Chapter 1

Forces around us affect the movement of objects.

Key Ideas

- A force is a push or pull that moves an object or holds it in place.
- Forces can be measured with a spring scale.
- Friction is a force that slows or stops movement.
- Surface texture, slope, and load affect the amount of force needed to make an object move.
- Forces can be combined to affect the way things move.

Skateboarders can really move! Some skateboarders look like they're flying through the air as they twist and turn. Then they land on the ground and come to a sudden stop. How can they change direction in a split second? How can they start and stop moving so quickly? Forces help skateboarders move, change direction, and stop.

In this chapter, you will learn about the ways that forces affect how things move. You will learn that forces can be used to start and stop motion and to change an object's speed and direction. You will also learn that other things affect the amount of force needed to make an object move.

Chapter 1

What Makes Things Move?

◀ You use a pushing force when you kick a soccer ball.

Have you ever played soccer? If you have, then you know that you have to use force to make the soccer ball go where you want it to go. A **force** is a push or a pull on an object. When you kick a soccer ball, you are pushing the ball in the direction you want it to go. When a goalie stops the ball, the goalie is pulling the ball in a different direction to stop it from going into the net.

Learning Tip

Important vocabulary words are highlighted. Make sure you understand what these words mean.

▲ When you pull an object in the direction you want it to go, you are using force.

Forces are all around you. They affect everyone and everything in different ways. You can see the effects of some forces, like the wind, the force of your foot kicking a soccer ball, or the pull or push of a magnet. There are also forces that are invisible, like the force of gravity [GRAV-uh-tee] pulling you to the ground.

Try This: Observe a Bouncing Ball

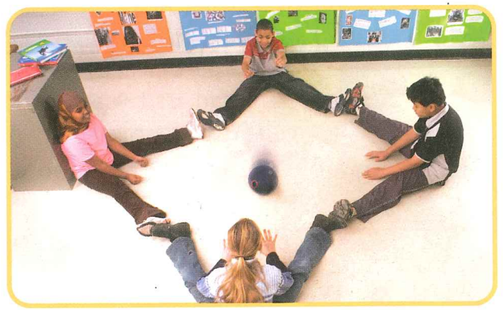
Skills Focus: observing, measuring

1. Drop a ball from a height of 1 m. Record how high the ball bounces.
2. How can you change the force you use on the ball to make the ball bounce higher or lower? Try it and see.
3. How did changing the force change the height that the ball bounced?

In the Try This activity, forces made the ball move. When you dropped the ball, the force of gravity pulled it to the ground. When you changed the force you used on the ball, the motion changed. For instance, when you increased the force you used on the ball, the ball bounced higher. The force you use affects how an object moves.

Try This: Observe How a Ball Moves

Skills Focus: predicting, observing, measuring



1. Roll the ball toward another student in your group. Change the force you use on the ball to make the ball roll faster. Now, change the force you use on the ball to make it roll slower.
2. Roll the ball around in the circle formed by your legs. Use force to make the ball change direction.
3. How can you use force to change the speed and direction of the ball?

You were able to control the speed and direction that the ball moved by controlling how you used force. When the amount of force used on an object changes, the motion of the object changes. For instance, when you changed the amount of force you used, the speed of the ball changed. When you changed the direction of the force, the direction of the ball changed. You were able to stop the ball by using force.

Forces affect the motion of objects around us every day. Some forces make things move. Other forces slow things down, stop them, or hold them in place.

Check Your Understanding

1. What is a force?
2. Think about riding a bike or going skateboarding. Choose one of these activities and describe, in words or pictures, how force is used to
   - start and stop moving
   - change speed
   - change direction

