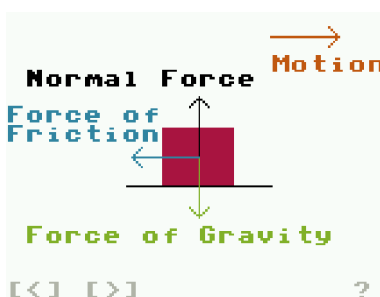
$$\mu = \frac{F_f}{F_n}$$

If you try to slide an object over a surface using a very small amount of force, the object may not move. In this case, the force of friction is equal to the force you have applied to the object. This is called **static friction**. If you increase the applied force, the object is able to "break free" and slide relative to the surface. The force of friction in this case is **kinetic friction**. You do not need to apply as much force to keep the object sliding as you needed to originally overcome static friction.

If you push a little bit on an object and it doesn't move, the object is pushing back with an equal force. If you push a little bit harder, the static friction force will push back a little harder. If you push just beyond the level of the maximum static friction force, the object will begin to accelerate.
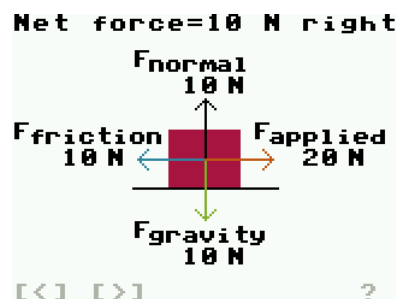
Move to pages 7-11.

Answer questions 1 - 2 on this activity sheet and read about net force and Newton's second law.

Q1. What is force?

5. Often there are several forces that are acting on an object at the same time. When you add these forces together, the remaining force that is not cancelled is called the net force. In the diagram on page 6, the normal force and the gravitational force are the same magnitude but in opposite directions and therefore cancel one another. The applied force is greater than the force of friction, resulting in a net force of 20 N to the right.

```
Net force=10 N right
      Fnormal
       10 N
         ↑
Ffriction    Fapplied
  10 N  ←██→   20 N
         ↓
      Fgravity
       10 N
[<] [>]              ?
```

6. Newton's second law of motion explains the behavior of objects that undergo an unbalanced force. The second law states that the acceleration of an object depends on two variables, the net force acting upon the object and the mass of the object:

$$F = ma$$

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

7. Newton's second law can be arranged to help understand the relationships between the three variables.
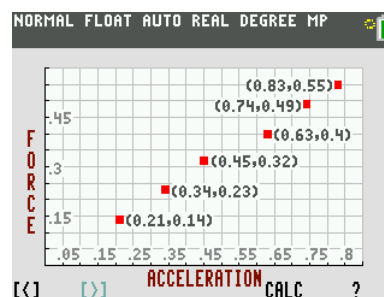
$$a = F/m$$

The net force is directly proportional to acceleration. The acceleration is inversely proportional to the mass; therefore, the greater the mass the less the acceleration for a given net force .

Move to pages 12-13.

Use the graph on page 12 to answer question 3.

8. The graph of force vs. acceleration of a cart on page 12 can be used to determine the mass of the cart. If you graph force (N) vs. acceleration (m/s^2), the slope of the line (m) is equal to the mass of the cart in kg.

Q3. What is the mass of the cart from page 12?

```
NORMAL FLOAT AUTO REAL DEGREE MP
                       (0.83,0.55)■
                     (0.74,0.49)■
   .45
 F              ■(0.63,0.4)
 O            ■(0.45,0.32)
 R .3
 R        ■(0.34,0.23)
 C
 E .15   ■(0.21,0.14)

   .05 .15 .25 .35 .45 .55 .65 .75 .8
[<]    [>]    ACCELERATION CALC    ?
```

Move to pages 14 – 18. Answer the following questions here, in the space provided.

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

    A. force is equal to mass times acceleration

    B. an object in motion tends to stay in motion

    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 _____.

    A. slow down and stop

    B. change the direction of its motion

    C. accelerate uniformly

    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 _____.

    A. left

    B. right

    C. ceiling

    D. floor

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.

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 _____.

    A. 0 N

    B. between 0 and 12 N

    C. 12 N

    D. greater than 12 N

Move to pages 19-24.

9. Read about the villain's diabolical plan on these pages. Based on your knowledge of forces and friction, consider which of the substances would be the best choice for helping the villain reach his gruesome goal.

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Move to pages 25. Answer the following question here, in the space provided.

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?

Move to pages 26.

Run the simulation for each of the following scenarios: water sprayed on the concrete, oil sprayed on the concrete, and the ice ray spraying a layer of ice on the concrete.
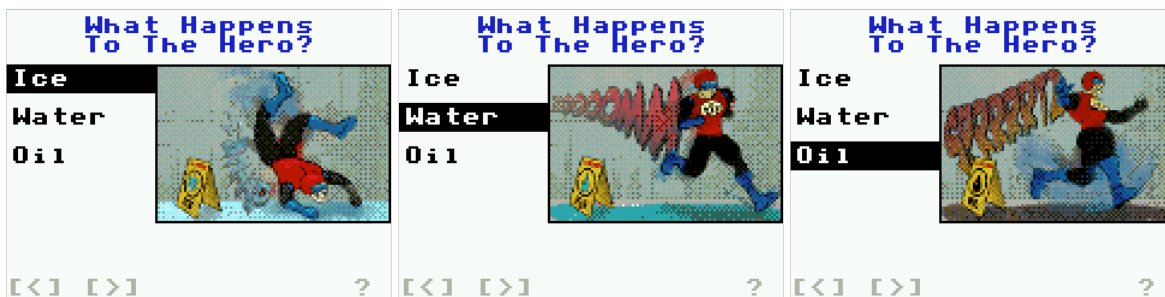
Move to pages 27-28. Answer the following questions here, in the space provided.

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

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

    A. normal force

    B. force of gravity

    C. coefficient of friction

Move to pages 29-30.

Read more about the coefficient of friction on page 29 and consider the values for the coefficients of kinetic friction between the surfaces in the table on page 30. If the hero were wearing rubber soled boots, what can you infer about the friction between the hero's boots and the various surfaces?

Move to pages 31-36. Answer the following questions here, in the space provided.

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.

A. dry concrete, wet concrete, ice

B. wet concrete, dry concrete, ice

C. ice, dry concrete, wet concrete

D. ice, wet concrete, dry concrete

10. The coefficient of static friction can be used to determine the maximum static friction force $F_{s,max}$ for the surfaces on which the hero is running,

$$F_{s,max} = \mu_s F_n$$

where μ_s is the coefficient of static friction and F_n is the normal force.

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

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

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

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.

Move to pages 37-38. Answer the following question here, in the space provided.

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?

Image Credits: Texas Instruments. See readme.txt for more acknowledgements.