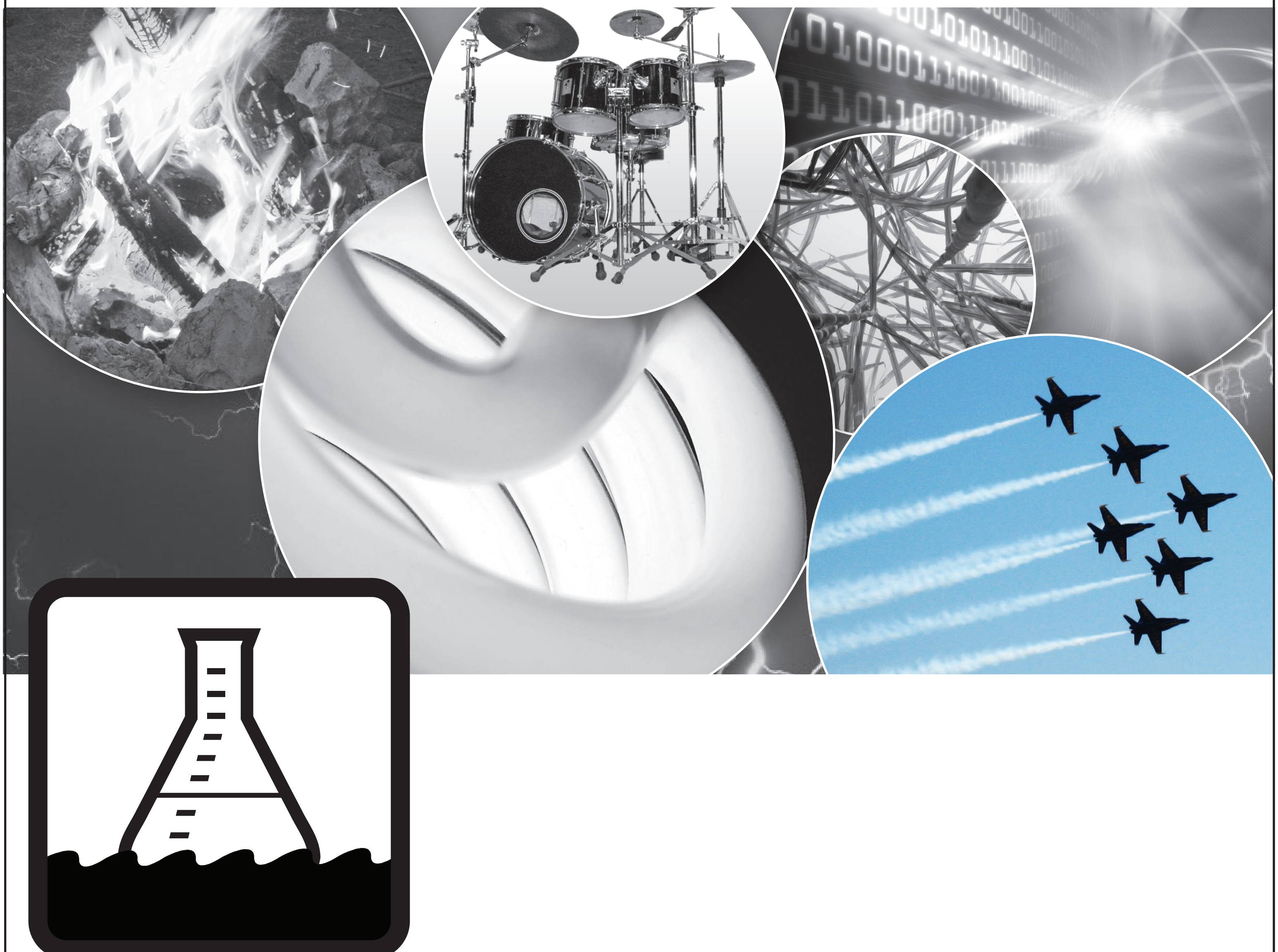
# EnergyWorks

## Student Guide

2017-2018



NEED
National Energy Education Development Project

**ELEMENTARY AND INTERMEDIATE**

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# EnergyWorks

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# Heat and Energy

**Energy** is a part of everything we do and see.

Heat and light are energy.

Energy helps us move and grow.

Energy makes machines work.

There is energy in everything in the world—in the air, in our bodies, in every rock and plant.

We use heat, called **thermal energy**, every day. We can't see heat, but we can feel it. Our bodies make heat and our stoves and lights do, too. We heat our houses, our food, and our water.

Sometimes there is too much heat and we move it. Refrigerators take heat away from the food inside. Air conditioners take heat from inside the house and move it outside. Swimming pools take heat from our bodies.

## Heat Is the Motion of Molecules

What is heat? Scientists say it is the **kinetic energy** in a substance. Kinetic energy is the energy of motion. Heat is the motion of the molecules in a substance, not the motion of the substance itself.

Everything is made of **atoms**. Atoms bond together to form molecules. **Molecules** are the building blocks of substances. Water is a substance. Have you ever heard water called H-2-O ($H_2O$)? That means a molecule of water has two hydrogen (H) atoms and one oxygen (O) atom.

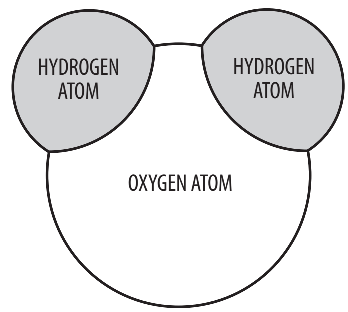
Even though we can't see them, the molecules in substances are never still. They are always moving. That motion is the kinetic energy called heat.

## Molecules Vibrate, Spin, and Move

The molecules in solids—like rocks, wood, or ice—cannot move much at all. They are held in one position and cannot flow through the substance. They do move back and forth in their positions. They vibrate. The more heat they have, the faster they vibrate.

**Liquids** and **gases** are called **fluids**. The molecules in fluids move more freely than in **solids**. They flow through the fluids. The more heat fluids have, the faster their molecules move.

### Water Molecule

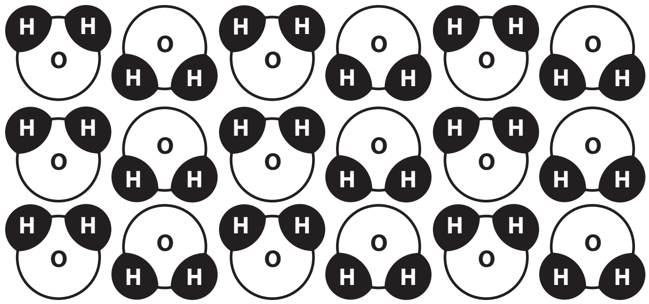



What happens when you heat an ice cube? Ice is a solid. A solid has a definite shape. Its molecules vibrate in one position. When you add heat, the molecules vibrate faster and faster. They push against each other with more force. They become a liquid—water. The molecules begin to move and spin. They are still bonded together, but not so tightly that they stay in one position.

A liquid flows to take the shape of its container. It has a definite volume, but can take any shape. **Volume** is the amount of space a fluid occupies.

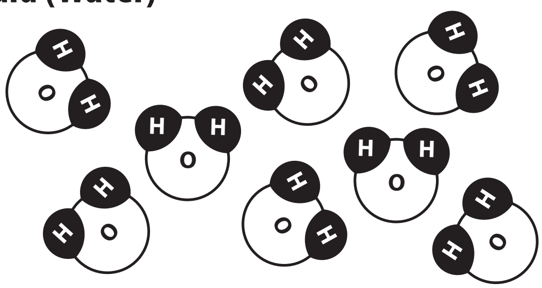
If you add more heat energy to the molecules, they move faster and faster. They crash into each other and move away. They become a gas—steam. A gas does not have a definite shape or volume. It spreads out and fills whatever space it is in.

## Solid (Ice)



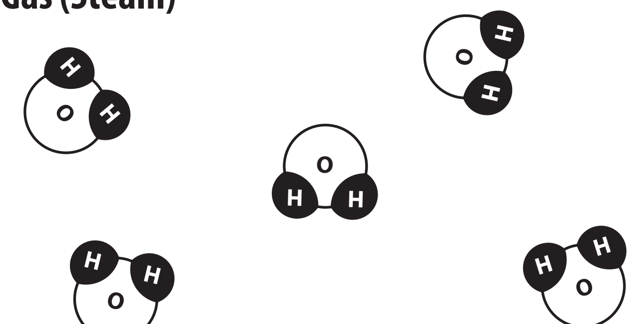
Molecules vibrate in one place.

## Liquid (Water)



Molecules spin and move close together.

## Gas (Steam)



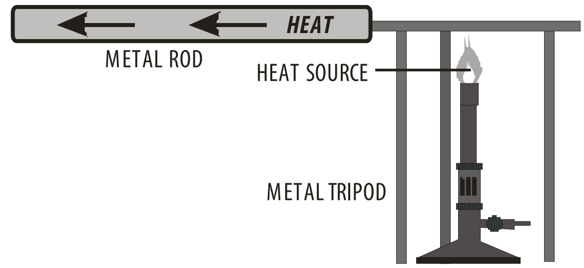
Molecules spin faster and move far away from each other.

## Heat Seeks Balance

Everything in nature seeks balance. Heat seeks balance, too. Heat flows from hotter places to colder places and from hotter substances to colder substances. What happens if you pour hot water into a cold tub? The molecules of hot water have more energy. They are fast moving. They crash into the colder molecules and give them some of their energy.

The molecules of hot water slow down. The molecules of cold water move more quickly. The cold water gets warmer. The hot water gets cooler. Soon all the water is the same temperature. All the water molecules are moving at the same speed. The heat in the water is in balance.

## Conduction in Solids




## Heat Energy Moves

Heat energy is always on the move. It moves to seek balance. Heat can move in many ways. When a hot object touches a cold object, some of the heat energy flows to the cold object. This is called conduction. **Conduction** is the way heat energy moves in solids.

When we cook food in a pan on an electric stove, we use conduction. The heating element on the stove is hot. The pan is cold. Some of the heat from the heating element flows to the pan. The heat from the pan flows to the food inside. The heat moves by conduction.

### Heat Moves by Conduction in Solids

How does the heat move? Let's think about it. All solids are made of molecules. The molecules in solids vibrate. The more energy they have, the faster they vibrate. In a hot object, the molecules vibrate fast. The molecules in a cold object vibrate more slowly.

Let's touch a hot object to a cold object. The fast-moving molecules in the hot object push against the slow-moving molecules in the cold object. The fast molecules give up some energy to the slower moving molecules. The vibration of the fast molecules slows down.

The molecules in the cold object gain some energy from the hot object. They vibrate faster. The cold object gets warmer. The hot object gets cooler. The energy in the molecules is seeking balance. When the energy is in balance, all the molecules vibrate at the same speed.

Look at the picture at the top of this page. The flame adds heat to the tripod. The tripod gets very hot because it is metal. The metal rod touches the tripod. The molecules in the tripod vibrate against the molecules in the end of the rod. The molecules in that end of the rod vibrate faster.

Now one end of the rod has more energy than the other end. What happens? The hotter molecules transfer some of their energy to the cooler molecules. The molecules in the rod conduct the heat from the hotter end to the cooler end. The heat moves from the tripod to the end of the rod touching it, then through the rod.

The energy flows from molecule to molecule as they vibrate against each other. Heat is moving by conduction.

## Conductors and Insulators

In some materials, heat flows easily from molecule to molecule. These materials are called **conductors**. They conduct—or move—heat energy well.

Look back at the picture with the metal rod and the tripod. You would not hold the metal rod with your bare hand. You would get burned! The metal would conduct the heat to your hand. Metals are good conductors of heat.

If you touched a wooden pencil to the tripod, would it conduct heat as well as the metal rod? No—wood is not a good conductor of heat. Materials that don't conduct heat well are called **insulators**.

The molecules in good conductors are close together. There is very little space between them. When they vibrate, they push against the molecules near them. The energy flows between them easily.

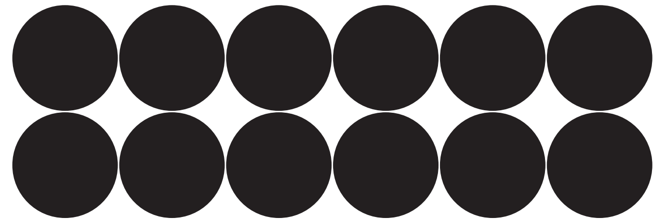
The molecules in insulators are not so close together. It is harder for energy to flow from one molecule to another in insulators.

Look at the objects to the right. The pot, the spoon, and the fork are made of metal. The pot and the fork have plastic handles. The dish is made of glass. The oven mitt is made of cotton fabric.

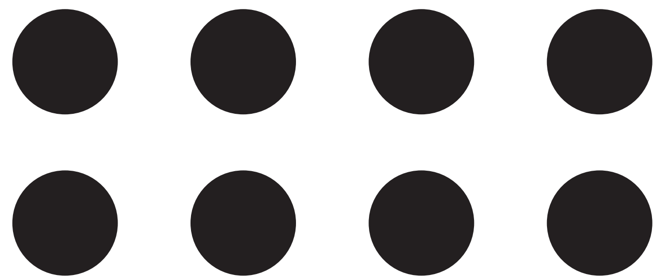
Which materials are the insulators? The insulators are the materials that don't move heat. They protect us from heat. Our experience tells us that wood, plastic, and cotton are all good insulators. Metals are good conductors. The metal part of the pan moves heat to the food inside to cook the food. The plastic handle protects our hands. The cotton glove protects our hands, too.

What about glass? It is not as good of a conductor or insulator as the other materials. It is used to conduct heat in pots and pans, and can also be used to insulate. It used to be used on power and telephone lines as an insulator.

### Good Conductor



### Good Insulator



### Conductors and Insulators

## Movement of Heat in Fluids

Fluids are liquids and gases. Heat also moves in fluids. Heat doesn't move by conduction. In fluids, the molecules are too far apart to conduct energy as they vibrate. The molecules in fluids are free to move and spin. As they move, they bounce against each other. The molecules with more energy give up some energy. The molecules with less energy gain some.

Heat energy in liquids and gases moves in currents by **convection**.

If we heat water on a stove, the water molecules begin to move and flow faster. The molecules near the flame have more energy. They push against each other and move farther apart.

The water at the top of the pan is cooler. Its molecules don't have as much energy. They are closer together than the molecules of hot water. They are denser.

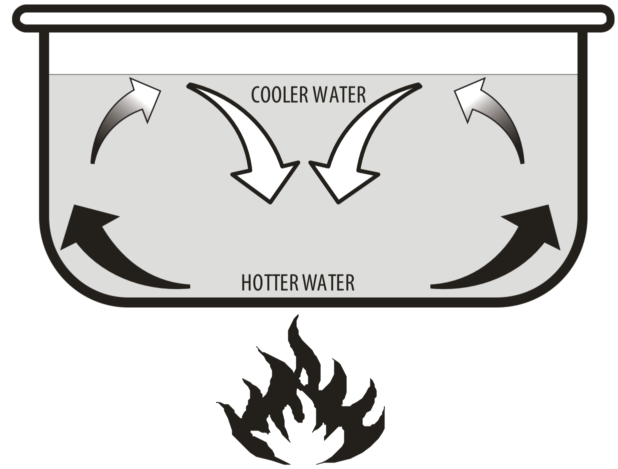
The cooler, denser molecules flow down. The warmer, less dense molecules rise up. They form currents of flowing molecules. During this motion, the hotter molecules transfer energy to the cooler molecules. This transfer of heat through the motion of currents is called convection.

Heat also moves by convection in gases. Air is the gas you know best. You may have noticed that the top floor of a building is warmer than the basement. The air near the ceiling is warmer than the air near the floor.

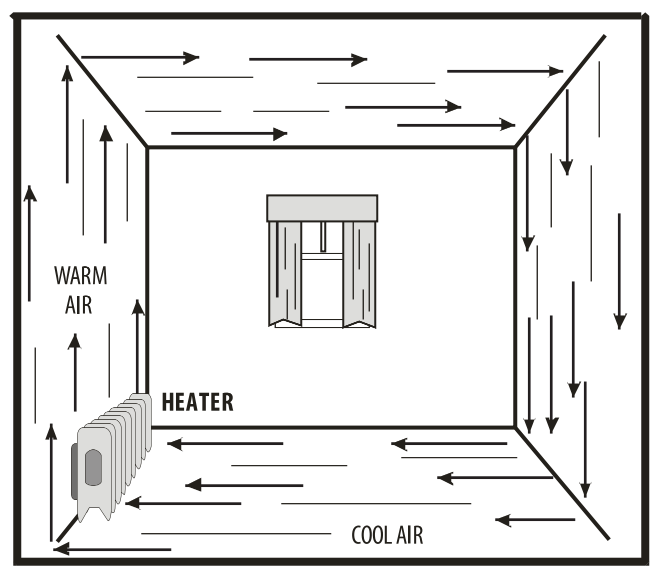
The molecules of gases are like molecules in liquids. The more energy they have, the farther apart they are. In a room, the cooler, denser air flows down. The warmer, lighter air rises. A current of flowing air is formed.

The warmer molecules give up energy as they bounce against cooler molecules. They give up some energy, become cooler, and flow down again. The heat is transferred by convection.

### Convection in Liquids




### Convection in Gases



## Wind Is a Convection Current

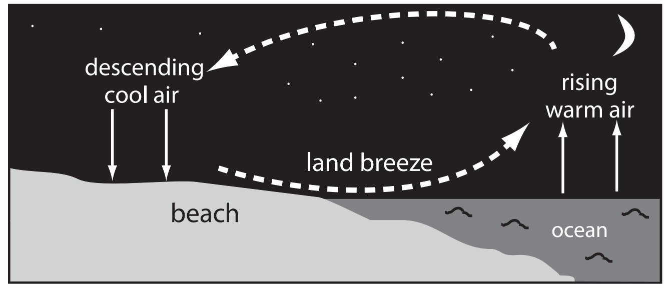
Heat moves all the time—all over the world. Even the wind is energy in motion.

When the sun shines on the Earth, the land gets warmer than the oceans. Land can absorb more energy from the sun faster than water. It changes the radiant energy into heat.

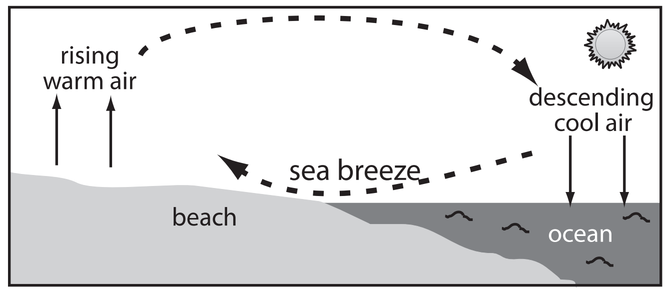
This makes the air over the land warmer than the air over the ocean. The warm air rises. The cooler air over the ocean flows in to take its place. The air flows in currents. The heat in the air is transferred by convection. This moving air is the **wind**.

The ocean is a fluid similar to air. Ocean waters have currents, too. The water near the Equator is warmed by the sun. The water near the poles is cold. The warm water rises to the surface. The cold water flows in to take its place. Ocean currents are formed by convection.

### Land Breeze




### Sea Breeze




## Energy Moves by Radiation

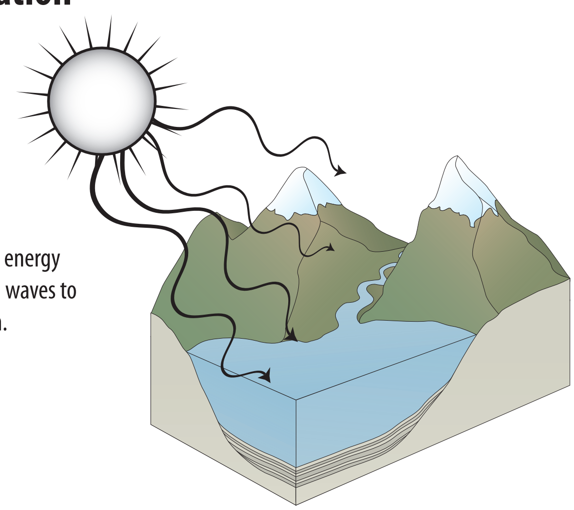
Most of the Earth's energy comes from the sun. Every day, the sun gives off a lot of energy. It comes from the sun in rays or waves. It is called **radiant energy**.

Energy does not travel from the sun as heat. Heat must move from molecule to molecule and there are no molecules in space. Solar energy travels in rays or waves as radiant energy.

When the radiant energy reaches the Earth, it hits molecules in the air, in the ocean, and on land. It hits our bodies. The molecules turn some of the radiant energy into heat.

The energy from the sun that we can see is visible light. Other kinds of radiant energy are ultraviolet rays, infrared **radiation**, and microwaves. Infrared radiation produces most of the heat on the Earth.

### Radiation



The sun's energy travels in waves to the Earth.

## Heat and Temperature

Heat and **temperature** are different things. Two cups of boiling water would have twice as much heat as one cup of boiling water, but the water would be at the same temperature.

A giant iceberg would have more heat energy than a cup of boiling water, even though its temperature is lower. It would have more heat energy because it is so big.

Heat is the total amount of kinetic energy in a substance. Temperature is a measure of the average kinetic energy of the molecules in a substance. Temperature is also described as a measure of the hotness or coldness of a substance.

Think about a pan in a hot oven. The pan and the air in the oven are the same temperature. You can put your hand into the oven without getting burned. You can't touch the pan. The pan has more heat energy than the air, even though it is the same temperature. The pan can transfer heat at a faster rate to your hand. The air is a better insulator than the pan.

### We Can Measure Temperature

We use thermometers to measure temperature. Thermometers can measure temperature using different scales. In the United States, we usually use the Fahrenheit (F) scale in our daily lives. Scientists usually use the Celsius (C) scale, as do people in most other countries.

On the Fahrenheit scale, the **boiling point** of water is 212 degrees. The **freezing point** of water is 32 degrees. On the Celsius scale, the boiling point of water is 100 degrees. The freezing point of water is 0 degrees.

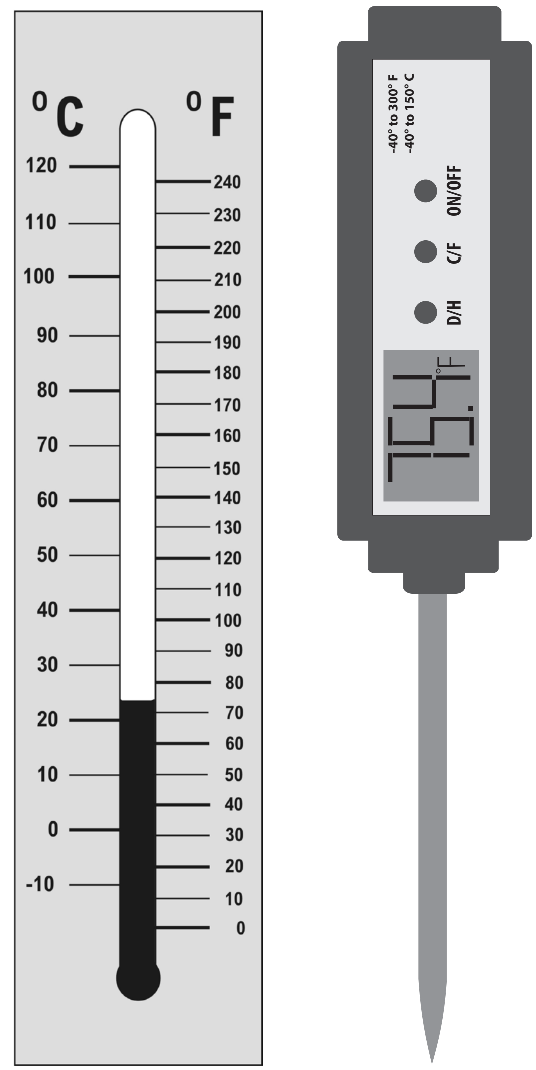
### Thermometers

There are many kinds of thermometers. Some have only one scale. Others have both Celsius and Fahrenheit scales.

