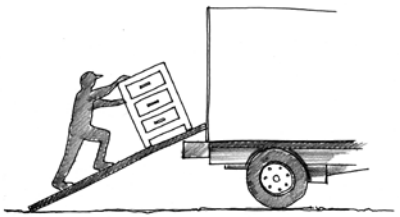
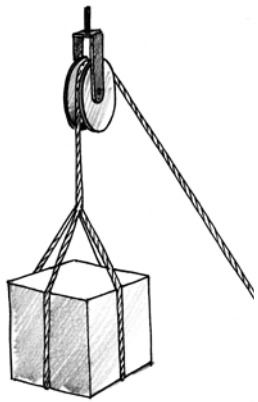
FOCUS ON SCIENCE

Energy and Machines

Advanced Level





Physical Science
Simple and Complex Machines

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Energy and Machines

Scientific Inquiry

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Independently formulate a hypothesis.

Physical Science

Energy exists in many forms, and when these forms change energy is conserved.

Energy cannot be created or destroyed, but only changed from one form into another.

Energy can change from one form to another, although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others.

Energy and matter interact through forces that result in changes in motion.

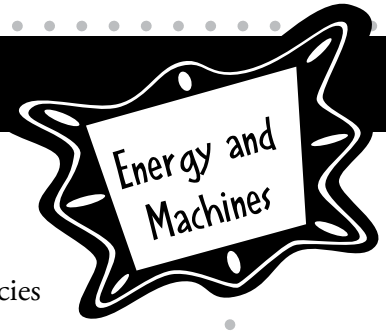
Machines transfer mechanical energy from one object to another. Friction is a force that opposes motion.

A machine can be made more efficient by reducing friction.

Some common ways of reducing friction include lubricating or waxing surfaces.

Machines can change the direction or amount of force, or the distance or speed of force required to do work.

Simple machines include a lever, a pulley, a wheel and axle, and an inclined plane. A complex machine uses a combination of interacting simple machines, e.g., a bicycle.



English Language Arts

The following is a selective listing of the competencies and indicators addressed in this book.

Literacy Competencies

Word Recognition

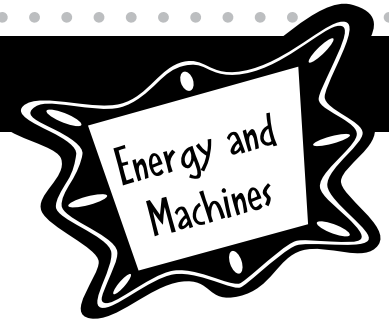
- Integrate sources of information to decode unfamiliar words, self-monitor, and self-correct for word-reading accuracy

Background Knowledge and Vocabulary

- Use self-monitoring strategies to identify specific vocabulary difficulties that disrupt comprehension, and employ an efficient course of action, such as using a known word base or a resource such as a glossary to resolve the difficulty

Comprehension/Strategies

- Ask questions to self-monitor comprehension, to clarify understanding, and to focus reading



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How to Help Your Students Make the Best Use of This Book

Encourage students to develop nonfiction literacy skills by completing the Active Reader activities. Also encourage them to . . .

- Underline main ideas in paragraphs.
- Circle details that support the main ideas.
- Write down questions as they read.
- Circle key words as well as unfamiliar words.

Printing Instructions

Student Book: print pages 5–26

Assessments: print pages 27–30

Answer Key: print pages 31–34

FOCUS ON SCIENCE

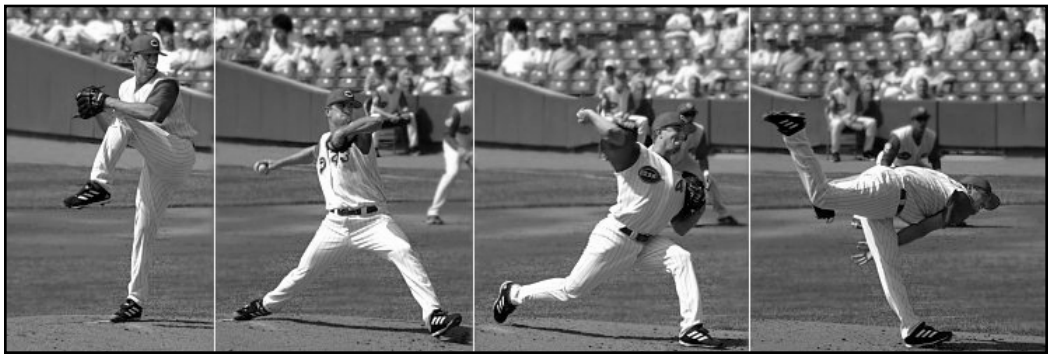
Energy and Machines

How do machines impact our lives?

What is work? A scientist would define work as a change in energy caused by a force. So, for example, when the pitcher in the photographs below throws a fast ball, he is doing work. The energy of the motion of his arm is transferred to the baseball, which moves in a line until it is acted upon buy another force, such as gravity, the batter's bat, or the catcher's mitt.

Machines do work because they transfer energy from one object to another and make it move. Friction, a force that opposes motion, can reduce the efficiency of a machine by converting some of the energy into heat.

In this book, you will learn about how machines harness energy to do work and how to make machines more efficient.



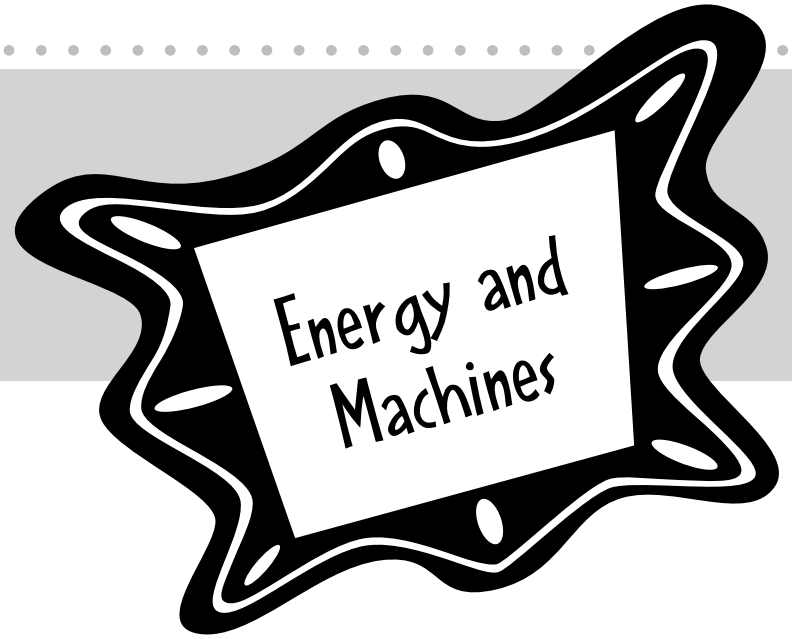


Table of Contents

Starting Points

Build Background

List

What are some tools you use when you work or do chores? List them on the lines below.

