

Physical Science

Force and Motion

On Level

# Force, Motion, and Simple Machines

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# Force, Motion, and Simple Machines

How do simple machines help us move objects?

## CORE CURRICULUM STATEMENTS

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

The position or direction of motion of an object can be changed by pushing or pulling.

The force of gravity pulls objects toward the center of Earth.

The amount of change in the motion of an object is affected by friction.

Mechanical energy may cause change in motion through the application of force and through the use of Simple Machines such as pulleys, levers, and inclined planes.

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# Student Book

*Force, Motion, and Simple Machines*

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## Force, Motion, and Simple Machines

How do simple machines help us move objects?

### CORE CURRICULUM STATEMENTS

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

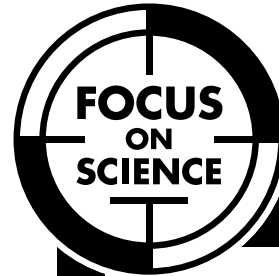
The position or direction of motion of an object can be changed by pushing or pulling.

The force of gravity pulls objects toward the center of Earth.

The amount of change in the motion of an object is affected by friction.

Mechanical energy may cause change in motion through the application of force and through the use of such simple machines as pulleys, levers, and inclined planes.

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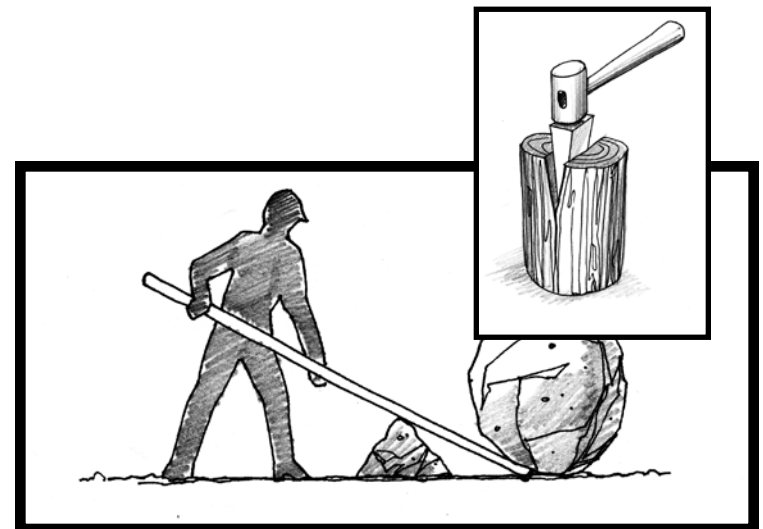


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# Force, Motion, and Simple Machines

by Michael Silverstone





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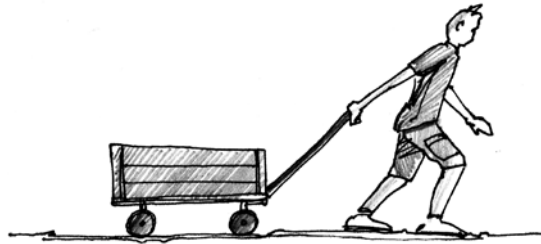
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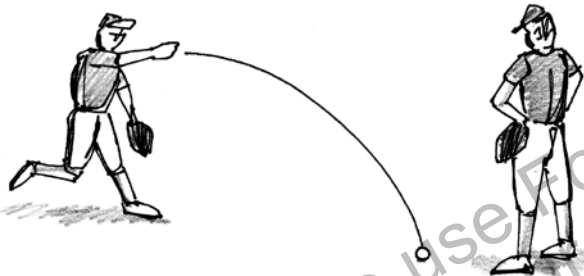
*–Predict–*

*What do you think you will  
learn from this book?*

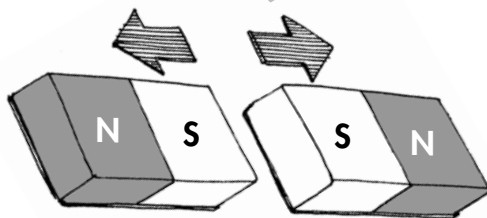
## Objects Move When Forces Push or Pull on Them



A pull from an outside force



A pull from gravity



A push from the force of magnets

## INTRODUCTION

# Motion Is Caused by Force

At a playground, a ball is hit with a bat. Bikes roll along the sidewalk. A child's muscles cause a swing to move. Gravity pulls a boy down a slide. All of these events are examples of **mechanical energy** causing changes in motion.

