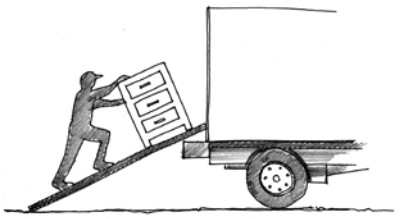
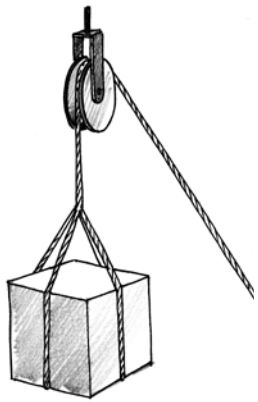
FOCUS ON SCIENCE

Energy and Machines

Basic 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.

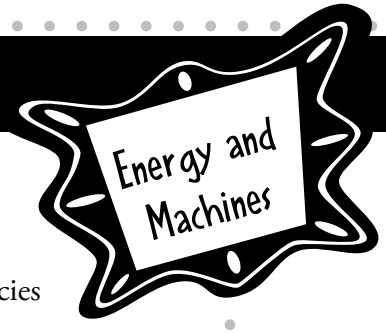
Machines transfer mechanical energy from one object to another. Friction is a force that opposes motion.

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

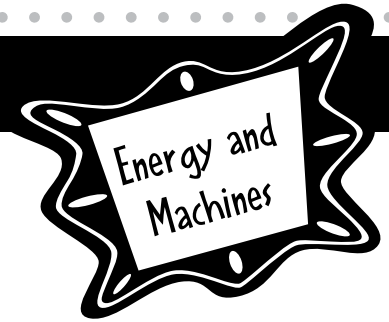
- Integrate sources of information to decode unfamiliar words, self-monitor, and self-correct for word-reading accuracy

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

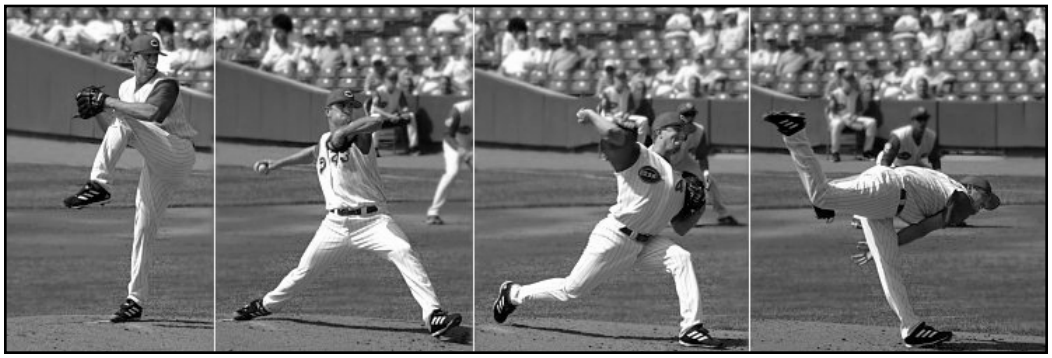
FOCUS ON SCIENCE

Energy and Machines

How do machines impact our lives?

What is work? Work is a change in energy caused by a force. For example, look at the pitcher in the photographs below. When he throws a fast ball, he is doing work. The energy of his moving arm is transferred to the baseball. The ball moves in a line until it is acted upon buy another force. For example, gravity can pull the ball toward Earth. The swinging batter's bat can send the ball in a new direction the batter's bat, or the catcher's mitt can stop it's motion..

Machines do work when they transfer energy from one object to another and make it move. In this book, you will learn about how machines harness energy to do work and how to make machines more efficient.



