

## READING WARM-UP

## Objectives

- Explain why friction occurs.
- List the two types of friction, and give examples of each type.
- Explain how friction can be both harmful and helpful.

## Terms to Learn

friction

## READING STRATEGY

**Brainstorming** The key idea of this section is friction. Brainstorm words and phrases related to friction.

**friction** a force that opposes motion between two surfaces that are in contact

## Friction: A Force That Opposes Motion

*While playing ball, your friend throws the ball out of your reach. Rather than running for the ball, you walk after it. You know that the ball will stop. But do you know why?*

You know that the ball is slowing down. An unbalanced force is needed to change the speed of a moving object. So, what force is stopping the ball? The force is called friction. **Friction** is a force that opposes motion between two surfaces that are in contact. Friction retards motion, which means that it can cause a moving object to slow down and eventually stop.

### The Source of Friction

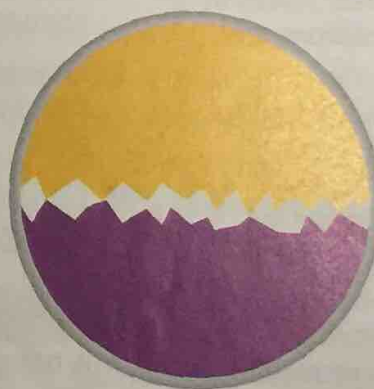
Friction occurs because the surface of any object is rough. Even surfaces that feel smooth are covered with microscopic hills and valleys. When two surfaces are in contact, the hills and valleys of one surface stick to the hills and valleys of the other surface, as shown in **Figure 1**. This contact causes friction.

The amount of friction between two surfaces depends on many factors. Two factors include the force pushing the surfaces together and the roughness of the surfaces.

### The Effect of Force on Friction

The amount of friction depends on the force pushing the surfaces together. If this force increases, the hills and valleys of the surfaces can come into closer contact. The close contact increases the friction between the surfaces. Objects that weigh less exert less downward force than objects that weigh more do, as shown in **Figure 2**. But changing how much of the surfaces come in contact does not change the amount of friction.

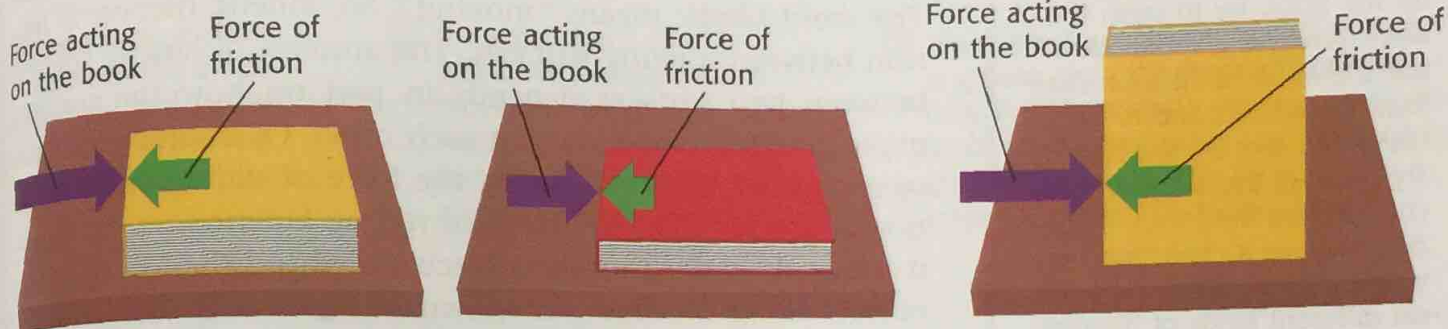
**Figure 1** When the hills and valleys of one surface stick to the hills and valleys of another surface, friction is created.



## Figure 2 Force and Friction

**a** There is more friction between the book with more weight and the table than there is between the book with less weight and the table. A harder push is needed to move the heavier book.

**b** Turning a book on its edge does not change the amount of friction between the table and the book.



### The Effect of Rougher Surfaces on Friction

Rough surfaces have more microscopic hills and valleys than smooth surfaces do. So, the rougher the surface is, the greater the friction is. For example, a ball rolling on the ground slows down because of the friction between the ball and the ground. A large amount of friction is produced because the ground has a rough surface. But imagine that you were playing ice hockey. If the puck passed out of your reach, it would slide across the ice for a long while before stopping. The reason the puck would continue to slide is that the ice is a smooth surface that has very little friction.

**Reading Check** Why is friction greater between surfaces that are rough? (See the Appendix for answers to Reading Checks.)

