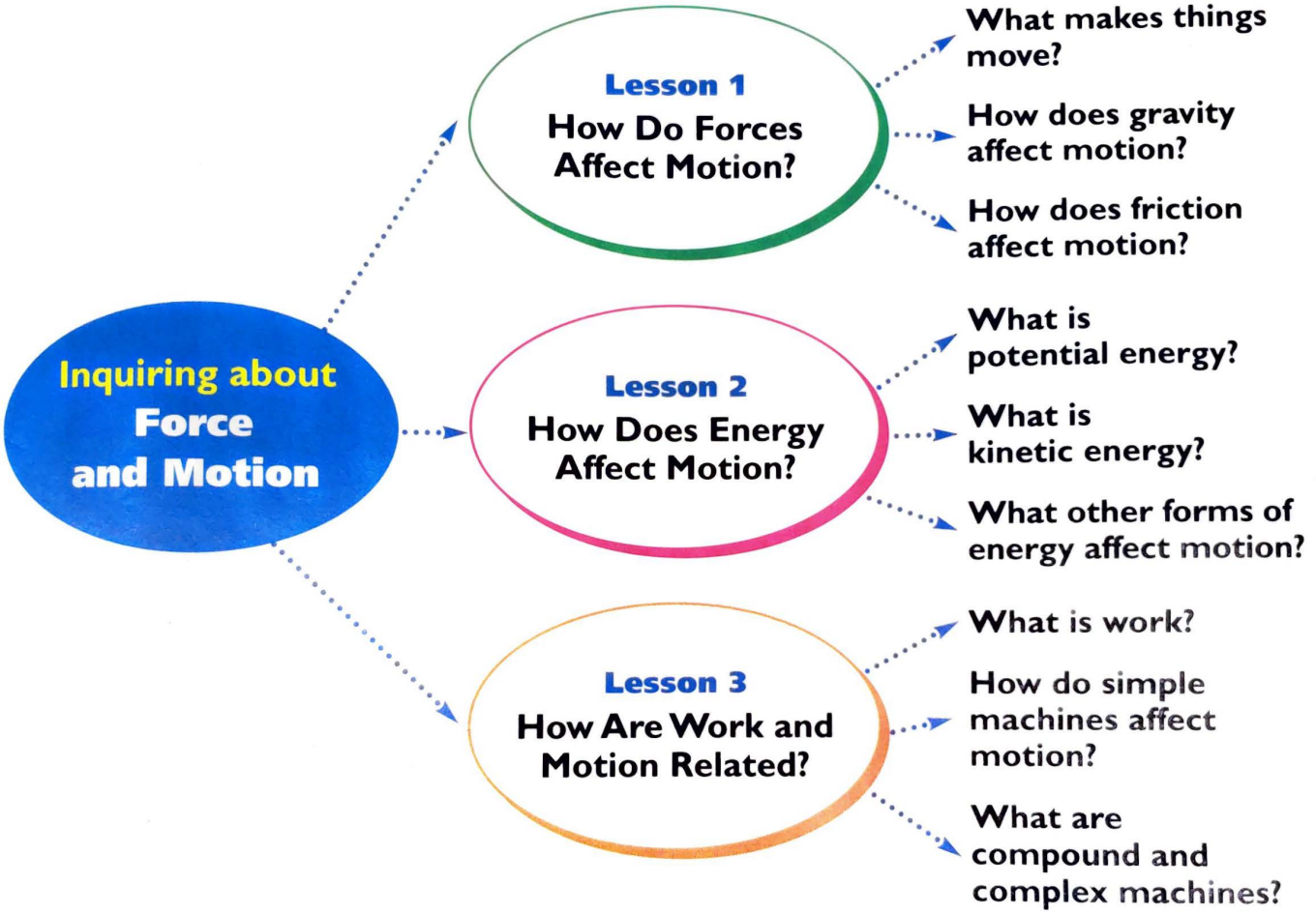
Chapter 2

Force and Motion



Copy the chapter graphic organizer onto your own paper. This organizer shows you what the whole chapter is all about. As you read the lessons and do the activities, look for answers to the questions and write them on your organizer.

What's the Big Idea?

You will learn:

- what makes things move.
- how gravity affects motion.
- how friction affects motion.

Lesson 1

How Do Forces Affect Motion?

VROOM! Up, down, and around you go on a roller coaster. **EEEE!** You scream as you feel yourself being pushed and pulled from side to side. You're in motion!