Consider

What tools or machines might you use to lift a heavy load of bricks up to the top floor of a building under construction?

Starting Points

Key Vocabulary

Rate Your Knowledge

Each word in the list below is important, but some may be new to you. Rate your knowledge of each by putting a check or a few words in the appropriate column. After completing this book, come back to this page and write the definitions of words you did not know.

	I don't know it.	I've seen it, and I think it means...	I know it well. It means...
fulcrum			
immovable			
lubricant			
mechanical energy			

Use a Dictionary

If you are not familiar with these words, look them up in a dictionary and answer these questions.

1. **Which word names something important to the operation of a lever?** _____
2. **Which word names something used to make things slippery?** _____
3. **Which word describes something that is fixed in space?** _____

Starting Points

Key Concepts

Potential and Kinetic Energy

Potential energy is stored energy. Pull back a bowstring and you are storing energy that can be transferred to an arrow when you let the bowstring go. Ride your bike to the top of a hill and you are storing energy that can be used to make the downhill ride an easy one.

Kinetic energy is the energy of motion.The arrow flying toward the bullseye has kinetic energy. The bike coasting downhill has kinetic energy. Kinetic energy depends on mass and speed. The bigger and faster something is, the more kinetic energy it has. If a train were coming toward you on a track at 30 miles per hour, you'd jump off the track because that train can harm you. Its mass is huge and, even if were going slowly, it would have a lot of energy. In contrast, something light and slow, like a butterfly, doesn't have the energy to harm you if it hits you. In fact, you'd barely feel it flit against you!

The potential energy of the bowstring will be converted into kinetic energy when the archer lets the arrow fly.

Sources of Energy

Energy can come from a variety of sources. Vibrations cause sound energy. Nuclear energy comes from the strong force that holds together the protons and neutrons in the nucleus of an atom. Burning fossil fuels releases chemical energy. Friction produces heat energy. Rub your hands together and you'll see.

The most important source of energy for living things on Earth is the sun. Green plants use the sun's energy to make glucose, a food that fuels the life cycle of plants. Humans tap into this energy source when we eat plants and animals that eat plants. In this way, our energy comes from the sun, as well.

ACTIVE READER

1 Extend *What is another example of an object that has kinetic energy?*

_____

_____

_____

_____

_____

2 Extend *What is another example of an object that has potential energy?*

_____

_____

_____

_____

_____

Chapter 1 Pushes and Pulls

FOCUS

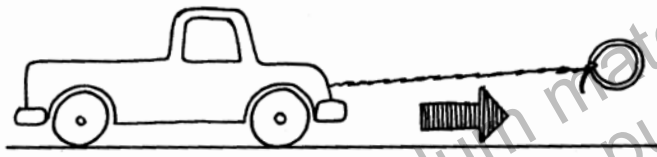
This section discusses the relationship between force and motion. As you read, look for an explanation of two different types of forces.

Motion is Caused by Force

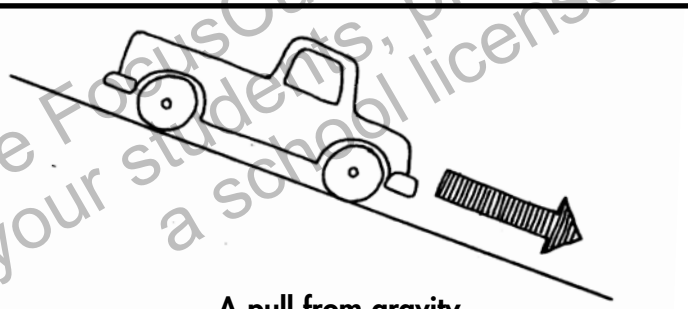
At a playground, a ball is set in motion when a girl kicks it. Bikes roll along the sidewalk. Muscles and gravity set swings moving. Gravity pulls a boy down a slide. All of these objects use mechanical energy. **Mechanical energy** is the energy an object has due to its motion, position, or condition.

One is contact force, where objects physically come into contact with each other. Examples include friction and collision.

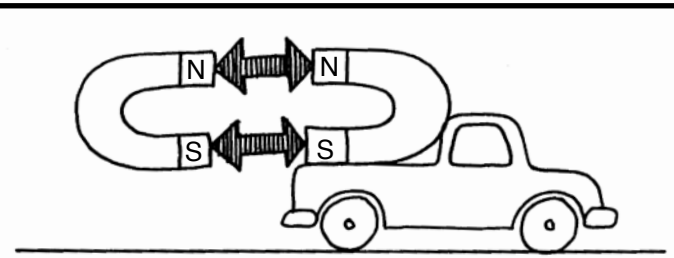
Another type of force is noncontact force, also known as action-at-a-distance force, where objects do not come in contact with each other. Gravity and magnetism are examples of noncontact forces. Keep reading to learn more about these forces.