## QUICK LAB

### The Friction 500

1. Make a short ramp out of a **piece of cardboard** and **one or two books** on a table.
2. Put a **toy car** at the top of the ramp, and let go of the car. If necessary, adjust the ramp height so that your car does not roll off the table.
3. Put the car at the top of the ramp again, and let go of the car. Record the distance the car travels after leaving the ramp.
4. Repeat step 3 two more times, and calculate the average for your results.
5. Change the surface of the table by covering the table with **sandpaper**. Repeat steps 3 and 4.
6. Change the surface of the table one more time by covering the table with **cloth**. Repeat steps 3 and 4 again.
7. Which surface had the most friction? Why? What do you predict would happen if the car were heavier?

## SCHOOL to HOME

### Comparing Friction

Ask an adult at home to sit on the floor. Try to push the adult across the room. Next, ask the adult to sit on a chair that has wheels and to keep his or her feet off the floor. Try pushing the adult and the chair across the room. If you do not have a chair that has wheels, try pushing the adult on different kinds of flooring. Explain why there was a difference between the two trials in your **science journal**.

### ACTIVITY

## Types of Friction

There are two types of friction. The friction you observe when sliding books across a tabletop is called *kinetic friction*. The other type of friction is *static friction*. You observe static friction when you push on a piece of furniture and it does not move.

### Kinetic Friction

The word *kinetic* means “moving.” So, kinetic friction is friction between moving surfaces. The amount of kinetic friction between two surfaces depends in part on how the surfaces move. Surfaces can slide past each other. Or a surface can roll over another surface. Usually, the force of sliding kinetic friction is greater than the force of rolling kinetic friction. Thus, it is usually easier to move objects on wheels than to slide the objects along the floor, as shown in **Figure 3**.

Kinetic friction is very useful in everyday life. You use sliding kinetic friction when you apply the brakes on a bicycle and when you write with a pencil or a piece of chalk. You also use sliding kinetic friction when you scratch a part of your body that is itchy!

Rolling kinetic friction is an important part of almost all means of transportation. Anything that has wheels—bicycles, in-line skates, cars, trains, and planes—uses rolling kinetic friction.

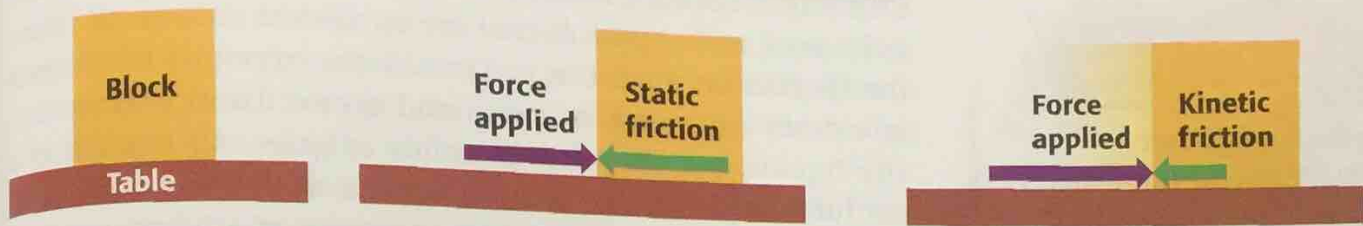
**Figure 3** Comparing Kinetic Friction

- a** Moving a heavy piece of furniture in your room can be hard work because **the force of sliding kinetic friction is large**.

- b** Moving a heavy piece of furniture is easier if you put it on wheels. **The force of rolling kinetic friction is smaller** and easier to overcome.



**Figure 4** Static Friction



- a** There is no friction between the block and the table when no force is applied to the block.
- b** If a small force (purple arrow) is exerted on the block, the block does not move. The force of static friction (green arrow) balances the force applied.
- c** When the force exerted on the block is greater than the force of static friction, the block starts moving. When the block starts moving, all static friction is gone, and only kinetic friction (green arrow) opposes the force applied.

### Static Friction

When a force is applied to an object but does not cause the object to move, *static friction* occurs. The word *static* means “not moving.” The object does not move because the force of static friction balances the force applied. Static friction can be overcome by applying a large enough force. Static friction disappears as soon as an object starts moving, and then kinetic friction immediately occurs. Look at **Figure 4** to understand under what conditions static friction affects an object.

**Reading Check** What does the word *static* mean?

### Friction: Harmful and Helpful

Think about how friction affects a car. Without friction, the tires could not push against the ground to move the car forward, and the brakes could not stop the car. Without friction, a car is useless. However, friction can also cause problems in a car. Friction between moving engine parts increases their temperature and causes the parts to wear down. A liquid coolant is added to the engine to keep the engine from overheating. And engine parts need to be changed as they wear out.

Friction is both harmful and helpful to you and the world around you. Friction can cause holes in your socks and in the knees of your jeans. Friction by wind and water can cause erosion of the topsoil that nourishes plants. On the other hand, friction between your pencil and your paper is necessary to allow the pencil to leave a mark. Without friction, you would just slip and fall when you tried to walk. Because friction can be both harmful and helpful, it is sometimes necessary to decrease or increase friction.