Moving Objects

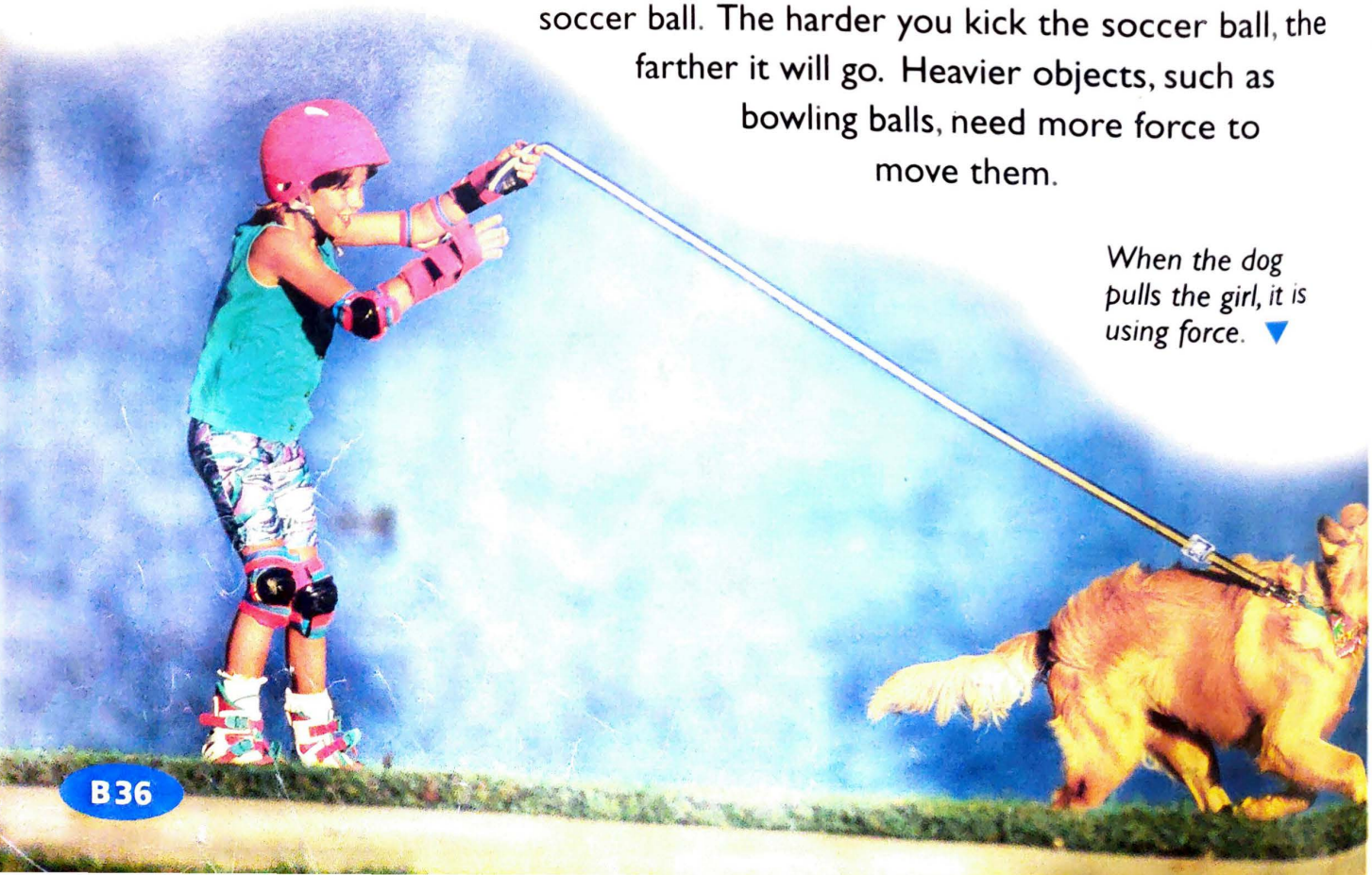
The dog in the picture is using force, a pull, to move the child. A **force** is a push or a pull on an object that can cause it to change motion. Forces also make roller coasters go up and down.

Forces can cause objects to start moving, speed up, slow down, stop, or change direction. For example, your friend kicks a soccer ball to you. You kick it back. You've just used a force to change the direction of the soccer ball. The harder you kick the soccer ball, the farther it will go. Heavier objects, such as bowling balls, need more force to move them.

Glossary

Glossary

force (fôrs), a push or a pull on an object that can cause it to change motion



When the dog pulls the girl, it is using force. ▼

Force of Gravity

Have you ever gone down the slope of a roller coaster and felt as if you were falling? You felt the effects of gravity. **Gravity** is the force that pulls two objects toward one another because of their mass. Gravity pulls you toward the center of the earth. The roller coaster cars in the picture are being pulled down toward the earth by the force of gravity.