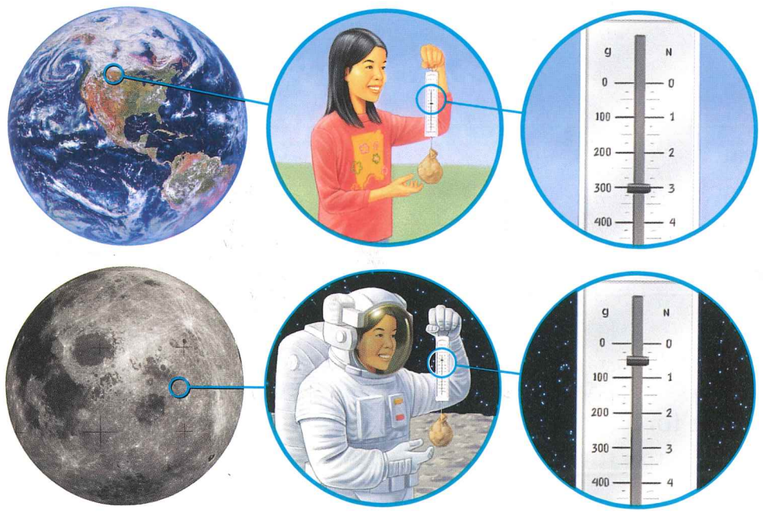
Chapter 1

2

Measuring Forces

You can measure forces using a spring scale. A spring scale measures force in a unit called newtons [NOO-tuhnz]. The symbol for newtons is N.

Weight [WAYT] is a measure of the force of gravity on an object. When you hang an object from the hook on a spring scale, the downward force of gravity stretches the spring. The scale shows the strength of the force of gravity in newtons.



▲ The weight of the marbles is 3.0 N on Earth, but only 0.5 N on the Moon.

The force of gravity is different depending on where you are. The force of gravity on Earth is about six times as great as the force of gravity on the Moon. There are even differences in the force of gravity at different places on Earth. The farther you are away from the centre of Earth, the less gravity is pulling on you.

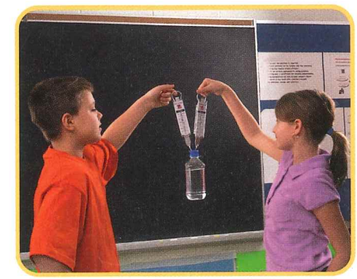
Try This

Measure Force

Skills Focus: predicting, observing, measuring

1. Using string, tie a 500 mL bottle with 400 mL of water in it to a spring scale. Pull the bottle up so that it is hanging from the spring scale. Hold it still to measure the force of gravity.

2. Predict how the amount of force would change if you measured the force acting on two identical bottles. Tie another bottle to the spring scale, and pull up both bottles. Read the measurement on the spring scale.
3. Work with a partner. Attach two spring scales to one bottle. Pull equally to raise the bottle. Read the spring scales when the bottle is still. How does the amount of force change when two people lift the bottle?



4. Predict how the amount of force would change if three or four people lifted the bottle. Try this to check your prediction.

Learning Tip

To read the measurement on a spring scale correctly, make sure that you look at the scale at eye level.

Check Your Understanding

1. What tool can you use to measure force?
2. Would you expect to get the same results in the Try This activity if you did it on the Moon? Explain your answer.

Chapter 7

3 Friction

Learning Tip

Check your understanding of friction by finding examples from your own life. When have you noticed friction slow something down or make something hard to move?

Try This

Observe Friction

Skills Focus: observing, inferring

1. Rub your hands together for one minute. What do you feel? What do you hear?
2. Put some liquid soap on your hands, and rub them again. What differences do you notice from step 1?
3. Cover your desk with a piece of newspaper. Rub two small pieces of sandpaper together. What do you feel? What do you hear? Is there anything on the newspaper?

Friction [FRIK-shun] is a force that resists movement. Friction slows down moving objects and makes objects that are not moving hard to move. Friction can create noise and heat. When you did the Try This activity, you experienced friction. When you rubbed your hands together, you heard the friction and felt your hands get warm. Friction can also cause surfaces to wear away, as you saw when you rubbed together two pieces of sandpaper.

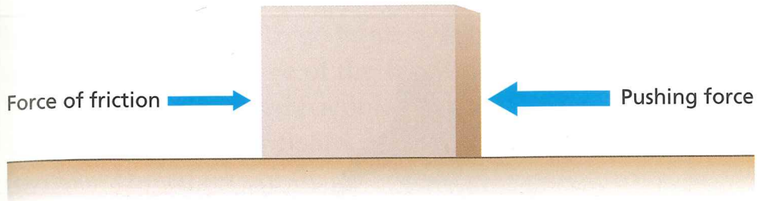
The way your running shoes keep you from sliding across a wood or tiled floor is an example of friction. Basketball players need friction between their shoes and the floor, so they can control how they move.