Everything that moves is put into motion by a force applied to it. Force results from pushing or pulling objects. There are different types of forces that affect motion.

One type is contact forces, where objects physically come into contact with each other, such as friction and collision.

Another type is noncontact forces, where objects do not come into contact with each other. Gravity and magnetism are examples.

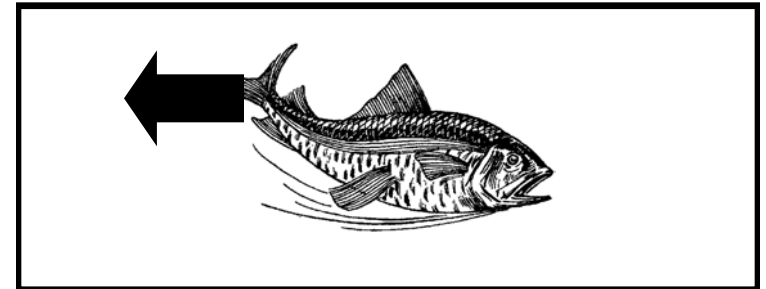
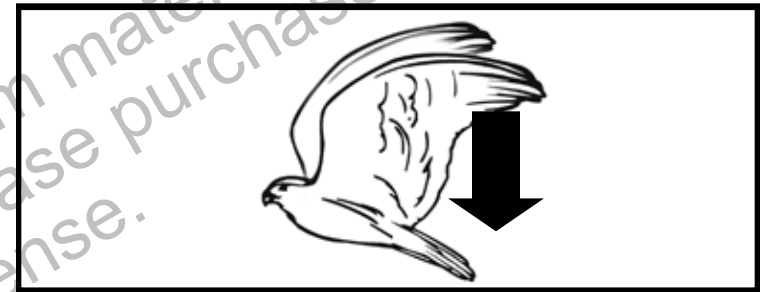
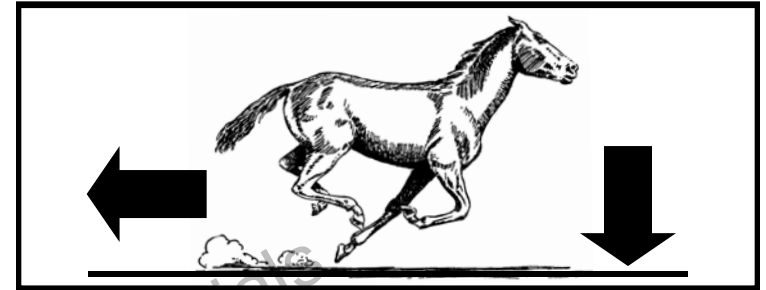
**mechanical energy:** energy an object has due to its motion, position, or condition

## Pushes and Pulls

Pushes and pulls are forces that usually start objects moving. Think of animals that move well, such as cheetahs, horses, sharks, and condors. They all have body parts 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 against the air. Sharks swing their tail fins from side to side and up and down to push against water.