In the diagram on the right, the thermometer on the left shows both scales. It is a long glass tube filled with colored alcohol. The alcohol expands—gets bigger—when it has more heat energy. It contracts—gets smaller—when it has less heat energy.

The thermometer on the right is digital. It does not have alcohol in it. It has a tiny computer chip and a battery. By pushing a button, it can measure the temperature on either the Fahrenheit or Celsius scale.

### Thermometers



## Expansion and Contraction

Why does the alcohol in a thermometer **expand** and **contract**? The alcohol is a liquid. Its molecules move and spin. When heat energy is added, its molecules move faster. They push apart from each other. The space between the molecules gets bigger. The alcohol in the tube expands.

The molecules don't get bigger, the space between them does. When heat energy is taken away, the molecules slow down. They move closer together. The alcohol contracts. The molecules don't get smaller—the space between them does.

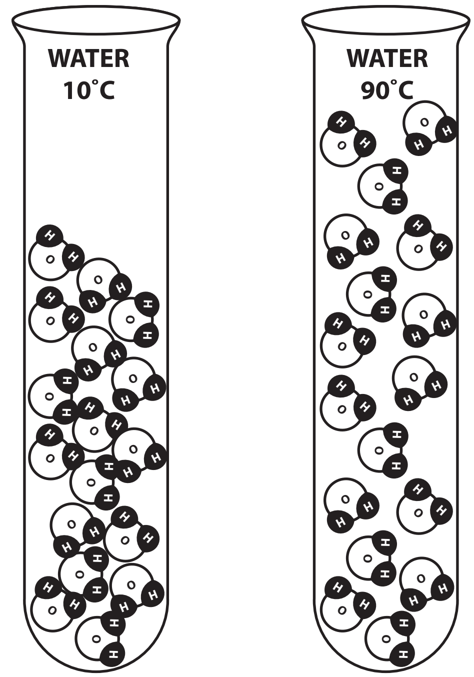
## Solids, Liquids, and Gases

All substances expand when they are heated. Some expand a little; some expand a lot. They all expand at different rates.

Solids expand a little when they are heated. The molecules in solids have strong bonds. They are held tightly in one position. They cannot move around—they can only vibrate. When heat energy is added, they vibrate faster. They push against each other with more energy. The space between them gets a little bigger. But they are still held in position.

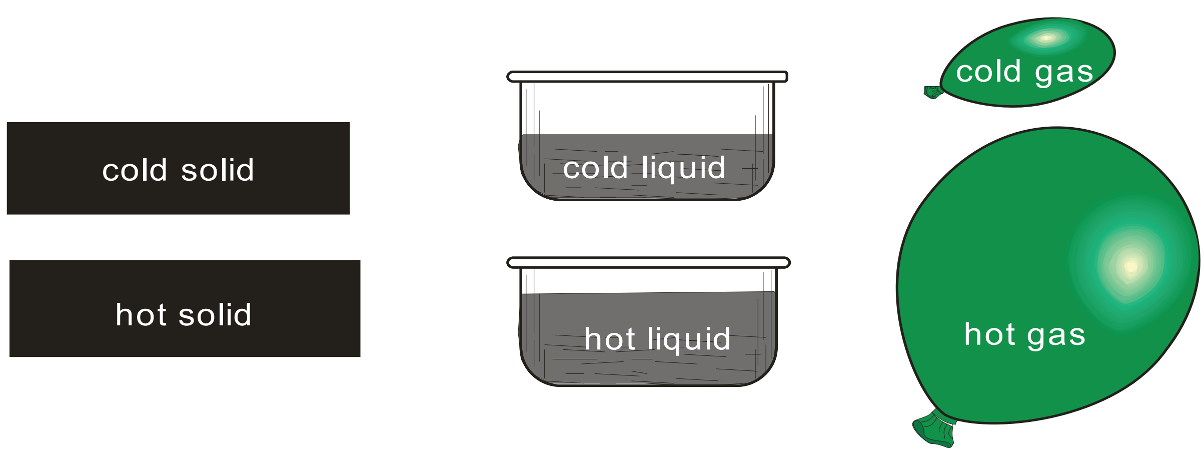
Have you ever seen doors that are hard to open in the summer? They have expanded because of the heat. Sidewalks are made with cracks so that the concrete can expand in the summer heat. Without the cracks, the sidewalks would swell and break. Bridges have spaces, too.

### Molecular Expansion




The same molecules of water take up more space when they are hotter.

### Expansion with Heat Energy



# Key Words—Heat

**Directions: Use each key word in one of the sentences below.**

| | | | | |
|---|---|---|---|---|
| **boiling point** | **contracts** | **freezing point** | **kinetic energy** | **radiation** |
| **conduction** | **convection** | **gas** | **liquid** | **solid** |
| **conductor** | **expand** | **insulator** | **molecules** | **temperature** |

1. ______________________________ is the energy of motion.
2. Heat energy moving in currents is called ____________________________ .
3. The molecules move fast and far apart in a(n) ___________________________ .
4. The temperature at which a liquid turns into a gas is called its ________________________ .
5. Adding heat to a substance makes it get bigger or ____________________________ .
6. _________________________ is the average kinetic energy of the molecules in a substance.
7. Energy from the sun moving in waves or rays is called ___________________________ .
8. The molecules of a(n) _________________________ vibrate in one position. They can't spin.
9. A substance that doesn't conduct heat well is called a(n) ________________________ .
10. Heat energy moving between two touching objects is called ______________________ .
11. The temperature at which a liquid turns into a solid is called its ________________________ .
12. The building blocks of substances are called _______________________ .
13. When a substance gets smaller as it loses heat energy, it __________________________ .
14. A substance that moves heat energy well is called a(n) ____________________________ .
15. The molecules flow and vibrate close together in a(n) _____________________________ .

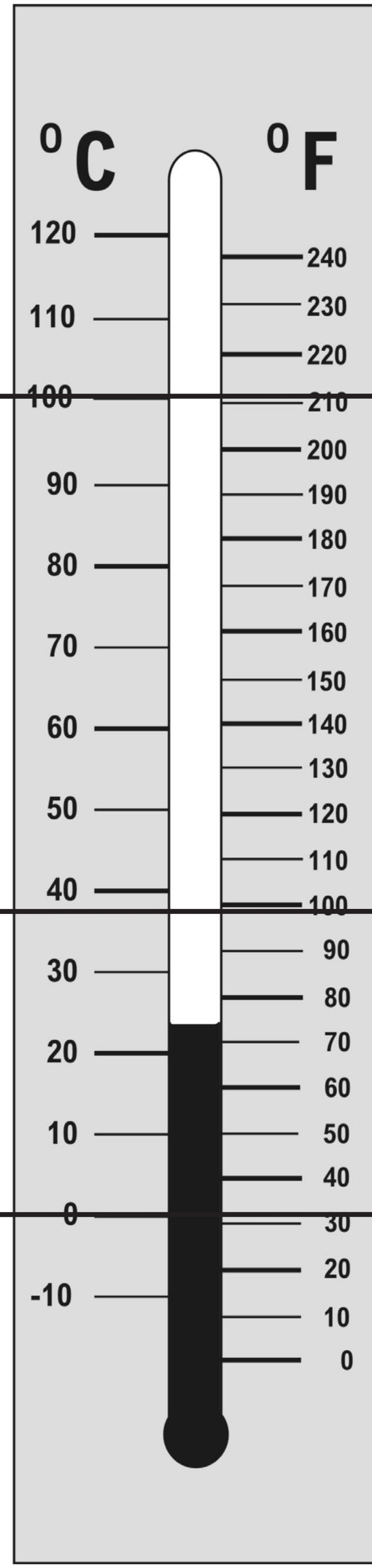
# Thermometer

A thermometer measures temperature. This thermometer measures temperature on both the Celsius and Fahrenheit scales.

Water Boils C F

Human Body C F

Water Freezes C F




We drew lines across the thermometer to show three temperature readings. Read both scales of the thermometer and write the temperature in the blank spaces on the lines.

Now, draw lines across the thermometer that show what you think the temperature is in the classroom, the temperature outside, and the temperature of the water in the drinking fountain. How can you check your predictions? Try it!

# Exploring Heat Transfer 1

***HEAT MODULE ONE***

## Question

In liquids, does heat move in predictable ways?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 1-1,000 mL Pitcher
- 2-500 mL Pitchers
- 1 Thermometer
- Colored pencils
- Cold and warm water, 250 mL each

**NOTE**

When the procedure calls for:

**cold water**, use water between 7-13°C or 45-55°F

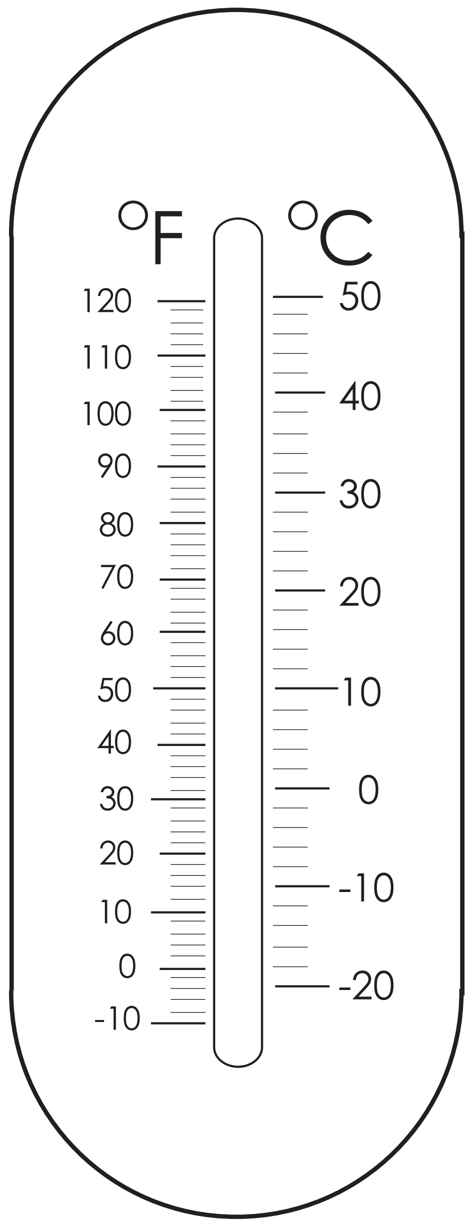
**ice water**, use water <7°C or <45°F

**warm water**, use water between 43-49°C or 110-120°F

**hot water**, use water just under boiling (the teacher should handle the container for hot water)

## Procedure

1. Fill one 500 mL pitcher with 250 mL cold water and record the temperature in Celsius and Fahrenheit in your science notebook.
2. Use a blue pencil to record the temperature of the cold water by drawing a line on the picture of the thermometer.
3. Fill one 500 mL pitcher with 250 mL warm water and record the temperature in Celsius and Fahrenheit in your science notebook.
4. Use a red pencil to record the temperature of the warm water on the picture.
5. Pour the warm water and the cold water into the 1,000 mL pitcher.
6. Estimate the temperature of the mixture by drawing a black line on the picture.
7. Measure the temperature of the mixture in Celsius *and* Fahrenheit and record it in your science notebook.
8. Record the temperature on the picture with a purple pencil. Was your estimate correct?




## Observations and Data

Record observations and data in your science notebook.

## Conclusion

1. Did the amount of heat lost by the warm water equal the amount of heat gained by the cold water? How can you tell? Find the average of the two temperatures to find out.
2. Did the heat move in predictable ways?

# Exploring Heat Transfer 2

***HEAT MODULE ONE***

## Question

In liquids, does heat move in predictable ways?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 2-1,000 mL Pitchers
- 1-500 mL Pitcher
- 1 Thermometer
- Colored pencils
- 500 mL Cold and 250 mL warm water

## ✔ Procedure

1. Put 500 mL of cold water in one 1,000 mL pitcher and record the temperature in Celsius and Fahrenheit in your science notebook.
2. Use a blue pencil to record the temperature of the cold water by drawing a line on the picture of the thermometer.
3. Fill a 500 mL pitcher with 250 mL warm water and record the temperature in Celsius and Fahrenheit in your science notebook.
4. Use a red pencil to record the temperature of the warm water on the picture.
5. Mix the 500 mL of cold water and 250 mL of warm water in the other 1,000 mL pitcher.
6. Estimate the temperature of the mixture by drawing a black line on the picture.
7. Measure the temperature of the mixture and record the temperature in Celsius and Fahrenheit in your science notebook.
8. Record the temperature on the picture with a purple pencil. Was your estimation correct?

## Observations and Data

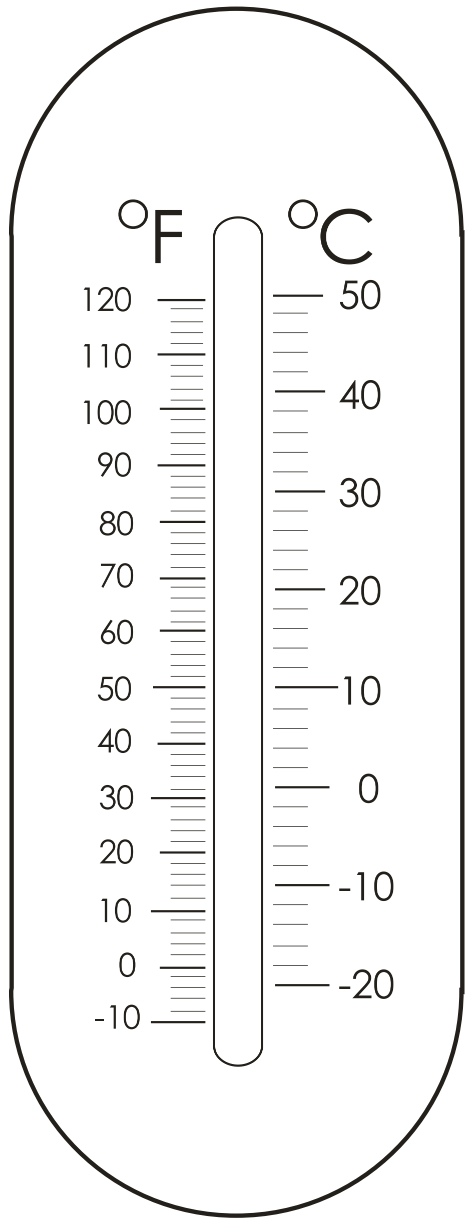
Record observations and data in your science notebook.

## Conclusion

1. Did the amount of heat energy lost by the warm water equal the amount of heat energy gained by the cold water?
2. What do you think the temperature of the mixture would be if you mixed 500 mL of warm water with 250 mL of cold water?

**NOTE**

When the procedure calls for:
**cold water**, use water between 7-13°C or 45-55°F
**ice water**, use water <7°C or <45°F
**warm water**, use water between 43-49°C or 110-120°F
**hot water**, use water just under boiling (the teacher should handle the container for hot water)



# Exploring Heat Transfer 3

*HEAT MODULE ONE*

## Question

In liquids, does heat move in predictable ways?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

**NOTE**

When the procedure calls for:

**cold water**, use water between 7-13°C or 45-55°F

**ice water**, use water <7°C or <45°F

**warm water**, use water between 43-49°C or 110-120°F

**hot water**, use water just under boiling (the teacher should handle the container for hot water)

## Materials

- 1 Wallpaper pan
- 2 Thermometers
- 2-500 mL Pitchers
- 500 mL Cold water
- 500 mL Warm water
- Room temperature water
- Metric ruler

## Procedure

1. Fill the wallpaper pan to a depth of 2 cm with room temperature water. Place a thermometer at each end of the pan and record the temperature in Celsius and Fahrenheit in your science notebook.
2. Fill one pitcher with 500 mL warm water and one pitcher with 500 mL cold water. Measure and record the temperatures of the cold water and the warm water in Celsius and Fahrenheit in your science notebook.
3. Pour 500 mL of cold water into one end of the pan and 500 mL of warm water into the other end. Immediately record the temperatures at both ends in Celsius and Fahrenheit in your science notebook.
4. Wait two minutes and record the temperature again at both ends of the pan. Record the temperatures in Celsius and Fahrenheit in your science notebook.

## Observations and Data

Record observations and data in your science notebook.

## Conclusion

1. Explain the evidence you have that supports heat from the warm water flowed to the cooler end.
2. Where have you observed this phenomenon?

# Conductors and Insulators

***HEAT MODULE TWO***

## Question

How does the material a cup is made of affect the transfer of heat?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

**NOTE**
When the procedure calls for:
**cold water**, use water between 7-13°C or 45-55°F
**ice water**, use water <7°C or <45°F
**warm water**, use water between 43-49°C or 110-120°F
**hot water**, use water just under boiling (the teacher should handle the container for hot water)

## Materials

- 1 Plastic cup
- 1 Foam cup
- 1 Metal cup
- 1 Paper cup
- 4 Digital thermometers
- 4 Rubber bands
- Plastic wrap
- Stopwatch or clock with second hand
- Ice water
- Hot water

## Procedure

1. Create the table below in your science notebook once for the ice water, once for the hot water.
2. Using a rubber band, attach a thermometer to the outside of each cup.
3. Fill each cup with the same amount of ice water.
4. Cover each cup with plastic wrap.
5. In 30 second intervals, record the temperature of each cup for a total of three minutes.
6. Calculate the change in temperature (ΔT) for each type of cup.
7. Repeat steps 3-6 with hot water.

## Observations and Data

| Material | 0 sec | 30 sec | 60 sec | 90 sec | 120 sec | 150 sec | 180 sec | Δ T (ºC) |
|---|---|---|---|---|---|---|---|---|
| Plastic cup | | | | | | | | |
| Foam cup | | | | | | | | |
| Metal cup | | | | | | | | |
| Paper cup | | | | | | | | |

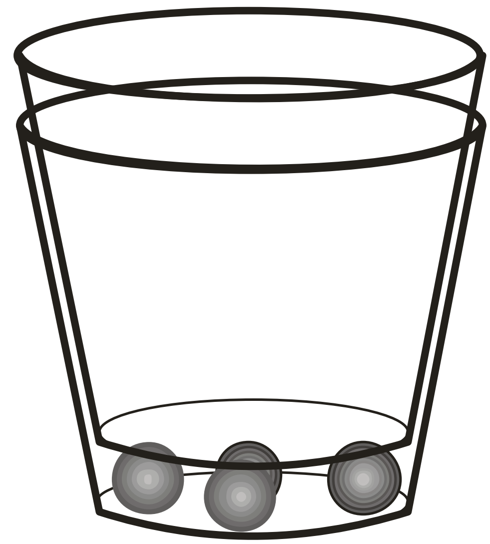
1. Use the data from the table to create a graph in your science notebook or use the graph paper on the following page.

## Conclusion

1. Which material had the greatest change in temperature? Is it a conductor or insulator?
2. Which cup would be the best for hot chocolate? Which would keep a drink cold the longest? Use data to support your answer.
3. What variables might have affected the results of your experiment?

# Exploring Heat in Solids, Liquids, and Gases 1

***HEAT MODULE THREE***



## Question

How does heat move through fluids?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 2 Clear plastic cups
- 4 Marbles
- Hot water
- Ice water
- Food coloring

## ✔ Procedure

1. Place the marbles in the bottom of one cup so they are evenly spaced around the cup's edge. Pour hot water in the cup until the water just covers the marbles.
2. Place the second cup inside the first one, resting on the marbles. The hot water in the first cup should touch the bottom of the second cup.
3. Fill the second cup almost to the top with ice water.
4. **Wait 15 seconds.** Carefully put one small drop of food coloring on top of the water.

**NOTE**

When the procedure calls for:
**cold water**, use water between 7-13°C or 45-55°F
**ice water**, use water <7°C or <45°F
**warm water**, use water between 43-49°C or 110-120°F
**hot water**, use water just under boiling (the teacher should handle the container for hot water)

## Observations and Data

Record your observations in your science notebook. Draw a diagram of the food coloring in the water. Use arrows to show the direction of movement.

## Conclusion

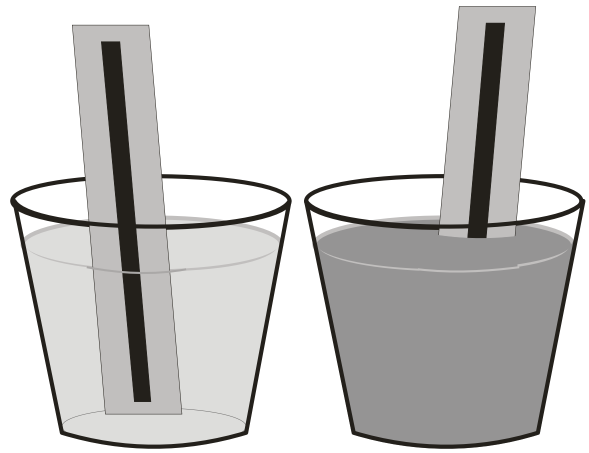
1. Look at your diagram. What did your investigation demonstrate?
2. Refer to your reading. Where else do we see heat move in this way?

# Exploring Heat in Solids, Liquids, and Gases 2

***HEAT MODULE THREE***

## Question

How does sunlight affect sand and water?



## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an"If... then... because..." format.

## Materials

- 2 Clear plastic cups
- 2 Thermometers
- Room temperature sand
- Room temperature water
- Sunny day or bright lamp

## Procedure

1. Create the table below in your science notebook.
2. Fill one cup with sand and place a thermometer in it. Record the starting temperature.
3. Fill the other cup with room temperature water and place a thermometer in it. Record the starting temperature.
4. Place the cups in the light source. Wait 10 minutes and record the temperatures of the water and sand. Wait another 10 minutes and record the temperatures again.
5. Let the cups stand away from the light for 10 minutes. Record the temperatures of the water and the sand on the chart.

**NOTE**

When the procedure calls for:

**cold water**, use water between 7-13°C or 45-55°F

**ice water**, use water <7°C or <45°F

**warm water**, use water between 43-49°C or 110-120°F

**hot water**, use water just under boiling (the teacher should handle the container for hot water)

## Observations and Data

| Materials | Starting Temperature | 10 Minutes | 20 Minutes | Temperature After Removed From Light |
|---|---|---|---|---|
| Sand | | | | |
| Water | | | | |

## Conclusion

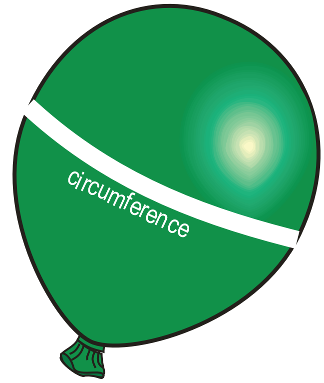
1. Which material had a greater increase in temperature? Why do you think this is?
2. From your reading of the text, how does this investigation show how wind is made?

# Exploring Heat in Solids, Liquids, and Gases 3

***HEAT MODULE THREE***

## Question

How does temperature affect air?




## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 1 Bowl of ice water
- 1 Bowl of hot water
- 1 Round balloon
- 1 Measuring tape
- 1 Thermometer

## Procedure

1. Create the table below in your science notebook.
2. Blow up the balloon about as big as a baseball and tie it. Let the balloon sit for a minute so that the air in the balloon is the temperature of the air in the room.
3. Using the measuring tape, measure the circumference of the balloon at its largest point. Circumference is the distance around an object. Measure the temperature of the room. Record the measurements in a table in your science notebook.
4. Put the balloon in the ice water for one minute. Measure the circumference of the balloon and the temperature of the water. Record the measurements.
5. Put the balloon in the hot water for one minute. Measure the circumference of the balloon and the temperature of the hot water. Record the measurements.