A pull from an outside force



A pull from gravity



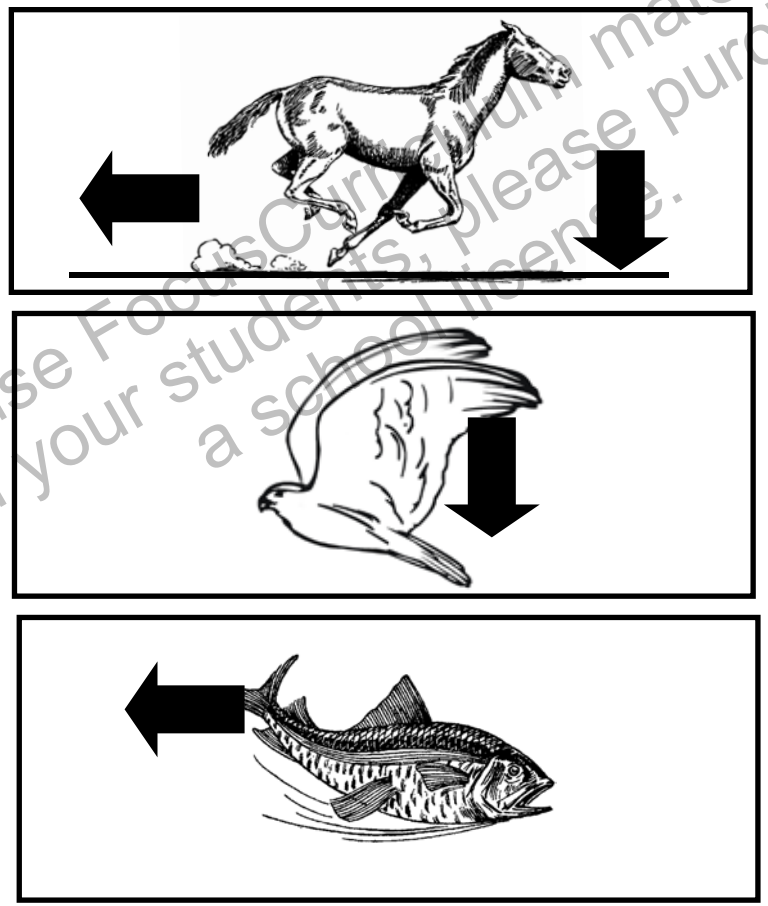
A push from the force of magnets

ACTIVE READER

1 Recall *What are two types of forces explained on this page? Give an example of each.*

Pushes and pulls are forces that start objects moving. Think of animals that move well, such as cheetahs, horses, sharks, and condors. All of these creatures have special physical structures that allow them to push on the ground, the air, or the water with great force.

Cheetahs and horses have muscles and joints that let them push hard against the ground with their feet and legs to move forward. Condors and other birds thrust themselves into the air by flapping their open wings. Their wings push air downward. In turn, the air reacts by pushing the bird upwards. Sharks swing their tail fins from side to side and up and down to push backwards against water. In turn, the water reacts by pushing the fish forwards, propelling the fish through the water.



Thrust is the push or pull that starts a movement. People and animals push against the ground with their feet and legs. A bird's wings push the air. A fish's tail pushes water to start movement.

ACTIVE READER

1 Describe *A batter hits a baseball up into the air. It flys up then drops into the stands for a home run. How do contact and non-contact forces cause its motion?*

Everything that moves is put in motion by a force applied to it. Force comes from the power of pushing or pulling. There are different types of forces that affect motion. For example, friction is a force that slows down motion.

The use of machines has allowed humans to move faster and farther than we could using only the power of our muscles. All of these machines, from bicycles to rockets, rely on pushes and pulls to cause an object to move.

ACTIVE READER

1 Identify *What is an example of a machine that uses the forces listed below to cause motion?*

the force of muscle power _____

_____

_____

the force of the wind _____

_____

_____

FOCUS QUESTIONS

1. How does an action-at-a-distance force work? Give two examples of an action-at-a-distance force.

_____

_____

2. Explain the difference between a force that pushes and one that pulls. Give an example of each type.

_____

_____

FOCUS

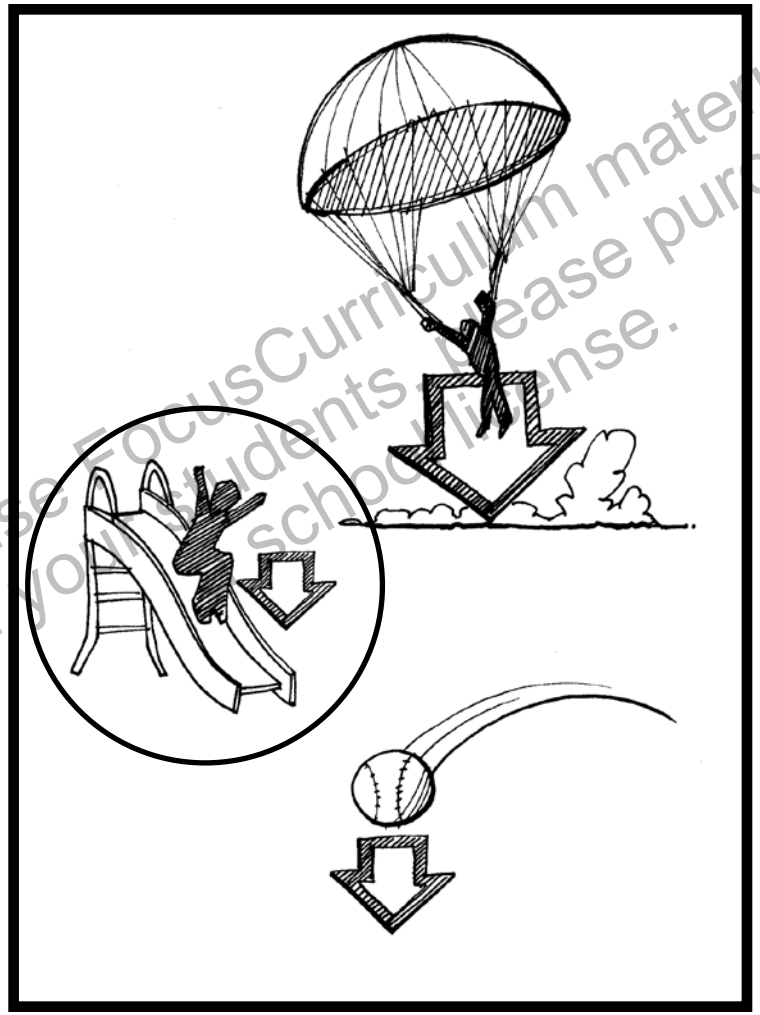
This section explains two non-contact forces: gravity and magnetism. As you read, look for examples of the effect of each force.

Gravity

All objects on Earth are pulled toward the center of Earth. The force that pulls things to Earth is invisible. Still, we can see the results of gravity everywhere. Acorns fall from trees. Water pours over a waterfall. Dandelion seeds ride the wind until they settle on the ground. Snow, mud, or rocks tumble downward in an avalanche. Meteorites burn through the sky and hit the ground.

This pull to Earth is the result of the force of gravity. Gravity is a pull that matter has on other matter. The more massive the matter, the stronger gravity's pull will be. The force of gravity is also greater between objects that are closer together.

It may sound funny to say, but Earth is the biggest thing in our world. Its gravity is so strong that it pulls everything near it toward its center.



The force of gravity pulls all matter on Earth toward the planet's center.

ACTIVE READER

1 Describe *What are three examples of gravity explained in the first paragraph?*

_____

_____

_____

2 Identify *In what direction does the force of gravity pull things on Earth?*

_____

_____

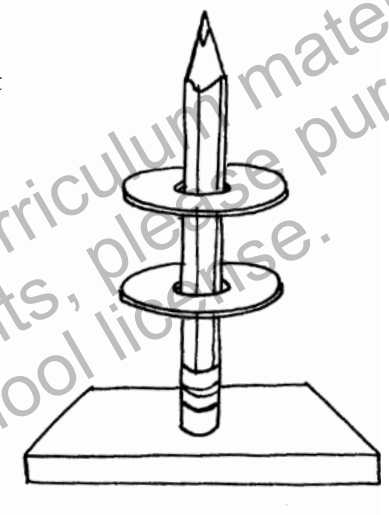
_____

Magnetism

In ancient China and Greece, people noticed that iron passing close by certain rocks was pulled toward the rocks. These rocks contained magnetite, a raw material that people now use to make magnets.