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

–Apply–

*What creates thrust when you walk?*



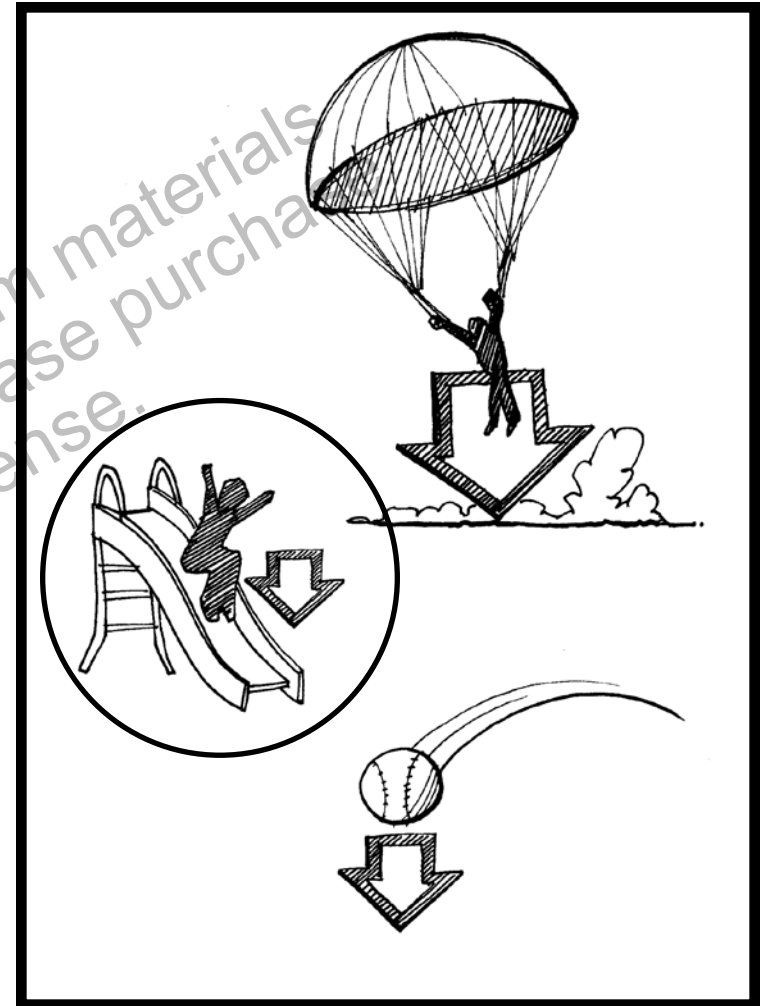
# Gravity

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 blow in the wind until they settle on the ground. Snow, mud, or rocks tumble downward in an avalanche.

This pull toward Earth is the result of the force of gravity. Gravity is the pull that objects have on other objects. Gravity pulls everything toward the center of Earth. It pulls more strongly on objects that have more **mass**.

**mass:** the amount of matter in an object

## The Force of Gravity



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

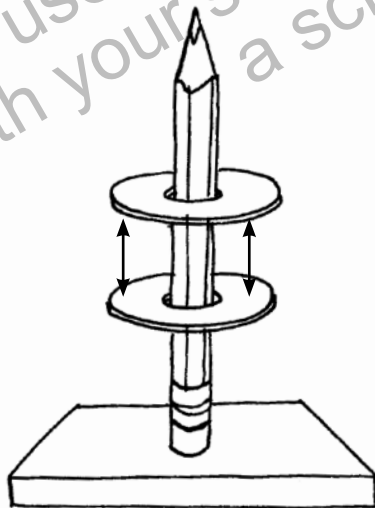
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## Magnetism

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 pull strongly on metals such as iron and steel. Magnets can also attract or repel each other with a force that can be stronger than gravity.

For example, in 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, so the top magnet will not drop.



---

## 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, an object will slow down or stop if it bumps against another object that is going in another direction. This is called a collision.

When one object collides with another, the energy of movement changes. If two objects 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.*

# Friction

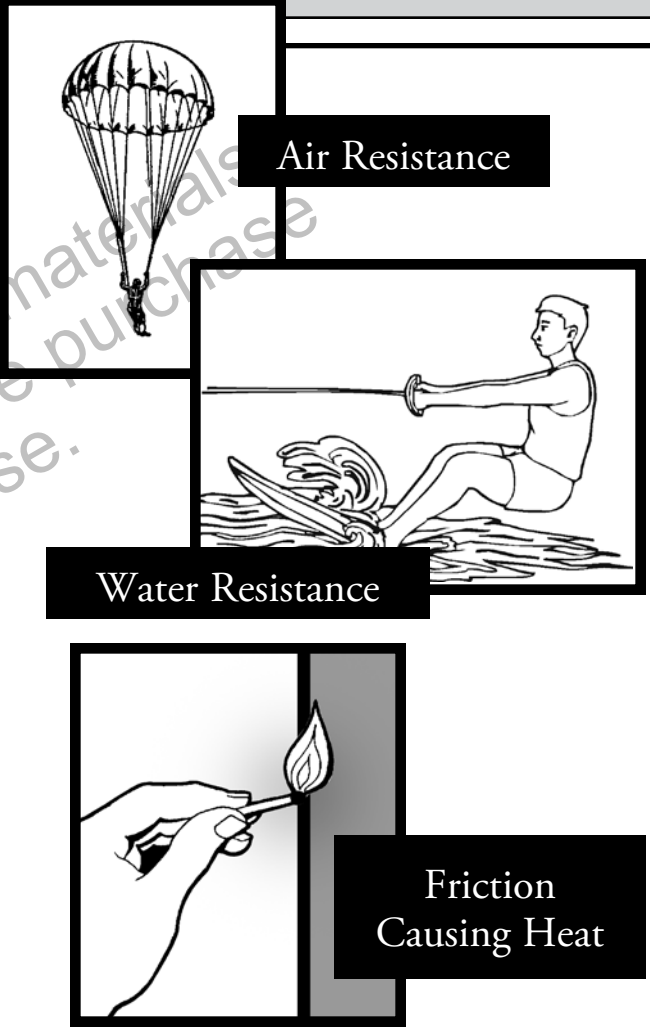
Friction is caused by collisions of objects or by the rubbing of one object against another. It is a force that slows down the movement of objects. Friction is what makes it hard to slide heavy things along the ground.