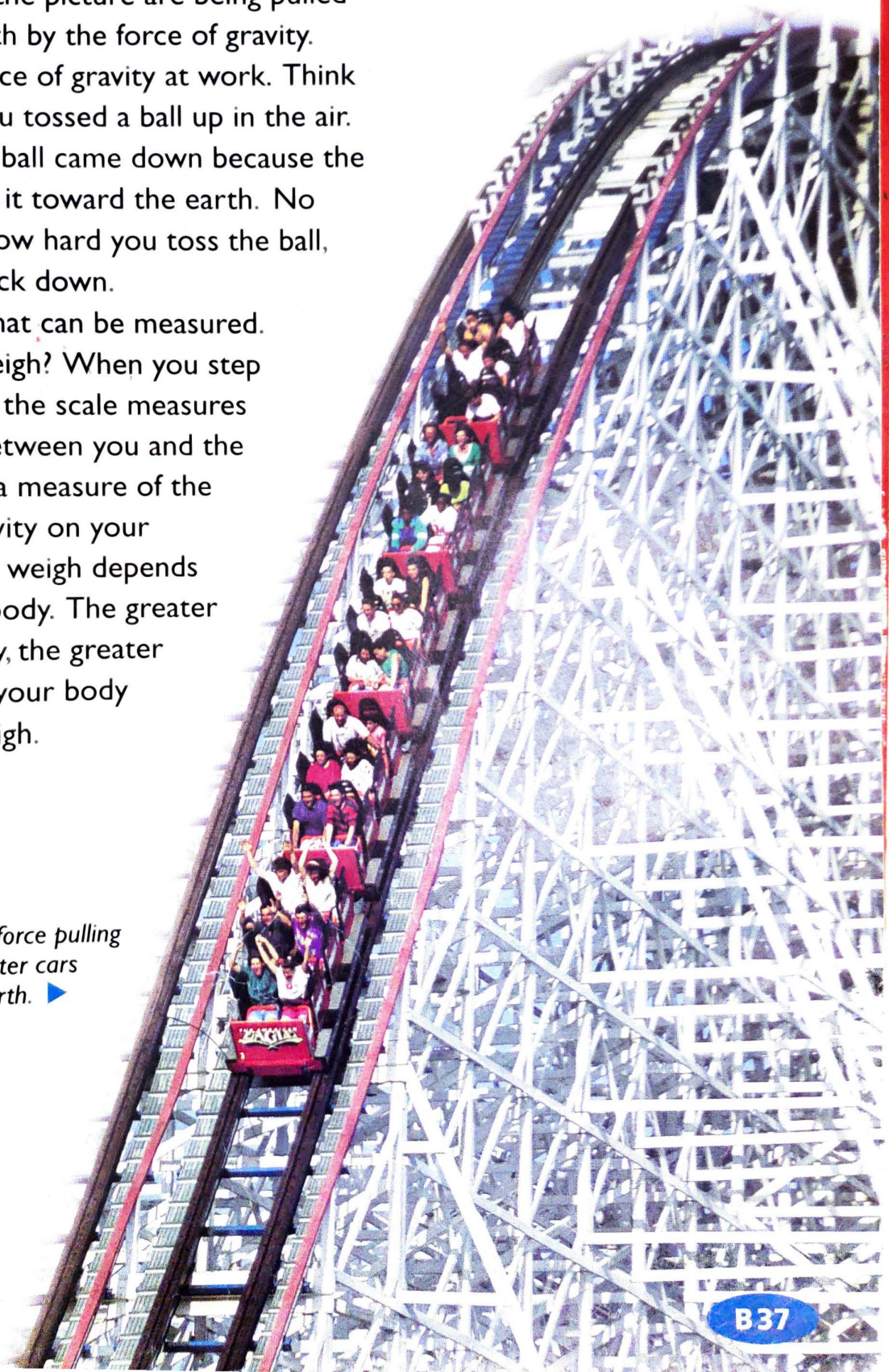
You can see the force of gravity at work. Think about the last time you tossed a ball up in the air. What happened? The ball came down because the force of gravity pulled it toward the earth. No matter how high or how hard you toss the ball, it will always come back down.

Gravity is a force that can be measured. How much do you weigh? When you step on a scale to find out, the scale measures the force of gravity between you and the earth. Your weight is a measure of the pull of the earth's gravity on your body. How much you weigh depends on the mass of your body. The greater the mass of your body, the greater the pull of gravity on your body and the more you weigh.

Glossary

gravity (grav′ə tē), a force that pulls any two objects toward one another, such as you toward the center of the earth

Glossary



Gravity is the force pulling the roller coaster cars toward the earth. ▶

Glossary

Glossary

inertia (in ėr′shə), the tendency of a moving object to stay in motion or a resting object to stay at rest

Force of Friction

History of Science

Many years ago, the scientist Isaac Newton made a discovery about moving objects. He learned that a moving object will continue moving in a straight line until a force causes it to slow down or stop. Newton also discovered that an object not moving, or at rest, will stay at rest until a force, such as a push or pull, moves it. The tendency of an object to keep moving in a straight line or to stay at rest is called **inertia**. All objects have inertia.

The children in the picture are in motion on in-line skates. The children used a pushing force to overcome inertia and begin moving. They will continue to move until another force slows them down or stops them. When the children stop, they will stay at rest until a force moves them.

These children will stay in motion until a force slows them down or stops them.

Imagine that you find a soccer ball on the ground. The soccer ball is at rest and will stay at rest until a force acts on it to move it. You kick the soccer ball. You have applied a force and the soccer ball begins to move. The soccer ball will keep moving until another force stops it.

As the soccer ball moves over the ground, the ground rubs against the ball. The rubbing of the ground slows the ball down. The ball continues to slow down until it stops.

The ground rubbing against the soccer ball caused friction. **Friction** is a force that slows down or stops moving objects such as a soccer ball in motion. Friction occurs when two objects rub against each other. Rub your hands together. Do your hands get warm? You are causing friction. Friction changes the energy of rubbing your hands into heat energy.