Magnets make a strong pull on metals such as iron and steel. Magnets can also attract or repel each other with a force that can be stronger than gravity. The reason for the pull or push is an electric current flowing through the magnetite and a similar electric flow through the iron and steel.

For example, the magnet on the bottom is fixed to the pencil. The magnet on top is being forced away by the bottom magnet. The magnetic force is stronger than the force of gravity, so the top magnet will not drop.



ACTIVE READER

1 Identify *What is the reason for a magnet's push or pull?*

FOCUS QUESTIONS

1. How does the force of gravity change when objects are more massive? When the distance between them is increased?

2. What would be required for magnets to defy the force of gravity?

FOCUS

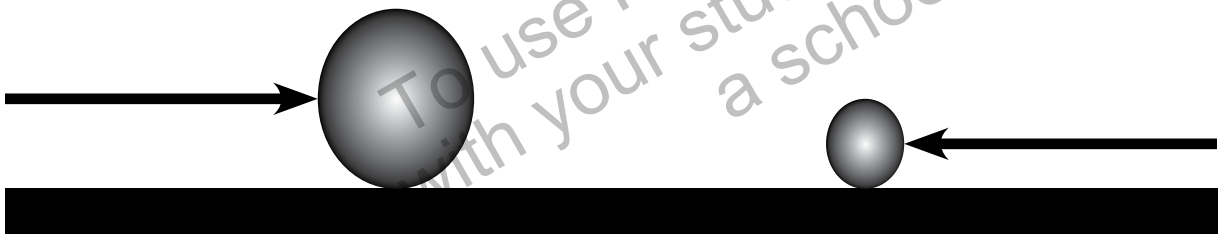
This section discusses the forces that act against other forces. As you read think about how the forces can affect motion.

Collision

In outer space, moving things keep going, just about forever. There is nothing to push or pull on them. However, on Earth, moving things are always slowing down or stopping.

For example, matter will slow down or stop if it bumps against other matter that is going in another direction. This is called a collision.

When one piece of matter collides with another, the energy of movement changes. If two pieces of matter collide from opposite directions, whichever has more energy and mass will affect the direction of the other.



What will happen if these two marbles roll at the same speed and collide directly into each other? What if the small one is going much faster? What if one hits the other from the side while the other is going straight ahead? Make a prediction and try it to see what happens.

ACTIVE READER

1 Describe *What happens to objects that are moving in space?*

2 Synthesize *What is the main idea of the third paragraph?*

Friction

As mentioned earlier, friction is a contact force. It is caused by collisions of matter or by the rubbing of matter against other matter. It is a force that slows down the movement of objects. Friction is what makes it hard to slide heavy things along the ground.

If you have ever tried to run underwater, you know that water's friction, or resistance, makes this hard. Even the air has resistance. This is what makes a parachute work. The friction of air particles against the open parachute slows down the movement of a person pulled toward Earth by gravity.

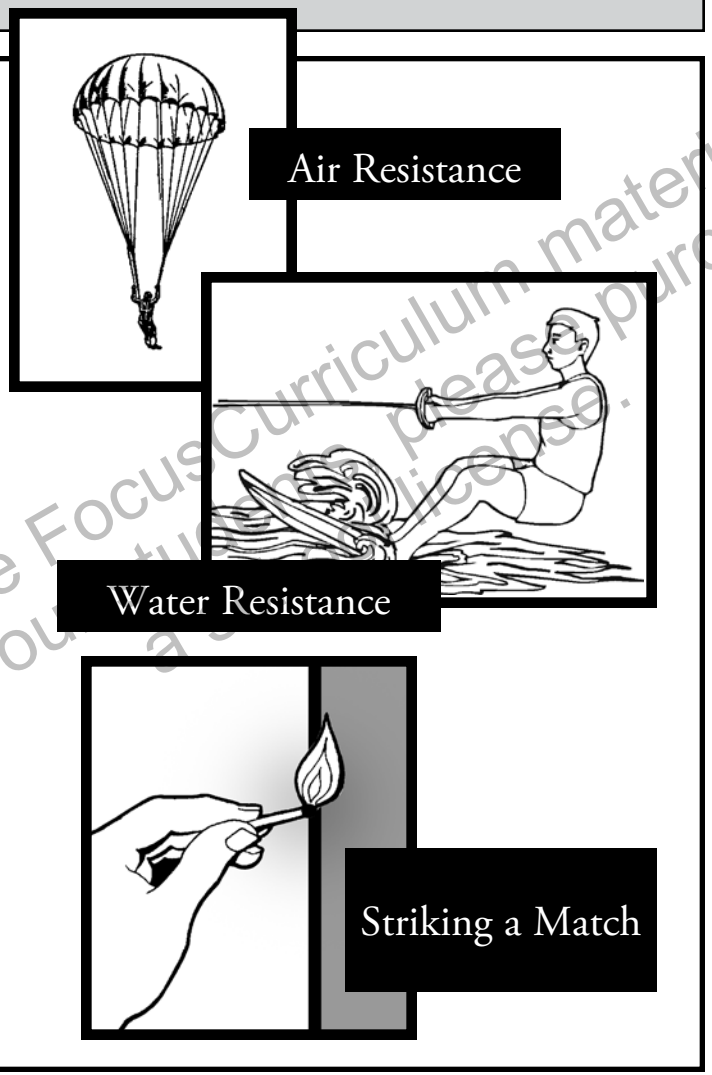
Friction also turns the energy of movement into heat. You can feel this for yourself when you rub your hands together quickly. Try it and explain what happens to a friend.

Reducing Friction

Sometimes things move more easily than other times. Objects that can slide easily on ice are much harder to move on a brick floor. A heavy box of books is easier to move when it moves on ice.

Thin, pointed objects move faster through air or water than wider, fatter ones. Why? It is easier to move when the friction is reduced.