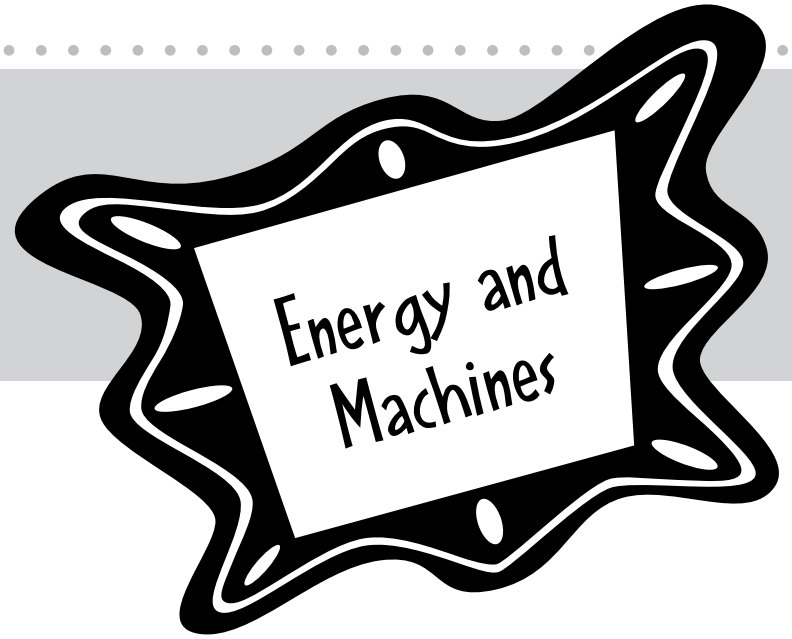


Table of Contents

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

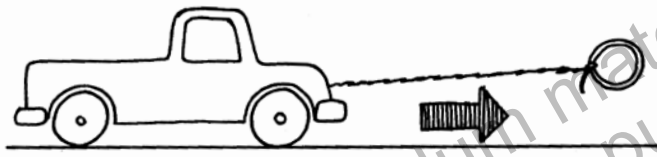
FOCUS

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

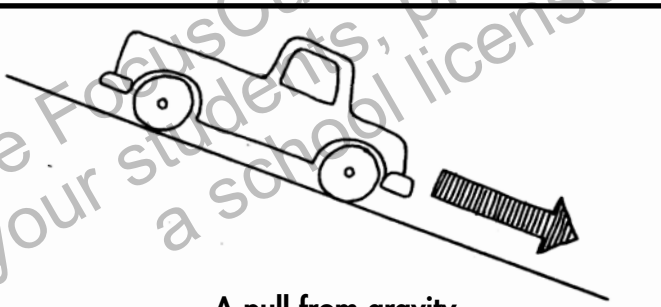
Motion is Caused by Force

Look around at a playground. Bikes roll on the ground. Children swing and slide. All around, there is movement. All these objects use **mechanical energy**.

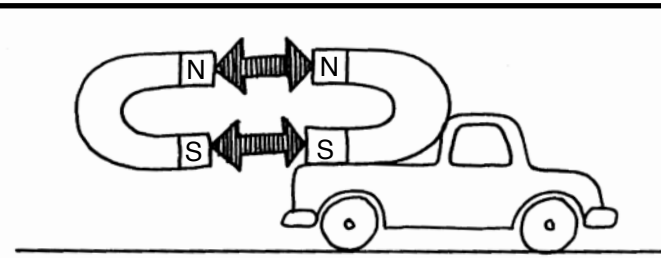
Everything on the playground is moved by force. Force comes from the power of pushing or pulling. There are different types of forces that affect motion. They are gravity, friction, collision, and magnetism. Read on to learn more about these forces.