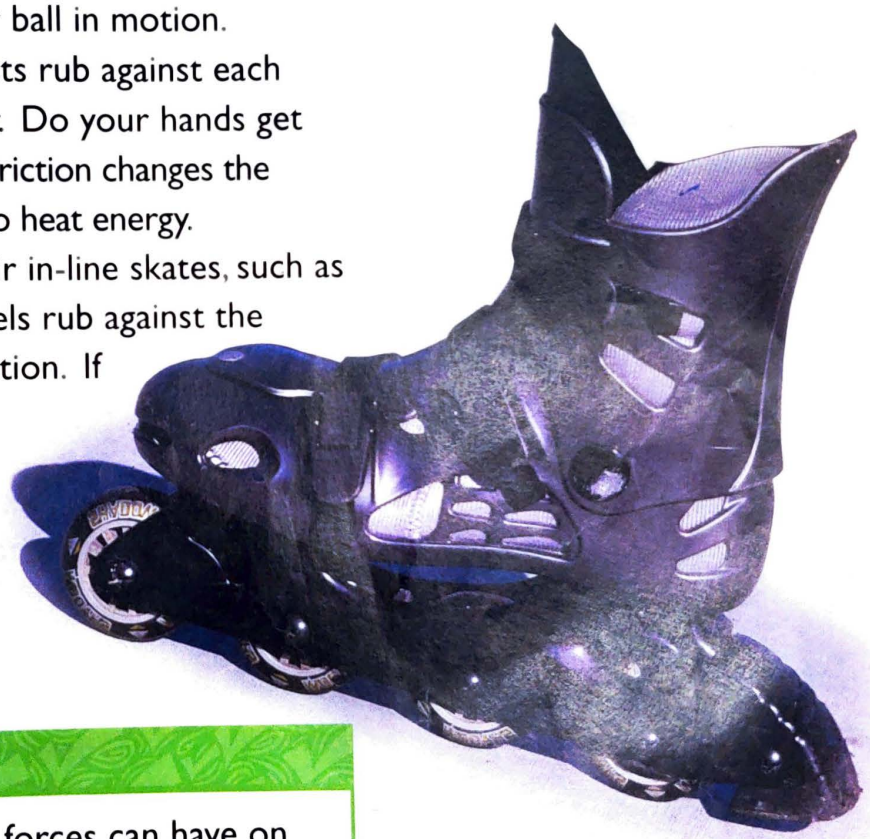
As the children move on their in-line skates, such as the one in the picture, the wheels rub against the ground. The rubbing causes friction. If the children stop pushing the skates, the friction slows them down. Using the brake causes more friction. The friction will slow them down or stop them.

Glossary

friction (frik′shən), a force that slows the motion of moving objects

Glossary

When two things rub together, they cause friction. The brakes on this in-line skate rub on the ground, causing friction. ▼



Lesson 1 Review

1. What are two effects that forces can have on motion?
2. How is a ball tossed in the air like a roller coaster car rolling down a track?
3. Describe how friction affects the motion of an object.
4. **Weight**
   Arrange the following objects in order from lightest to heaviest: bowling ball, roller coaster, soccer ball, astronaut.

What's the Big Idea?

You will learn:

- what potential energy is.
- what kinetic energy is.
- about other forms of energy that affect motion.

Lesson 2

How Does Energy Affect Motion?

YIPPIE! Back and forth you swing. Higher and higher you go as you lean forward and tilt back. WHEE! Did you know that swinging uses energy?

Potential Energy

You have probably heard people talk about energy many times, but what is energy? In science, **energy** is the ability to do work. You use energy every time you do work—or move an object. Energy has many forms and can change from one form to another.

Did you ever sit at the top of a slide, such as the one in the picture, waiting to go down? While you sat at the top of the slide, you had potential energy.

Potential energy is energy that an object has because of position. Find the child in the picture on the next page who is at the highest point on the swing set. The swing has the most potential energy at this point. The higher the swing goes up, the faster it will come down and the farther it will move forward.

Glossary

energy (en′ər jē), the ability to do work

potential energy (pə ten′shəl), energy that an object has because of position

◀ *The boy has potential energy because he is at the top of the slide.*

Kinetic Energy

When anything moves, it has a form of energy called kinetic energy. **Kinetic energy** is the energy of motion. Look again at the children on the swings. The swing moving downward has kinetic energy. As it goes back up, the kinetic energy becomes potential energy, or energy of position. Potential energy changes to kinetic energy and back to potential energy with each swing.

Glossary

kinetic (ki net′ik) **energy**, energy of motion

Glossary

Potential energy changes to kinetic energy as the swing moves down. Kinetic energy changes to potential energy as the swing moves up. ▼

Glossary

Glossary

mechanical (mə kan′ə kəl) **energy**, the kind of energy an object has because it can move or because it is moving