Different Types of Friction and Resistance



ACTIVE READER

1 Explain *Explain the effect of each example of friction shown in the chart on this page.*

Air Resistance _____

_____

_____

_____

_____

Water Resistance _____

_____

_____

_____

_____

_____

Striking a Match _____

_____

_____

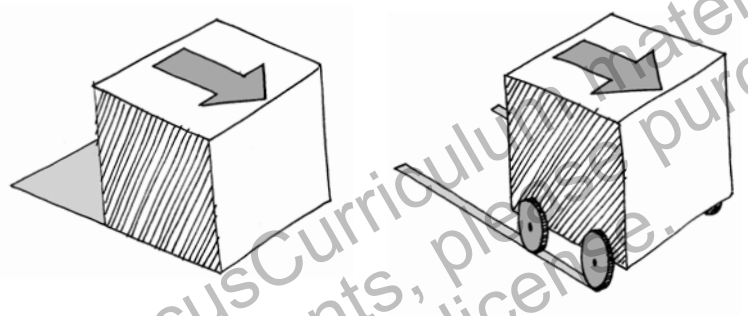
_____

_____

Reducing Friction Between Solid Matter

The smooth surface of ice reduces friction so much that people can slip and lose their balance trying to walk on it. Rough surfaces, such as a sidewalk, have more places to rub against. This causes more friction when a person's foot touches the ground. The foot does not slip as easily.

Applying a **lubricant**, such as oil or grease, to a surface also reduces friction. Lubricants minimize the contact between rough surfaces. The lubricant's particles slide easily against each other, causing less friction between the surfaces.



Wheels reduce friction when moving this box because less solid surface area comes in contact with the ground as the box moves.

ACTIVE READER

1 Explain *What effect will wide, fat tires have on a push cart?*

FOCUS QUESTIONS

1. If two objects collide with one another, what factors influence the result?

2. Explain how collision and friction are related.

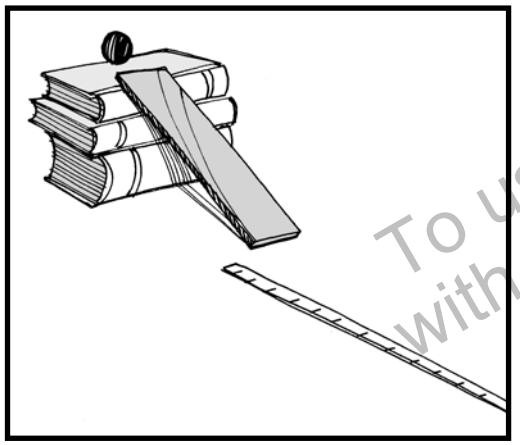
Stop and Think

This page will help summarize what you have read so far.

1. A plastic cup rests, motionless, on the table. Which force is acting on the cup?

(1) gravity
(2) friction
(3) magnetism
(4) electricity

Some students want to measure how far a marble rolls on different surfaces. The picture below shows the set-up for the experiment. Base your answer to question 2 on the picture and on your knowledge of science.



2. Why will the marble roll further on glass than on dirt?

(1) Glass has less mass than dirt.
(2) Glass has less energy than dirt.
(3) Glass offers more resistance than dirt.
(4) Glass offers more resistance than dirt.

Dear Ms. Understanding,

If moving things is a lot easier when you lessen the friction of materials rubbing against each other, why do mountain bikes have those thick knobby tires? Wouldn't smooth tires mean less friction and easier biking?

Riding in Rochester

Dear Riding,

When it comes to moving things, not all friction is bad. Yes, smooth tires on a mountain bike will lessen the friction. But that also means slipping and sliding through puddles and mud. In this case, more friction is the better choice. Knobby tires will help you control your bike when the going gets slippery.

Ms. Understanding

Chapter 2 Simple Machines

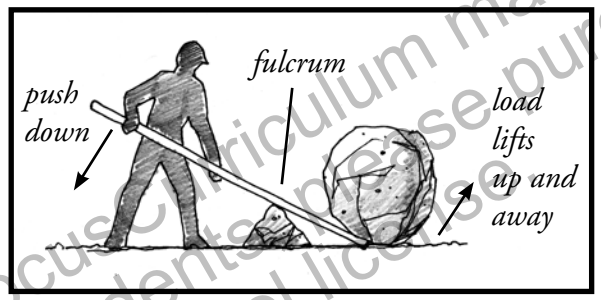
FOCUS

The first paragraph states important ideas about how simple machines help us do work. As you read, think about the simple machines you use every day.

Simple machines are devices that help us perform work more easily. They put mechanical energy to work. Simple machines allow us to use a smaller force to overcome a larger force. These machines include the lever, incline plane, wheel and axle, screw, pulley, and wedge.

Lever

A lever is a stiff bar that rests on a support or turning point. This turning point is called the **fulcrum**. An object that a lever moves is called the **load**. The closer the load is to the fulcrum, the easier it is to move.



ACTIVE READER

1 Explain *How do the fulcrum and load affect the usefulness of a lever?*

Design an Experiment Do you think that placing the fulcrum closer or farther away from the load makes lifting with a lever easier? How could you design an experiment to discover the answer? *Hint: You might use a twelve-inch ruler as a lever, a pencil as a fulcrum, and pennies as load.* How could you measure the force required to lift a stack of pennies with the fulcrum placed at different distances from the load? Prepare a report that explains the hypothesis you developed, the design of your experiment, and the results you found.

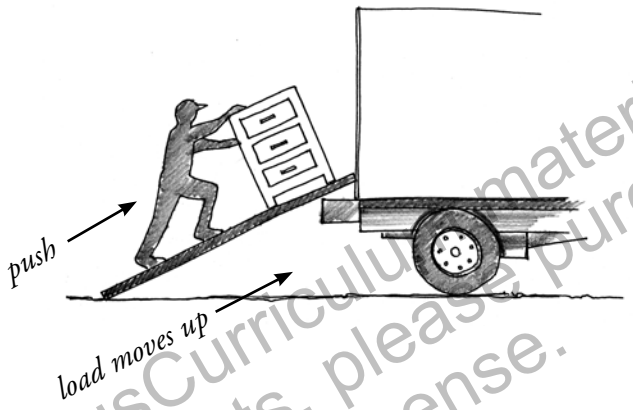
Good to Know

A lever is a simple tool that has been used since prehistoric times. Archimedes, the Greek mathematician, was the first to describe a lever. Today you can find levers everywhere in your daily life. From a see-saw to a wheelbarrow, levers are used in many different applications.

Inclined Plane

An inclined plane is a slanting surface that allows you to move an object to a lower or higher place. It makes the work of moving the object easier. An inclined plane allows you to overcome a largeresistance by applying a smaller force over a longer distance. You need less energy and force to move objects with an inclined plane. Examples of inclined planes are ramps and slides.