### INTERNET ACTIVITY

For another activity related to this chapter, go to [go.hrw.com](http://go.hrw.com) and type in the keyword **HP5MOTW**.

### CONNECTION TO Social Studies

**WRITING SKILL** **Invention of the Wheel** Archeologists have found evidence that the first vehicles with wheels were used in ancient Mesopotamia sometime between 3500 and 3000 BCE. Before wheels were invented, people used planks or sleds to carry loads. In your **science journal**, write a paragraph about how your life would be different if wheels did not exist.

# Quick Lab

## Reducing Friction

1. Stack **two or three heavy books** on a table. Use one finger to push the books across the table.
2. Place **five round pens or pencils** under the books, and push the books again.
3. Compare the force used in step 1 with the force used in step 2. Explain.
4. Open a **jar** with your hands, and close it again.
5. Spread a small amount of **liquid soap** on your hands.
6. Try to open the jar again. Was the jar easier or harder to open with the soap? Explain your observations.
7. In which situation was friction helpful? In which situation was friction harmful?




## Some Ways to Reduce Friction

One way to reduce friction is to use lubricants (LOO bri kuhnts). *Lubricants* are substances that are applied to surfaces to reduce the friction between the surfaces. Some examples of common lubricants are motor oil, wax, and grease. Lubricants are usually liquids, but they can be solids or gases. An example of a gas lubricant is the air that comes out of the tiny holes of an air-hockey table. **Figure 5** shows one use of a lubricant.

Friction can also be reduced by switching from sliding kinetic friction to rolling kinetic friction. Ball bearings placed between the wheels and axles of in-line skates and bicycles make it easier for the wheels to turn by reducing friction.

Another way to reduce friction is to make surfaces that rub against each other smoother. For example, rough wood on a park bench is painful to slide across because there is a large amount of friction between your leg and the bench. Rubbing the bench with sandpaper makes the bench smoother and more comfortable to sit on. The reason the bench is more comfortable is that the friction between your leg and the bench is reduced.

 **Reading Check** List three common lubricants.

**Figure 5** When you work on a bicycle, watch out for the chain! You might get dirty from the grease or oil that keeps the chain moving freely. Without this lubricant, friction between the sections of the chain would quickly wear the chain out.



## Some Ways to Increase Friction

One way to increase friction is to make surfaces rougher. For example, sand scattered on icy roads keeps cars from skidding. Baseball players sometimes wear textured batting gloves to increase the friction between their hands and the bat so that the bat does not fly out of their hands.

Another way to increase friction is to increase the force pushing the surfaces together. For example, if you are sanding a piece of wood, you can sand the wood faster by pressing harder on the sandpaper. Pressing harder increases the force pushing the sandpaper and wood together. So, the friction between the sandpaper and wood increases. **Figure 6** shows another example of friction increased by pushing on an object.



**Figure 6** No one likes cleaning dirty pans. To get this chore done quickly, press down with the scrubber to increase friction.

## SECTION Review

### Summary

- Friction is a force that opposes motion.
- Friction is caused by hills and valleys on the surfaces of two objects touching each other.
- The amount of friction depends on factors such as the roughness of the surfaces and the force pushing the surfaces together.
- Two kinds of friction are kinetic friction and static friction.
- Friction can be helpful or harmful.

### Using Key Terms

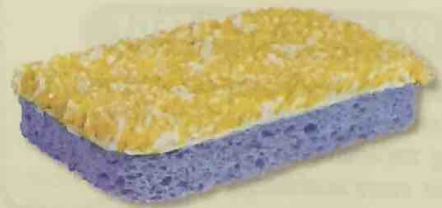
1. In your own words, write a definition for the term *friction*.

### Understanding Key Ideas

2. Why is it easy to slip when there is water on the floor?
  - a. The water is a lubricant and reduces the friction between your feet and the floor.
  - b. The friction between your feet and the floor changes from kinetic to static friction.
  - c. The water increases the friction between your feet and the floor.
  - d. The friction between your feet and the floor changes from sliding kinetic friction to rolling kinetic friction.
3. Explain why friction occurs.
4. How does the roughness of surfaces that are touching affect the friction between the surfaces?
5. Describe how the amount of force pushing two surfaces together affects friction.
6. Name two ways in which friction can be increased.
7. List the two types of friction, and give an example of each.

### Interpreting Graphics

8. Why do you think the sponge shown below has a layer of plastic bristles attached to it?



### Critical Thinking

9. **Applying Concepts** Name two ways that friction is harmful and two ways that friction is helpful to you when riding a bicycle.
10. **Making Inferences** Describe a situation in which static friction is useful.

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