**NOTE**

When the procedure calls for:

**cold water**, use water between 7-13°C or 45-55°F

**ice water**, use water <7°C or <45°F

**warm water**, use water between 43-49°C or 110-120°F

**hot water**, use water just under boiling (the teacher should handle the container for hot water)

## Observations and Data

| Air Temp. | Balloon Circumference | Ice Water Temp. | Balloon Circumference | Hot Water Temp. | Balloon Circumference |
|---|---|---|---|---|---|
| | | | | | |

1. Use the data from the table to create a graph in your science notebook or use the graph paper on the following page.

## Conclusion

1. How did temperature affect the balloon? Use data to support your reasoning.
2. Draw a line through the points on your line graph, then extend the line as far as you can. Estimate the circumference of your balloon at 40°C and at 80°C.

# Light and Energy

We use light energy every day.

Without light, our lives would be very different.

Close your eyes and think about a world without light.

We use light energy for more than seeing.

The energy in light helps plants grow.

Doctors use special light to help in surgery.

We can also use light to make products and electricity.

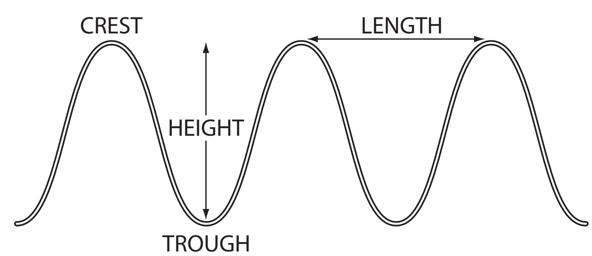
## Light Is Energy in Waves

What is light? Light is energy that travels in waves. All the energy we get from the sun travels in waves. Some of that energy is in light waves we can see—it is visible light. Some is in waves we can't see. We can't see infrared waves, but they can warm us when they touch our skin. We can't see ultraviolet waves, but they can burn our skin.

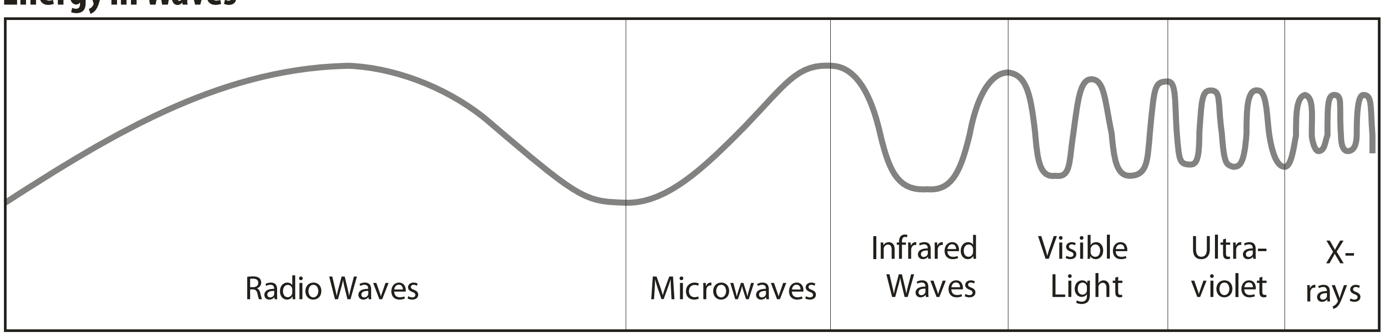
Some waves of energy—like radio waves—are very long. Radio waves can be a mile long. Other waves are very short—like light waves and x-rays. There are about 50,000 light waves in an inch.

We measure waves by the distance from the top, or **crest**, of one wave to the top of the next. This distance is called its **wavelength**. The shorter the wavelength, the more energy the wave has.

### Wave Measurements




### Energy in Waves



## Light Waves Travel in Straight Lines

Light waves travel in straight lines. They do not change direction unless they are reflected or refracted.

When light from the sun hits a tree, it cannot pass through it. It cannot go around the tree. The light is **reflected** and **absorbed** by the tree, and an area without light is made—a **shadow**.

Early Egyptians understood shadows. They knew the sun travels the same path in the sky everyday. They knew that shadows change as the sun moves across the sky. They used this knowledge to develop a tool to tell time—a sundial. They placed a stick in the ground. The position and length of the stick's shadow told the people the time.

### Shadows

## An Eclipse Is a Shadow

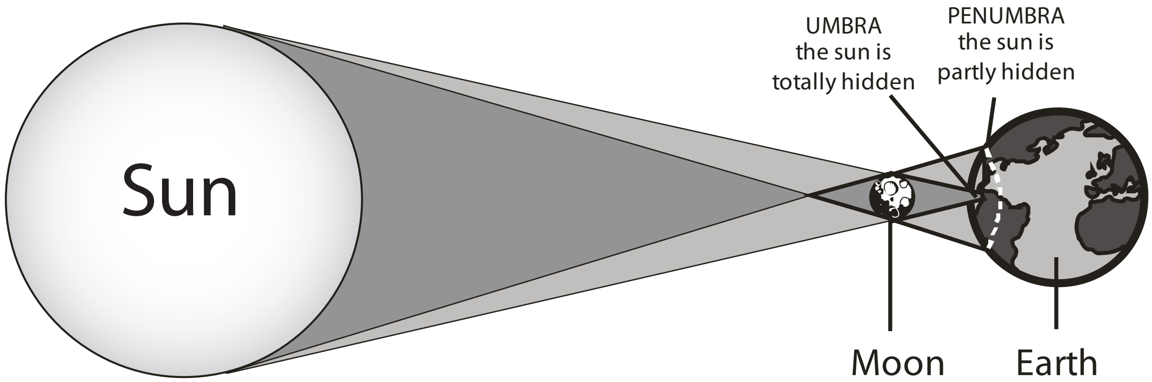
Sometimes the moon moves between the Earth and the sun. The sun's light cannot pass through the moon to reach the Earth. A large shadow covers the Earth. This is called a solar **eclipse**.

During an eclipse, some parts of the Earth get no light at all. They become as dark as night. This area is called the **umbra**. Some parts of the Earth get some light. They are in part shadow, part light. This area is called the **penumbra**.

## When Light Waves Hit Substances

Light waves travel in straight lines. When light waves hit something, three things can happen. The light wave can pass through **transparent** substances. This may cause the light wave to speed up or slow down. If a light wave changes speed, it will bend where the two substances meet. The bending of light waves as they travel from one substance to another is called **refraction**. Light waves can enter a substance and be absorbed. Plants absorb some light waves and convert them into sugars. Light waves can also bounce off a substance. When light bounces off a substance, this is called reflection. A mirror reflects light waves. Many substances absorb some light waves and reflect others.

### Eclipse



## Light Has Many Wavelengths

**Visible light**—the wave energy we can see—is made of many colors. Every color has a different wavelength. The longest wavelengths are reds. The medium wavelengths are yellows. The shortest wavelengths are violets. All of the colors mixed together make white light.

## A Prism Separates Light Waves

A **prism** is a piece of clear glass or plastic that bends light waves as they pass through it. A prism is often shaped like a triangle.

A prism can separate visible light into its different wavelengths. It can separate all of the colors that make up white light.

A prism bends—or refracts—light waves. The wavelengths of each color bend at a different angle. The light that goes into the prism spreads out as it leaves the prism.

Have you ever seen a rainbow? Rainbows are formed when the sun shines while it is raining. Drops of rain act like tiny prisms to bend the sunlight. The raindrops separate the light waves into colors.

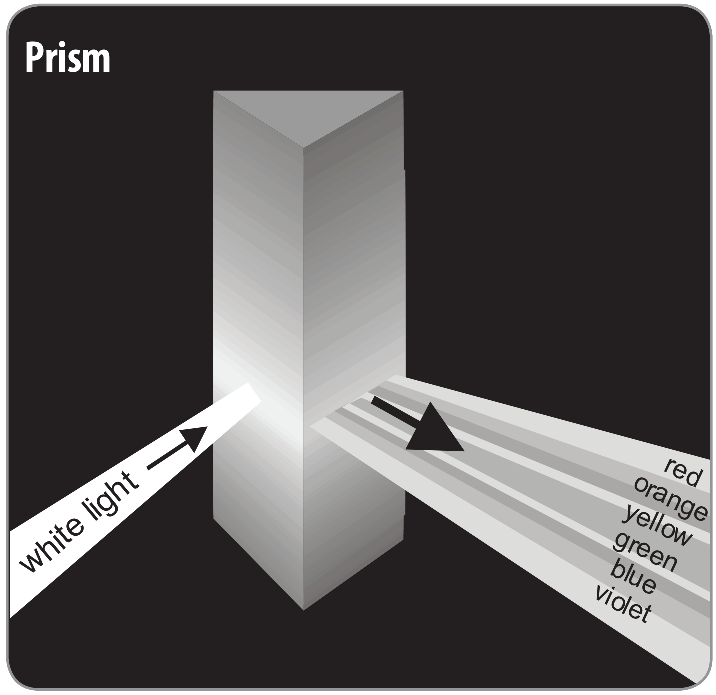
Light is refracted as it travels through water too. Light bends as it enters the water. Have you ever noticed that things look different in the bathtub or swimming pool? As the light waves enter and leave the water, they are refracted.

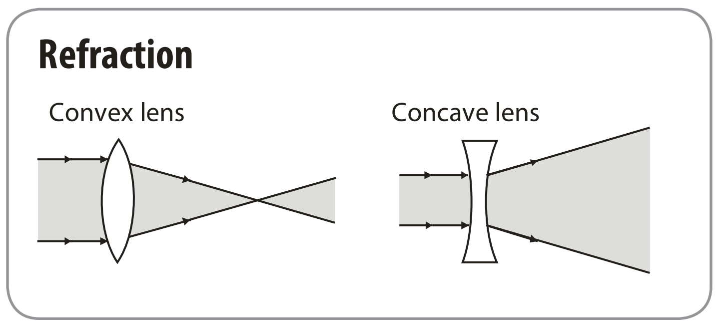
## We Can Bend Light With a Lens

We can use pieces of glass in different shapes—called lenses—to bend light.

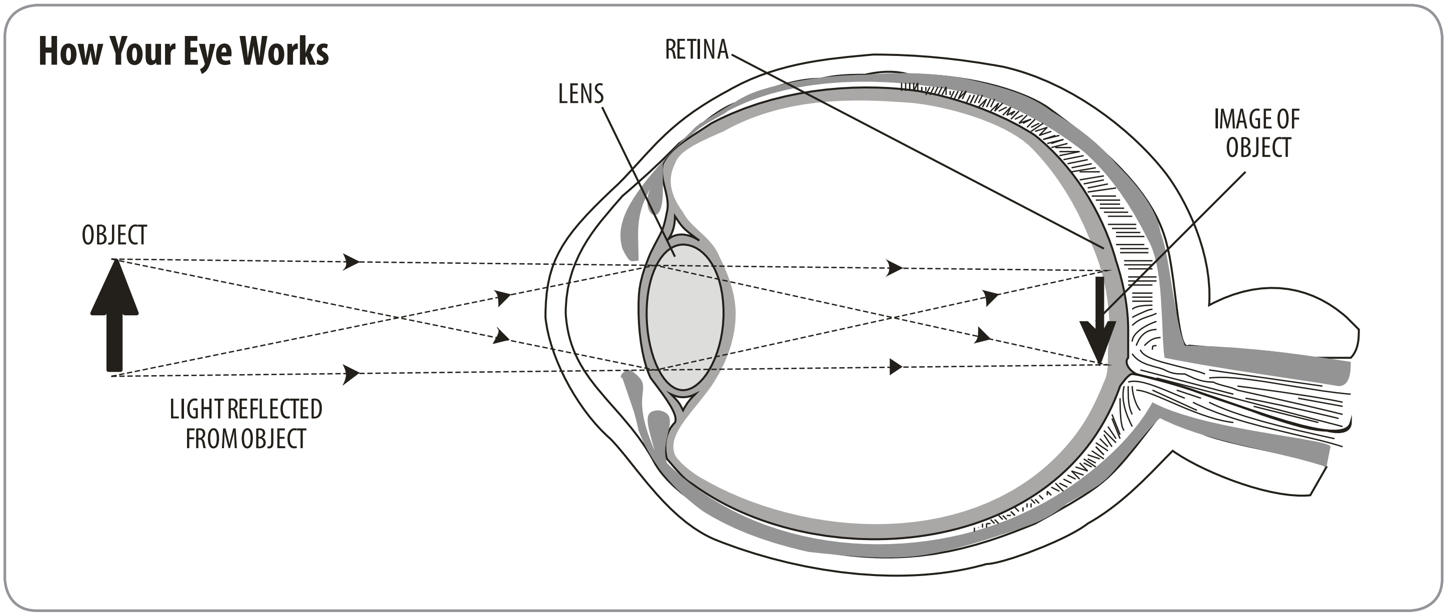
A **convex** lens is thicker in the middle than on the ends. It bends light waves toward a point. A convex lens can make objects look larger.

A **concave** lens is thinner in the middle than on the ends. It spreads out light waves that pass through it. A concave lens can make objects look smaller.




A magnifying glass is a convex lens.




## We Use Lenses Every Day to Refract Light

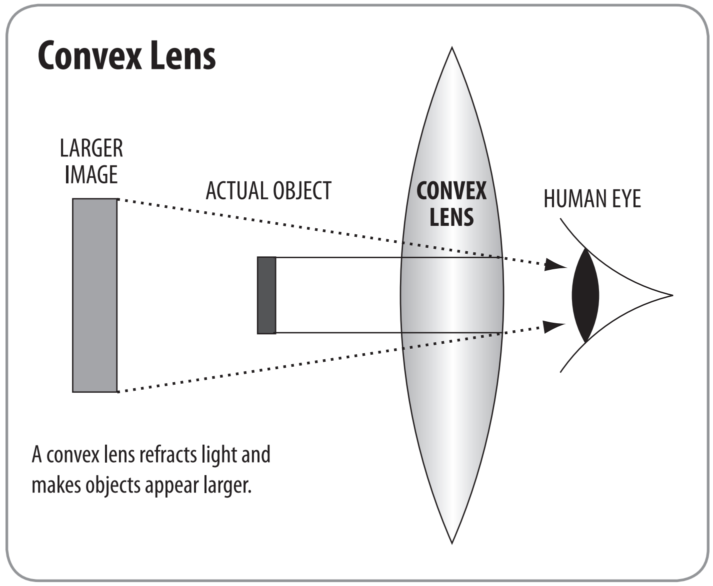
The human eye has a convex lens. The eye sees light waves bouncing off an object. The lens in the eye refracts the light waves as they pass through it. The light waves hit the retina in the back of the eye. The light waves make an **image** of the object on the retina. The image on the retina is upside down. When we are babies, our brains quickly learn to turn the images around. Otherwise, everything would look upside down.

If our eyes are not the right shape, we cannot see clearly. The image does not focus on the retina. It is blurry.

We can use lenses in eye glasses to help us see better. The lenses refract the light waves so that they focus the image on the retina. Contact lenses do the same thing.

A magnifying glass is a convex lens with a handle. Telescopes and microscopes have convex lenses, too. They can make small objects look larger or distant objects appear closer.

The picture to the right shows how a convex lens works. Light waves bounce off an object and bend as they pass through the lens. The eye sees the larger image shown by the dotted lines.




## Light Waves Can Be Reflected

How do we see things? We see the light waves that bounce off things—the light that is reflected by substances. When you look at your teacher, you are really seeing reflected light waves. Think about it. When there are no light waves, you can't see anything.

When you look in the mirror, the image you see is made by light waves. Light from all around you bounces off of you. Some of the light waves travel toward the mirror. The mirror reflects the light waves. Some of the light waves from the mirror travel toward your eyes. Your eyes see these reflected light waves.

**A disco ball is made of many mirrors that reflect light in different angles into a design on a dance floor.**

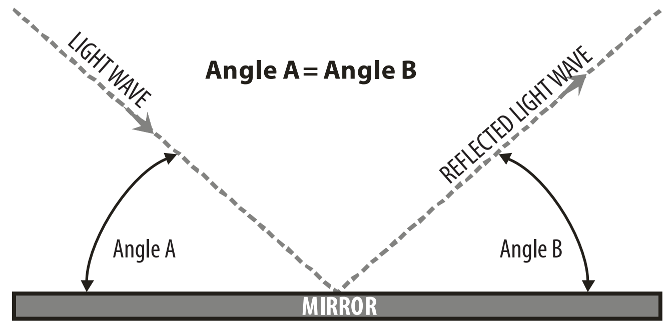
## Reflection of Light Is Predictable

Light waves don't just bounce around. They are reflected at **angles** we can predict. The reflection of light is a lot like bouncing a round ball on a smooth surface. If you drop the ball straight down, it will bounce straight back up. If you bounce the ball away from you, it will continue to move away from you in a straight line. It won't bounce to the left or right, or back toward you. It bounces away at the same angle you throw it.

Light waves reflect in the same way. Light waves travel in straight lines. When a light wave hits an object and reflects, it will reflect in a straight line. If the light wave hits an object at an angle, it will reflect at the same angle.

Look at the picture to the right. The light wave is traveling toward the mirror at an angle—labeled Angle A. When the light wave hits the mirror, it reflects at an angle—labeled Angle B. Both angles are the same. Angle A equals Angle B.

### Reflection of Light




## Light Waves Can Be Absorbed

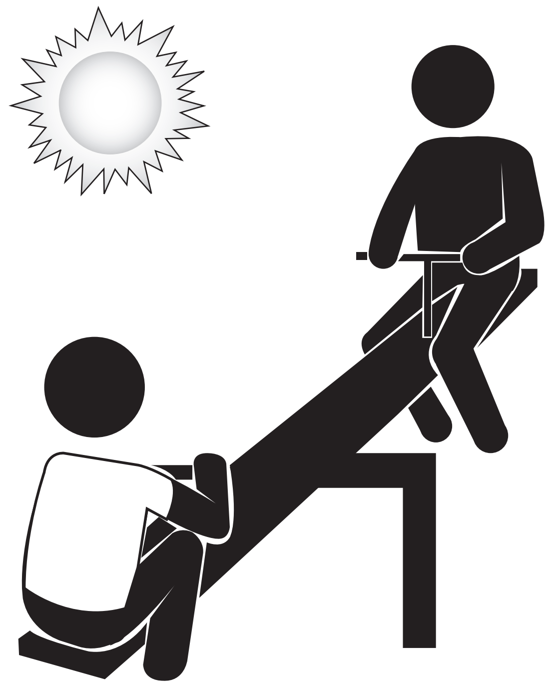
We know that light waves can pass through a substance and bend—be refracted. Water and prisms refract light waves.

We also know that light waves can hit something and be reflected. We can see objects only because light waves are reflected off the objects and into our eyes.

Light waves can also enter a substance and change into other forms of energy. The light energy can be absorbed by the substance. When we are in the sun, some of the light waves enter our skin and turn into heat. Our bodies absorb some of the light waves.

Have you heard that dark colored clothes make you hotter in the sun? That's because dark colors absorb light waves and light colors reflect them.

### Who is Cooler?



## Black and White

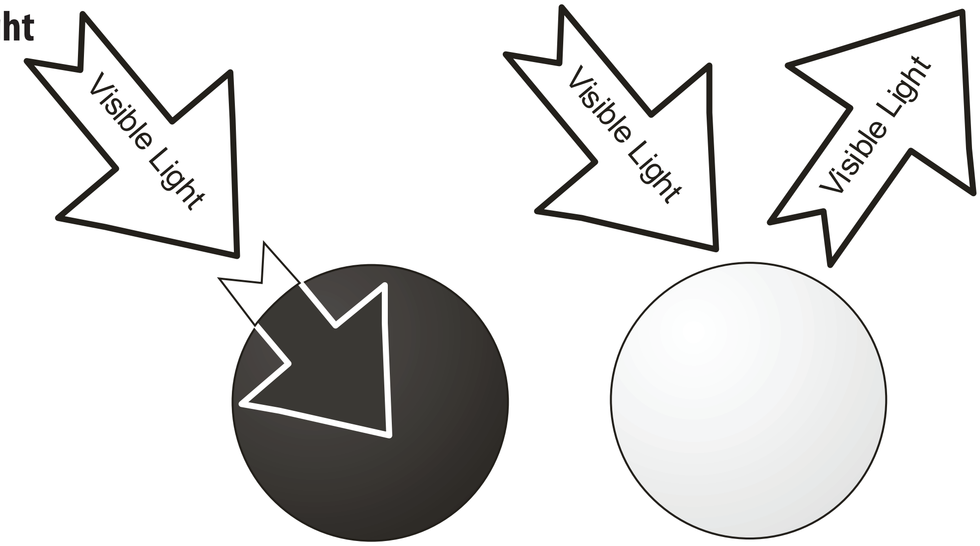
Most substances reflect some light waves and absorb others. That's why we see colors! Visible light is made of every color. Every color has a different wavelength.

When a substance absorbs all wavelengths of visible light, the substance looks black. No light waves are reflected to reach our eyes. The light waves—which are waves of energy—enter the substance. The substance changes the light energy to other forms of energy. When a substance reflects all wavelengths of visible light, the substance looks white.

## Absorbing and Reflecting Light

The black ball absorbs most wavelengths of visible light.

The white ball reflects most wavelengths of visible light.

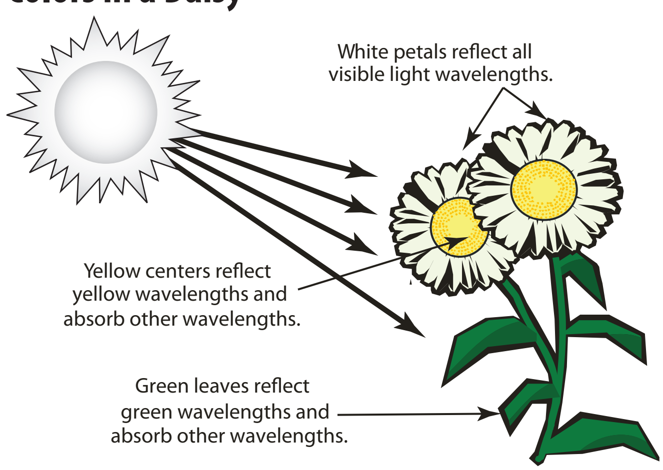



## Seeing Colors

We see many colors because most substances absorb some wavelengths of light and reflect others. We see the colors that are reflected by the substances. A rose looks red because it is reflecting the red light waves and absorbing the oranges, yellows, greens, blues, and violets.

A blue bird looks blue because it is reflecting blue light waves and absorbing the others. The dirt looks brown because it is reflecting several light waves that together look brown, and absorbing other light waves.

## Colors in a Daisy




## Using Light Energy

We use light energy every day to see. We use it in many other ways, too.

The leaves of plants reflect green light waves and absorb others. The energy they absorb is used by the plants to make sugars. These sugars feed the plants and the plants we eat give energy to us. All the energy we get to move and grow comes from plants.

We can use the energy in light to make heat in many ways. We can color things black to absorb the light waves. We can use mirrors to reflect many light waves onto an object that absorbs them and turns them into heat. We can use this heat to warm houses and water or to cook food.

We can also use light energy to make electricity. **Solar cells** can absorb light waves and turn the energy into electricity.