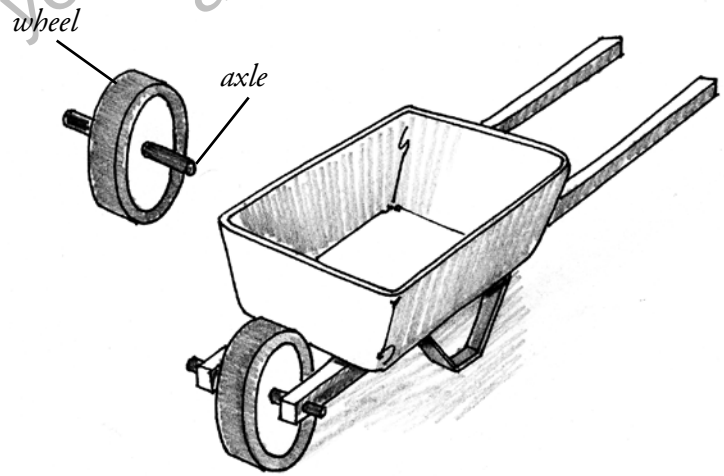
Less force is required to move this object because of the longer distance of the ramp.



Wheel and Axle

The wheel and axle is another simple machine. It is probably the single most important invention of all time. The oldest wheel known was discovered in Mesopotamia and probably dates back to 3,500 B.C.

The wheel and axle is made from two objects. A large wheel is secured to a smaller wheel called an axle. This allows the wheel to turn around the axle. It makes it easier to move things from place to place. For example, a wheelbarrow makes is easier to move heavy loads of dirt.

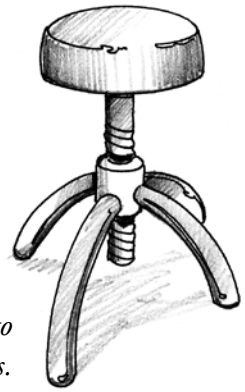


ACTIVE READER

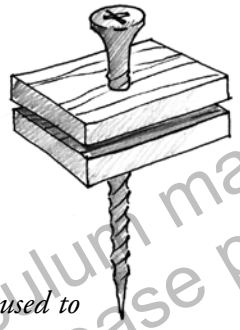
1 Explain *How can the inclined plane and wheel and axle help reduce the effect of friction?*

Screw

A screw is a simple machine made from another simple machine. A screw is an inclined plane wrapped around a pole. Some screws are used to lower and raise things. They are also used to hold objects together.



A screw can be used to raise or lower things.

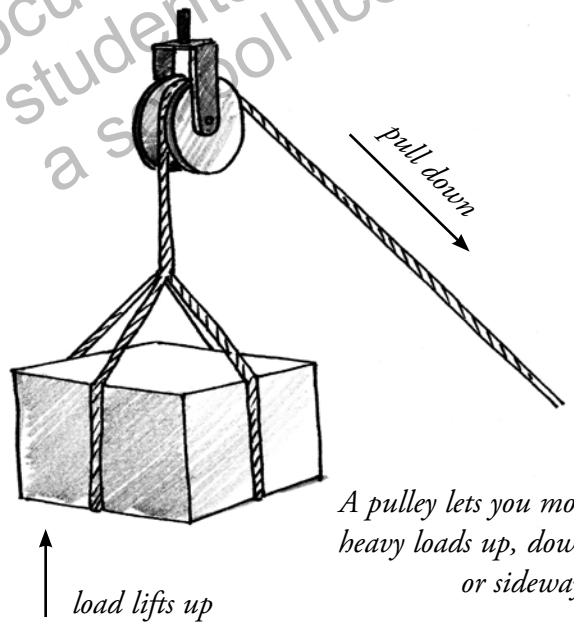


A screw can be used to hold things together.

Pulley

A pulley is a device that allows you to lift a large load with a much smaller force. This simple machine is made up of a grooved wheel, axle, and a rope. The rope fits on the groove of the wheel. One end of the rope is attached to the load. When you pull on one side of the pulley, the wheel turns and the load will move. Pulleys let you move loads up, down, or sideways.

In a simple pulley, the grooved wheel is attached to an **immovable** object, such as a ceiling or beam. When a person pulls down on one end of the rope, the load at the opposite end of the rope is raised.



A pulley lets you move heavy loads up, down, or sideways.

ACTIVE READER

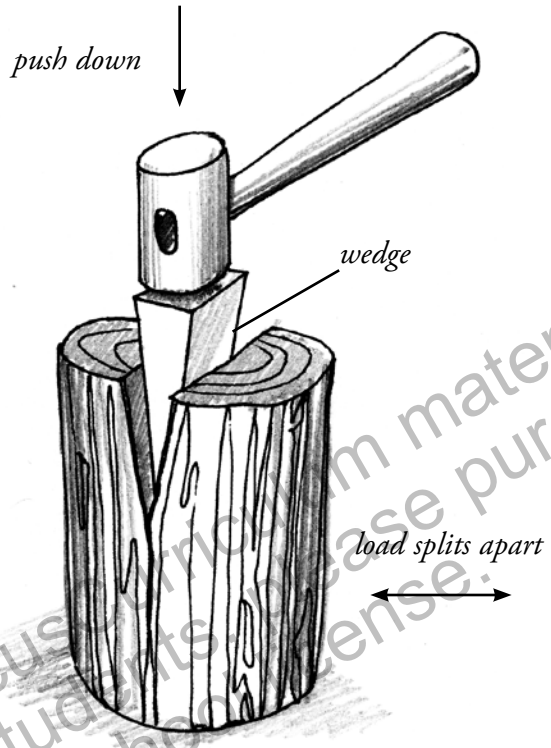
1 Identify *Underline two sentences on this page that describe cause and effect relationships.*

Web Quest

A block-and-tackle is a device that uses pulleys to raise a heavy load. A block-and-tackle often uses more than one pulley at the same time. Find pictures and animations showing a block-and-tackle and research how they work. Build a working model and demonstrate it to the class.

Wedge

A wedge is a simple machine used to separate two objects. A wedge is made up of two inclinedd planes. These planes meet and form a sharp edge. A fairly weak force, applied to the wide end of a wedge will send a strong force to the narrow end pushing out at the sides. The wedge can then split things apart. The knife you use to eat with is a wedge. It cuts or split food apart. Forks, axes, chisels, and nails are other examples of wedges.



ACTIVE READER

1 Recall *What other simple machine is also made up of an inclined plane?*

FOCUS QUESTIONS

1. What type of energy do simple machines use?

2. What are two simple machines used to raise heavy loads?

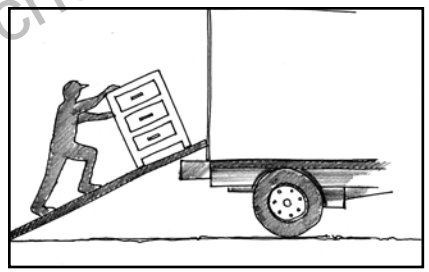
Stop and Think

This page will help summarize what you have read so far.