If you have ever tried to run underwater, you know that water's friction, or **resistance**, makes this hard. Even 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 can turn mechanical energy into heat energy. You can feel this for yourself when you rub your hands together quickly. Try it and explain what happens to a friend.

**resistance:** when something pushes against an object to slow it down or stop it from moving

## Different Types of Friction and Resistance



The diagram consists of three vertically stacked rectangular panels, each with a black border. The top panel shows a parachute with a person hanging from it, with a black box to its right containing the text "Air Resistance". The middle panel shows a person rowing a boat on water, with a black box below it containing the text "Water Resistance". The bottom panel shows a hand rubbing a matchstick, with a flame on the tip, and a black box to its right containing the text "Friction Causing Heat".

–Analyze–  
Where is the friction in each picture?

---

## Reducing Friction

Sometimes things move more easily than at other times. Objects that can slide easily on ice are much harder to move on carpet. 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 is this? In all of these cases, it is easier to move objects when friction is reduced.

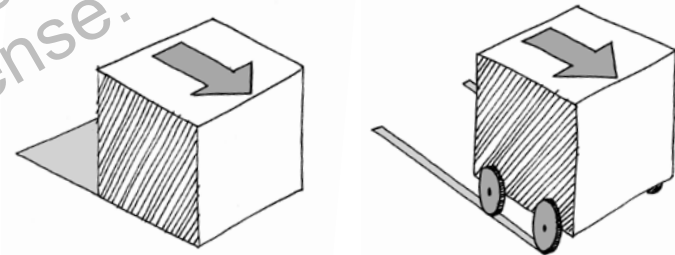
### Reducing Friction Between Surfaces

Rough surfaces, such as a sidewalk, create friction when a person's shoe touches the ground. When a sidewalk is icy, the smooth surface reduces the friction so much that people can slip trying to walk on it.

*–Explain–  
Identify and explain forces that  
affect the motion of an object.*

---

Here is another example. A box on wheels moves much more easily than one that does not have them. Wheels reduce the amount of matter that rubs against the floor. Only the small area at the bottom of each wheel touches the ground. Without wheels, the whole surface of the box creates much more friction, making it harder to move.



### Shapes that Help Things Move Faster in Air and Water

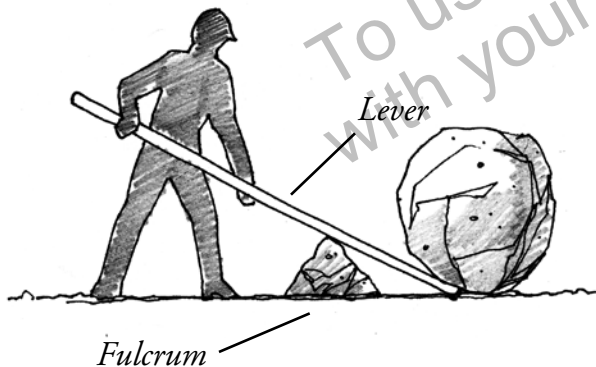
The size and shape of an object can change the amount of friction it creates. Smooth, rounded shapes move through the air more easily than flat or rough surfaces. That's because these shapes have fewer places for air or water to bump up against and slow them down.

## Simple Machines

Simple machines are **devices** that help us perform work more easily. Simple machines allow us to use a smaller force to overcome a larger force.