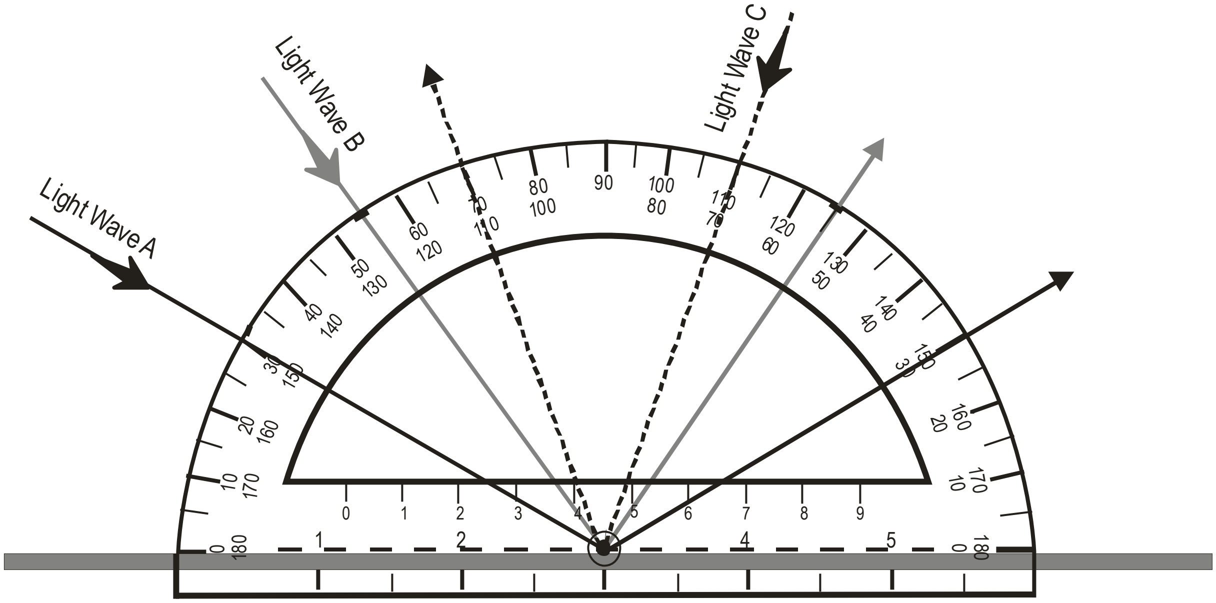
# Key Words—Light

**Directions: Use each key word in one of the sentences below.**

| | | | |
|---|---|---|---|
| **absorbed light** | **degrees** | **protractor** | **shadow** |
| **angle** | **eclipse** | **radiant energy** | **visible light** |
| **concave lens** | **image** | **reflected light** | **wavelength** |
| **convex lens** | **prism** | **refracted light** | |

1. A lens that can make objects look bigger is called a(n) ______________________________ .
2. A tool that measures angles is a(n) ______________________________ .
3. A(n) ________________________ can separate visible light into colors.
4. A(n) ________________________ makes objects look smaller.
5. The distance from the top of one wave to the top of the next is its ____________________ .
6. Light waves we can see are ______________________________ .
7. Energy that travels in transverse waves is ____________________________ .
8. Light that bends as it travels through a substance is ____________________________ .
9. Light that bounces off an object or substance is ________________________________ .
10. How an object appears to our eyes is called its __________________________ .
11. Light that enters a substance and transfers its energy is _____________________________ .
12. A(n) ____________________________ is an area that light waves do not reach.
13. A(n) ___________________________ is a shadow of the moon that darkens the Earth.
14. A circle is divided into 360 ________________________ .
15. Light waves are reflected at the same ______________________ they hit a surface.

# Protractor




Let's practice reading angles using a protractor. In the diagram above, three light waves are reflected by a mirror. Light waves A and B are traveling from the left, so you use the top set of numbers to measure the angle of the light wave and the bottom set of numbers to measure the angle of its reflected wave. Light Wave C is entering from the right, so use the bottom set of numbers for the light wave and the top numbers for the reflected light wave. Remember, the angle of the light wave should equal the angle of the reflected light wave.

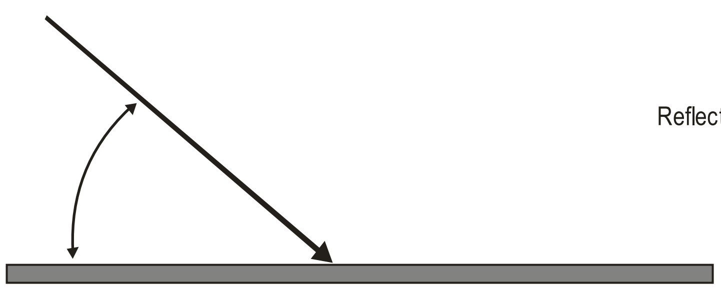
**ANGLE OF LIGHT WAVE A** ________________ **ANGLE OF REFLECTED LIGHT WAVE A** ________________

**ANGLE OF LIGHT WAVE B** ________________ **ANGLE OF REFLECTED LIGHT WAVE B** ________________

**ANGLE OF LIGHT WAVE C** ________________ **ANGLE OF REFLECTED LIGHT WAVE C** ________________

Use a protractor to measure the angle of the light wave below and draw the reflected light wave.

Light Wave Angle = ______



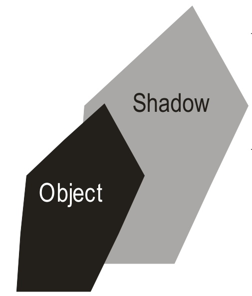
Reflected Light Wave Angle = ______

# Exploring Light 1

## *LIGHT MODULE ONE*

## Question

What happens to light when it hits an object?




## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 1 Wooden spool
- 1 Ruler
- 1 Flashlight
- 1 Piece of white paper (11" x 17")
- Tape

## Procedure

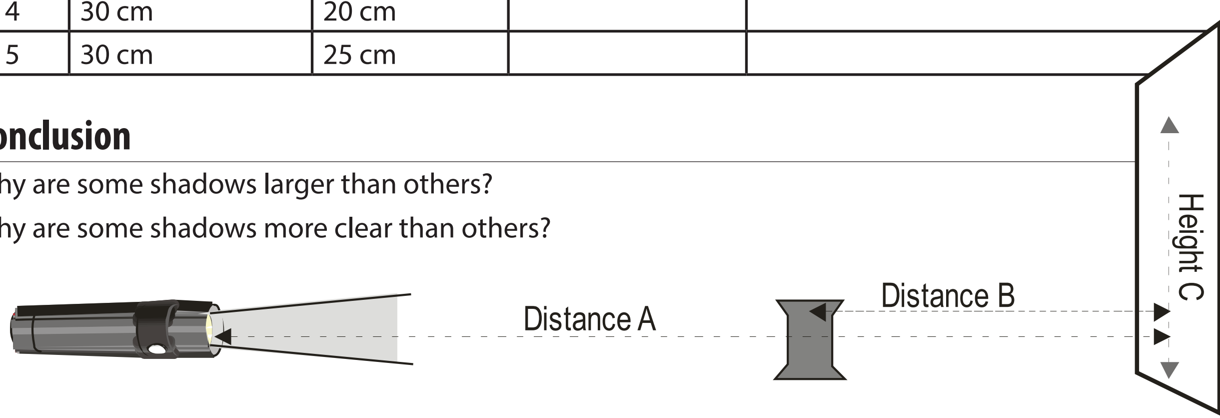
1. Create the table below in your science notebook. Record your observations and data in your science notebook.
2. Tape the paper to a wall next to a table. The bottom of the paper should be at the same level as the top of the table. Place the flashlight on the table pointed at the paper.
3. Measure the height of the wooden spool with the ruler. Record the height in your science notebook.
4. Place the wooden spool between the flashlight and the paper.
5. Using your ruler, place the middle of the spool and the flashlight at the distances listed for Trial 1.
6. Measure and record the height of the shadow. Record your observations in the table.
7. Observe how clear the shadow is. Record your observations in the table.
8. Follow steps 5-7 for the remaining trials.

## Observations and Data

| Trials | Flashlight Distance to Wall<br>Distance A | Spool Distance to Wall<br>Distance B | Height of Spool's Shadow (cm)<br>Height C | Clarity of Shadow |
|---|---|---|---|---|
| Trial 1 | 30 cm | 5 cm | | |
| Trial 2 | 30 cm | 10 cm | | |
| Trial 3 | 30 cm | 15 cm | | |
| Trial 4 | 30 cm | 20 cm | | |
| Trial 5 | 30 cm | 25 cm | | |

## Conclusion

1. Why are some shadows larger than others?
2. Why are some shadows more clear than others?



# Exploring Light 2

***LIGHT MODULE ONE***

## Question

What happens when light bends?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

***Part One***
- 1 Spectroscope
- 1 Prism
- 1 Flashlight
- Colored pencils

***Part Two***
- 1 Beaker full of water
- 1 Piece of white paper
- 1 Pencil
- 1 Flashlight

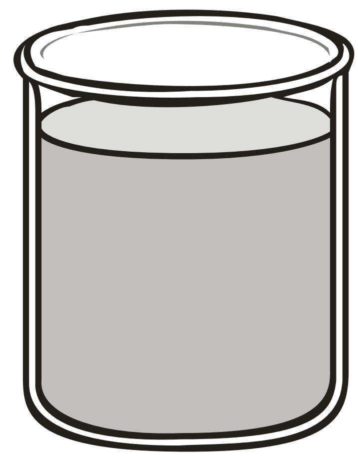
## Procedure

***Part One***

1. Look through the round end of the spectroscope toward the flashlight. Turn the spectroscope until you see a spectrum of light on the sides.
2. In your science notebook, draw the colors of light you see in the order they appear.
3. Shine the flashlight on the prism. Adjust the flashlight and prism until you see a spectrum of light come through the prism.
4. Draw what you see in your science notebook.

***Part Two***

1. Place the pencil in the glass of water. Let the water become still. Draw a picture of the pencil in the glass of water in your science notebook. Remove the pencil.
2. Shine the flashlight onto the paper from about 20 cm away. Draw a picture of the image the light makes on the paper in your science notebook.
3. Place the glass of water in front of the flashlight beam. Look at the image on the paper now. Draw a picture of the image in your science notebook.



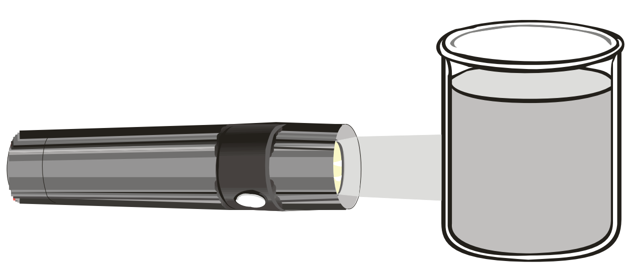
Draw the pencil

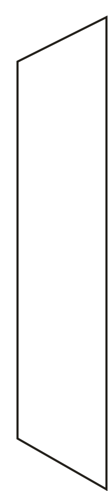
## Observations and Data

1. Record all of your observations in your science notebook. Remember to label your drawings.

## Conclusion

1. Compare and contrast the light spectrums you saw in the spectroscope and prism.
2. Where else have you seen a light spectrum like this? How was it created?
3. What happens to light waves when they pass through water? What do you think would happen if you used a square bottle? Colored water?





# Exploring Light 3

***LIGHT MODULE TWO***

## Question

What happens to light when it refracts through a convex lens? What happens to the image of an object when viewed through a convex lens?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 1 Magnifying glass
- 1 Ruler
- 1 Flashlight
- 1 Penny
- 1 Sheet of white paper

## Procedure

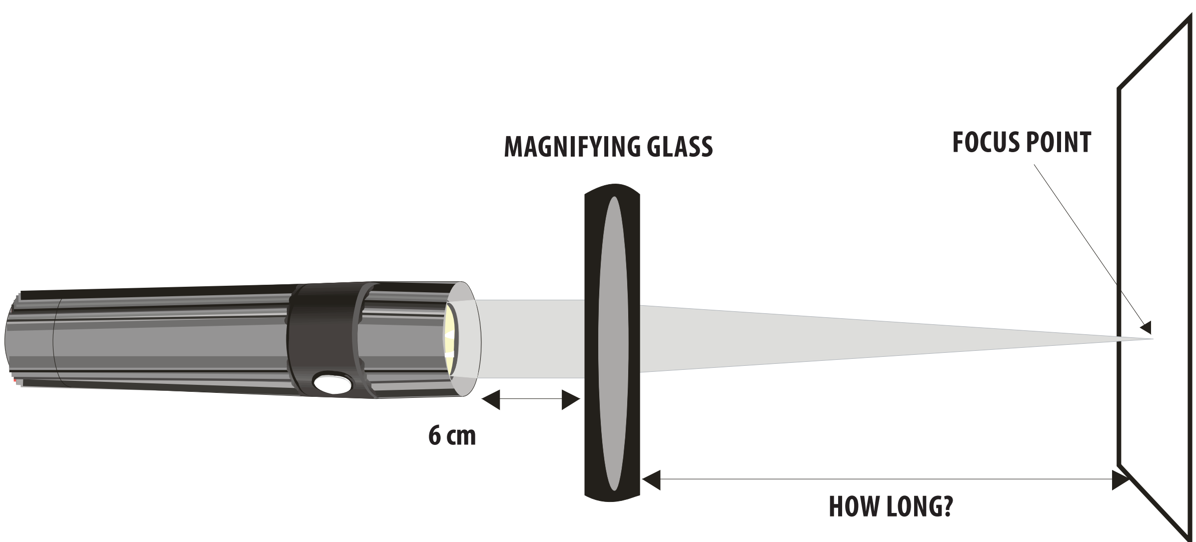
1. Place the magnifying glass on its side on a table. Shine the flashlight through the convex lens at the distance shown in the diagram below. Hold the paper upright in the beam of light coming through the lens. Move the paper away from the lens until you find the point where the light becomes a sharp point. Measure the distance from the lens to the paper and record it in your science notebook.
2. Place the penny on the table. Hold the magnifying glass about 6 cm from your eye. Move toward the penny with the magnifying glass until you get a sharp image. How far is the magnifying glass from the penny? Draw the size of the penny without magnification and its magnified size in your science notebook.

## Observations and Data

1. Draw pictures of what you see in your science notebook. Be sure to include measurements as needed. Use words to explain what you saw.

## Conclusion

1. Compare the results from the two explorations using your data to support what you saw.
2. How did the convex lens refract the light?
3. If you hold the magnifier closer to your eye, will you need to move it closer to the penny to get a sharp image? Will the image of the penny be the same size? What if you hold the magnifier close to the penny and far from your eye?



# Exploring Light 4

## *LIGHT MODULE TWO*

## Question

What is the relationship between angles as light reflects from a mirror?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 1 Full-length mirror
- Colored pencils
- Protractor

## Procedure

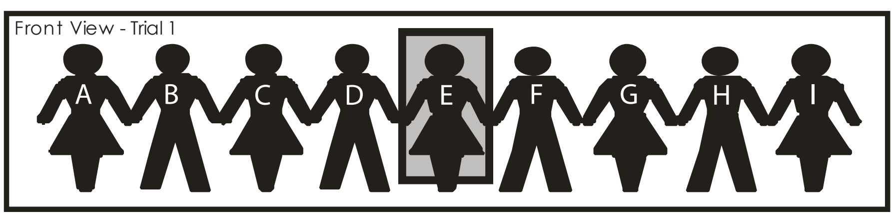
1. Hang the mirror (vertically oriented) on a wall about 20 cm up from the floor. Arrange nine students, labeled A through I, in a line about 40 cm apart and 1.5 meters away from the mirror, as shown in the picture below. Student E stands directly in front of the mirror. Each student looks into the center of the mirror and announces who he/she can see.
2. On the diagram *Overhead View—Trial 1*, draw straight lines from each student to the mirror, then to the student he/she sees in the mirror. Use a different color for each student.
3. Use a protractor to measure the angles.

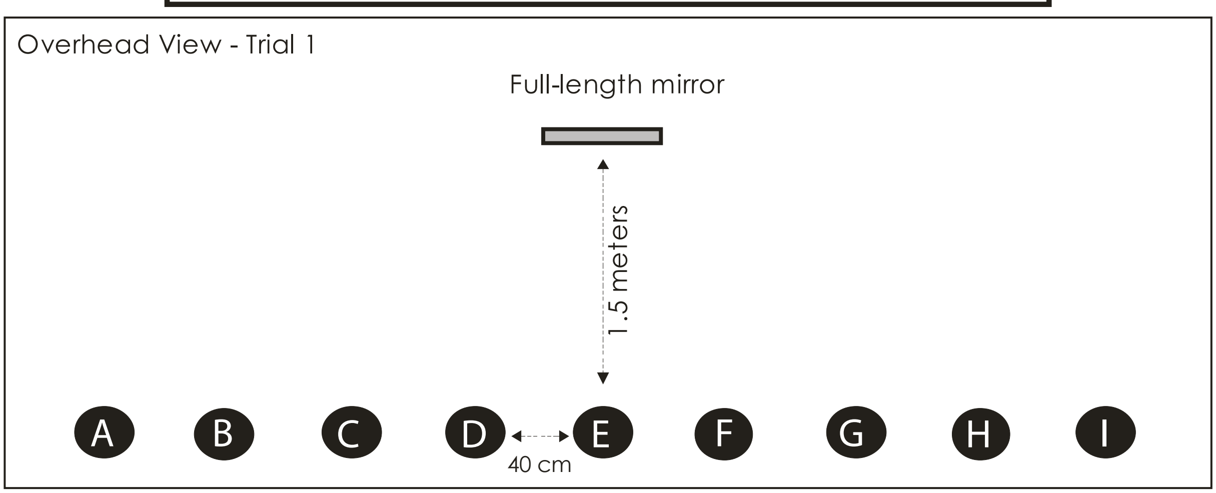
## Observations and Data

1. Draw a picture of how you and your classmates were arranged with the mirror. Record your observations, be sure to include angle measurements.

## Conclusion

1. What is the pattern for who sees who? How does this correspond to the reflection of light?
2. Does every point have a corresponding point? Why or why not?



# Exploring Light 5

***LIGHT MODULE THREE***

## Question

What is the relationship between angles as light reflects from a mirror?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 5 Small mirrors
- Flashlight or laser pointer
- Protractor
- Clay
- Colored pencils

## Procedure

1. Use clay to support the mirrors. Arrange the mirrors as shown on page 35.
2. Shine the light into the first mirror (marked START). Observe where the light travels as it reflects off the mirror.
3. Adjust the angle of the light until it reflects from mirror to mirror until you reach the last mirror and the light wave leaves the page.
4. Once the light is reflecting off every mirror, use a protractor to measure the angle of the light as it hits and reflects off of each mirror.

*HINT*: Focus on the middle of the mirrors.

## Observations and Data

1. Use the worksheet and draw the light waves on page 35 being reflected. Record all of the angle measurements.

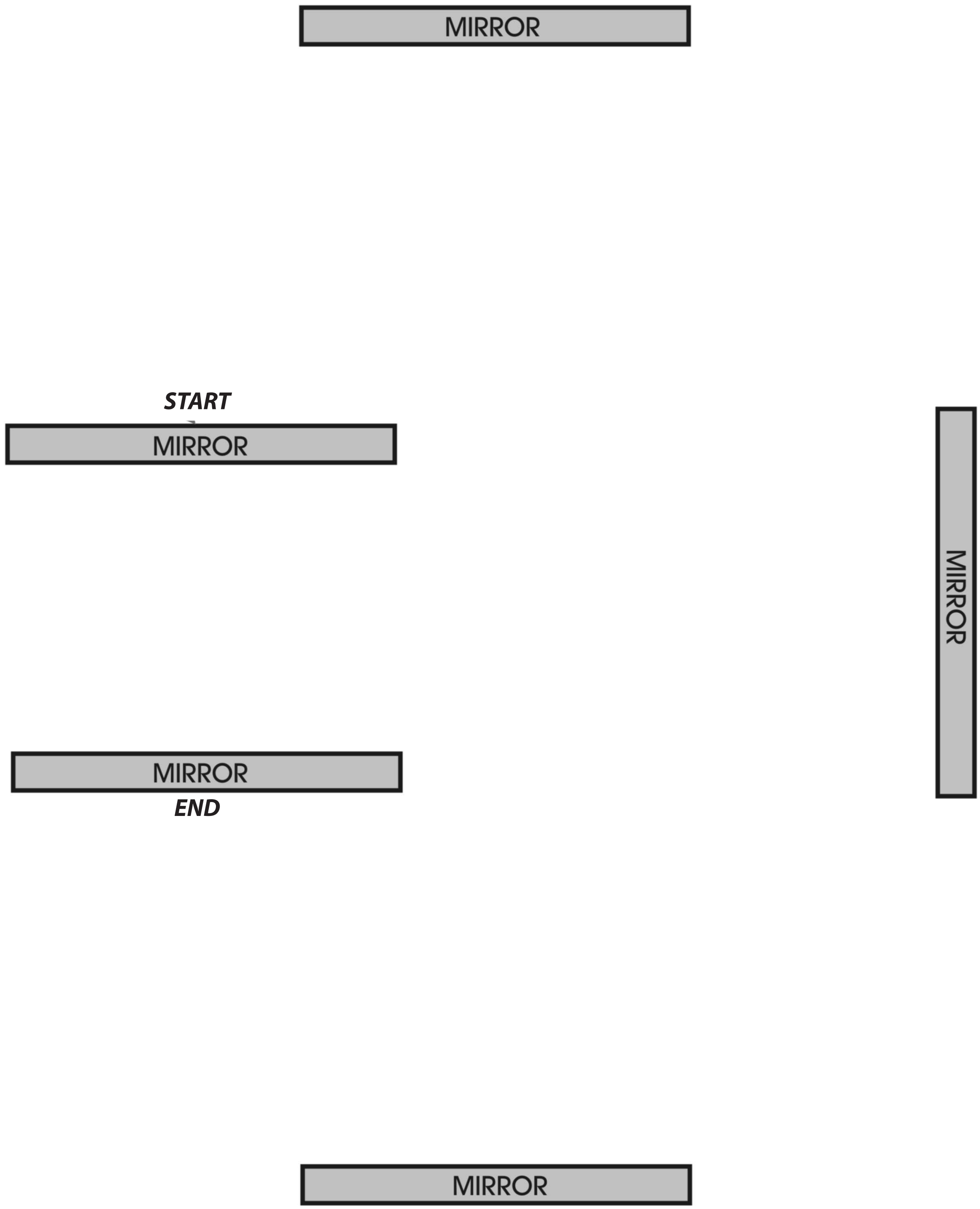
## Conclusion

1. What is the relationship between angles as light reflects from a mirror?
2. What did you do in order to successfully complete the maze?

## Extension

1. Design your own maze and answer key. Give your classmates your maze to solve.

# Exploring Light 5



# Exploring Light 6

## *LIGHT MODULE THREE*

### Question

How does a colored filter change what you see in a  spectroscope?

### Hypothesis

Read the procedure and record  your hypothesis in your science notebook using an "If... then... because..." format.

### Materials

- Colored pencils
- Flashlight
- 4 Colored filters
- Spectroscope

### ✔ Procedure

***Part One***

1. Color the rainbow on page 37 with colors in the order you think they appear. Do research to find out if you are correct.
2. Color the objects on page 37. Write the wavelengths of color that are reflected and the wavelengths that are absorbed by the objects.

***Part Two***

1. Look through the round end of the spectroscope toward a bright light in the room, but NOT the sun.
2. Turn the spectroscope until you see a spectrum of light on the sides.
3. In your science notebook, draw the colors of light that you see in the order they appear.
4. Place each of the colored filters over the end of the spectroscope one at a time. Observe the difference in the colors produced.