1. **Screws and wedges are both forms of**
   (1) a pulley
   (2) an axle
   (3) an inclined plane
   (4) a lever

2. **A lever won't work without**
   (1) a fulcrum
   (2) an immovable object
   (3) an axle
   (4) a pole

3. **The pulley incorporates**
   (1) a screw
   (2) an inclined plane
   (3) an lever
   (4) a wheel and axle



The mover shown in the illustration at the right is using an inclined plane to make his job easier. Base your answer to question 4 on the illustration and your knowledge of science.

4. **Explain how a different simple machine might be used to accomplish this same task.**

_____

_____

Dear Ms. Understanding,

I noticed that my bicycle uses several simple machines. Wheel and axle is an obvious one and the pedals turn a pulley. What other simple machines are used in a bicycle?

Still Riding in Rochester

Dear Riding,

I can think of two off the top of my head. Screws hold pieces of the bike together. And the brake controls on the handlebars are levers. I'm sure there are more. Write back if you think of any.

Ms. Understanding

Glossary

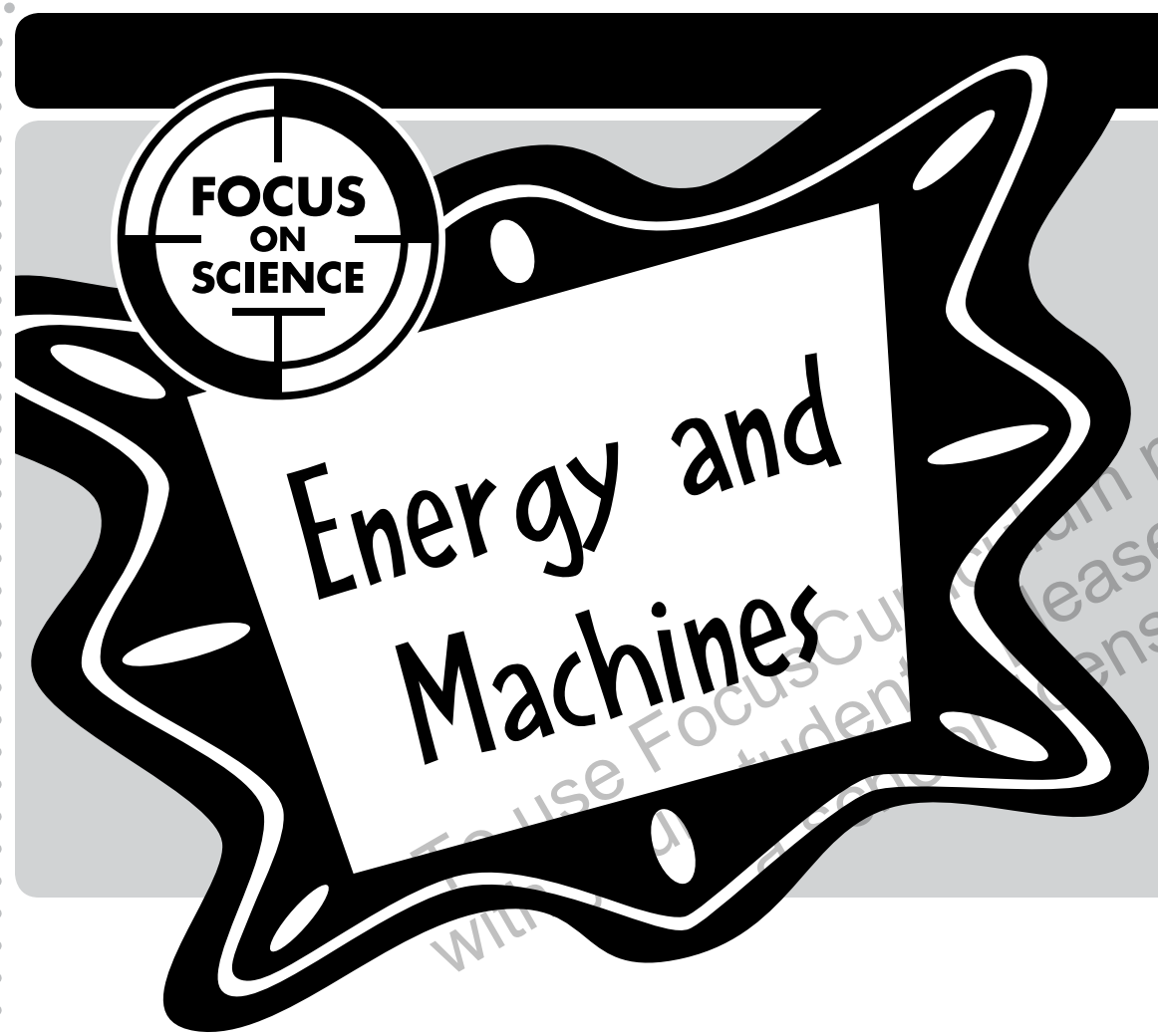
fulcrum—the point at which a lever rests when it is lifting something

immovable—not able to be moved

load—the object moved when using a simple machine to move it

lubricant—a slippery material such as oil or grease put on machine parts to lessen friction and make them move more smoothly against each other

mechanical energy—the energy that an object gains when work is done on it; energy created by movement is mechanical energy



Assessments

Check Understanding

In the Answer Document on this page, mark your answer in the row of circles for each question by filling in the circle that has the same number as the answer you have chosen.