### Lever

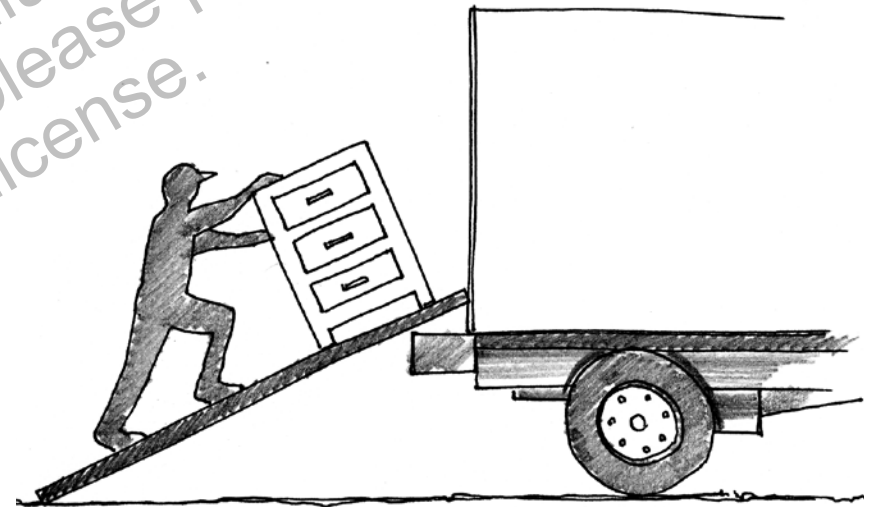
A lever is a straight, stiff bar that rests on a support or fixed point. This fixed point is called the **fulcrum**. An object that a lever lifts is called the **load**. The closer the load is to the fulcrum, the easier it is to lift.



**devices:** things made or invented for a special use  
**fulcrum:** the support or fixed point that a lever rests on  
**load:** an object that is lifted or about to be lifted by a lever

### Inclined Plane

An inclined plane is a slanting surface that allows you to move an object to a lower or higher place. You can apply a smaller force over a longer distance which makes moving the object easier. Examples of inclined planes include ramps and slides.



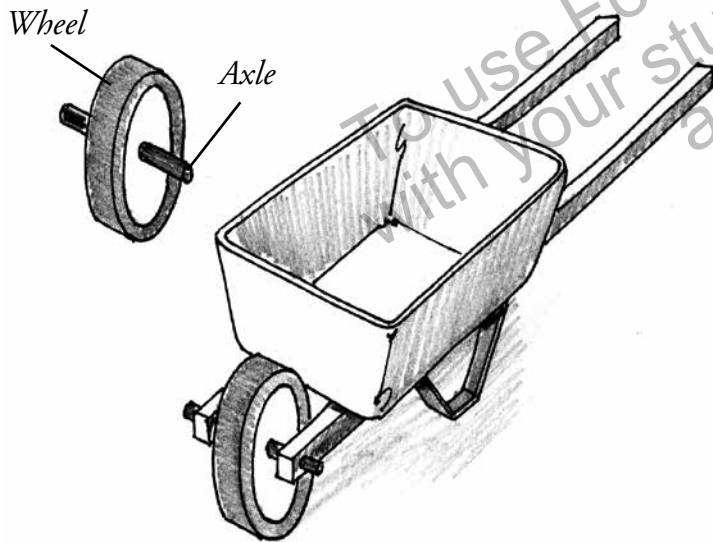
*Less force is required to move this object because of the longer distance of the ramp.*

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## Wheel and Axle

The wheel and axle is another simple machine. The wheel and axle is made from two objects. A large wheel is secured around a post called an axle. The wheel turns around the axle.

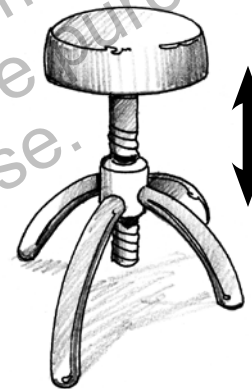
The wheel and axle make it easier to move things from place to place. For example, a wheelbarrow makes it easier to move heavy loads of dirt.