◀ The friction between a basketball player's shoes and the floor stops the basketball player from sliding forward.

When two things come in contact with each other, there is friction. Imagine pushing a box along a floor. The force of friction acting on the box occurs between the surface of the floor and the side of the box sliding along the floor.

Learning Tip

Read the first paragraph on this page and examine the diagram and the caption below it. Then use your own words to explain the diagram to a partner.



▲ Friction occurs between the bottom of the box and the floor.

Friction and Surface Texture

Friction occurs because surfaces are not perfectly smooth. Even ice, which looks perfectly smooth, actually has a bumpy, uneven surface.

▲ Ice may look smooth, but, when it is magnified 20 times, you can see its rough surface.

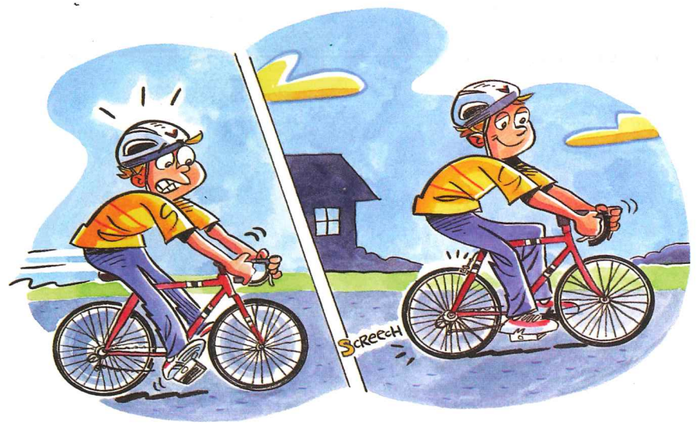
The amount of friction between two objects depends on what the objects are made from. Different objects feel different when you touch them. The way that an object feels is called its **surface texture.** Surfaces can be rough, smooth, or slippery. How would you describe the surface texture of sandpaper, a mirror, and liquid soap?

Surface texture affects the amount of friction between two surfaces. The rougher the surfaces, the more friction there is between the objects. If you move an object over a rough surface, such as a bumpy sidewalk, you will have to use more force than if you move the same object over a smoother surface, such as ice.

▶ Movement is easy on a smooth surface, like ice, because there is less friction to slow things down.

The Advantages and Disadvantages of Friction

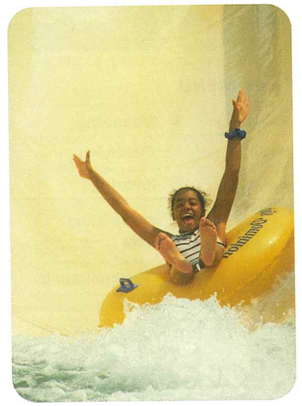
Friction is helpful to us in many ways. Without friction, you would not be able to walk. Your feet would slip out from under you! It is the friction between the surface of your shoes and the ground that allows you to walk. Friction also lets you slow down or stop moving. Bicycles need the friction between their brakes and their wheels, and between their wheels and the road, to slow them down.



▶ The friction between two surfaces slows movement. It makes it possible for us to slow down and stop.

Sometimes friction can be a disadvantage. Friction slows down objects and makes them harder to move. When you are skating or going down a waterslide, you want to go fast. It is friction that slows you down.

If you are snowboarding, friction slows you down as you travel over the snow. To go faster, you have to spread wax over the bottom surface of the snowboard to reduce friction. However, you also need friction when you are snowboarding. The edges of the snowboard are shaped to make use of friction. The edges are sharp so that you can control your movement when turning and stop when you need to.



▲ The water on a waterslide reduces friction so you can go faster.

◀ Snowboarders want less friction so they can go fast, but they also need friction to control their speed and direction.

Check Your Understanding

1. What is friction? How does friction change the way things move?
2. Name three things that can happen when two surfaces rub together.
3. How does surface texture affect the amount of friction between objects?
4. Draw two pictures. In one picture, show an activity where friction is an advantage. In the other picture, show an activity where friction is a disadvantage. Write one sentence for each picture to explain your ideas.