1. Ken is pulling on a rope attached to a heavy rock. He is moving the rock up a ramp. What simple machine is Ken using?

   (1) pulley

   (2) wedge

   (3) inclined plane

   (4) lever

2. Motion is the movement of an object from one place to another. What causes motion?

   (1) force

   (2) energy

   (3) friction and collision

   (4) simple machines

Answer Document

1. ① ② ③ ④ 2. ① ② ③ ④

Check Understanding

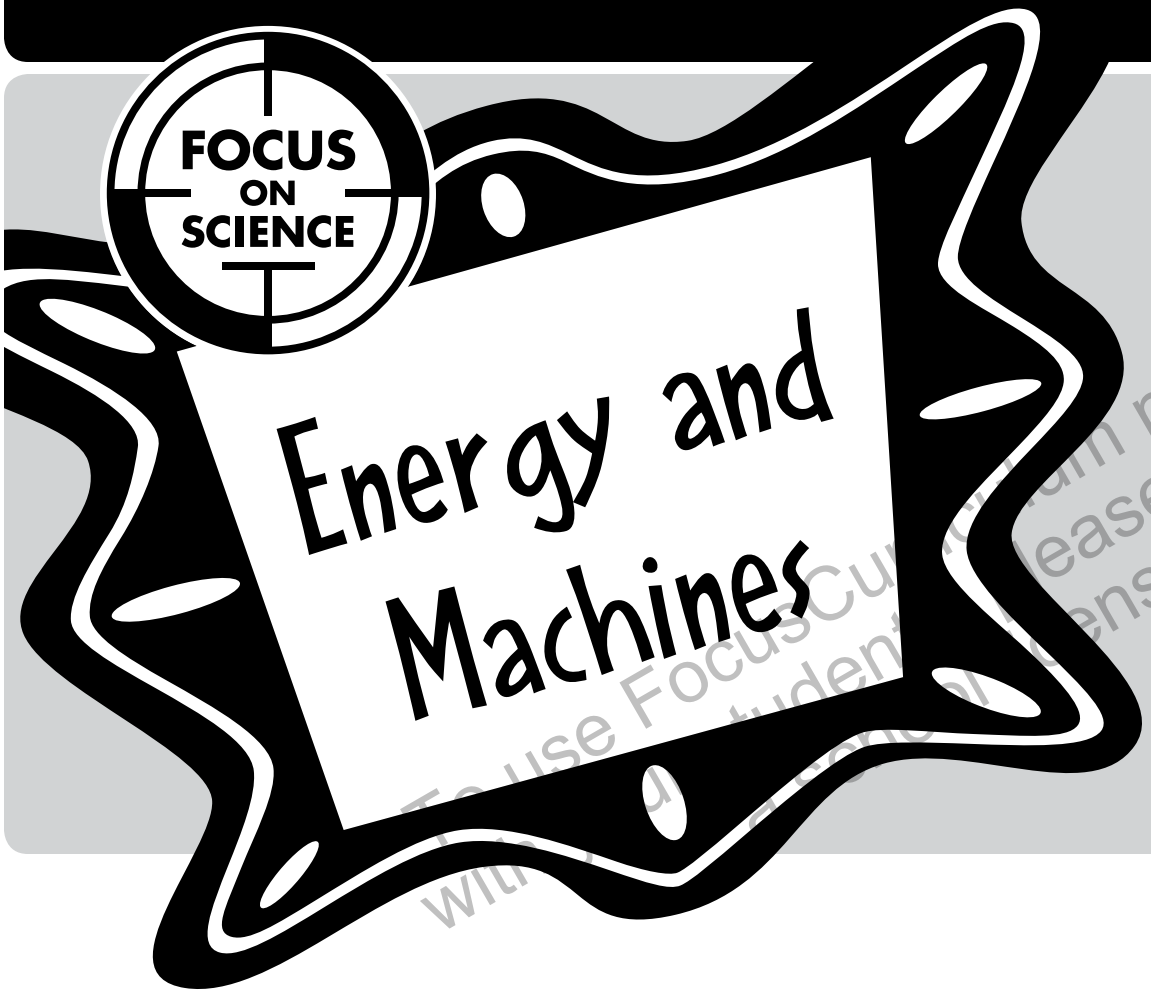
Base your answer to question 3 on your knowledge of science.

3. Joseph wants to move a soccer goal ten feet to the left on the end line so that the goal is postioned in the center of the field. The goals is too heavy for Joseph to move by himself and none of his teammates are there to help him.

   What simple machine could Joseph use to move the goal by himself?

   What parts make up this simple machine?

   How does this simple machine make Joseph's work easier?



Answer Key

Answer Key

Page 8: Starting Points
Build Background
List: Sample answers: rakes, shovels, vacuum cleaners, lawn mowers
Consider: Sample answers: crane, pulleys, block and tackle

Page 9: Starting Points
Key Vocabulary
Rate Your Knowledge: Answers will vary according to the student's prior knowledge.
Use a Dictionary:
1. fulcrum; 2. lubricant; 3. immovable;

Page 10: Starting Points
Key Concepts
Active Reader: 1. Any object in motion has kinetic energy; a thrown baseball or a kicked soccer ball, for example.; 2. Sample answer: A ball held above your head or a yo-yo ready to unwind.

Page 11: Chapter 1
Active Reader: 1. Contact force: friction or collision; Noncontact force: gravity or magnetism

Page 12: Chapter 1
Active Reader: The contact force of the bat hitting the ball sent it flying. The contact force of air resistance (friction) slowed it down. The noncontact force of gravity brought it down to Earth.

Page 13: Chapter 1
Active Reader: 1. Sample answers: muscle power: hammer, hand lawnmower, scissors; wind: windmill
Focus Questions: 1. Gravity and magnetism act on objects across space.; 2. A pushing force is a bird's flapping wing or a fish's swishing tail. A pulling force is gravity.

Page 14: Chapter 1
Active Reader: 1. acorns falling from trees, water pouring over a waterfall, and snow tumbling downward in an avalanche; 2. toward the center of the Earth

Page 15: Chapter 1
Active Reader: 1. A magnet acquires it's magnetic properties because of a flow of electrons.; 2. The magnetic force must be greater than the force of gravity.

Page 16: Chapter 1
Active Reader: 1. Objects moving in space stay in motion unless they are acted upon by a force.; 2. When two objects collide, the one with greater mass changes the motion of the other.

Page 17: Chapter 1
Active Reader: 1. Air particles rub against the parachute and slows its descent.; The friction between the water and the water ski creates a resistance to the movement of the ski through the water.; The friction of the match head against a surface creates enough heat to ignite the match.

Page 18: Chapter 1
Active Reader: 1. Wide fat tires actually reduce friction over deep sand as compared with narrow tires, which sink in.
Focus Questions: 1. The mass and speed of the objects will influence the results.; 2. Both are contact forces.

Page 19: Chapter 1
Stop and Think: 1. (1); 2. (4)

Page 20: Chapter 2
Active Reader: 1. The closer the load is to the fulcrum, the easier it is to lift the load.

Page 21: Chapter 2
Active Reader: 1. The inclined plane allows you to apply a smaller force over a longer distance. A wheel and axle allows you to overcome friction to move heavy loads.

Page 22: Chapter 2
Active Reader: 1. In the last two paragraphs, these sentences describe a cause and effect relationship: When you pull on one side of the pulley, the wheel turns and the load will move.; When a person pulls down on one end of the rope, the load at the opposite end of the rope is raised.

Answer Key

Page 23: Chapter 2
Active Reader: 1. a screw
Focus Questions: 1. mechanical energy; 2. pulleys, levers, screws

Page 24: Chapter 2
Stop and Think: 1. (3); 2. (1); 3. (4); 4. Sample answers: Wheels underneath the cabinet could help reduce friction.; A pulley system hanging of the back of the truck could raise the load.; A screw mechanism could lift a tailgate to raise the cabinet.

Page 29: Check Understanding
1. (3); 2. (1)

Page 30: Check Understanding
3. Joseph could use a lever to move the goal.

He will need a stiff bar and a fulcrum.

If Joseph puts the fulcrum close to the goal, it will require less energy to lift and move the goal.