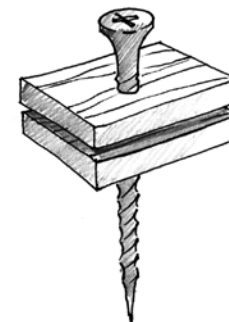
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## Screw

A screw is a simple machine made from another simple machine, an inclined plane. 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.*

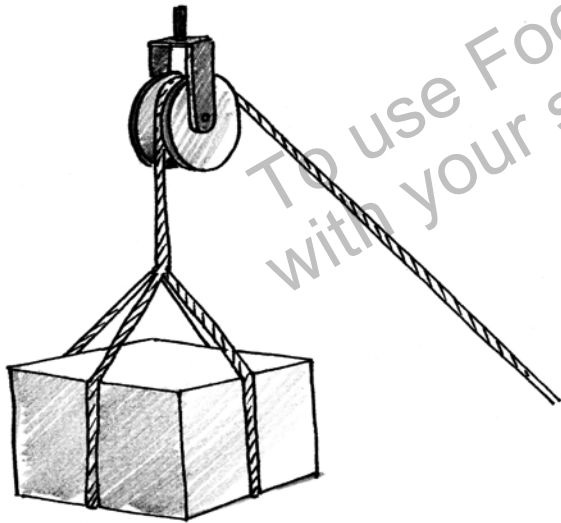


*A screw can be used to hold things together.*

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## 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 with less force.

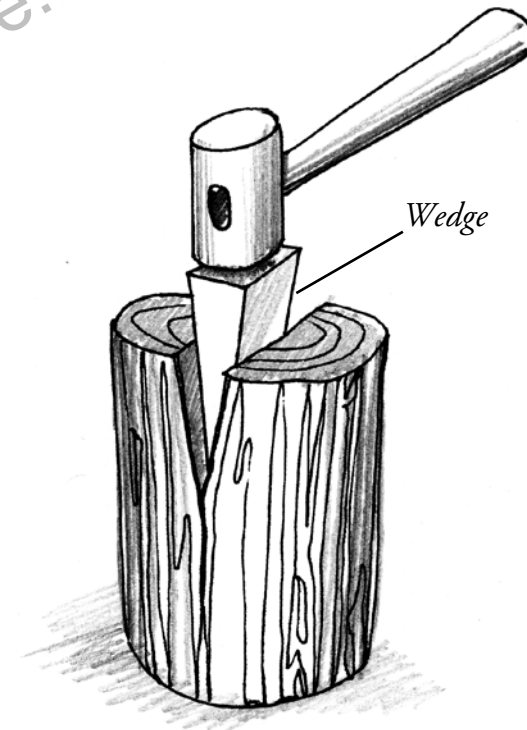


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## Wedge

A wedge is a simple machine used to separate two objects. A wedge is made up of two inclined planes. These planes meet and form a sharp edge.

A fairly weak force from a wedge can split things apart. For example, 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.



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## Glossary

**devices**—things made or invented for a special use

**fulcrum**—the support or fixed point that a lever rests on

**load**—an object that is lifted or about to be lifted by a lever

**mass**—the amount of matter in an object

**mechanical energy**—energy an object has due to its motion, position, or condition

**resistance**—when something pushes against an object to slow it down or stop it from moving

---

## To Find Out More . . .

Want to learn more about simple machines?

### Try these books

*Force & Motion* by Peter Lafferty. Dorling Kindersley, Inc., 1992

*Speed and Acceleration* by Richard Spilsbury. Heinemann Library, 2007.

### Access these Web sites

The Little Shop of Physics  
<http://littleshop.physics.colostate.edu/>

Fizzics Fizzle! An Interactive Guide to Physics  
<http://library.thinkquest.org/16600/>

### Write for more information

National Student Research Center  
606 Lafitt Street  
Mandeville, Louisiana 70448

National Academy of Engineering  
500 Fifth Street, NW  
Washington, DC 20001



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# Assessments

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Print pages 20–22 of this PDF for the assessments.

# Check Understanding

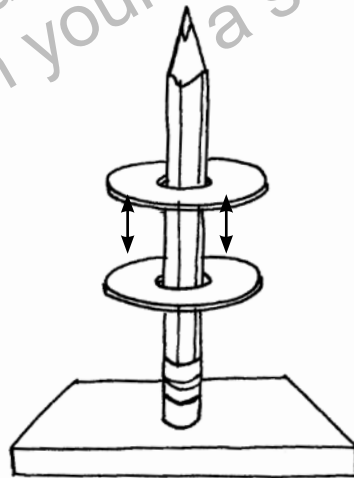
Shade the circle next to the correct answer or write your answer on the lines provided.