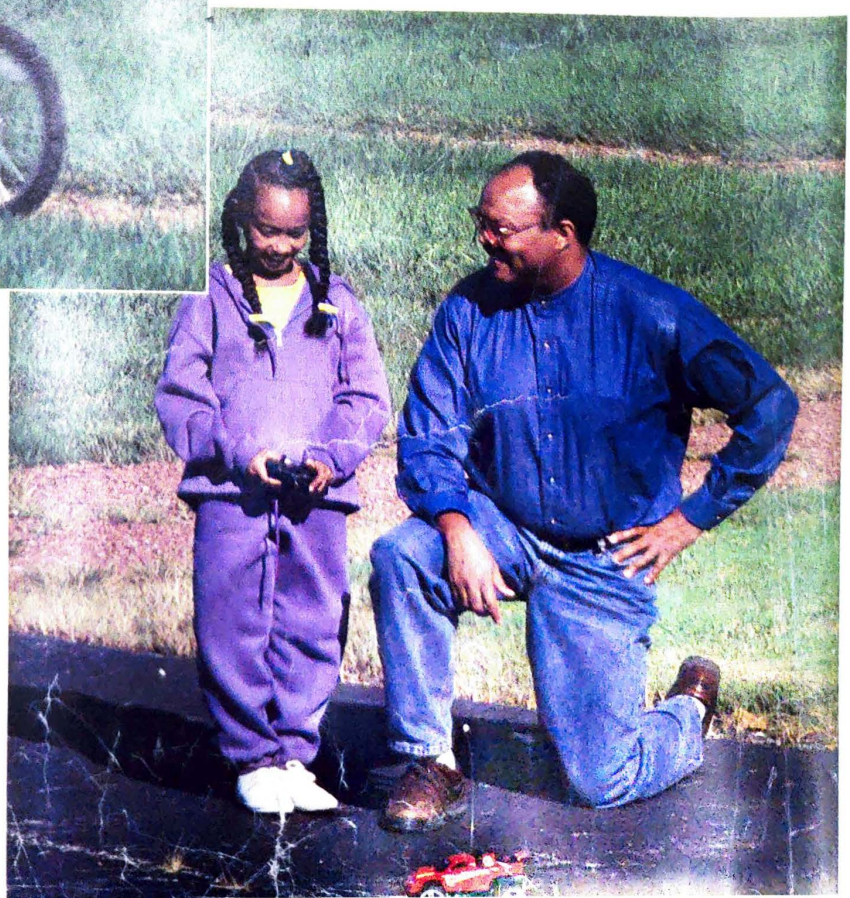
chemical (kem′ə kəl) **energy**, energy that comes from chemical changes

electrical (i lek′trə kəl) **energy**, energy that comes from the flow of electricity

Other Forms of Energy

Kinetic and potential energy may take different forms. Mechanical, chemical, and electrical energy are forms of energy. Light, heat, and sound are other forms of energy. Think about the last time you plugged in your radio, turned the propeller of a model airplane, or put a battery into a game. Each of these objects uses energy. Look at the pictures to see how energy affects motion.

◀ ***Mechanical energy*** *is the energy an object has because it can move or because it is moving. Mechanical energy can be potential energy or kinetic energy. When the bicycle moves, potential mechanical energy is changed to kinetic mechanical energy.*



Chemical energy *is a kind of potential energy you find in things like gasoline and other fuels. The battery that runs the toy in the picture has potential chemical energy. All matter has potential chemical energy. Some matter, such as the foods you eat, can release their chemical energy. Your body uses the chemical energy from the food to grow and move.* ▶

▲ *Electrical energy is a form of energy that comes from the flow of electricity. Electrical energy moves this merry-go-round.*

Lesson 2 Review

1. What is potential energy? Give an example.
2. When does an object have kinetic energy? Give an example.
3. List three other forms of energy. Describe how each one affects motion.
4. **Main Idea**
   What is the main idea of the caption for chemical energy on page B44?

What's the Big Idea?

You will learn:

- what work is.
- how simple machines affect motion.
- what compound and complex machines are.

Lesson 3

How Are Work and Motion Related?

Homework! Housework! Yard work! WHEW! Do you ever wonder what the word *work* means? How do you know you are doing work?

Work

You use energy to work every day. When you lift a glass of milk or pull open a door, you have done work.

Two things must happen for work to be done. A force must act on an object and the force must have enough energy to make the object move. **Work** is done when a force moves an object. You learned that pushes and pulls are forces. When pushes and pulls move objects, work is done.