A pull from an outside force



A pull from gravity

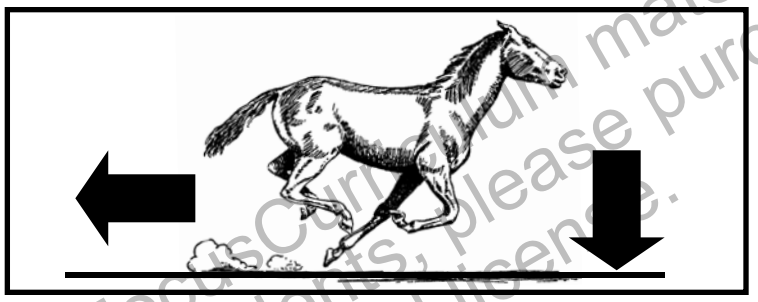


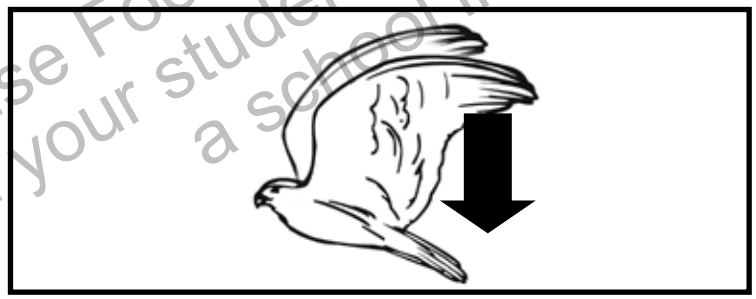
A push from the force of magnets

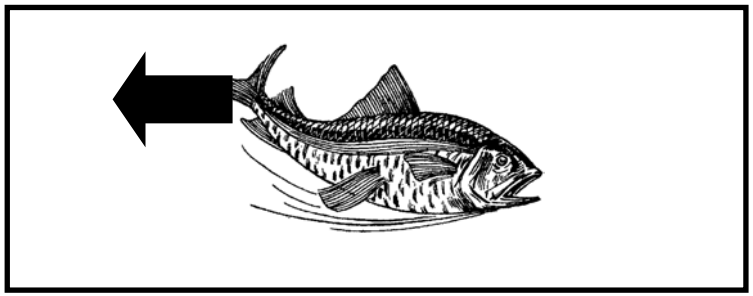
ACTIVE READER

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. For example, humans and animals push with their legs to move. Birds push with their wings. People attach ropes to objects and pull to move them..







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?*

Inventions have allowed us to move faster and farther than we could using only our muscles. They all rely on pushes and pulls to create movement.

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.

_____

_____

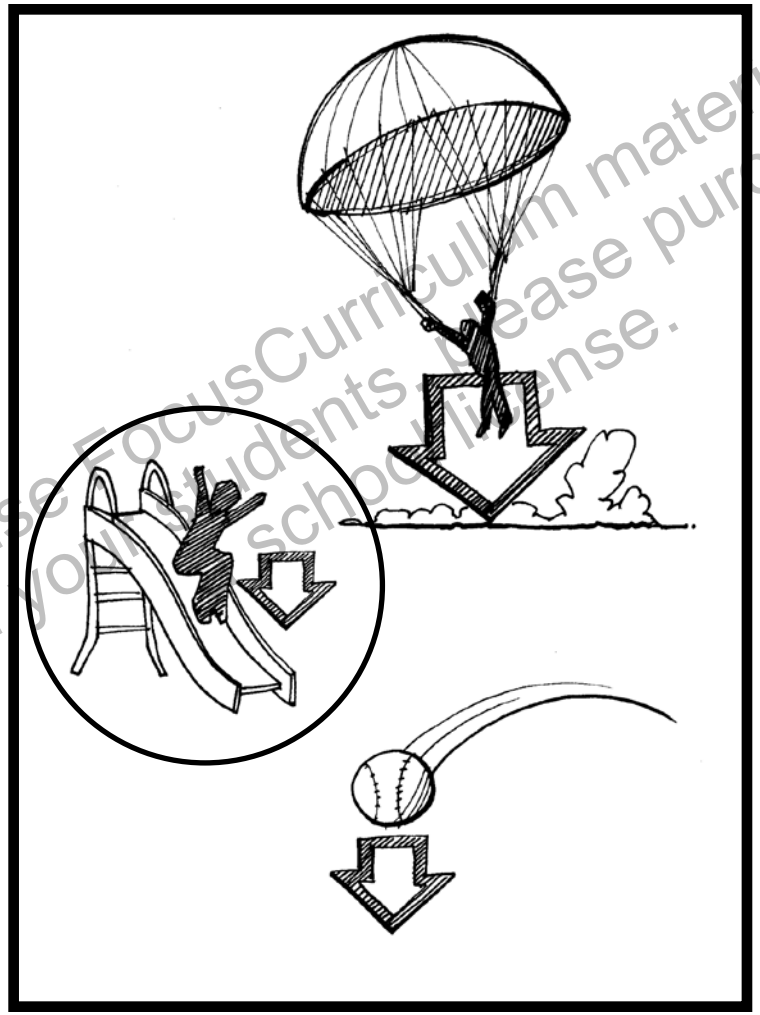
FOCUS

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

Gravity

The force that pulls things to Earth is gravity. It is invisible. Still, we can see the results of gravity whenever something falls.

Gravity is a pull that **matter** has on other matter. The more massive the matter, the stronger gravity's pull. It may sound funny, but Earth is the biggest thing in our world. Its gravity is so strong it pulls everything on 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?*

_____

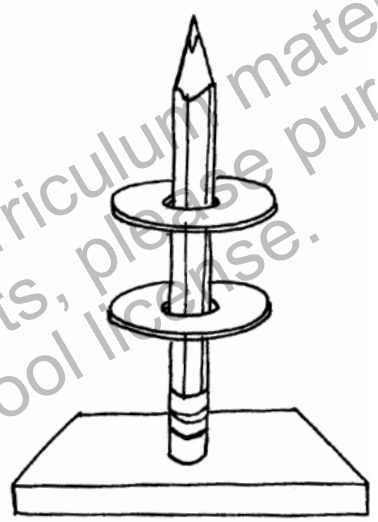
_____

_____

Magnetism

Long ago, people discovered magnetism. Iron passing close by certain rocks was pulled toward the rocks. People use these rocks to make magnets. Magnets can attract or repel each other. This force can be stronger than gravity.