### Observations and Data

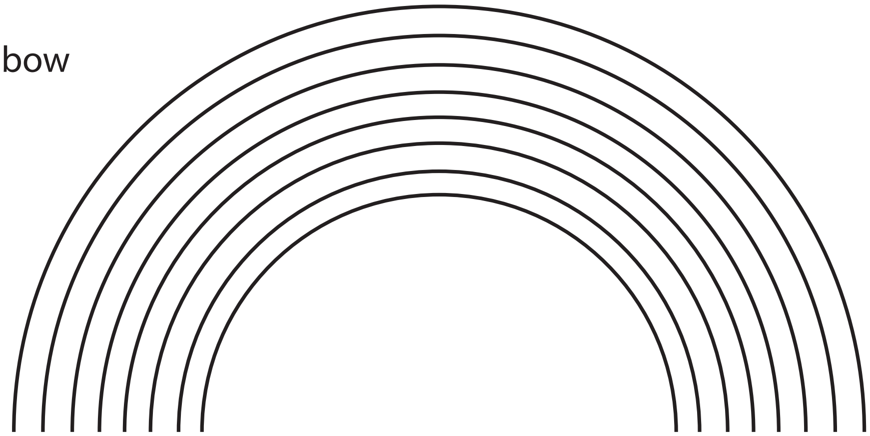
1. In your science notebook, record your observations detailing what you see with each filter in Part Two.

### Conclusion

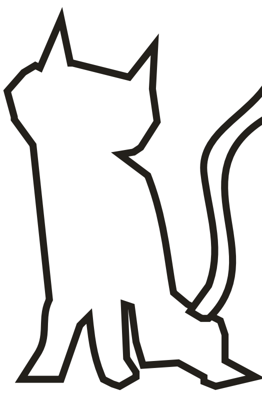
1. What happened when you placed the colored filters between the light and the spectroscope?
2. Why do you think this happened?

# Exploring Light 6

Rainbow



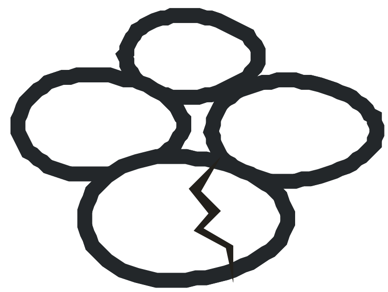
Black Cat



Colors Reflected:

Colors Absorbed:

Eggs



Colors Reflected:

Colors Absorbed:

Leaf

Colors Reflected:

Colors Absorbed:

Apple

Colors Reflected:

Colors Absorbed:

# Motion and Energy

Look around you. Many things are moving. They are in **motion**. Clouds drift across the sky. Leaves fall from trees. A car speeds by. Birds fly. Hearts pound. Bells ring. Babies cry. Plants grow and so do you. The Earth moves, the air moves, and so does every living thing.

All of this motion takes energy. Nothing can move without energy. Cars get their energy from **gasoline**. The clouds move because of energy in the wind. The wind gets its energy from the sun. So do growing plants. All of your energy comes from the sun, too.

## Kinetic and Potential Energy

The energy of motion is called kinetic energy. All moving objects have kinetic energy. Many objects also have energy because of the place they are in—their position. The energy of place or position is called **potential energy**.

A rock on the top of a hill has energy. It is not moving—it has no kinetic energy. But it has energy because of its position on the hill. It has potential energy.

If the rock begins to roll down the hill, its energy changes. The potential energy changes into kinetic energy as it rolls. When the rock stops rolling at the bottom of the hill, it has no more kinetic or potential energy.

### ▪ Potential Energy Is Stored Energy

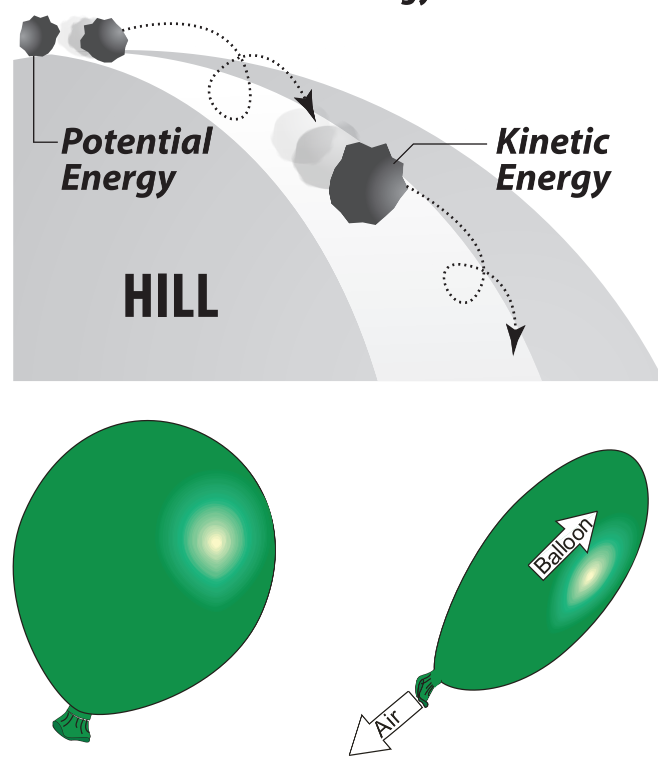
Potential energy is also energy that is stored in an object. When you blow up a balloon, you are putting air into it. You are also putting energy into it—potential energy.

If you tie the balloon and place it on the floor, it will not move. It has no kinetic energy. But it has potential energy—stored energy.

If you untie the balloon, the stored energy is released. The air rushes out in one direction. The balloon moves in the other direction.

The potential energy stored in the balloon changes to kinetic energy—the energy of motion.

**Potential and Kinetic Energy**




**Potential Energy** **Kinetic Energy**

## Newton's Laws of Motion

Objects move in orderly ways that we can predict. They move according to laws of motion that were developed by Sir Isaac Newton and are called **Newton's Laws of Motion**.

### NEWTON'S FIRST LAW OF MOTION

#### ▪ Inertia

Newton's first law is about **inertia**. It says that a moving object will keep moving until an unbalanced **force** changes its motion. A force is a push or a pull. A force adds energy to an object.

Inertia means that an object at rest—not moving—will stay that way until a force moves it. A moving object will keep moving in the same direction at the same speed until a force changes its motion.

The first part of the law is easy to understand—an object at rest will remain at rest. An object that is not moving will not start moving by itself. If we see an object start to move, we always look to see what force is moving it. If we don't see a force, we might get nervous.

The second part of the law is harder to understand—an object in motion will remain in motion until a force changes its motion. On Earth, we never see an object stay in motion forever.

If we throw a ball into the air, it doesn't keep going—it falls to the ground. If we roll a ball down the street, it stops after a while. Nothing on Earth stays in motion forever. Does this mean that Newton's Law is wrong? Or is there an invisible force acting on the ball?

## ▪ Gravity

There is a force that changes the motion of all moving objects on Earth. It is the force of **gravity**. Gravity is the force of attraction between all objects. The more matter an object has, the greater the force of gravity upon it. The amount of matter an object has is called its mass. Mass is measured in grams and kilograms.

The Earth is large. It has a lot of mass. Its force of gravity pulls the objects on Earth toward it. Gravity holds us to the Earth. The sun has a huge mass. The force of attraction between the sun and the planets keeps the planets in orbit around the sun.

Your body would have the same mass on Earth and the moon. But you would weigh more on Earth. Weight is a measure of the force of gravity on an object.

## ▪ Friction Changes the Motion of Objects

Another force that acts on objects is **friction**. Friction is the force that slows the motion of objects that are rubbing together. When a ball flies through the air, it comes into contact with air molecules. The air molecules and the molecules on the surface of the ball rub against each other. Some of the kinetic energy in the ball changes into heat. The ball doesn't have as much energy, so it slows down.

Rub your hands together. Feel how the kinetic energy in your hands turns into heat. Some energy turns into sound, too.

If you roll a ball on a wood floor, it will roll a long way. There is not much friction between the ball and the floor. If you roll the same ball with the same force on a carpet, it won't roll nearly as far. The ball sinks down into the carpet. More molecules of the carpet and the ball are touching each other. There is more friction between the ball and the carpet. More of the kinetic energy in the ball is turning into heat.

## Newton's First Law of Motion

An object at rest will remain at rest until a force acts upon it to make it move. A moving object will keep moving until a force changes its motion.


Image courtesy of U.S. Department of Defense

**A ball that is thrown into the air will fall down because of the forces of inertia and gravity.**

## Force of Gravity

The Earth has more mass than the moon. The Earth has a stronger force of gravity. The force of attraction between the two keeps the moon in orbit around the Earth.

## NEWTON'S SECOND LAW OF MOTION

Newton's second law explains how the motion of an object will change when a force is applied. If an object is moving, a force will speed it up, slow it down, or change its direction. The law explains that an object will always move in a predictable way according to the mass of the object and its acceleration. The heavier an object is, the more force required to move it.

Newton's Second Law states that

**FORCE = MASS X ACCELERATION (F = ma)**

**Force** is defined as a push or pull—the energy it takes to do work or make a change. **Mass** is defined as the amount of matter in an object and **acceleration** is defined as the rate at which an object's speed changes over time.

If a soccer ball is not moving and you give it a hard kick, it will roll in the direction you kick it—in the direction of the force. If you kick it again in the same direction, you increase the force and the ball goes faster.

Look at the picture to the right. If the girl pulls the wagon by herself, she applies a certain amount of force to pull it at a constant speed. If a girl comes and pushes from behind, force is added to the wagon. The mass of the wagon doesn't change, so its acceleration increases. When mass remains the same, force and acceleration must change in the same way—as the force increases, the acceleration increases.

If, on the other hand, the second girl jumps into the wagon, the mass of the wagon increases. If the force remains the same, the acceleration decreases—the speed of the wagon slows. To keep the same speed, the first girl must increase the amount of force she applies to pulling the wagon.

When force remains the same, mass changes in an opposite way as acceleration—as mass increases, acceleration decreases. As the number of people in the wagon goes up, the speed of the wagon will go down.

### Newton's Second Law of Motion

Force = Mass x Acceleration

**SOCCER**

**PULLING A WAGON**

## NEWTON'S THIRD LAW OF MOTION

Newton's third law states that for every action, there is an equal and opposite reaction. If an object is pushed or pulled, it will push or pull with equal force in the opposite direction. When you walk, you apply a force to the ground. The ground applies an equal and opposite force against you. It holds you up. If the ground didn't apply as much force, you would sink into the ground. If the ground applied more force, you would be pushed into the air.

Here's another way to think about it. Forces are always found in pairs. If you apply a force to an object, the object applies a force to you.

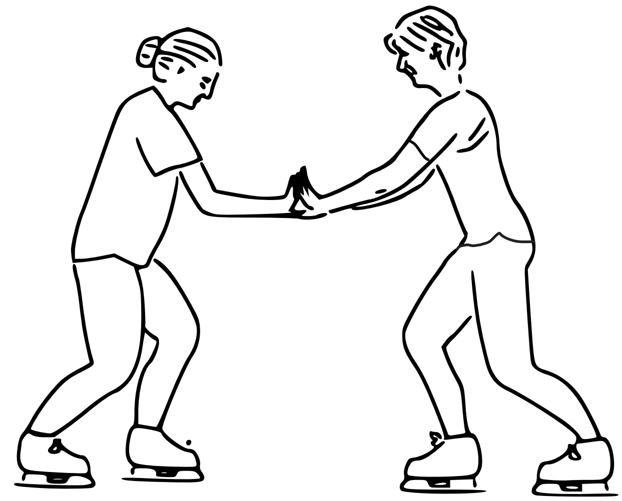
Look at the skaters. If one skater pushes against the other, what happens? Both skaters move backwards. When one skater applies a force, there is an equal force applied by the other skater. If both skaters weigh the same, they will both move the same distance. If one skater weighs more, the other skater will move farther. It takes more force to move a heavy object than a light one. It takes more force to move an object a long distance than a short distance.

A squid moving through the water is another example of Newton's third law. The squid takes in water and applies a force to push it out behind it. The water exerts a force pushing the squid forward. The forces are equal and opposite. The water moves in one direction, the squid moves in the other.

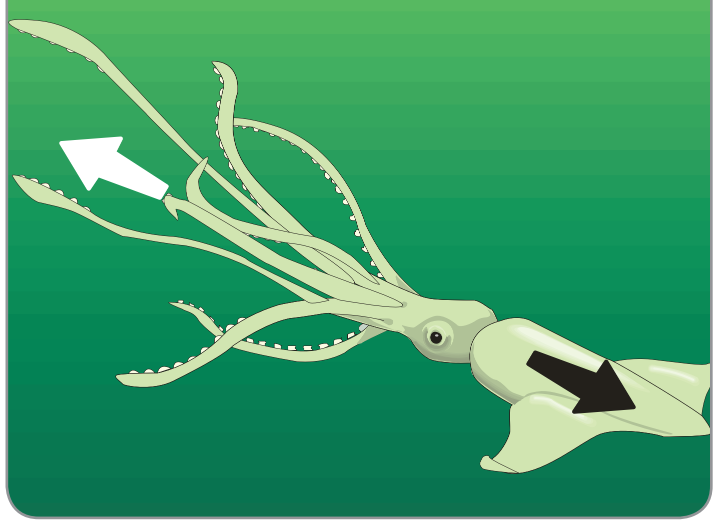
### Newton's Third Law of Motion

For every action, there is an equal and opposite reaction.

### Newton's Third Law of Motion



### Squid



## We Can Measure Force

We measure force in **pounds** or **newtons**. We think of pounds as a measure of weight. It is, of course. Weight is really the same thing as force. How much something weighs is the amount of force that gravity applies to an object.

Your body would have the same amount of mass anywhere in the universe, but you wouldn't weigh the same. The force of gravity on the moon would be much less than on Earth.

We can use scales to measure force in pounds (lb) or newtons (N). One pound equals almost four and a half newtons. A sixty pound child would weigh 267 newtons.

## Changing Motion

Newton's Laws explain force moving in straight lines. We can change force into a circular motion.

If you swing a yo-yo in a circle, then let go of the string, what happens? It doesn't continue in a circular motion, does it? It moves away in a straight line. The force from your hand is pushing the yo-yo away from you in a straight line. The force of the string on the yo-yo holds the yo-yo at a constant distance from your hand.

This force is called **centripetal force**. Centripetal means toward the center. When you let go of the string, the centripetal force is gone. The yo-yo moves away from your hand. It moves away in a straight line.

### ▪ A Pendulum Moves Back and Forth—It Vibrates

A swing is a **pendulum**. It changes force into a circular motion, too. The force of gravity pulls the swing straight down. The force in the swing is toward the top bar where it is attached.

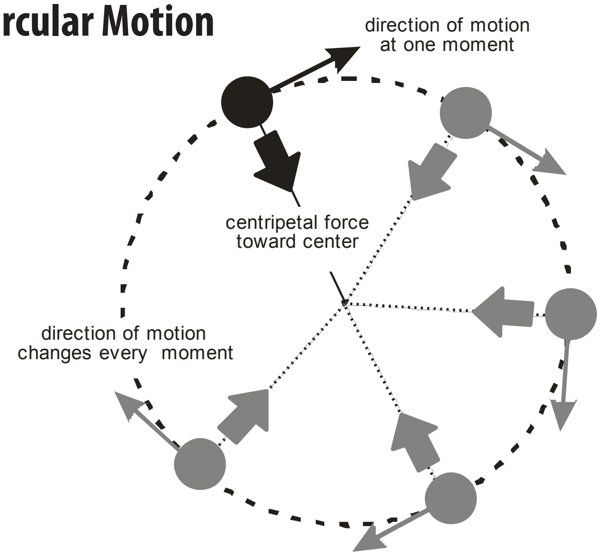
A pendulum is any hanging object that is free to swing. The movement of a pendulum is back and forth, back and forth. One back and forth motion is called a **vibration**.

The vibrations of a pendulum are measured in two ways. They are measured by the size of the vibration and the time it takes for one vibration. The size of the vibration from one side to the other is called its **amplitude**. The time it takes for one vibration is called its **period**.

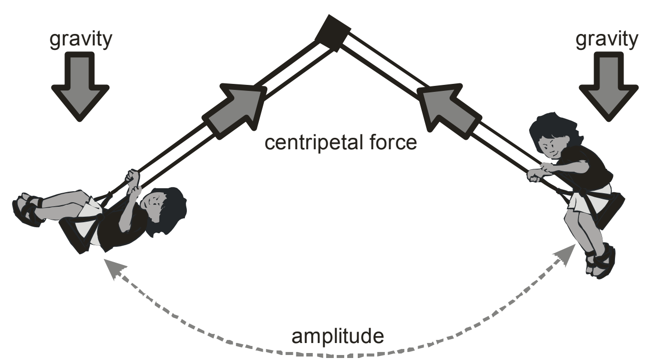
The amplitude of a pedulum depends on the amount of force or energy that is used to begin the motion. The amplitude decreases as friction with the air changes some of the energy into heat.

The period of a pendulum depends on its length. The longer the length of the pendulum, the longer it takes for it to complete one vibration. The weight of the pendulum doesn't affect its period.

### Circular Motion




### Pendulum



# Key Words—Motion

**Directions: Use each key word in one of the sentences below.**

| | | | | |
|---|---|---|---|---|
| **amplitude** | **friction** | **kilogram** | **newton** | **potential energy** |
| **centripetal force** | **gravity** | **kinetic energy** | **pendulum** | **vibration** |
| **force** | **inertia** | **mass** | **period** | **weight** |

1. The force of attraction between two objects is called ______________________________ .
2. The amount of matter in an object is its __________________________________________ .
3. A(n) ________________________ is a measure of mass.
4. A(n) ________________________ is a measure of force.
5. The energy of position is called _____________________________________________ .
6. The force that slows two objects rubbing together is _________________________ .
7. The energy of motion is called _______________________________________________ .
8. The amount of gravity acting on an object is its ________________________ .
9. An object at rest stays at rest because of ______________________________ .
10. A(n) _________________________ is a push or a pull on an object.
11. An object that swings freely back and forth is called a(n) ________________ .
12. One back and forth motion of a pendulum is a(n) ________________________________ .
13. In circular motion, the force that acts toward the center is ________________________ .
14. The size of a pendulum's vibration is called its _______________________________ .
15. The time it takes for one vibration of a pendulum is its ___________________________.

# Spring Scale

A spring scale measures force. It can measure weight, which is the force of gravity on an object. It can measure the amount of force it takes to overcome the inertia of an object at rest. It can measure the amount of force it takes to move an object at a steady speed.

This spring scale has a handle that can be used to hang or pull the spring scale to measure force. It has a metal nut on the top to adjust the spring scale so that it reads exactly zero when no force is applied. You can turn the nut in either direction until the top of the bar is exactly on zero.

This spring scale measures force or weight in newtons (N). The scale measures from 0 N up to 2.5 N of force. It takes about 4.5 N to equal one pound of force or weight.

The other side of the scale measures mass in grams. The scale would only be accurate on Earth because it depends on the force of the Earth's gravity. Do you see the relationship between grams and newtons?

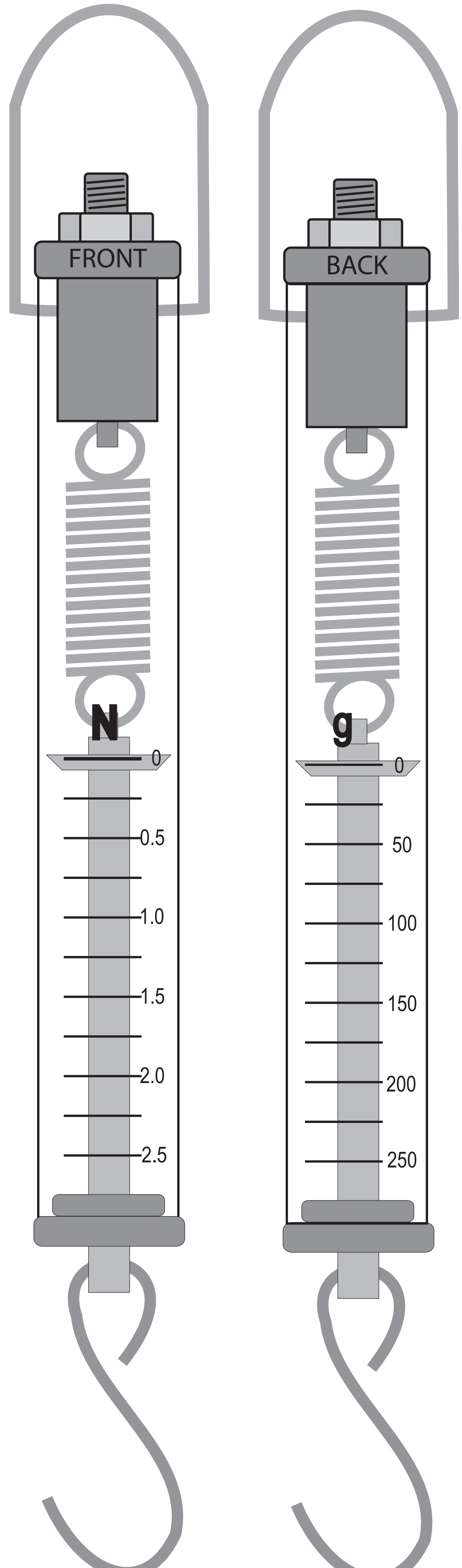
See if you can answer the questions below:

1. How many newtons of force would 200 grams apply?

2. What would be the mass of an object that weighs 7 N on Earth?

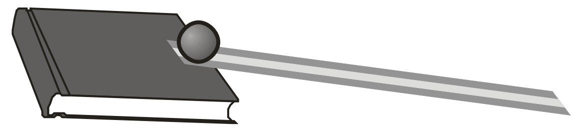
3. If an object weighs 450 N, how much does it weigh in pounds?

Practice using the spring scale. First, check the scale to make sure it reads zero. Adjust the screw if needed. Hang a pair of scissors on the hook and read both measurements. Hang another pair on and see if the measurements double. Try pulling a small book across a table to read the scale as it is moving.



# Exploring and Graphing Potential Energy 1

***MOTION MODULE ONE***



## Question

Do the height and weight of an object affect its potential energy?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

## Materials

- 1 Grooved metric ruler
- 1 Marble
- 1 Metal sphere—same size as marble
- 1 Metric measuring tape
- 5 Thin books—each about 1 cm thick
- Red and blue colored pencils

## Procedure

1. Create the table below in your science notebook.
2. Examine the two spheres. Record the differences in your science notebook.
3. On the floor, place the ruler on one book as shown in the picture.
4. Place the marble at the top the ruler and let it go. Don't give it a push; let it roll.
5. Use the measuring tape to measure the distance the marble rolls from the lower end of the ruler.
6. Record the distance in the table.
7. Repeat the trial two more times.
8. Repeat the trials using two books, three books, four books, then five. Record the data set in the table under the correct trial.
9. Repeat Steps 3-8 using the metal sphere.

## Observations and Data

| | Trial 1 Marble (cm) | Trial 2 Marble (cm) | Trial 3 Marble (cm) | Average Marble (cm) | Trial 1 Metal Sphere (cm) | Trial 2 Metal Sphere (cm) | Trial 3 Metal Sphere (cm) | Average Metal Sphere (cm) |
|---|---|---|---|---|---|---|---|---|
| One Book | | | | | | | | |
| Two Books | | | | | | | | |
| Three Books | | | | | | | | |
| Four Books | | | | | | | | |
| Five Books | | | | | | | | |

1. Find the average distance for each experiment by adding the three trials together, then dividing the total by three. Record the average distances in the table.
2. Create a line graph in your science notebook. Use the red pencil to plot the average distance the marble moved at each height.
3. Use the blue pencil to plot the average distance traveled by the metal sphere.
4. Using your ruler, draw a straight line with the red pencil that comes as close to as many of the red dots as possible. Extend the straight line to the end of the graph. Use the blue pencil to draw a straight line for the blue colored dots in the same way.