1. Which type of energy is needed to move a heavy box up a ramp?

- A sound
- B light
- C mechanical
- D electrical

2. The following picture shows how magnetism works. The bottom magnet is fixed to the pencil. The top magnet is not. Which statement is true?

- A The magnets are attracted to each other.
- B Gravity is pushing the top magnet away.
- C The pencil is made of magnetic material.
- D The magnetic force is stronger than gravity.



3. Gravity is a type of force. Identify **one** example of gravity that you can see.

\_\_\_\_\_

Explain what gravity is.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

4. Which type of energy is used to split a log into two pieces?

- A friction
- B magnetic
- C electrical
- D mechanical

# Check Understanding

Write your answers on the lines provided.

5. Objects only move when something pushes or pulls them. Identify **two** animals that use pushes and pulls.

- 1) \_\_\_\_\_
- 2) \_\_\_\_\_

Explain how each animal does this.

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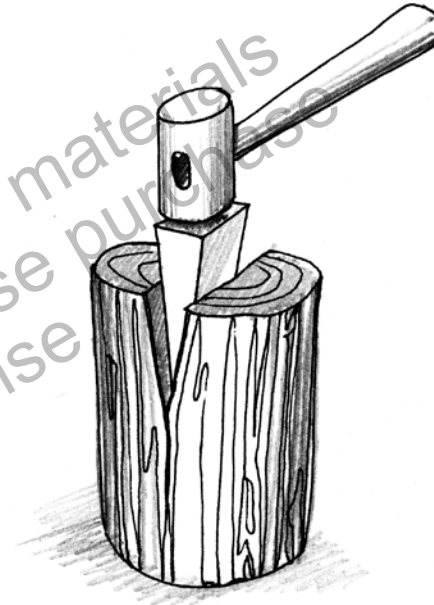
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6. The diagram below shows a simple machine splitting a piece of wood.



What simple machine is being used to help split the wood.

- (A) hammer
- (B) balance
- (C) wedge
- (D) pulley

# Assessment Scoring Guidelines

1. Answer C is correct.
2. Answer D is correct.
3. Answers will vary.  
Gravity is a pull that matter has on other matter.
4. Answer D is correct.
5. Shark  
Sharks swing their fins side to side and up and down to push against the water.  
  
Horse  
Horses push hard against the ground with their feet and legs.  
  
Condor  
Condors use their wings to push down on the air.
6. Answer C is correct.

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# English Language Arts Activities

*Force, Motion, and Simple Machines*

Print pages 24–28 of this PDF for the reading activities.

# Graphic Organizers

## TRY THE SKILL

Graphic organizers are visual ways to show how important ideas are related.

**Read this paragraph from. Then read the graphic organizer, which shows the ideas.**

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 against the air. Sharks swing their tail fins from side to side and up and down to push against water.

### Forces that Move Things

<b>Cheetahs</b>	feet and legs push hard against the ground to move forward
<b>Sharks</b>	swing tail fins to push against the water
<b>Condors</b>	flap open wings against the air

**Read the paragraph. Complete the graphic organizer.**

Here are some different examples of friction. A parachute slows the fall of a jumper when its sail causes air resistance as it falls. Water skiers feel resistance when they get pulled through the water by a motor boat. The friction of a match rubbing against a rough strip on the box causes enough heat to make the match ignite.

<b>Friction</b>	Example:
<b>Water Resistance</b>	Example:
<b>Air Resistance</b>	Example:

# Identify Cause and Effect

## TRY THE SKILL

To find the connection between what happened and why it happened, look for words such as *because, so, makes, causes, that's why,* and *comes from*.

**Read these paragraphs and look for words that show what happened and why it happened.**

Smooth, rounded shapes move through the air more easily than flat or rough surfaces. That's because these shapes have fewer places for air or water to bump up against and slow it down.

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

The difference is, matter will slow down or stop if it bumps against other matter that is going in another direction. When this happens, it is a collision.

**Write the letter of the phrase that can complete each sentence correctly.**

- that's why it is easier to move.
- which makes it more slippery.
- because the friction of the air heats it as it falls through the atmosphere.
- so a dolphin can swim very quickly through the ocean.
- come from a mineral called magnetite.
- which makes the force of gravity stronger there.