Look at the drawing below. 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. 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?**

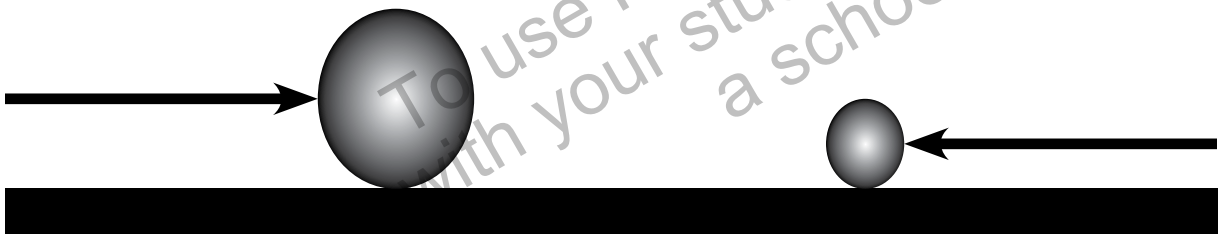
FOCUS

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

Collision

What happens when you hit a baseball with a bat? The ball changes direction. When objects bump into each other, they slow down, change direction, or stop. This is called a collision.

What happens if two pieces of matter collide from opposite directions? Whichever has more energy and **mass** will affect the direction. The bat has more energy and mass than the baseball. So, the baseball changes direction.



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

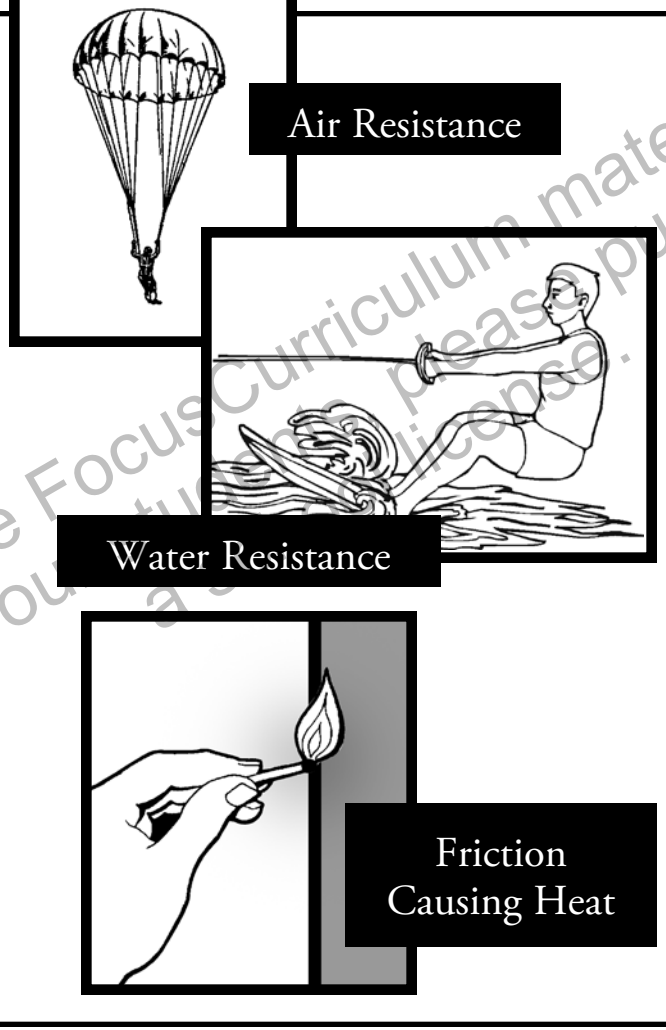
Friction is caused by matter rubbing together. Friction slows down the movement of objects. Have you ever tried to run underwater? You know that water's friction, or resistance, makes this hard. Air has resistance. This is what makes a parachute work.

Friction also turns the energy of movement into heat. Rub your hands together quickly. Explain what happens to a friend.