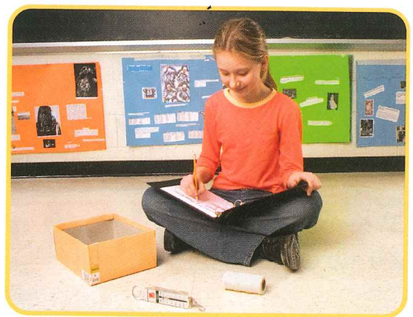
Chapter 5

What Affects the Amount of Force Needed to Move an Object?

Try This — Predict What Affects Force

Skills Focus: predicting, observing, measuring, inferring

1. Place an object in the box. Use a spring scale to measure the amount of force needed to pull the box across the floor or a table.



2. What could you do that would increase the amount of force needed to move the box? What could you do that would decrease the amount of force needed to move the box? Copy the table on the right into your notebook. Write your predictions in your table.
3. Test the predictions you wrote in your table. Use a spring scale to measure the force.

What Affects Force

Prediction	Was your prediction correct?
I would need to use more force if...	
I would need to use less force if...	

Forces affect the way things move. You need forces to start and stop the motion of an object. There are things that affect the amount of force you need to make an object move. For example, surface texture, slope [SLOHP], and load all affect the amount of force you need to make an object move.

Surface Texture

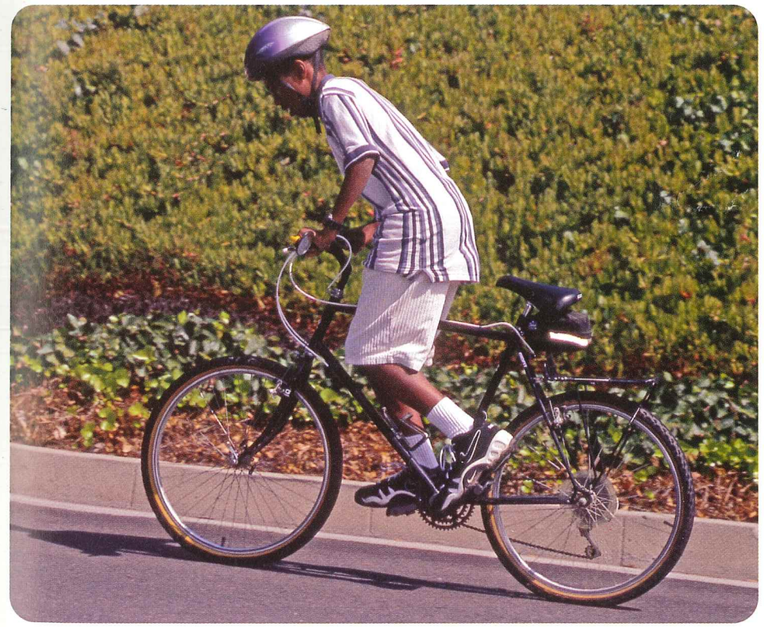
You have learned that surface texture affects the amount of friction between two surfaces. The more friction there is between two surfaces, the more force you need to make an object move.

▲ The rough surface texture of the sandpaper creates a lot of friction between the sandpaper and the wood.

Slope

Slope affects the amount of force needed to make an object move. Slope is a change in height between two points. When a surface is sloped, it is on an angle. For example, the roofs of many houses are sloped. A sloped surface is also called a **ramp.**

When slope changes, the amount of force needed to move an object also changes. Moving an object up a ramp requires more force than moving an object across a flat surface. If you increase the slope of a ramp, the amount of force you need to move an object up the ramp also increases.



▲ If you ride a bike up the slope of a hill, you need to use a lot of force.

Learning Tip

Look at the section title and the headings on this page and the next page. When you have finished reading this section, check your understanding by answering the question in the section title.

Moving an object down a ramp requires less force than moving an object across a flat surface. If you increase the slope of a ramp, the amount of force you need to move an object down the ramp decreases.

▲ If you ride down a hill, you need to use less force.

Load

Load affects the amount of force needed to make an object move. **Load** is the weight of the object you are trying to move. The larger the load is, the more force you need to move it. For example, you need more force to lift a backpack with four textbooks in it than a backpack with one textbook in it.

▲ You need more force to lift a backpack when you increase the load of the backpack.