## Conclusion

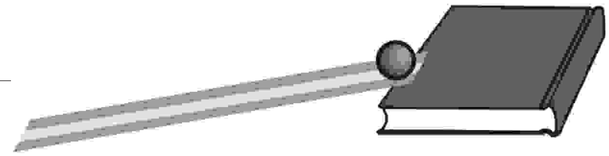
1. Why was it important to do three trials for each experiment?
2. How does the height of an object affect its potential energy?
3. How does the weight of an object affect its potential energy?
4. Extrapolate (estimate) how far each of the spheres would have rolled at a height of 6 books and then at 8 books.

# Exploring and Graphing Potential Energy 2

***MOTION MODULE TWO***

## Question

How is the motion of an object affected by the surface of its path?



## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

## Materials

- 1 Grooved metric ruler
- 1 Book about 1 cm thick
- 1 Marble
- 1 Metric measuring tape
- 4 Different surfaces, such as wood, tile, carpet, and concrete

## Procedure

1. Create the data table below in your science notebook.
2. Locate areas that have four different surfaces. Which surface do you think will produce the most friction? Record that as Surface 1 in the data table and then rank the other surfaces to complete the table.
3. On Surface 1, place the ruler on the book as shown in the picture. Hold the marble at the top of the ruler and let it go. Don't give it a push; let it roll.
4. Use the metric measuring tape to measure the distance the marble rolls from the end of the ruler.
5. Record the distance to complete the data set in the table below. Repeat each trial two more times.
6. Repeat Steps 3 through 5 on the other three surfaces.

## Observations and Data

| | Trial 1 (cm) | Trial 2 (cm) | Trial 3 (cm) | Average (cm) |
|---|---|---|---|---|
| Surface 1 ______________________ | | | | |
| Surface 2 ______________________ | | | | |
| Surface 3 ______________________ | | | | |
| Surface 4 ______________________ | | | | |

1. Calculate the average distance for each surface by adding the three trials together, then divide the total by three.
2. Record the average distances in the final column of the table.

## Conclusion

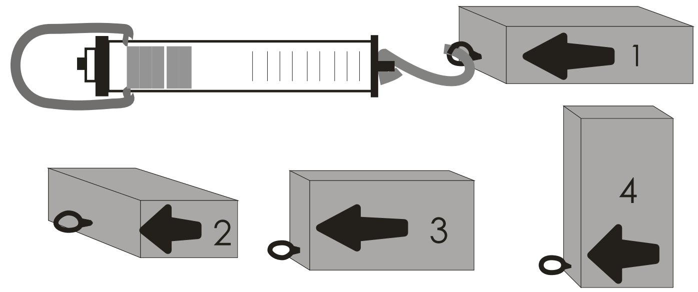
1. Use your data to explain what happened in this investigation and why.
2. How do the results compare to your initial hypothesis?
3. Describe the results you would see if you chose a different fifth surface.
4. How does friction affect one aspect of your daily life? How would a change in friction affect this activity?
5. Can you think of something we do to reduce friction?

# Exploring Force and Motion

***MOTION MODULE THREE***

## Question

How is the force to start and move an object affected by the amount of surface area in contact with the floor?




**NOTE: The friction block is one block with four eye hooks in different positions.**

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

## Materials

- 1 Spring scale
- 1 Wooden block with 4 eye hooks (friction block)
- 2 Different surfaces

## Procedure

1. Create two tables like the one below in your science notebook, one for each surface you are testing.
2. Set up the equipment for Position 1 and practice pulling the block at a slow, steady speed.
3. Using the set-up for Position 1 above, slowly pull on the handle of the spring scale until the block begins to move. Have a partner read the scale at the exact moment the block starts to move. Have your partner read the scale as the block continues to move. Record the measurements in the table below. Repeat the trial two more times. Conduct the experiment for Positions 2, 3, and 4. Try to pull the block at the same steady speed each time. Conduct three trials and record the measurements. Repeat the process on a different surface.

## Observations and Data

**Surface: ____________________**

| | Force to Start | | | | Force to Continue Moving | | | |
|---|---|---|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Average | Trial 1 | Trial 2 | Trial 3 | Average |
| Position 1 | | | | | | | | |
| Position 2 | | | | | | | | |
| Position 3 | | | | | | | | |
| Position 4 | | | | | | | | |

1. Calculate the average for each position.
2. Record the average forces in the data table.

## Conclusion

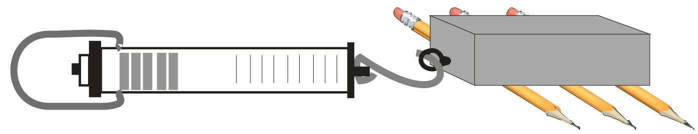
1. Use your data to explain what happened in this investigation and why.
2. How do the results compare to your initial hypothesis?
3. Describe the results you would see if the block had a larger surface area.
4. How would a change in friction affect this activity?

# Exploring Friction and Inertia

***MOTION MODULE FOUR***

## Question

What is the relationship between friction and inertia?



## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

## Materials

- 1 Spring scale
- 1 Wooden block
- 3 Round pencils
- 3 Hexagonal (6-sided) pencils
- 2 Pieces of notebook paper
- Smooth surface (such as wood, tile, or desk top)

## Procedure

1. Create the table below in your science notebook.
2. Using the set-up shown in the picture without the pencils, slowly pull on the spring scale until the block starts to move. Have a partner read the scale as the block starts to move. Continue pulling the block slowly and steadily. Record the data in the table.
3. Conduct two more trials.
4. Conduct the same investigation with the round and hexagonal pencils. Try to pull at the same steady speed each time.

## Observations and Data

| | Force to Start | | | | Force to Continue Moving | | | |
|---|---|---|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Average | Trial 1 | Trial 2 | Trial 3 | Average |
| Block alone | | | | | | | | |
| Block with round pencils | | | | | | | | |
| Block with 6-sided pencils | | | | | | | | |

1. Calculate the average of each data set.

## Conclusion

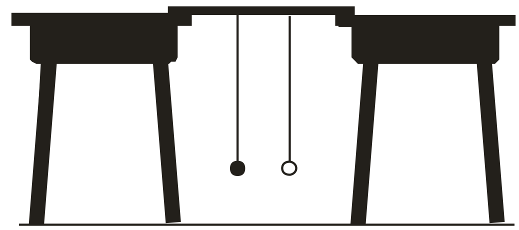
1. What does this experiment teach you about the relationship between friction and inertia?
2. In which set-up did it use the least amount of energy? Why?
3. How does the shape of the pencils affect the amount of force needed?
4. What ways can you think of to reduce friction between the block and the smooth surface?

# Exploring Gravitational Force

***MOTION MODULE FIVE***

## Question

Does gravitational force always move in a straight line?



## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

## Materials

- 2 Pieces of string (60 cm long)
- 2 Drilled spheres with different masses
- Stopwatch
- Measuring tape
- Meter stick
- Masking tape

## ✔ Procedure

1. Create the data table below in your science notebook.
2. Assign one person to use the stopwatch, one to count the cycles of the pendulum, one to conduct the experiment, and one to record the data.
3. Place the meter stick across two tables or desks of the same height and tape it in place. Tie each of the spheres to one end of a piece of string. Tie the string to the meter stick so that the spheres drop down 40 cm.
4. Raise the heavy sphere out to the side so that the string is tight and the sphere is the same height as the meter stick. Let go of the sphere and let it swing back and forth. Each complete back and forth motion is one vibration. Using the stopwatch, count and record the number of vibrations the pendulum makes in 10 seconds. Record the data under trial 1 on the table.
5. Raise the heavy sphere to the side about half the height of the meter stick and count the number of vibrations the pendulum makes in ten seconds. Records the data under trial 2 on the table.
6. Repeat Steps 3–5 with the string 30 cm long, then 20 cm long. Record the number of vibrations in 10 seconds in the table.
7. Repeat Steps 3–6 with the light sphere. Record the number of vibrations.

## Observations and Data

| | Vibrations at 40 cm | | Vibrations at 30 cm | | Vibrations at 20 cm | |
|---|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 1 | Trial 2 | Trial 1 | Trial 2 |
| Heavy Sphere | | | | | | |
| Light Sphere | | | | | | |

## ⁂ Conclusion

1. How does the weight of the sphere affect the period of the pendulum?
2. How does the amplitude of the vibration affect the period of the pendulum?
3. How does the length of the string affect the period of the pendulum?
4. What other variables would affect the period of the pendulum?

# Sound and Energy

Energy is moving around you all the time—energy in the form of **sound waves**. Sound waves are everywhere. Even on the quietest night you can hear sounds. Close your eyes, hold very still and listen for a moment. How many different sounds can you hear?

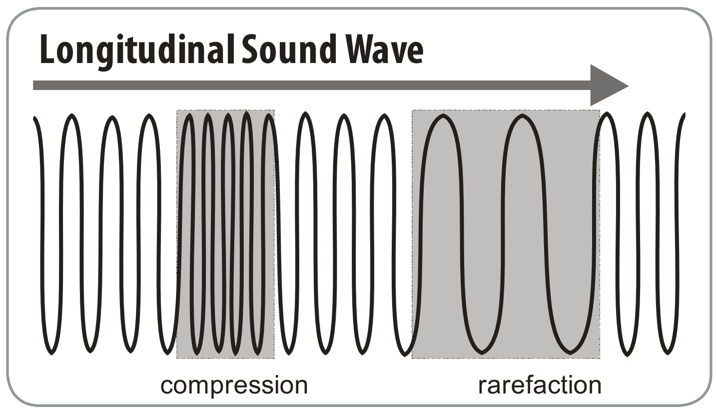
## Sound Is Energy Moving in Waves

Sound is a special kind of kinetic, or motion, energy. Sound is energy vibrating through substances. All sounds are caused by vibrations—the back and forth motion of molecules. The molecules collide with each other and pass on energy as a moving wave. You can sometimes feel the vibrations of sound. Place your fingers on your throat as you hum a tune.

Sound waves can travel through gases, liquids, and solids. The sounds you hear are usually moving through air. When a sound wave moves through air, the air molecules vibrate back and forth in the same direction as the sound. The vibrations push the air molecules close together, then pull them apart. These waves are called **longitudinal** waves. Longitudinal waves move in the same direction as the force making them.

The part of a longitudinal wave in which the molecules are squeezed together is called a **compression**. The molecules are compressed, or squeezed together into a smaller space.

The part of a longitudinal wave in which the molecules are pulled apart is called a **rarefaction**. There are the same number of molecules as in a compression, but they are farther apart.

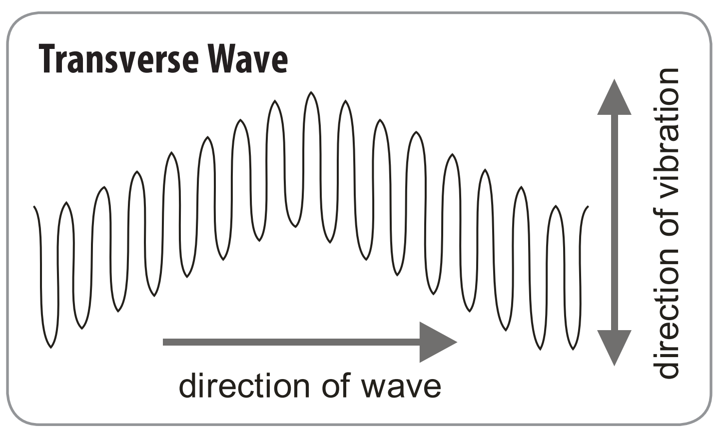



## Transverse Waves

Energy also travels in other kinds of waves. When you throw a stone into water, waves of energy move across the surface. The waves move away from the place where the stone hit the water. The water molecules vibrate up and down, at a right angle to the direction of the waves.

A wave in which the molecules vibrate in one direction and the wave of energy moves in another is called a **transverse wave**.

If you've ever been to the ocean, you've probably floated on transverse waves. If you go out beyond the breakers, you can float on the waves without moving closer to shore.



## Producing Sound

Sounds are all around us. Some sounds are made by nature, such as thunder, the roar of the ocean, and wind blowing through trees. Some sounds are made by animals and humans to communicate. Other sounds are just noise—the sounds made by trucks on the highway and big machines. These sounds are by-products of other tasks. As a truck moves down the road, some of its energy turns into vibrations, producing noise.

Humans produce sound by forcing air from our lungs past the vocal cords in our throats. The moving air makes the vocal cords vibrate. By changing the shape of our mouths, the muscle tension on our vocal cords, and the amount of air, humans can make many different sounds. We can change the loudness, as well as the **pitch**, of the sounds we make. The pitch of a sound is how high or low it is.


Large machines, like this firetruck, produce sound.

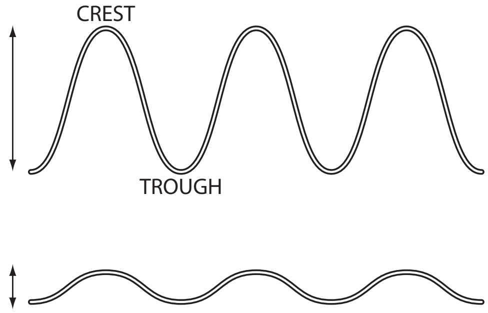
## Amplitude of Sound Waves

The loudness of a sound wave is called its amplitude. The amplitude of a wave depends on its size—the height of a wave from its crest to its **trough**. The crest is the highest point of the wave; the trough is the lowest point. The louder a sound is, the higher its amplitude. The higher the amplitude of a sound wave, the more energy it has.

If you turn up the volume on your radio, you increase the amplitude of the sound waves. The frequency of the sound waves remains the same.

If you push more air past your vocal cords, the sound you make will be louder. You will increase the amplitude of the sound. You will put more energy into the sound.

### Amplitude of Sound Waves



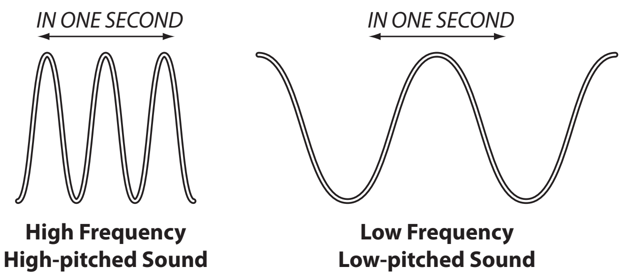

## Frequency of Sound Waves

The pitch of a sound depends on the wavelength of its vibrations. The number of wavelengths that pass a point in one second is called the **frequency** of the wave. The more wavelengths, the higher the frequency. Objects that vibrate quickly have a high frequency.

Sound waves with a high frequency produce a high-pitched sound, like a whistle. Sound waves with a low frequency produce a low-pitched sound, like a tuba.

By changing the muscle tension on our vocal cords, we can change the frequency of the sound waves we make. We can change the pitch of the sounds.

### Frequency of Sound Waves



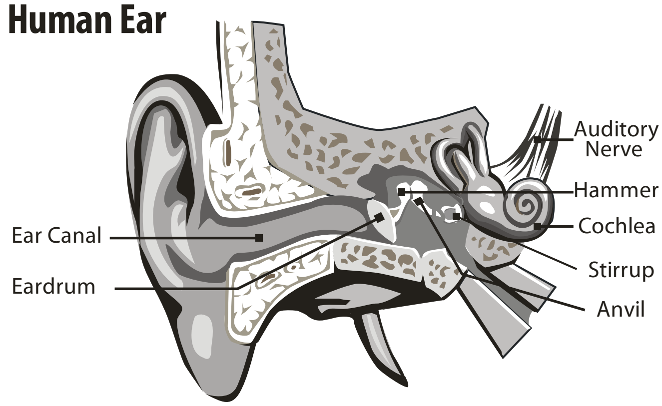
## Hearing Sound

Sound waves are all around us. Our ears are amazing organs that change sound waves into electrical signals and send them to our brains. Sound waves enter the ear canal and travel back to the eardrum. The eardrum is a thin layer of skin that is stretched tightly over the end of the ear canal, much like the skin of a drum. The sound waves transfer their energy to the **eardrum**, which begins to vibrate.

As the eardrum vibrates, it moves a tiny bone called the hammer back and forth. The hammer moves against the anvil—another tiny bone—which vibrates a third bone called the stirrup. The stirrup transfers the vibrations to the **cochlea**, which is filled with liquid and lined with hundreds of tiny hairs. The hairs vibrate, sending signals to the **auditory nerve**, which carries the signals to the brain.

Our brains can also tell the direction of the sound by differences in the amplitude of the sound and when it reaches the ear. A sound on the left, for example, will reach the left eardrum before it reaches the right one. It will also be louder on the left than on the right.

### Human Ear

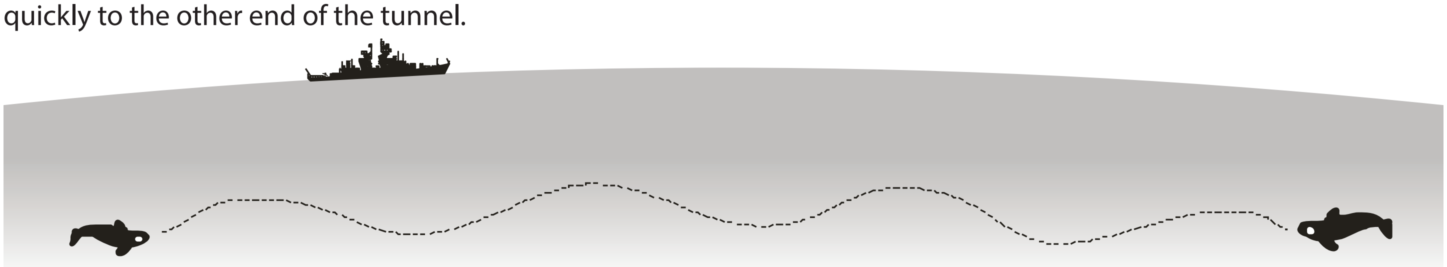



## Sound Can Move Through Liquids and Solids

Sound travels faster and farther through liquids than through air. The molecules of liquids are closer together than the molecules of gases. It is easier for energy to move from one molecule to another when the molecules are close together. Sound travels best in solids because the molecules are so close together. Sound travels about four times faster in water than in air, and about 17 times faster in steel. In air, sound travels at 1,130 feet per second (343 meters per second). It takes almost five seconds for sound to travel one mile. In water, it only takes about one second for sound to travel a mile.

Whales and dolphins use sound to navigate and communicate with each other. Scientists believe whales sing songs underwater that are heard by other whales hundreds of miles away. The builders of the underwater tunnel between England and France communicated by tapping signals on the steel tunnel. The signals traveled quickly to the other end of the tunnel.

Whales and dolphins communicate with sounds underwater.



## The Movement of Sound Waves

Sound waves move through air in a straight line. When they reach an object, they can be reflected or absorbed by the object. You have heard reflected sound waves as **echoes**.

Hard objects usually reflect sound waves. If you yell into a cave, the sound waves will bounce off the walls and produce echoes. Since the walls are not flat, the sound waves will scatter, bouncing in many directions.

Bats use sound waves to fly without bumping into things. They make sounds that bounce off objects. The bats can tell where the objects are by listening to the reflected sounds. Their hearing is so good that they can find the insects they eat using sound waves.

Soft objects usually absorb sound waves. People often use carpets and curtains to absorb sound waves in houses. The insides of cars are covered with soft materials to absorb noise, too.

## Measuring Sound

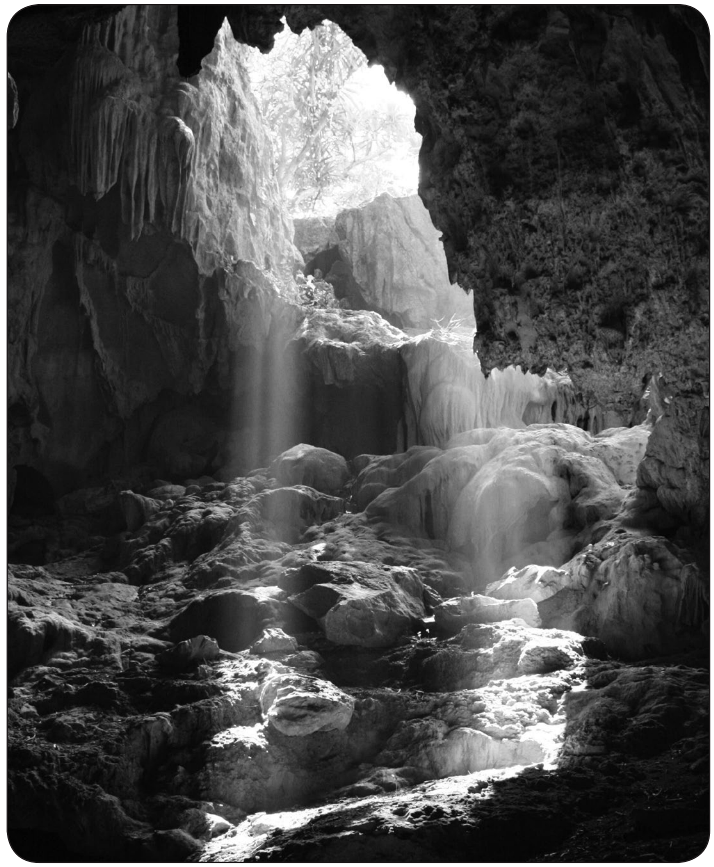
We can measure sound in different ways. We can measure the frequency of a sound—the number of wavelengths that pass a point in one second. Frequency is measured in **Hertz (Hz)**. One Hertz is equal to one vibration per second. An object that vibrates 100 times a second has a frequency of 100 Hz. Humans can hear sounds with frequencies from 20-20,000 Hz. The frequency of normal conversation ranges between 500 and 3,000 Hz, but we can make sounds from about 50-10,000 Hz. A dog can hear frequencies as high as 50,000 Hz, and a bat can hear frequencies up to 200,000 Hz.

We can also measure the amplitude of sound—how loud it is. The amplitude depends on the amount of energy a sound wave has. The **decibel (dB)** is used to measure the amplitude of sound.

The decibel scale is a multiplier scale. For every 10 decibels that are added to the sound level, the loudness is multiplied by 10. This means that increasing the sound by 20 decibels multiplies the loudness by 10 x 10 = 100 times.

Zero on the decibel scale is the smallest sound that can be heard by humans. At 130 decibels, the sound level becomes painful and can damage human ears. For people working in noisy places, the sound level should not exceed 90 decibels.