Reducing Friction

A heavy box of books is hard to push on the ground. Yet, it moves easily on ice. Why is this? It is easier to move objects when 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 _____

_____

_____

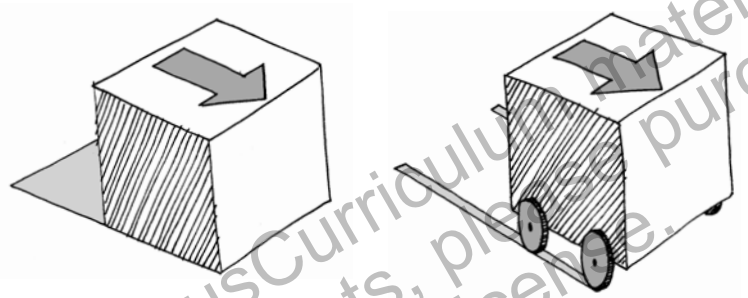
_____

_____

Reducing Friction Between Solid Matter

Ice is smooth. Smooth things have less friction. That makes your feet slip easily on ice. The ground is rough. Rough surfaces have more places to rub against. This creates more friction.

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

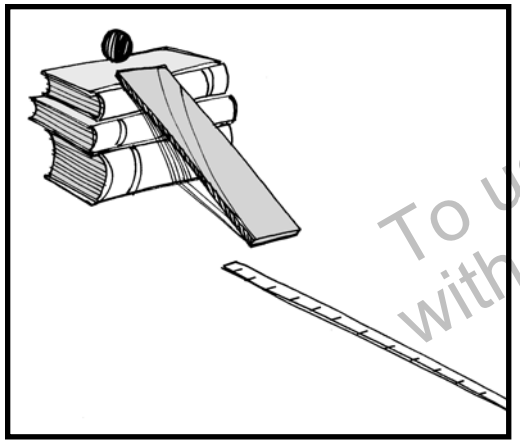
Stop and Think

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

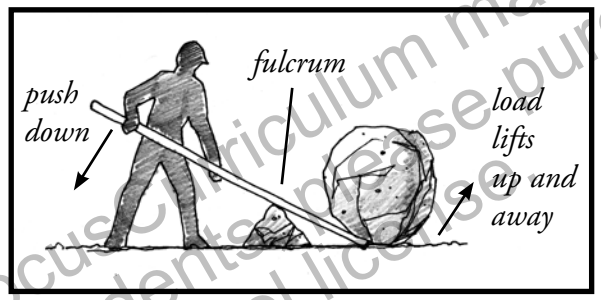
Chapter 2 Simple Machines

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 allow us to use a smaller force to overcome a larger force.

Lever

A lever is a stiff bar that rests on a **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?*

Think Like A Scientist

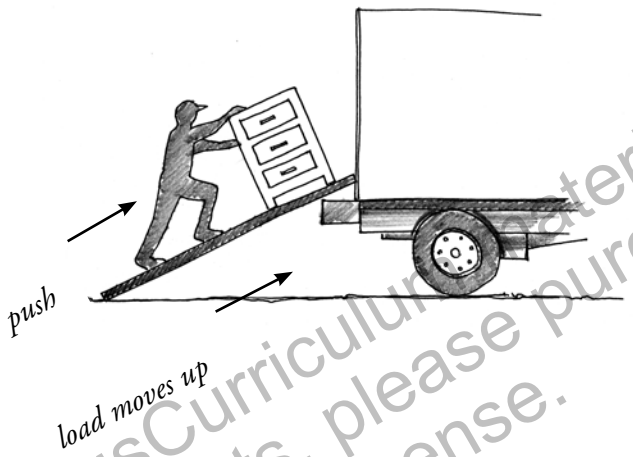
Design an Experiment Do you think that placing the fulcrum closer or farther away from the load makes lifting with a lever easier? How could you design an experiment to discover the answer? *Hint: You might use a twelve-inch ruler as a lever, a pencil as a fulcrum, and pennies as load.* How could you 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

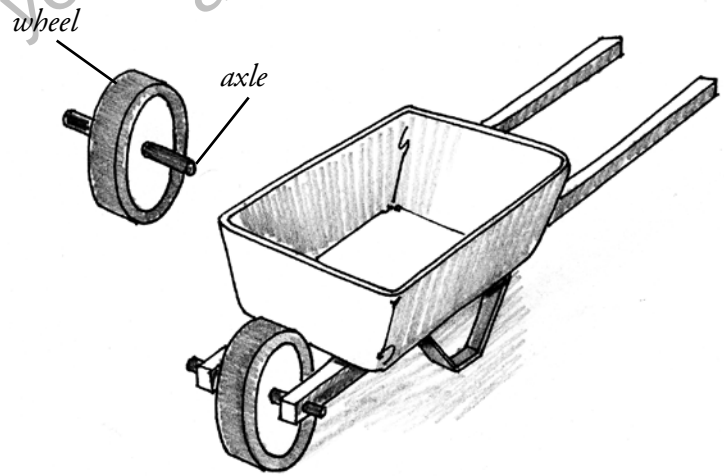
An inclined plane is a slanting surface. It allows you to move an object to a lower or higher place. You can apply a smaller force over a longer distance. This makes moving the object easier.