Check Your Understanding

1. Look at each pair of pictures. What is affecting the amount of force needed to move? Which student in each pair of pictures would be able to use the least amount of force?

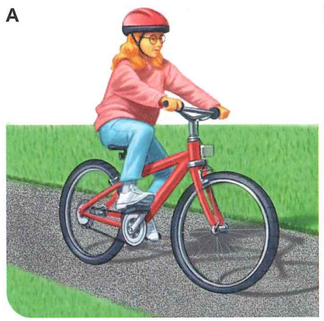
A

B

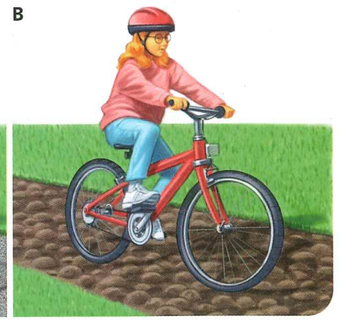
A

B

A



B



Chapter 7

Combining Forces

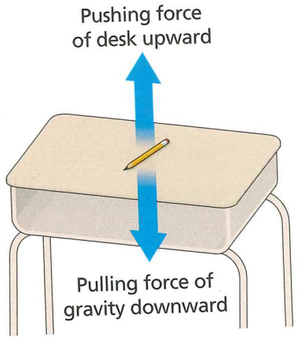
Most objects have more than one force acting on them at the same time. When forces combine, they affect the way that an object moves.

▲ When you fly a kite, gravity, the wind, and the pull of the string affect how high and in what direction the kite flies.

Balanced Forces

Consider a pencil sitting on your desk. What forces are acting on it? There is the downward pull of gravity and the upward push of your desk. When two forces of equal strength act in opposite directions, they are called **balanced forces.** As long as the two forces acting on the pencil remain balanced, the pencil will not move.

When the forces on an object are balanced, the object is said to be in **equilibrium** [EE-kwuh-LIHB-ree-um]. When an object is in equilibrium, there is no change in the motion of the object.



▲ When the forces are equal, the pencil will not move.

Try This

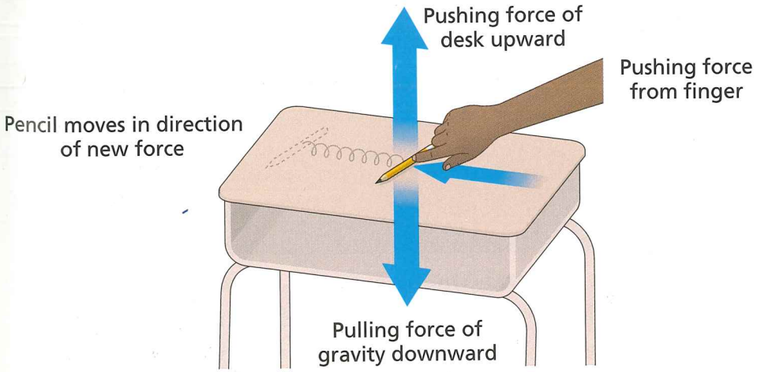
Observe Balanced Forces

Skills Focus: observing, inferring

1. Work with a partner. Stand back to back, leaning against each other. Slowly move your feet away from your partner until they are about 1 m apart. Continue pushing against each other, trying to remain balanced and motionless. Think about the way that you and your partner are using force to remain balanced.
2. Slowly bend your knees. How have you adjusted the amount of force you are using to remain balanced and motionless?
3. How would your movement change if one person used more force than the other?

Unbalanced Forces

Think back to the pencil on your desk. To change the motion of the pencil, one of the forces has to be greater than the other, or a new force has to be added. For example, if you add a force by gently pushing the pencil with your finger, the pencil will move in the direction of the new force you added.



▲ When a new force is added, the combined forces are unbalanced and there is a change in the motion of the pencil.

Learning Tip

To check your understanding of balanced and unbalanced forces, explain them to a partner. Use a different example than the pencil on a desk.

Unbalanced forces happen when one of the forces acting on an object is greater than another force acting in the opposite direction. When you pushed the pencil with your finger, the forces acting on the pencil became unbalanced. The pencil moved because there was no other force to balance the force you applied with your finger. The pencil moved in the direction of the greater force.