**CAVE**



### Decibel Scale

| | |
|---|---|
| **Minimum Human Hearing** | **0 dB** |
| **Rustling Leaves** | **10 dB** |
| **Whisper** | **20 dB** |
| **Utility-scale Wind Turbine** | **45 dB** |
| **Normal Conversation** | **60 dB** |
| **Busy Street Traffic** | **70 dB** |
| **Vacuum Cleaner** | **80 dB** |
| **Large Orchestra** | **98 dB** |
| **MP3 Player at Maximum Level** | **100 dB** |
| **Front Rows of Rock Concert** | **110 dB** |
| **Threshold of Pain** | **130 dB** |
| **Military Jet Takeoff** | **140 dB** |
| **Instant Perforation of Eardrum** | **160 dB** |

# Key Words—Sound

**Directions: Use each key word in one of the sentences below.**

| | | | | |
|---|---|---|---|---|
| **amplitude** | **crest** | **echo** | **longitudinal** | **sound wave** |
| **auditory nerve** | **decibels** | **frequency** | **pitch** | **transverse** |
| **compression** | **eardrum** | **Hertz** | **rarefaction** | **trough** |

1. The lowest point of a wave is its ____________________________ .
2. The number of vibrations in one second is the _____________________________ of a wave.
3. The _________________________ of a wave depends on the amount of energy it has.
4. A(n) _______________________________ is energy moving through a substance in a wave.
5. A(n) ____________________ is reflected sound waves.
6. The _______________________________ carries sound signals to the brain.
7. The amplitude of a sound is measured in __________________________________ .
8. The frequency of a sound wave is measured in ___________________________ .
9. The _________________________ is how high or low a sound is.
10. The tight layer of skin that vibrates when sound waves hit it is a(n) ____________________ .
11. The part of a wave in which molecules are squeezed together is a(n) _______________
12. The top point of a wave is its _________________________ .
13. The part of a wave in which the molecules are pulled apart is a(n) _____________________.
14. In a(n) _____________________ wave, the vibrations move in the same direction as the wave.
15. The vibrations are right angles to the direction of the wave in a(n) ___________________ wave.

# Exploring Sound 1

***SOUND MODULE ONE***

## Question

How do longitudinal sound waves travel compared to transverse energy waves?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 1 Slinky spring
- 1 8' Long table

## Procedure

1. Students A and B: Stand at opposite ends of the table, each holding one end of the spring.
2. Student B: Hold the spring on the table, so that your end of the spring does not move.
3. Student A: Slowly move the spring up and down about 4 inches. Observe the motion of the spring. Move the spring more quickly, keeping the size of your motion the same. Observe the motion of the spring. Increase the height of the motion to 8 inches. Begin slowly, then increase the speed of your motion until it is very fast. Observe the motion of the spring.
4. Student A: Hold the spring on the table, so that your end of the spring doesn't move.
5. Student B: Push and pull the end of the spring forward and backward on the table top about 6 inches toward Student A. Begin slowly, then increase the speed of your motion. Observe the motion of the spring. Increase the length of your movement to 12 inches. Begin slowly, then increase the speed of your motion until it is very fast. Observe the motion of the spring.

## Observations and Data

1. Record your observations in your science notebook. What did you notice as you moved the spring at different speeds? Did the waves react in the same manner?
2. Draw diagrams of the different waves you made and label the transverse wave and longitudinal wave. Use your reading to help you determine which wave was which.

## Conclusion

1. How do sound waves travel compared to other energy waves?
2. How does increasing the speed of a vibration affect a transverse wave? How does increasing the speed of a vibration affect a longitudinal wave?
3. How does increasing the size of a vibration affect a transverse wave? How does increasing the size of a vibration affect a longitudinal wave?

# Exploring Sound 2

## *SOUND MODULE TWO*

## Question

How do sound waves change with different pitches and volumes?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

## Materials

- 2 Tuning forks—256 Hz and 1024 Hz
- 1 Mallet
- 1 Metal can
- Tape
- Various objects made of different materials (for example: wood, plastic, fabric)

## Procedure

1. Examine the two tuning forks. Observe any differences in size and weight.
2. Hold a tuning fork firmly by the end of the handle. Tap one tine lightly with the mallet. Observe the pitch and amplitude of the sound, as well as the vibration of the tuning fork.
3. Explore and record your observations:
    - What is the best place to hit the fork with the mallet? Why?
    - Which tuning fork produces sound that lasts longer?
    - Which fork has the loudest sound?
    - Hit the tuning fork and touch the part you hold to your forehead. What happens? What do you feel?
    - Hit the tuning fork and lightly touch the tines to your cheek. What happens? What do you feel?
    - What happens when you touch something that is wood?
    - What happens when you touch something that is plastic?
    - What happens when you touch different parts of the tuning fork on different parts of the can?
    - How can you make the sound produced by the tuning fork softer?
    - How can you make the sound produced by the tuning fork louder?
    - How can you make the sound last the longest?

## Observations and Data

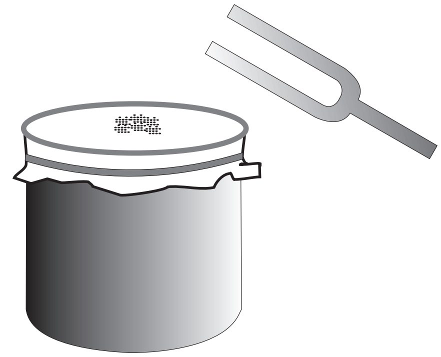
1. Record your observations in your science notebook using diagrams and words to explain what you tested and what you observed.

## Conclusion

1. Review page 51 in your Student Guide. Review your notes in your science notebook about amplitude and pitch. How do sound waves change depending on pitch? Use your observations to describe the different pitch of the tuning forks and draw a diagram of what sound waves at high and low pitches look like.
2. How do sound waves change depending on their volume? Use your observations to describe different volumes you were able to produce with the tuning forks and what their sound waves must have looked like.

# Exploring Sound 3

***SOUND MODULE THREE***



## Question

How can you prove that sound causes vibrations of different frequencies?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the format "If... then... because..." format.

## Materials

- 2 Tuning forks–256 Hz and 1024 Hz
- 1 Mallet
- 2 Metal cans
- 1 Large rubber band
- Plastic wrap (12” x 12”)
- Pepper

## ✔ Procedure

1. Place the plastic wrap over the open end of one of the metal cans and secure it with the rubber band, as in the picture. Gently pull the plastic wrap to make it as tight and smooth as you can over the end of the can.
2. Shake some pepper onto the plastic wrap.
3. Strike the 256 Hz tuning fork gently with the mallet and hold the fork a few inches over the top of the can. Observe the action of the pepper. Strike the tuning fork with more energy and observe any difference in the action of the pepper.
4. Move the tuning fork to different positions on and around the can. Observe the action of the pepper.
5. Repeat Steps 3-4 with the 1024 Hz tuning fork. Observe the action of the pepper. Record any differences in the action between the 256 Hz and 1024 Hz tuning forks.
6. Fill the other can with water. One at a time, strike the tuning forks sharply with the mallet and touch the surface of the water. Observe the effect on the water. Observe the difference between the two tuning forks.

## Observations and Data

1. Draw three pictures of what you observed using the 256 Hz fork. Show what happened to the pepper and water. Draw the tuning fork to show where you touched each can.
2. Draw three pictures of what you observed using the 1024 Hz fork. Show what happened to the pepper and water. Draw the tuning fork to show where you touched each can.

## Conclusion

1. How does this experiment show that sound waves are vibrations?
2. Did the pepper react differently to the different frequencies of the tuning forks? Explain.
3. How did moving the tuning forks farther from the cans and to the side change the motion of the pepper?
4. How did the water react to the different frequencies of the tuning forks? Explain.

# Exploring Sound 4

***SOUND MODULE FOUR***

## Question

What happens when different objects are held in the path of sound waves?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

## Materials

- 5 Materials of your choosing—some suggestions:
  - Paper
  - Textbook
  - Jacket or shirt
  - Paper towel roll

## ✔ Procedure

1. Gather materials.
2. Sit facing your partner, one meter apart.
3. Using your collected materials, put them in front of your mouth one at a time as you talk. Be sure to talk using the same volume each time.
4. Your partner records his or her observations about how sound is affected by the different objects.
5. Switch places with your partner. Repeat steps 3-4.

## Observations and Data

1. Record your observations in your science notebook.
2. Rank the materials from the best to worst sound conductor.

## Conclusion

1. Where have you seen different materials used to either mute or amplify sounds?
2. Student A reads his essay with his paper and clipboard held in front of his face. Student B reads her essay with her elbow on the table and her hand at her mouth. Student C reads her essay with nothing in front of her face. Which student will be the clearest? Who will be the hardest to hear? Use your observations to explain your answer.

# Exploring Sound 5

## *SOUND MODULE FIVE–OPTIONAL*

### Question

How does sound travel through different types of matter?

### Hypothesis

Read the procedure and record your hypothesis in your science notebook using the "If... then... because..." format.

### Materials

- Water tube (pre-assembled)
- Water
- 8′ Table
- Pencil
- Clay
- Empty tube
- Quarters

### Procedure

1. Two students (A and B) hold the ends of Tube 1, which is filled with air, and two students (C and D) lift the tube off the table.
2. Student A holds the quarter flat to his face right in front of his ear. Student B taps the quarter on her end of the tube with a pencil, barely making a noise. Student A observes the loudness of the sound.
3. Student B observes and Student A taps.
4. Students A and B hold the tube, while Students C and D observe and tap.
5. Conduct Steps 1-4 with Tube 2, which is filled with water. Make sure you tap with the same amount of energy.
6. Stick quarters to both ends of the table with a small amount of clay. Conduct Steps 2 - 4 with sound traveling through the table.

### Observations and Data

1. Record your observations in your science notebook.

### Conclusion

1. Does sound travel better in solids, liquids, or gases? Using your observations, justify your reasoning.

# Growth and Energy

Every living thing is growing all the time. Sometimes they grow bigger. Sometimes they do not get bigger, but they still grow. They grow new cells to replace old ones.

It takes energy to grow—**chemical energy** stored in simple **sugars**. The energy to make these sugars comes from radiant (light) energy. Most of this light energy comes from the sun.

## Photosynthesis

Plant cells have a special chemical called **chlorophyll**. The chlorophyll absorbs light energy. The electrons in the chlorophyll become very energized. During **photosynthesis**, these energized electrons cause a **chemical reaction**.

During a chemical reaction, one or more substances change into other substances. In photosynthesis, **carbon dioxide** from the air and water from the soil are turned into **oxygen** and **glucose**. Plants use the energy they have absorbed from the sun to make oxygen and glucose.

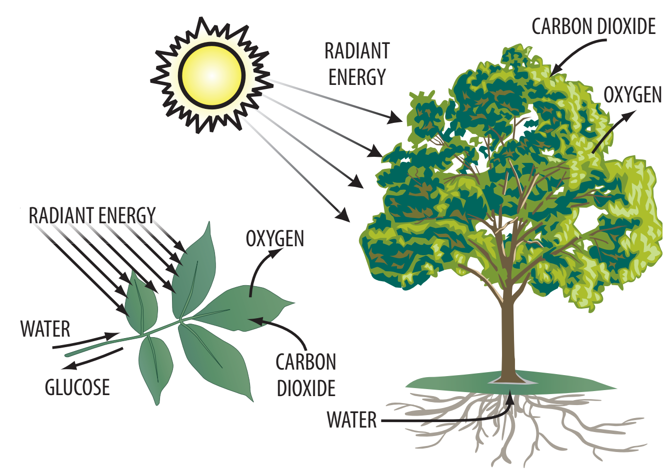
Glucose is a simple sugar that plants and animals use for food. The glucose is stored in the plants' cells. It is this chemical energy that fuels every living thing. Plants are called **producers** because they produce food.

The plants use some of the glucose they make to grow and reproduce, but they make much more than they need. The rest of the glucose is stored in their cells as chemical energy.

Animals and people need oxygen to live. They breathe in the oxygen made by plants during photosynthesis. They make carbon dioxide when they breathe out. It is an amazing cycle: plants use carbon dioxide and make oxygen; animals use oxygen and make carbon dioxide.

### Photosynthesis

In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose (or sugar).




**water + carbon dioxide + sunlight → glucose + oxygen**

$$6\ H_2O + 6\ CO_2 + \text{radiant energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

## Animals Get Their Energy From Plants

Animals do not have chlorophyll. Their bodies cannot make glucose using light energy. They must get their energy from plants. Animals are called **consumers** because they consume other organisms and food made by plants.

Animals that eat plants are called **herbivores**. Herbivores eat plants and absorb the glucose into their cells. They use the glucose to move and grow. They store the glucose in their cells as chemical energy.

Cows are herbivores.

## Carnivores Eat Other Animals

Some animals do not eat plants; they eat other animals. Animals that eat only animals are called **carnivores**.

Carnivores get their energy from the animals they eat. Chemical energy is stored in the muscles and fat of animals. The energy in the bodies of every animal originally came from plants. Animals use this energy to move and grow.

A lion is a carnivore. It eats other animals, but it doesn't eat plants. The gazelle that a lion eats is a herbivore. The gazelle eats plants and absorbs the glucose into its cells.

Lions are carnivores.

## Omnivores Eat Plants and Animals

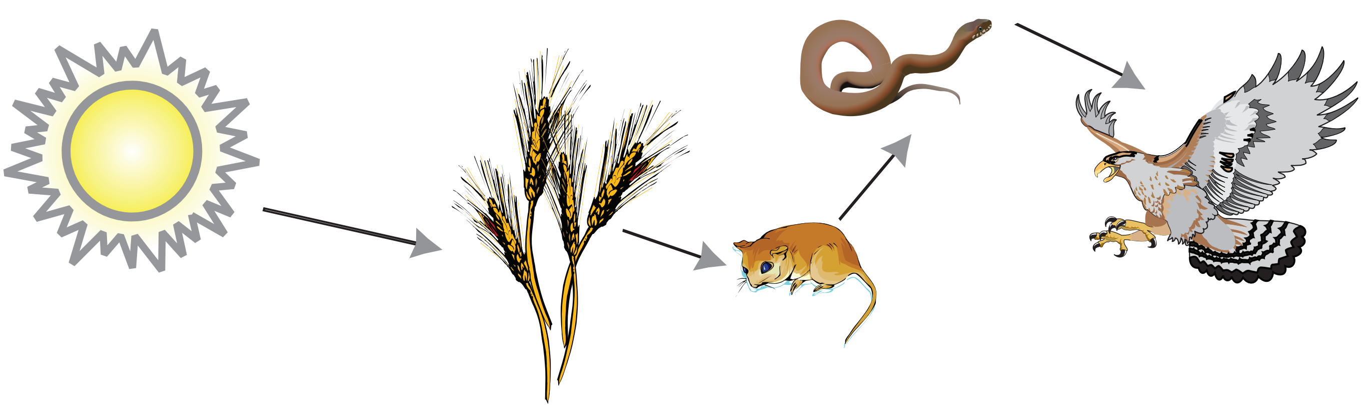
Many animals eat both plants and animals. Animals that eat plants and animals are call **omnivores**. Omni means all. Most human beings are omnivores. We eat bread that is made from wheat or corn—plants. We eat eggs that come from chickens. We eat hamburgers made from cows, with lettuce, pickles, and ketchup that come from plants. A pizza with cheese, pepperoni, sausage, peppers, mushrooms, and tomato sauce is a favorite American omnivore meal.

An omnivore's dinner.

## The Food Chain

The movement of energy from plants through animals is called the **food chain**. Light energy is used by plants to make glucose. The plants use some of the glucose to grow. The animals that eat the plants use some of the glucose to grow. They store the energy in their cells. Animals that eat animals use the energy stored in their cells to grow.

### Food Chain



# Key Words—Growth

**Directions: Use each key word in one of the sentences below.**

| | | | |
|---|---|---|---|
| **carbon dioxide** | **consumer** | **growth** | **oxygen** |
| **carnivore** | **food chain** | **herbivore** | **photosynthesis** |
| **chemical energy** | **glucose** | **omnivore** | **producer** |

1. Using energy to produce new cells is called ______________________ .
2. The simple sugar produced by plants during photosynthesis is __________________ .
3. The flow of energy through plants and animals is called the _____________________ .
4. An animal that eats other animals is called a(n) ______________________ .
5. The energy in the cells of animals is stored as _______________________________ .
6. An organism that produces food is a(n) ________________________ .
7. An animal that eats only plants is called a(n) ________________________ .
8. Plants convert light energy into chemical energy during ________________________ .
9. An organism that consumes food produced by other organisms is a(n) _______________.
10. A person who eats meats and grains would be a(n) ______________________ .
11. In photosynthesis, plants change water and ____________________________ into glucose and _____________________________ .

# Exploring Growth 1

## *GROWTH MODULE*

### Question

How does light affect seed germination and growth?

### Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

### Materials

- 6 Clear zip-lock sandwich bags
- 6 Paper towels
- 2 Cups of water in a jar with a lid
- Bag of kidney beans
- Marker
- Brown paper grocery bag
- Stapler

### ✔ Procedure

1. Label the sandwich bags: *No Light, 1 Hour, 2 Hours, 3 Hours, 4 Hours, All Day.*
2. Fold the paper towels twice so that they will fit into the sandwich bags. Place one towel into each bag so that it reaches the bottom of the bag.
3. Slowly pour water onto the paper towel. The paper towel should be completely wet, but there shouldn't be extra water in the bottom of the bag.
4. Place three seeds into each bag. Close the bags. Place the bag labeled *All Day* in a sunny place for the length of the experiment. This will be your control.
5. Put a row of staples across the bag, directly above the paper towel. The staples should be spaced approximately 1 cm apart (end to end).
6. Place the bag labeled *No Light* in the paper bag and leave it there for the length of the experiment.
7. The other bags should be placed in the sunny place for the number of hours listed on the label.
8. For the rest of the time, the seed bags should be placed in the paper bag. Add a little more water throughout the investigation if the paper towels begin to dry.

### Observations and Data

1. Observe the seeds for 10 days. Record all of your observations in your science notebook including the following information:
   - What was the weather like each day? How much sun did the seeds actually receive?
   - When did the seeds germinate? Did all of them germinate?
   - Once the seeds germinate, record plant growth.

### Conclusion

1. How did the amount of light energy the seeds received affect their germination?

# Exploring Growth 2

### GROWTH MODULE

## Question

How does light affect plant growth?

## Hypothesis

Read the procedure and record your hypothesis in your science notebook using an "If... then... because..." format.

## Materials

- 6 Small plants of the same variety and equal size
- 2 Cups of water in a jar with a lid
- 4 Heavy-duty brown paper lunch bags
- 1 Tablespoon
- 1 Marker

## Procedure

1. Label two paper bags with each of these labels: *No Light, 4 Hours*
2. Place all of the plants in a sunny area such as on a windowsill. Two plants will stay uncovered for the whole experiment; these plants are CONTROLS. Cover two plants with the bags that say *No Light*.
3. Leave these bags on the plants for the length of the experiment. The other two plants will be exposed to light four hours a day, then covered with the *4 Hours* bags the rest of the time.
4. Water each of the plants with one tablespoon of water each day.

## Observations and Data

1. Observe the plants every day for 10 days. Look for changes in size, leaf color, and general health of the plants. Record your observations in your science notebook.

Note: You may want to use a magnifying glass and ruler to help you make your observations.

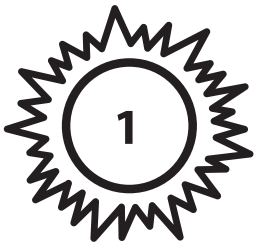
## Conclusion

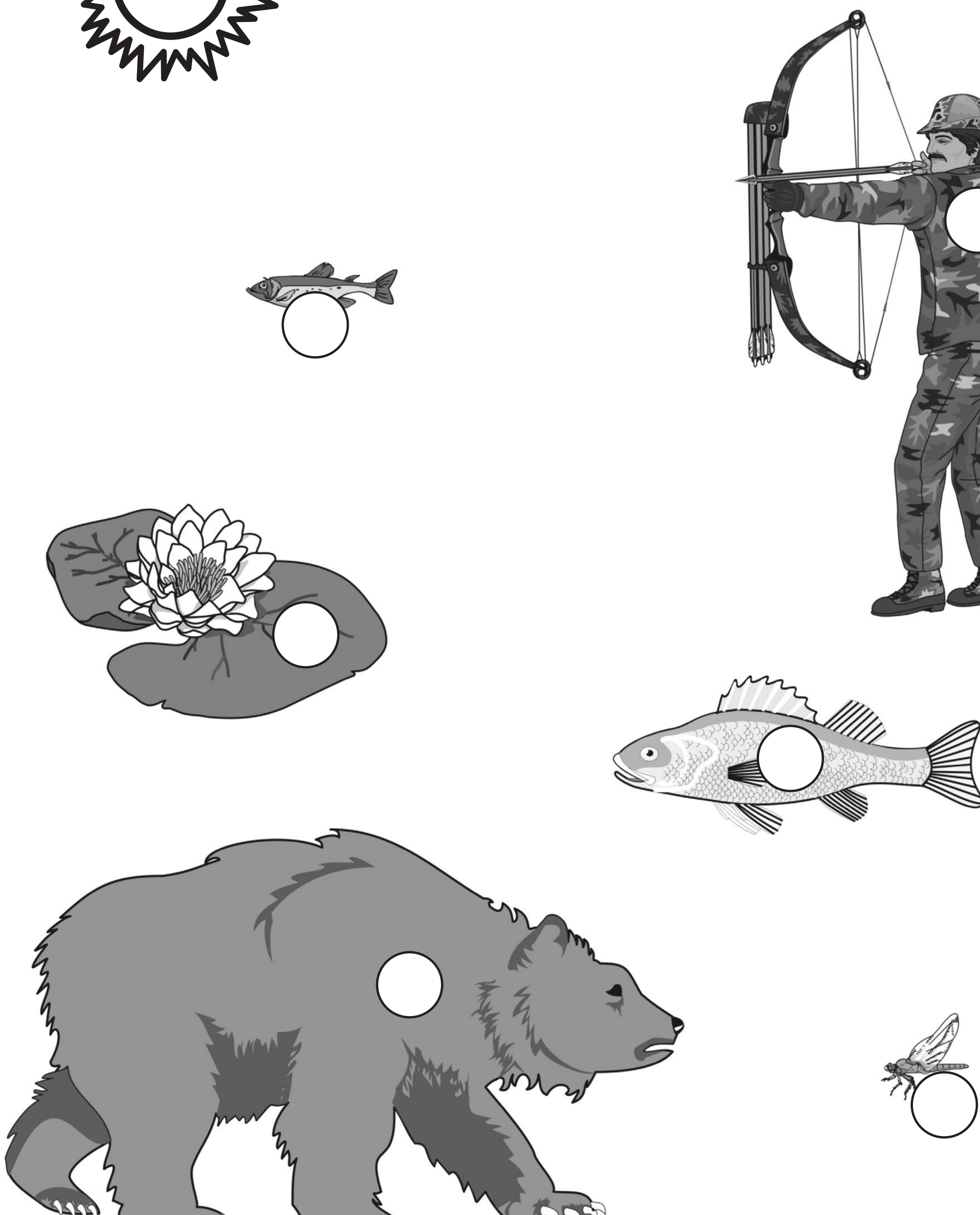
1. How did the amount of light energy the plants received affect their growth?

# Energy Flow

***GROWTH MODULE***

**Trace the flow of energy from the sun through all of the pictures by writing numbers 2-7 in the correct circles.**



# Technology and Energy

We live in a world that is changing very quickly. We have gone from Model T cars to spaceships, telegrams to e-mails. We zap our food in a microwave and watch a game being played 1,000 miles away on the TV. We talk to people on the other side of the world and they sound as if they are next door. Assembly lines manufacture hundreds of identical products in one day.

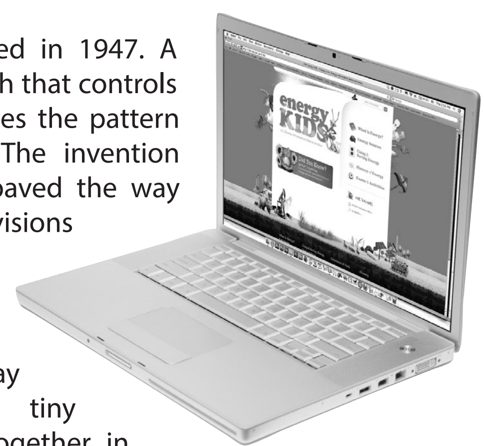
**Technology** is the science of making and using things. It is how we turn the natural materials in the world into tools and machines to help us live. When early people learned how to use fire, they were able to make tools and pottery. As time went on, people learned more about the natural world and how it functions.