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. A wheel is attached 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.

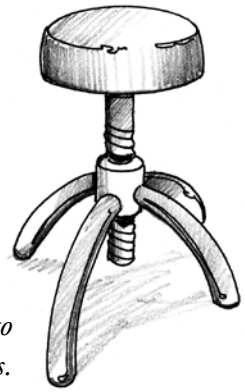


ACTIVE READER

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

Screw

A screw is a simple machine used to lower and raise things. Screws are also used to hold objects together.

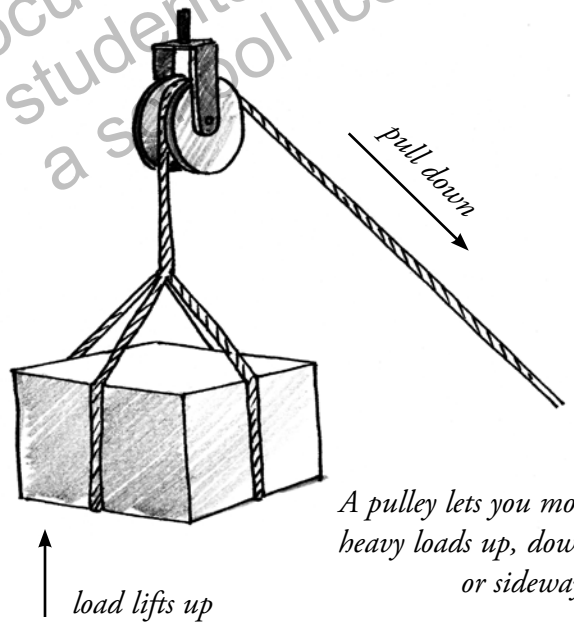


A screw can be used to raise or lower things.

A screw can be used to hold things together.

Pulley

A pulley allows you to lift a large load with a much smaller force. It is made with a grooved wheel, axle, and a rope. One end of the rope is attached to the load. When you pull on one side of the pulley, the wheel turns. Then the load moves.



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

ACTIVE READER

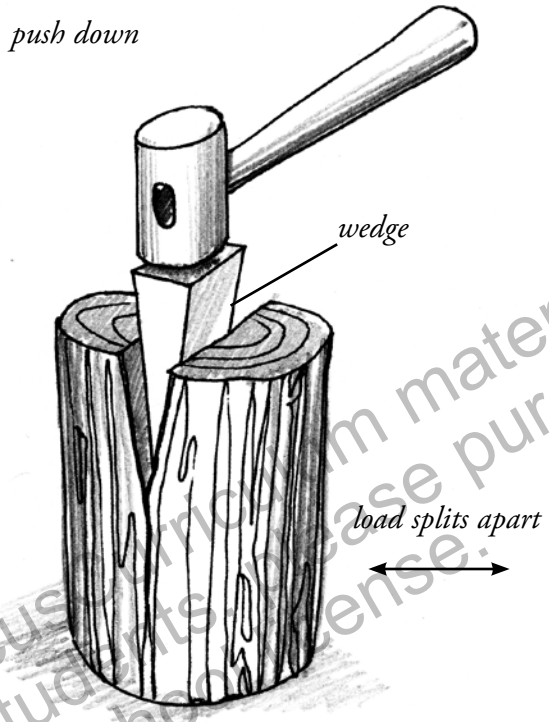
1 Identify *Underline two sentences on this page that describe cause and effect relationships.*

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 has a sharp edge. A fairly weak force can split things apart. For example, the knife you use to eat with is a wedge. It cuts or split food apart.



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

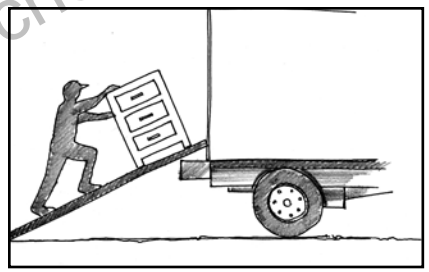
This page will help summarize what you have read so far.