- Meteorites burn up as they fall to Earth . . . \_\_\_\_
- Wheels put less of the object in contact with the floor, . . . \_\_\_\_
- Magnets can be found in nature and . . . \_\_\_\_
- Ice has a smoother surface than the road, . . . \_\_\_\_
- Water travels easily over rounded surfaces . . . \_\_\_\_
- Jupiter is a planet that has more mass than Earth, . . . \_\_\_\_

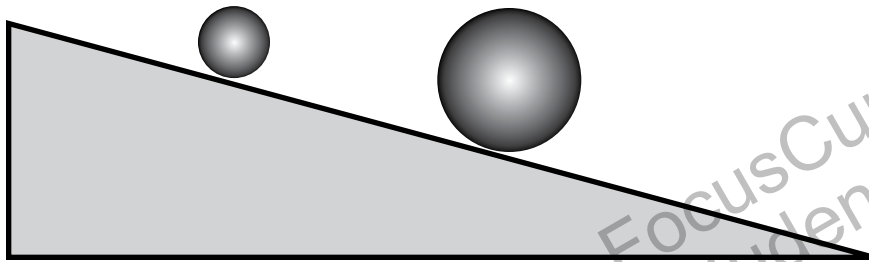


# Make Inferences

## TRY THE SKILL

Making inferences can help you understand information that is not stated directly in the text. The key is using clues and reasoning, like a detective, to gain deeper meaning of the text.

**Read the question below and make an inference.**



1. Which ball do you think would be harder to stop as it travels downhill?  
Ⓐ the large ball  
Ⓑ the small ball  
Ⓒ no difference

Since the ball on the right is larger, it probably has more mass. Since it is ahead of the smaller ball, it is probably going faster, too. Both of those things would make it harder to stop than the smaller ball. The correct answer would be A.

**Read the paragraph. Shade the circle next to the correct answer. Then explain why you chose that answer.**

### Galileo Galilei (1564-1642)

Galilei discovered and proved rules about how falling objects are affected by gravity. He noticed that falling things get faster as they fall, and that they all speed up at the same rate. Galileo also was the first to use a telescope to learn about planets, moons, and stars.

1. Why weren't ancient scientists before Galileo able to learn about the moons of Jupiter?  
Ⓐ Earlier scientists were not as lucky.  
Ⓑ Earlier scientists were not as patient as Galileo.  
Ⓒ Earlier scientists did not have telescopes.

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# Summarize Main Idea

## TRY THE SKILL

Summarizing means retelling the main idea of what you have read. Summarizing helps you understand what you read.

**Read this paragraph and try summarizing it.**

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 use to make magnets. Magnets make a strong pull on metals such as iron and steel.

**Is this a good summary?**

Ancient China and Greece were full of magnets.

**No! There is no evidence that the statement is true. We only know that there were magnets in these places. Also, the paragraph discusses other topics not mentioned in this summary. Is this a good summary?**

Magnets make a strong pull on metals such as iron and steel.

**Yes! This is the main idea of the paragraph.**

**Read these paragraphs. Then shade in the circle next to the best summary.**

1. The size and shape of an object can change the amount of friction it creates as it moves through air or water. Smooth, rounded shapes move through the air more easily than flat or rough surfaces. That's because these shapes have fewer places for air or water to bump up against and slow it down.
  - Ⓐ Smooth, rounded shapes move through the air easily.
  - Ⓑ Size and shape can affect friction.
  - Ⓒ Water cools down as things move in it.
2. All of this falling 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. It may sound funny to say, but Earth is the biggest thing in our world. Its gravity is so strong that it pulls everything on it toward its center.
  - Ⓐ Earth is the biggest thing in the world.
  - Ⓑ Gravity is caused by the pull of matter on matter.
  - Ⓒ The cause of falling to Earth is gravity.

# Answer Key

## Graphic Organizers

### Friction

Example: match struck against the box

### Water Resistance

Example: water skiers pulled by a boat

### Air Resistance

Example: a parachute sail slowing the fall of a jumper

## Identify Cause and Effect

1. C
2. A
3. E
4. B
5. D
6. F

## Make Inferences

1. C

## Summarize Main Idea

1. B
2. B

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