Glossary

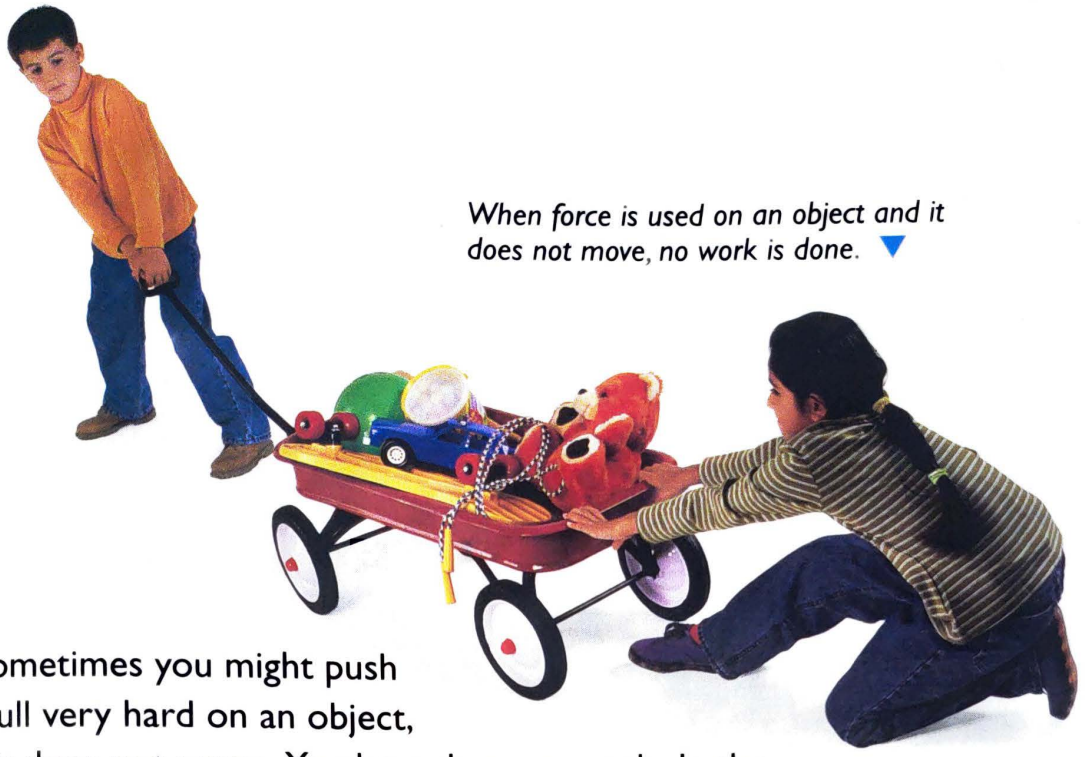
Glossary

work (wėrk), the result of a force moving an object

The woman in the picture is using a force, a push, to move the swing. When the swing moves in the direction of the force, work is done.

The amount of work you do depends on how much force you use and how far the object moves. The woman does more work if she pushes harder and the swing moves higher. The woman would do even more work if the child were heavier. She would need to use more force to move the swing.