When the forces acting on an object are unbalanced, the motion of the object usually changes. The pencil moved because the forces acting on it were unbalanced. If you know the size and direction of all the forces acting on an object, you can predict how an object may move.

Learning Tip

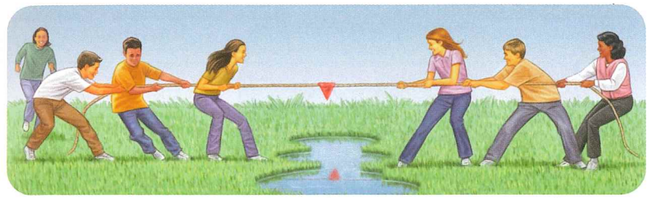
Check your understanding of what you have just read by trying to answer the questions under the photo. Then read the last paragraph to see if your answers were correct.

▲ What forces are acting on this toboggan to keep it sitting at the top of the hill? How could the forces change? What would happen if they did?

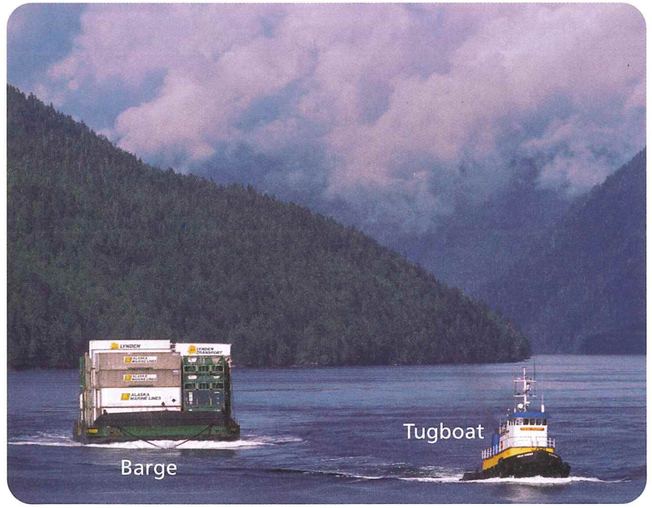
Think about the forces acting on a toboggan when it is sitting at the top of a hill. There is the downward force of gravity and the upward force of the ground. As long as these forces are equal, the movement of the toboggan will not change. The toboggan is in equilibrium. If you add another force, such as the force of using your arms to push you forward, the toboggan will move forward because the forces are no longer balanced.

Check Your Understanding

1. Write two or three sentences to explain what will happen when one student joins one of the sides. Use the words equilibrium, balanced, and unbalanced in your sentences.



2. Tugboats are used to push or pull barges that are loaded with heavy containers. Draw a sketch with arrows to show how tugboats and a barge will move in each of the following situations:
   - Two identical tugboats are pulling a barge upstream together.
   - Two identical tugboats are pulling a barge in opposite directions.
   - One tugboat is more powerful than the other tugboat, and they are pulling in opposite directions.



Chapter 1

Chapter Review

Forces around us affect the movement of objects.

Key Idea: A force is a push or pull that moves an object or holds it in place.

Vocabulary
force p. 5

Key Idea: Forces can be measured with a spring scale.

Vocabulary
weight p. 8

Key Idea: Friction is a force that slows or stops movement.

Vocabulary
friction p. 10
surface texture p. 11

Key Idea: Surface texture, slope, and load affect the amount of force needed to make an object move.

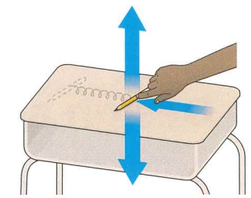
surface texture

slope

load

Vocabulary
ramp p. 17
load p. 18

Key Idea: Forces can be combined to affect the way things move.



Vocabulary
balanced forces p. 24
equilibrium p. 24
unbalanced forces p. 26

Review Key Ideas and Vocabulary

Use the vocabulary words in your answers to the questions.

1. What are forces? How do forces affect the way that things move?
2. How can you measure the amount of force that is needed to pull a toy car toward you?
3. Explain how putting sand on an icy road can help prevent cars from sliding.
4. Use drawings and words to explain how load, slope, and surface texture can affect the way the bobsled moves.

5. Use the words balanced forces and unbalanced forces to explain why the ball is not moving. What could change the motion of the ball?