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

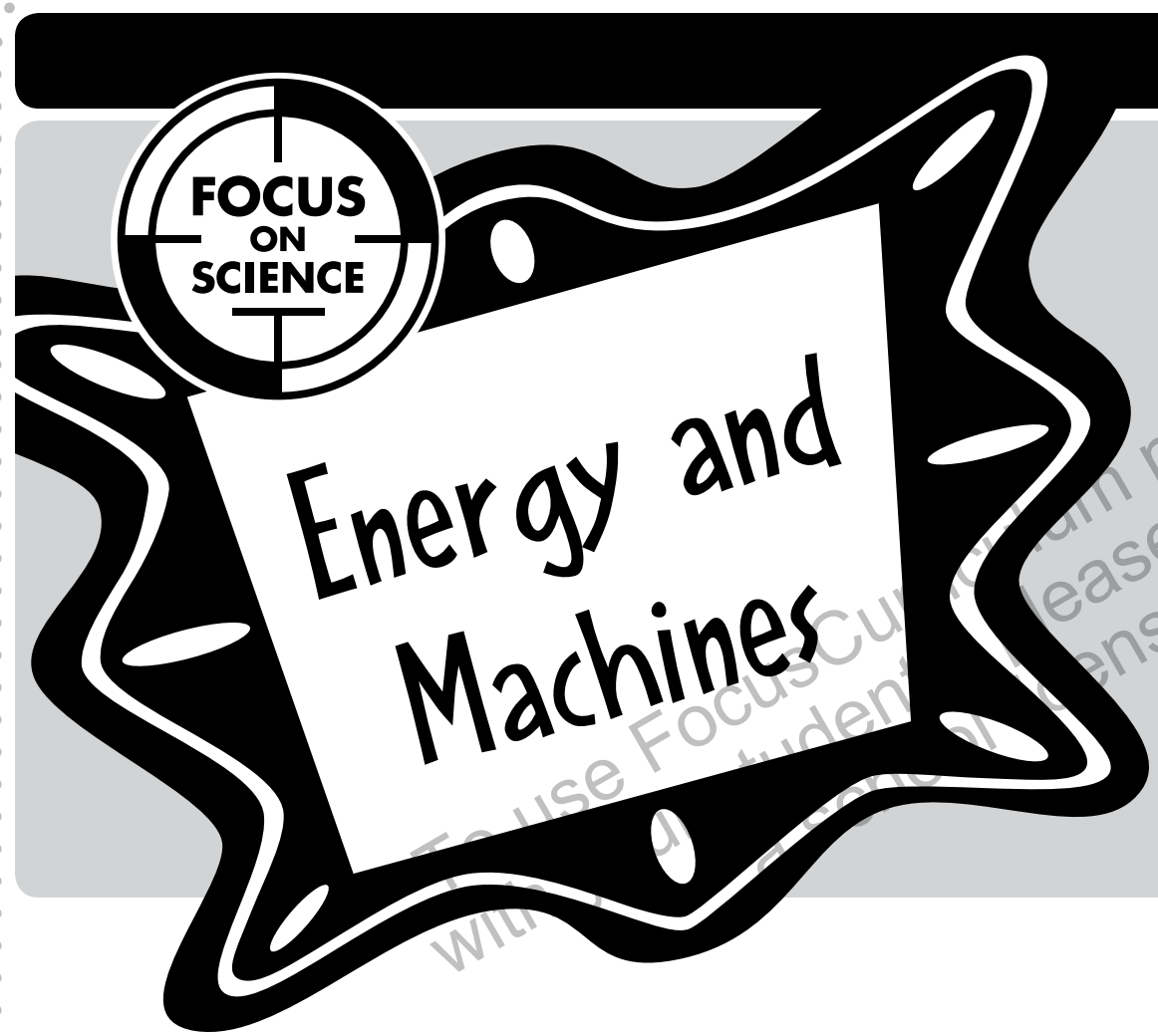
fulcrum—the point at which a lever rests when it is lifting something

immovable—not able to be moved

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

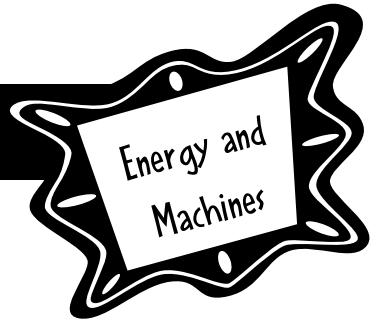
lubricant—a slippery material such as oil or grease put on machine parts to lessen friction and make them move more smoothly against each other