◀ *The woman is using a force to move the swing. Work is being done.*

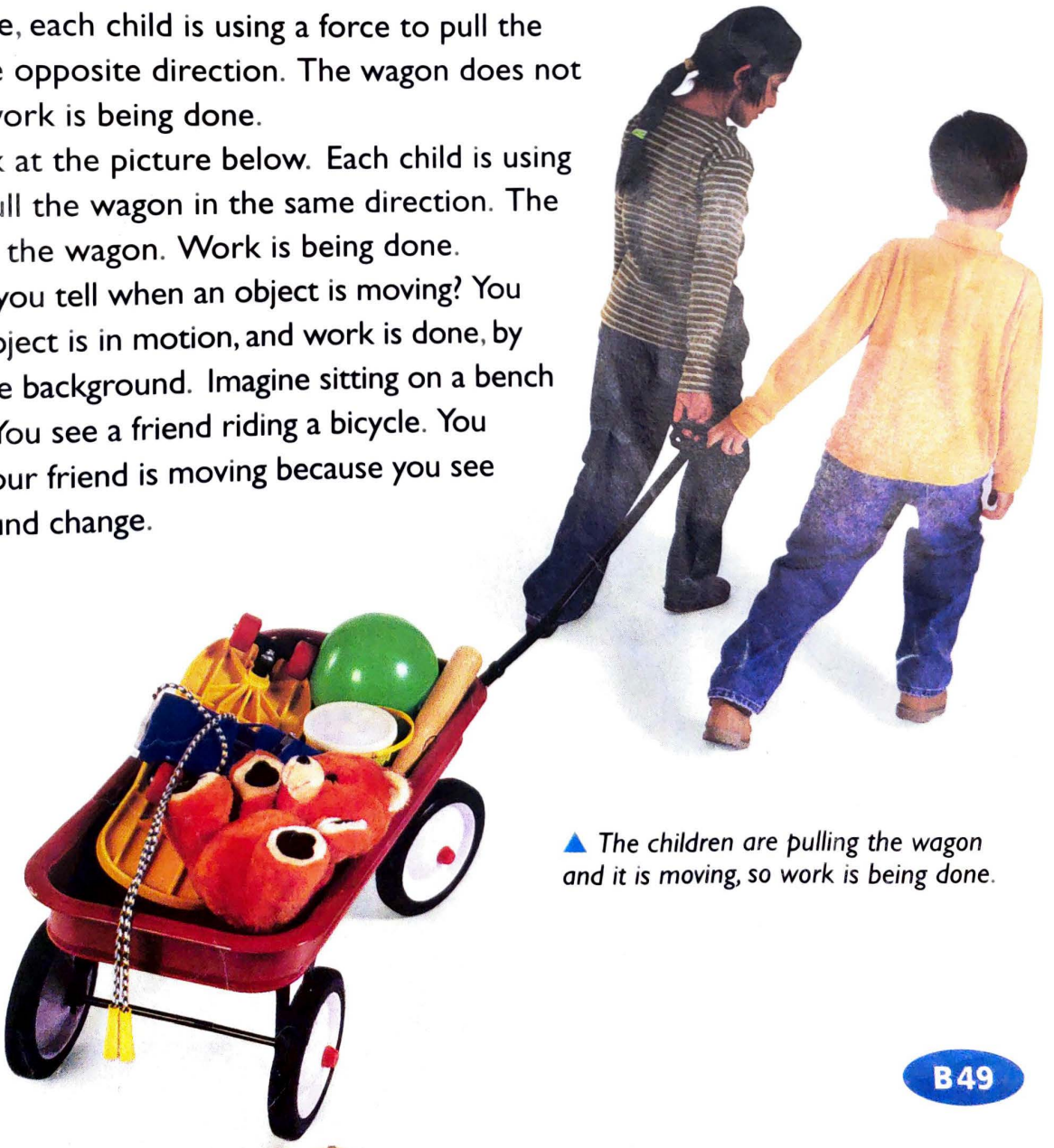


When force is used on an object and it does not move, no work is done. ▼

Sometimes you might push or pull very hard on an object, but it does not move. You have done no work. In the picture above, each child is using a force to pull the wagon in the opposite direction. The wagon does not move. No work is being done.

Now look at the picture below. Each child is using a force to pull the wagon in the same direction. The force moves the wagon. Work is being done.

How can you tell when an object is moving? You can tell an object is in motion, and work is done, by looking at the background. Imagine sitting on a bench in the park. You see a friend riding a bicycle. You know that your friend is moving because you see the background change.



▲ *The children are pulling the wagon and it is moving, so work is being done.*

Glossary

Glossary

simple machine
(sim′pəl mə shēn′),
a machine made of one or two parts

Simple Machines

Suppose you want to help build a tree house for your community. What things will you need? You will definitely need tools. A tool is a machine that makes work easier. A **simple machine** is a machine made of one or two parts. Notice that everyone in the picture is using a simple machine to help build the tree house. Read to find out about each of the simple machines.

Inclined Plane
The child below is easily moving heavy materials in a wheelbarrow by using an inclined plane. An inclined plane is a simple machine with a flat surface and one end higher than the other. A ramp is an inclined plane. It makes moving heavy items easier.

Wheel and Axle
The wheelbarrow is rolling on a wheel and axle. A wheel and axle is a simple machine made of a wheel attached to a rod. As the wheel turns, it turns the rod.

Wedge
A wedge is a simple machine that has slanted sides. A nail is a wedge. The slanted sides of the nail make it easier to pound the nail into the wood. The adult is about to use a nail to hold wood together.

Pulley

This child is using a pulley to raise materials up to the tree house. A pulley is a simple machine that uses a rope and a wheel. As the child pulls down on one end of the rope, the other end of the rope pulls the materials up.

Screw

This child is using a screw to put up the sign. A screw is a simple machine that holds materials together. A screw is an inclined plane wrapped around a rod. The inclined plane makes the screw easier to put into the wood. The grooves also help hold the screw in the wood.

Lever

The screwdriver is an example of a simple machine called a lever. The edge of the paint can is part of this lever too. Notice that the child puts one end of the screwdriver under the lid of the can. The edge of the can supports this lever. Therefore, the edge of the can is the fulcrum for this lever. To open the can, the child pushes down on one end of the screwdriver. The fulcrum changes the direction of the force, and the other end of the screwdriver pushes up on the lid.

Glossary

Glossary

compound machine (kom′pound mə shēn′), a machine made of two or more simple machines

Compound and Complex Machines

A **compound machine** is made up of two or more simple machines. The simple machines that make up the garden shears shown in the picture are a lever and two wedges. The cutting edges of the blades are wedges. The pin is the fulcrum that changes the direction of the force on the garden shears. When the handles of the shears are pulled in one direction, the blades of the shears move in the opposite direction.

▲ *Garden shears*

The hand mower below is also a compound machine. Notice the simple machines that make up the hand mower. The handle is a lever. Each blade is a wedge that cuts grass. The mower rolls on two wheels and an axle. All these simple machines together make up a compound machine—the hand mower.

On the next page, notice the picture of another compound machine—a bicycle. Look at the pictures to see what kinds of simple machines make up a bicycle.

◀ *Hand mower*

Parts of a Compound Machine

Screws

A bicycle has many screws that hold the parts of the bicycle together.

Wheel and Axle

The pedals are connected by cranks to the big sprocket. The big sprocket is the big-toothed wheel that is turned by the pedals and cranks.

Levers

The hand brakes on the bicycle are levers.

Wheel and Axle

The small sprocket, or small-toothed wheel, and the rear wheel on the bicycle are another wheel and axle. When the sprocket turns, the rear wheel turns. When the back wheel turns, it makes the front wheel turn, and the bicycle moves.