In the last few hundred years, people have learned a lot about why substances and machines act the way they do. We have learned about atoms and molecules. We have learned about friction and gravity. We have learned about the laws of motion. We have used this knowledge to improve old machines and build new ones.

## Electricity Powers Modern Technology

The discovery of electricity and how to use it has led to some of the biggest changes in history. **Electricity** is the flow of electrons. We use it to produce heat, light, sound, and motion. We use electricity everyday to operate lights, machines, and appliances.

Electronics is the use of devices to control the flow of electricity. The key to electronics is the **transistor**, which was invented in 1947. A transistor is a switch that controls electrons. It changes the pattern of the electrons. The invention of the transistor paved the way for the first televisions and simple computers.



Computers work with a microchip.

In 1967, scientists discovered a way to have many tiny transistors work together in a **microchip**. The microchip is the key to modern electronics. Microchips can contain more than a million transistors. These transistors control each other and perform complex tasks in modern machines.

Every year, we use electronic technology to perform more tasks. Each year, we use more electricity to power these machines. Energy experts predict that more of the energy we use every year will be in the form of electricity.

# Key Words—Technology

**Directions: Use each key word in one of the statements below (1-5). Then, answer questions 6-9 at the bottom of the page.**

| | | | | |
|---|---|---|---|---|
| **electricity** | **electronics** | **microchip** | **technology** | **transistor** |

1. ____________________ use(s) devices to control the flow of electricity to do work for us.
2. A(n) ___________________________ is a switch that changes the pattern of electrons.
3. The science of using natural materials to help us in our lives is ________________________.
4. Many tiny transistors linked together to control electrons is a(n) ______________________ .
5. The movement of electrons is a form of energy called ________________________ .
6. What electronic technology do you think has changed the world the most? Why?
7. What new technology would you like to develop? What kind of energy would it use?
8. List all of the things in your classroom that use electronic technology.
9. What kind of energy do they use for power?

# Facts of Light

## Facts of Light

Ten years ago, we used a lot of energy in the form of electricity to make light to be able to see. Thirty percent of the electricity schools used was for lighting, and homes used about 14 percent of their electricity consumption for lighting. That's because homes, schools, and other commercial buildings used a lot of **incandescent** lighting. These inefficient bulbs were perfected by Thomas Edison in 1879 and didn't change much for the next 125 or more years! These bulbs were surprisingly inefficient, converting up to 90 percent of the electricity they consumed into heat.

The Energy Independence and Security Act of 2007 changed the standards for the efficiency of light bulbs used most often. As of 2014, most general use bulbs must be 30 percent more efficient than traditional, inefficient incandescent bulbs. What do the new standards mean for consumers? The purpose of the new efficiency standards is to give people the same amount of light using less energy. Most incandescent light bulbs have since been phased out and are no longer available for sale. This has resulted in significant energy savings for homes and schools. Newer, efficient lighting now accounts for only 17 percent of the electricity used in schools, and eleven percent used in homes.

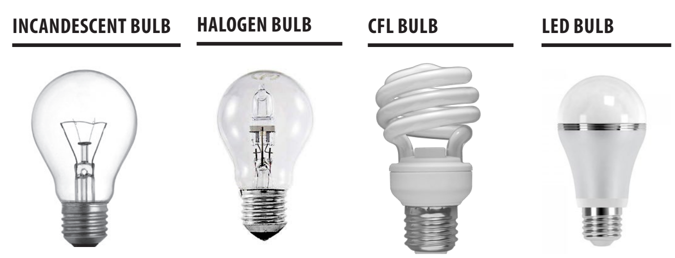
There are several lighting choices on the market that meet the new efficiency standards. Energy-saving incandescent, or **halogen**, bulbs are different than traditional, inefficient incandescent bulbs because they have a capsule around the **filament** (the wire inside the bulb) filled with halogen gas. This allows the bulbs to last three times longer and use 25 percent less energy.

**Compact fluorescent light bulbs (CFLs)** provide the same amount of light as incandescent bulbs, but use up to 75 percent less energy and last ten times longer. CFLs produce very little heat. Using CFLs can help cut lighting costs and reduce environmental impacts. Today's CFL bulbs fit almost any socket, produce a warm glow and, unlike earlier models, no longer flicker and dim. CFLs have a small amount of mercury inside and should always be recycled rather than thrown away. Many retailers recycle CFLs for free.

**Light emitting diodes**, better known as LEDs, are gaining in popularity. Once used mainly for exit signs and power on/off indicators, improved technology and lower prices are enabling LEDs to be used in place of incandescents and CFLs. LEDs are one of the most energy-efficient lighting choices available today. LEDs use 75 percent less energy than traditional incandescents, and have an average lifespan of at least 25,000 hours. The cost of LEDs has dropped in the last five years and may continue to drop. They use even less energy than CFLs, save more electricity, and produce fewer carbon dioxide emissions. The U.S. Department of Energy estimates that widespread adoption of LED lighting by 2027 would reduce lighting electricity demand by 33 percent. This would avoid construction of 40 new power plants.

### Did You Know?

Only 10 percent of the energy used by a traditional incandescent bulb produces light. The rest is given off as heat.




LEDs offer better light quality than incandescent bulbs and halogens, last 25 times as long, and use even less energy than CFLs. LEDs now have a wide array of uses because technology has improved and costs have decreased. It is possible to see CFL use decrease as LED costs continue to improve.

# Cost of 25,000 Hours of Light

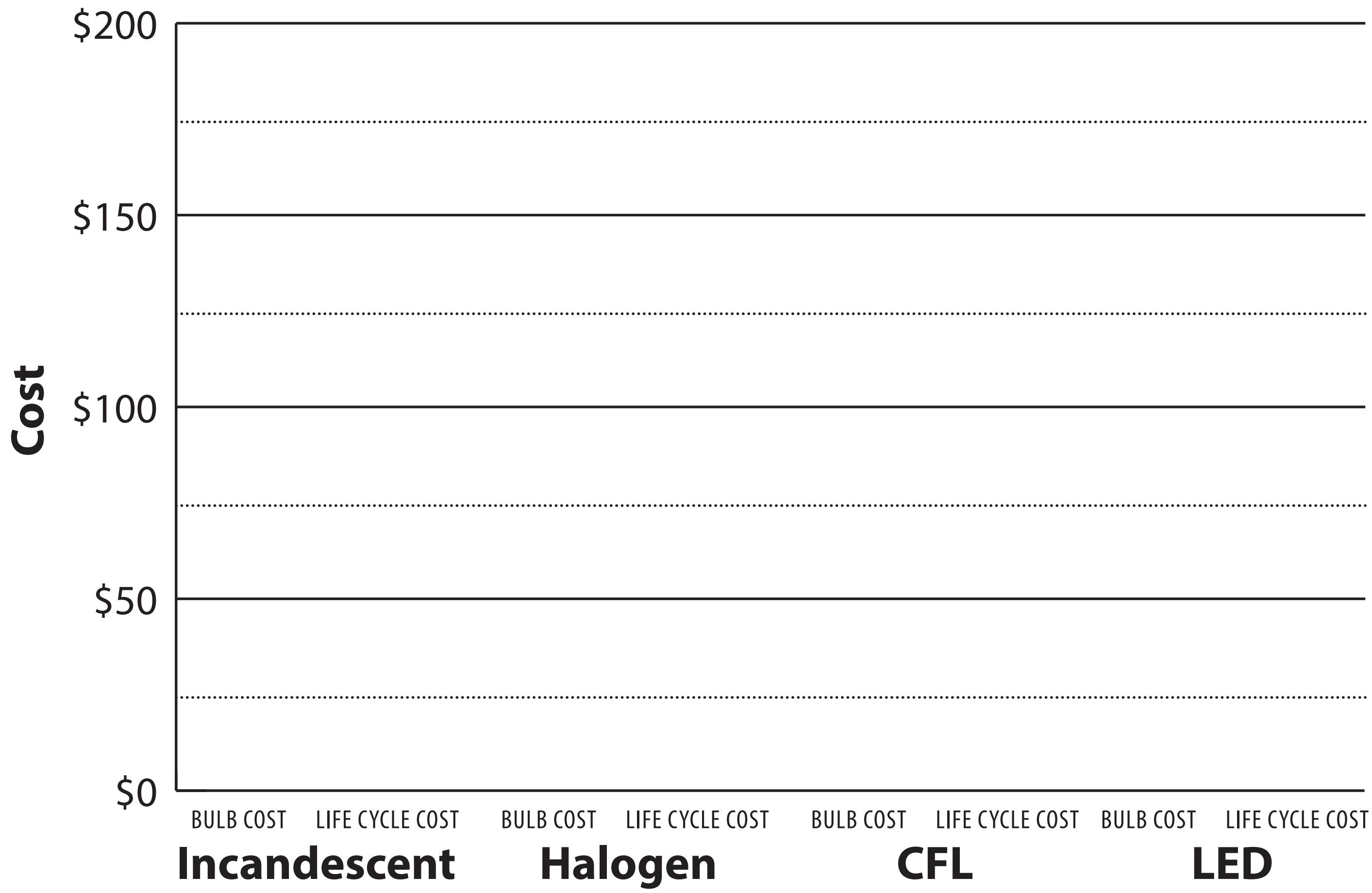



All bulbs provide about 850 lumens of light.

| | COST OF BULB | INCANDESCENT BULB | HALOGEN | COMPACT FLUORESCENT (CFL) | LIGHT EMITTING DIODE (LED) |
|---|---|---|---|---|---|
| | Life of bulb (how long it will light) | 1,000 hours | 3,000 hours | 10,000 hours | 25,000 hours |
| | Number of bulbs to get 25,000 hours | 25 bulbs | 8.3 bulbs | 2.5 bulbs | 1 bulb |
| x | Price per bulb | $0.50 | $3.00 | $3.00 | $4.00 |
| = | **Cost of bulbs for 25,000 hours of light** | **$12.50** | **$24.90** | **$7.50** | **$4.00** |
| | **COST OF ELECTRICITY** | **INCANDESCENT BULB** | **HALOGEN** | **COMPACT FLUORESCENT (CFL)** | **LIGHT EMITTING DIODE (LED)** |
| | Total Hours | 25,000 hours | 25,000 hours | 25,000 hours | 25,000 hours |
| x | Wattage | 60 watts = 0.060 kW | 43 watts = 0.043 kW | 13 watts = 0.013 kW | 12 watts = 0.012 kW |
| = | Total kWh consumption | 1,500 kWh | 1,075 kWh | 325 kWh | 300 kWh |
| x | Price of electricity per kWh | $0.13 | $0.13 | $0.13 | $0.13 |
| = | **Cost of Electricity** | **$195.00** | **$139.75** | **$42.25** | **$39.00** |
| | **LIFE CYCLE COST** | **INCANDESCENT BULB** | **HALOGEN** | **COMPACT FLUORESCENT (CFL)** | **LIGHT EMITTING DIODE (LED)** |
| | Cost of bulbs | $12.50 | $24.90 | $7.50 | $4.00 |
| + | Cost of electricity | $195.00 | $139.75 | $42.25 | $39.00 |
| = | **Life cycle cost** | **$207.50** | **$164.65** | **$49.75** | **$43.00** |
| | **ENVIRONMENTAL IMPACT** | **INCANDESCENT BULB** | **HALOGEN** | **COMPACT FLUORESCENT (CFL)** | **LIGHT EMITTING DIODE (LED)** |
| | Total kWh consumption | 1,500 kWh | 1,075 kWh | 325 kWh | 300 kWh |
| x | Pounds (lbs) of carbon dioxide per kWh | 1.5 lb/kWh | 1.5 lb/kWh | 1.5 lb/kWh | 1.5 lb/kWh |
| = | **Pounds of carbon dioxide produced** | **2,250.0 lbs carbon dioxide** | **1,612.5 lbs carbon dioxide** | **487.5 lbs carbon dioxide** | **450.0 lbs carbon dioxide** |

# The Facts of Light Activity

## Comparing Light Bulbs







| | Incandescent | Halogen Incandescent | CFL | LED |
|---|---|---|---|---|
| Bulb Cost | $12.50 | $24.90 | $7.50 | $4.00 |
| Electricity Cost | $195.00 | $139.75 | $42.25 | $39.00 |
| Life Cycle Cost | $207.50 | $164.65 | $49.75 | $43.00 |

Note: Bulb cost reflects the number of bulbs needed to produce 25,000 hours of light, which is the lifespan of one LED bulb. To produce the same amount of light, it would take 25 incandescent bulbs and 2.5 CFL bulbs.

**Answer the following questions in your science notebook.**

1. Draw the Comparing Light Bulbs graph in your science notebook. Use the data provided to create a bar graph.
2. Looking at the graph and the data table, what conclusions can you draw about the cost of each type of bulb?
3. If you were going to change all of the light bulbs in your home, which bulbs would you use and why?

# Electric Nameplates Investigation

Some appliances use more energy than others to accomplish the same task. Appliances that are very energy efficient are approved by the government's ENERGY STAR® program and have the ENERGY STAR® label on them. This means they have met high standards set by the government for energy efficiency.

Every machine that runs on electricity has an electric nameplate on it. The nameplate is usually a silver sticker that looks like the picture below. The nameplate has information about the amount of electricity the machine uses. Sometimes, the current is listed. The current is measured in amperes (A). Sometimes, the voltage the machine needs is listed. The voltage is listed in volts (V). Sometimes, the wattage is listed. The wattage is measured in watts (W). If the wattage isn't listed, then the current and voltage are both listed.

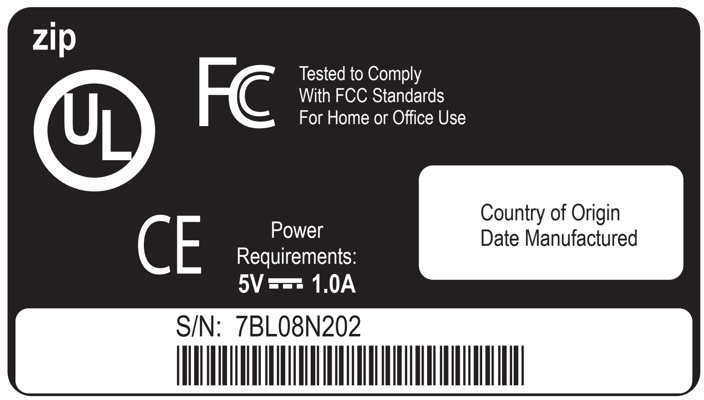
If the wattage is not listed, you can calculate the wattage using the following formula:

**wattage = current x voltage**

**W = A x V**

**W = 1.0A x 5V**

**W = 5W**




Often, the letters UL are on the nameplate. UL stands for Underwriters Laboratories, Inc., which conducts tests on thousands of machines and appliances. The UL mark means that samples of the machines and appliances have been tested to make sure they are safe.

You can find out how much it costs to operate any appliance or machine if you know the wattage. Let's take a look at some of the machines in your school. The nameplate is usually located on the bottom or back. See if you can find the nameplates on the computers, printers, monitors, televisions, and other machines in your classroom. Put the information in the chart below and figure out the wattage for each one.

| MACHINE | CURRENT | VOLTAGE | WATTAGE | UL TESTED |
|---|---|---|---|---|
| *Copier* | *11A* | *115V* | *1,265W* | *yes* |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

# Cost of Using Machines Investigation

Calculate how much it costs to operate the machines in your classroom that you looked at before. You need to know the wattage, the cost of electricity, and the number of hours a week each machine is used.

You can estimate the number of hours the machine is used each week, then multiply by 40 to get the yearly use. We are using 40 weeks for schools, because school buildings aren't used every week of the year. Using the copier as an example, if it is used for ten hours each week, we can find the yearly use like this:

**Yearly use = 10 hours/week x 40 weeks/year = 400 hours/year**

Remember that electricity is measured in kilowatt-hours. You will need to change the watts to kilowatts. One kilowatt is equal to 1,000 watts. To get kilowatts, you must divide the watts by 1,000. Using the copier as an example, divide like this:

**kW = W/1,000**

**kW = 1,265/1,000 = 1.265**

The average cost of electricity for schools in the U.S. is about eleven cents a kilowatt-hour and thirteen cents in U.S. homes. You can use one of these rates or find out the actual rate from your school's electric bill. Using the average cost of electricity, we can figure out how much it costs to run the copier for a year by using this formula:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Yearly cost** | **=** | **Hours used per year** | **x** | **Kilowatts** | **x** | **Cost of electricity (kWh)** | | |
| **Yearly cost** | **=** | **400 hours/year** | **x** | **1.265 kW** | **x** | **$0.11/kWh** | | |
| **Yearly cost** | **=** | **400** | **x** | **1.265** | **x** | **0.11** | **=** | **$55.66** |

| MACHINE OR APPLIANCE | HOURS PER WEEK | HOURS PER YEAR | WATTS (W) | KILOWATTS (kW) | RATE ($/kWh) | ANNUAL COST |
|---|---|---|---|---|---|---|
| *Copier* | *10* | *400 hours* | *1,265 W* | *1.265 kW* | *$0.11* | *$55.66* |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

# Glossary

| | |
|---|---|
| **absorbed** | taken in or held |
| **acceleration** | a change in speed or direction |
| **amplitude** | the height of a wave; the size of the path on which a pendulum swings |
| **angle** | the distance between two lines or surfaces |
| **atom** | a tiny unit of matter made up of protons, neutrons, and electrons |
| **auditory nerve** | the nerve that carries sound signals from the cochlea to the brain |
| **boiling point** | the temperature at which a liquid begins to boil |
| **carbon dioxide** | a gas in the air, water, and soil that plants use to make food |
| **carnivore** | organisms that eat only animals |
| **centripetal force** | a force directing an object moving in a circular path |
| **chemical energy** | the energy stored in chemical bonds of substances |
| **chemical reaction** | a change or process that creates new substances |
| **chlorophyll** | the substance in plants that allows them to absorb light to make food |
| **cochlea** | the part of the ear with hairs and fluid that help transfer sound |
| **compact flourescent light bulb** | a light bulb made of specially coated glass and filled with a gas that glows when electricty passes through it |
| **compression** | to press or squeeze together |
| **concave** | curving inward, thinner in the middle than on the ends |
| **conduction** | transferring energy from one place to another by touching |
| **conductor** | a material that transfers energy through it well, often metal |
| **consumer** | an organism that gets its energy from other organisms |
| **contract** | to shrink in size |
| **convection** | transfer of energy through a liquid or a gas |
| **convex** | curving outward, thicker in the middle than on the ends |
| **crest** | the top of a wave |
| **current** | the flow of electricity |
| **decibels (dB)** | a measurement of the height or intensity of a sound wave, the energy in a wave (how loud it is) |
| **eardrum** | a tiny part of the ear that vibrates to move the ear's parts to transfer sound |
| **echo** | reflected sound waves |
| **eclipse** | a shadow created by the sun or the moon |
| **electricity** | electrons in motion |
| **energy** | the ability to do work, produce change, or move an object |
| **expand** | to increase in size |
| **filament** | a thin metal piece that glows when heated, used in some light bulbs |
| **fluid** | term used to describe a liquid or a gas |
| **food chain** | energy transferring from one organism to another through consumption |
| **force** | a push or pull |
| **freezing point** | the temperature at which a liquid will become solid |

| | |
|---|---|
| **frequency** | the number of waves passing a point in one second |
| **friction** | a force that opposes motion |
| **gas** | a substance without a definite shape or volume; a gas fills any container in which it is placed |
| **gasoline** | a fuel made from petroleum that runs many vehicles |
| **glucose** | simple sugar, produced during photosynthesis; see *sugar* |
| **gravity** | the force of attraction between two items |
| **growth** | a change in size or development |
| **halogen** | a bulb that uses a heated filament and a special tube of gas to create light |
| **herbivore** | organism that eats plants only |
| **Hertz (Hz)** | a measurement of the amount of waves that vibrate past a point |
| **image** | a picture |
| **incandescent light bulb** | a bulb using a heated filament to produce light; the filament is surrounded by a gas and creates more heat than light; see *filament* |
| **inertia** | when an object resists changing its motion |
| **insulator** | a material that does not transfer energy well |
| **kinetic energy** | the energy of motion |
| **light emitting diode** | a bulb or device that produces light from energized particles called photons |
| **liquid** | a substance with a definite volume, but not a definite shape; a liquid takes the shape of the container in which it is placed |
| **longitudinal** | waves that move in a horizontal fashion, in the same direction as the force acting on them |
| **mass** | amount of matter in an object; how much inertia an object has |
| **microchip** | device holding transistors in electronic devices |
| **molecule** | two or more atoms bonded to each other that act like one atom |
| **motion** | change in position, movement; a form of energy |
| **newton** | measurement of force |
| **Newton's Laws of Motion** | laws that describe how all things will act when in motion |
| **omnivore** | organisms that eat both plants and animals |
| **oxygen** | a gas made by plants during photosynthesis; necessary for breathing |
| **pendulum** | any hanging object that swings |
| **penumbra** | an area during an eclipse that receives some shadow and some light |
| **period** | amount of time needed for a certain motion to occur (one vibration of a pendulum) |
| **photosynthesis** | when plants make food (sugar) using the energy in sunlight |
| **photovoltaic** | meaning energy from light; a device that uses light to create electricity; see *PV cell* or *solar cell* |
| **pitch** | the loudness of a sound; the angle of an item |
| **potential energy** | energy that is stored, not in motion |
| **pound** | measurement of force |
| **prism** | glass or plastic that bends light waves as they pass through |
| **producer** | organism that makes food for others |
| **protractor** | a tool used to measure angles |
| **PV cell** | a device made of silicon that can use light energy to create electricity; also called a solar cell or photovoltaic |

| | |
|---|---|
| **radiant energy** | energy that travels in waves or rays, such as light |
| **radiation** | the movement of waves |
| **rarefaction** | the pulling apart of a wave |
| **reflected** | bounced back from a surface |
| **refracted** | bent light waves traveling from one substance to another |
| **shadow** | an area without light |
| **solar cell** | see *PV cell* |
| **solid** | a substance with a definite shape and volume |
| **sound wave** | energy vibrating through substances in a long path |
| **sugar** | an energy-rich substance made by plants |
| **technology** | the science of making and using things |
| **temperature** | a measure of thermal energy |
| **thermal energy** | energy within a substance, caused by friction or movement of the atoms and particles (heat) |
| **transistor** | a device that controls the movement of electrons in machines and appliances |
| **transparent** | a substance that allows light to travel through it, "see-through" |
| **transverse wave** | a wave that moves in a different direction than the force applied |
| **trough** | the bottom of a wave |
| **umbra** | the shadowed area during an eclipse that is completely dark, no light is seen |
| **vibration** | moving back and forth; one back and forth motion of a pendulum |
| **visible light** | wave energy that can be seen |
| **voltage** | a measurement of electrical energy, measured in volts |
| **volume** | a measure of the space occupied by a substance |
| **wattage** | a measurement of electric power or work done by a device |
| **wavelength** | the distance between two waves from crest to crest |
| **wind** | movement of air |

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Phillips 66
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Quarto Publishing Group
Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
Robert Armstrong
Roswell Geological Society
Salt River Project
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University of North Carolina
University of Tennessee
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U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy–Wind for Schools
U.S. Energy Information Administration
United States Virgin Islands Energy Office
Wayne County Sustainable Energy
Western Massachusetts Electric Company
Yates Petroleum Corporation