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

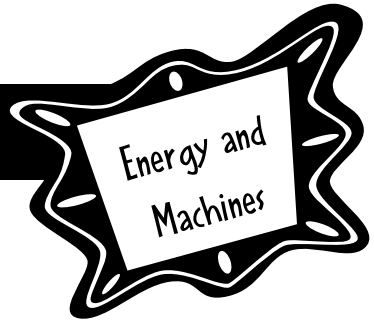
   (3) friction and collision

   (4) simple machines

Answer Document

1. ① ② ③ ④ 2. ① ② ③ ④

Check Understanding



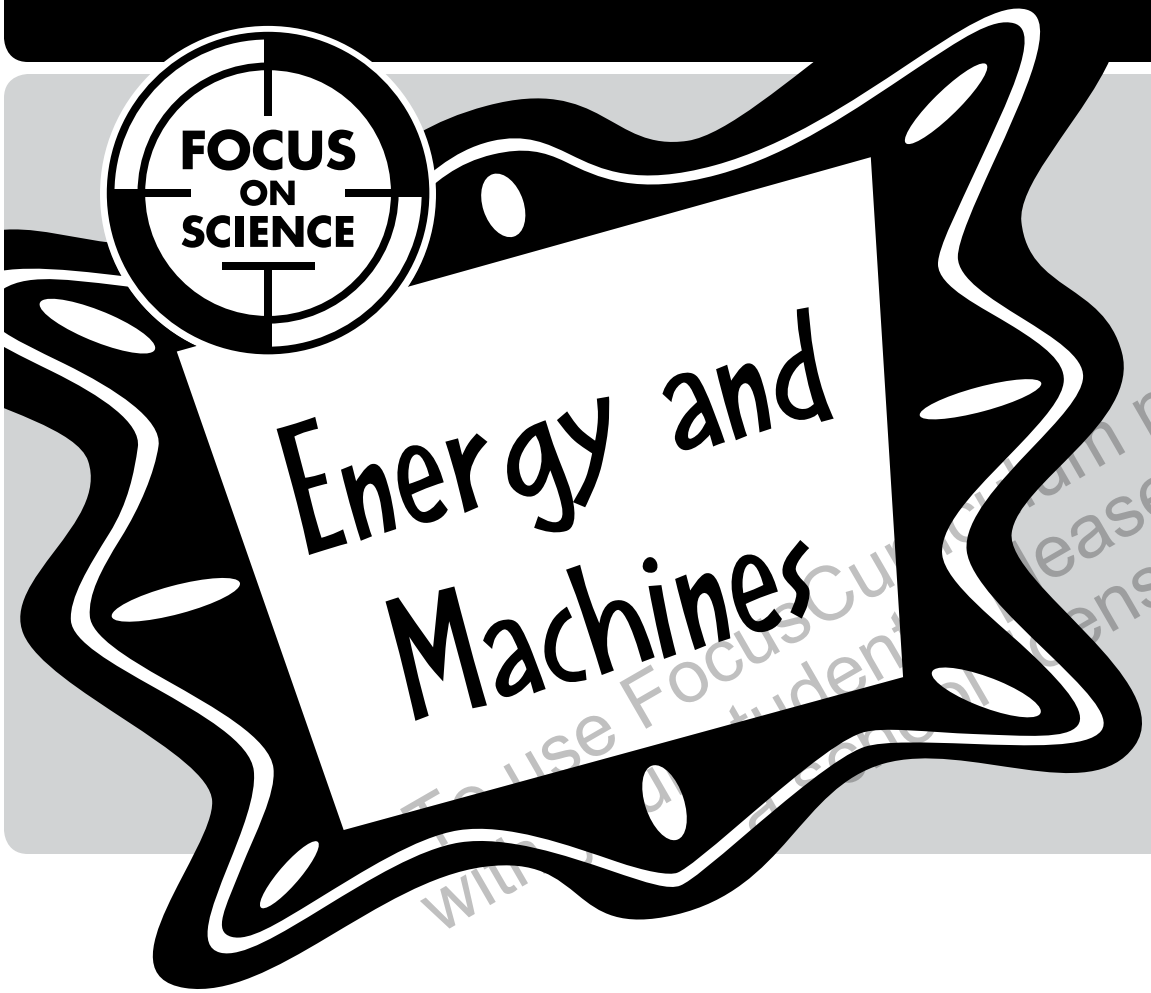
Base your answer to question 3 on your knowledge of science.

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

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.