Wheel and Axle

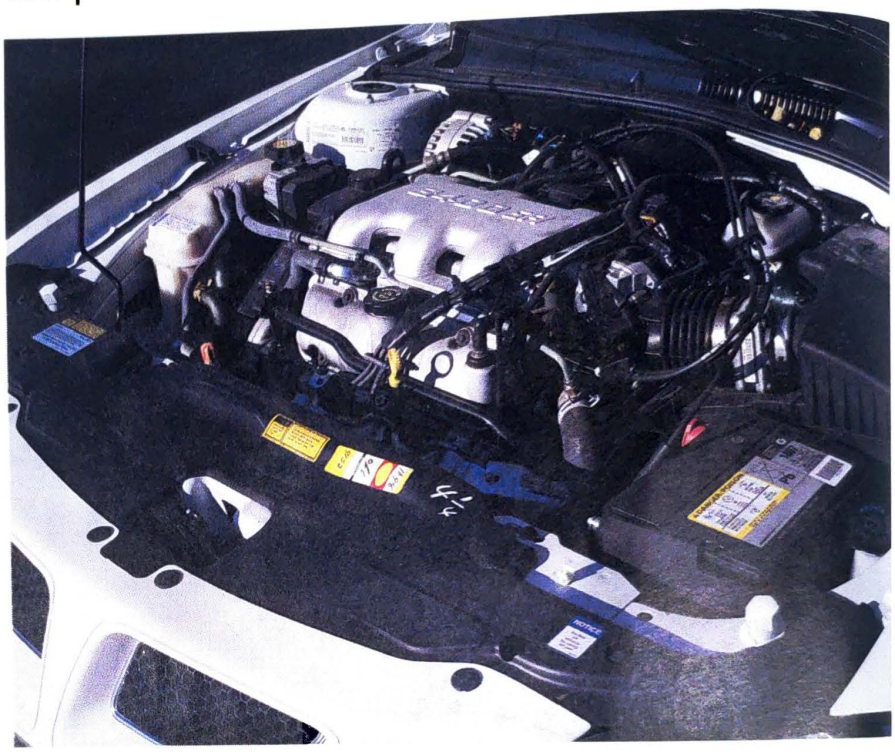
Together, the pedals, cranks, and big sprocket make up a wheel and axle.

Glossary

Glossary

complex machine (kom′pleks mə shēn′), a machine made of many simple and compound machines

Motorcycles, cars, and robots are complex machines. A **complex machine** is a machine made up of many simple and compound machines. The car engine in the picture is a complex machine. Most complex machines are run by electricity or fuels.



A car engine is made up of many moving parts. ▶

Lesson 3 Review

1. When is work done? Give an example.
2. How many parts does a simple machine have? Describe a situation in which a simple machine can be used to do work.
3. How is a compound machine similar to a simple machine? How are complex machines different from compound machines?
4. **Main Idea**
   What is the main idea of the paragraph at the top of this page?

Chapter 2 Review

Chapter Main Ideas

Lesson 1

- A force is a push or a pull that can make an object move.
- Gravity is the force that pulls two objects together and pulls you toward the center of the earth.
- Friction slows down or stops objects that are in motion.

Lesson 2

- Potential energy is energy that an object has because of its position.
- Kinetic energy is the energy an object has because of its motion.
- Mechanical, electrical, and chemical energy are forms of energy that can affect motion.

Lesson 3

- When a force moves an object, work is done.
- Simple machines are tools with one or two parts that are used to make work easier.
- Compound machines are made up of two or more simple machines; complex machines are made of many simple and compound machines.

Reviewing Science Words and Concepts

Write the letter of the word or phrase that best completes each sentence.

a. chemical energy
b. complex machine
c. compound machine
d. electrical energy
e. energy
f. force
g. friction
h. gravity
i. inertia
j. kinetic energy
k. mechanical energy
l. potential energy
m. simple machine
n. work

1. A roller coaster car goes up and down because it is moved by a ____.
2. The force of ____ is what pulls a roller coaster car toward the earth.
3. The tendency for an object to stay in motion until a force stops it is called ____.
4. When you apply the brakes on your bike, the brakes rub against the wheel and cause ____.
5. You can do work because you have potential ____.
6. As a child moves down a slide, ____ becomes energy of motion.

7. When you throw a ball, potential energy becomes ___.
8. A bicycle in motion has kinetic energy in the form of ___.
9. A battery has a kind of potential energy called ___.
10. A merry-go-round can be moved by the flow of electricity, or ___.
11. If you kick a soccer ball and it moves, you know that you have done ___.
12. A wheel and axle is a ___ that has two parts.
13. A bicycle is a ___ that is made up of several simple machines.
14. The engine of a car is a ___.

Explaining Science

Write a sentence or sentences to answer these questions.

1. What did Isaac Newton discover about moving objects?
2. What is the difference between kinetic energy and potential energy?
3. How do you know when work is done?

Using Skills

1. Use what you learned about **weight** to arrange the following objects in order from heaviest to lightest: pencil, bicycle, soccer ball, feather.
2. Suppose a small child and an adult are climbing a hill at the same speed. **Apply** what you have learned to decide who is doing more work. Explain your answer.
3. **Observe** your arms and legs. Decide which simple machine your arms and legs are similar to.

Critical Thinking

1. A child has a box of comic books she got from a garage sale. She brought the books home in a wagon, but she can't carry the box up the steps into the house. **Make a decision** about which simple machine she can construct that will help her get the box of comics up the steps.
2. A boy hits a ball as hard as he can. The ball bounces along the field and comes to a stop without anyone touching it. **Make** an **inference** about what forces caused the ball to slow down and stop.
3. What changes in forms of energy take place when you walk to school? **Communicate** your explanation.