chapter 13 Electricity

section ● Electric Charge

What You'll Learn

- how electric charges exert forces
- about conductors and insulators
- how things become electrically charged

Before You Read

Think about some electric objects that are plugged into an outlet. But cars, cell phones, and even wristwatches also use electricity. List three things you use every day that use electricity but do not plug in.

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Mark the Text

Identify Main Ideas Highlight the main point under each heading. Then explain the main point in your own words.

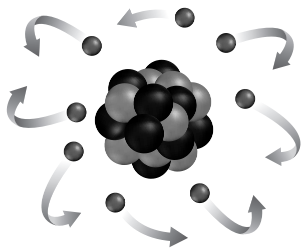
Read to Learn

Positive and Negative Charge

Sometimes, when you walk across a carpet and then touch an object, you get a shock. Why does this happen? The answer has to do with electric charge. The center of an atom is made up of particles called protons and neutrons. Other particles, electrons, move around the center of the atom. Protons and electrons have electric charge. Neutrons have no electric charge. In the figure below, the light gray particles are the protons, the black particles are the neutrons, and the floating particles are the electrons.

Picture This

1. **Differentiate** Circle the electrons with a colored pen or pencil.



Center of an Atom

There are two types of electric charge, positive and negative. Protons have positive electric charge. Electrons have negative electric charge. The amount of positive charge on a proton is the same as the amount of negative charge on an electron. Each atom has the same number of protons and electrons. So, the positive and negative charges cancel each other out. This makes atoms electrically neutral. They have no overall electric charge. An atom becomes negatively charged if it gains extra electrons. An atom that loses electrons becomes positively charged.

How is electric charge transferred?

Electrons are bound more tightly to some atoms and molecules than to others. Electrons in the soles of your shoes are bound tightly to the atoms. Electrons in atoms in carpet are not bound as tightly. When you walk on carpet, electrons are transferred from the carpet to the soles of your shoes.

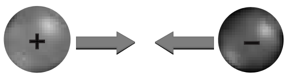
Now, the soles of your shoes have more electrons than protons. They are negatively charged. The carpet has fewer electrons than protons. It is positively charged. The transfer of electrons changed the electric charge of each object. **Static electricity** is the buildup of electric charges on an object. When there is static electricity, electric charges are not balanced.

Is new electrical charge created?

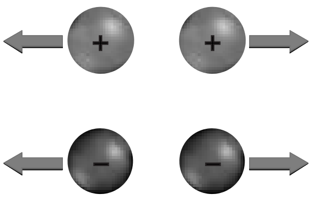
The electrons that moved to your shoe are not new electrons. The **law of conservation of charge** states that charge can be transferred from one object to another, but it cannot be created or destroyed. An object becomes charged when electric charges move from one place to another.

What happens when electrical charges move?

Have you ever taken clothes out of a dryer and had them cling together? Look at the figure below. Opposite electric charges attract each other. They tend to move toward each other. Electric charges that are the same repel each other. They tend to move away from each other.



Opposite charges attract



Like charges repel

When clothes tumble in a dryer, the atoms in some clothes lose electrons. Those clothes become positively charged. The atoms in other clothes gain electrons and become negatively charged. The clothes have opposite charges. Objects that have opposite charges attract each other, so the clothes cling together.

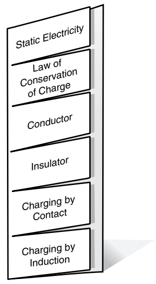
How do charges exert forces?

The electric force between two charged objects depends on how far apart the objects are. The electric force between two charges decreases as the charges move farther apart.

The electric force also depends on the amount of charge on each object. When the amount of charge on one of the objects increases, the electric force increases.

FOLDABLES™

Build Vocabulary As you read this section, make the following vocabulary Foldable. Write the definition for each vocabulary word under its tab.



Picture This

2. **Illustrate** Look at the figures of like and unlike charges. Highlight the negative charges in one color and the positive charges in other color. Notice the charges only attract when the colors are different.

What are electric fields?

When a charged balloon comes near your hair, your hair will move toward it. Your hair does not have to touch the balloon for an electric force to act on it. So what makes your hair move? It is positively charged. The balloon is negatively charged. They are attracted to each other because they have opposite electric charges.

Picture This

3. Identify Look at the figure of electric fields. Why do the arrows point outward from the positive field? Why do they point inward toward the negative field?

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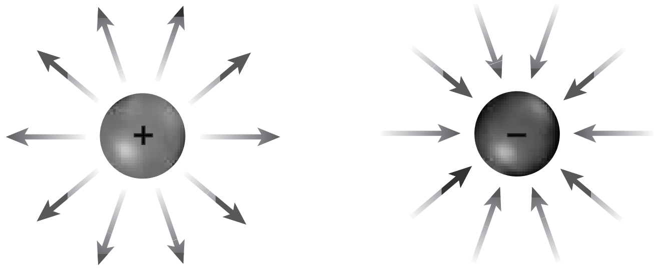
Move of a Positive Charge in Electric Fields



There is an electric field around every electric charge. The electric field exerts a force that attracts or repels other electric charges. The figure shows two electric fields. The arrows show the direction a positive charge would move in each electric field. Your hair has the positive charge and moves to the balloon.

The force of gravity between you and Earth seems very strong. However, electric forces are much stronger. Electric forces between the protons and the electrons hold the particles in atoms together. For example, the electric force between a proton and an electron in a hydrogen atom is a thousand trillion, trillion, trillion times larger or, 10^{39} times larger than the attractive gravitational forces between the same proton and electron.

Forces Between Atoms Atoms also are held together by electric forces. Electric forces between atoms cause chemical bonds. These electric forces are also much greater than the gravitational forces between the atoms.

Think it Over

4. Explain in your own words why usually there is very little electric force between two objects.

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Forces Between Objects Many of the forces that act on objects are due to the electric forces between atoms and molecules. All atoms contain electrically charged protons and electrons. When atoms or molecules get close enough, they can exert forces that attract or repel. For example, when you push on a door, the atoms in your hand get close to the atoms in the door. The atoms are close enough to exert forces on each other. The forces between the atoms in your hand and the atoms in the door cause the door to move.

Conductors and Insulators

Remember the example of electrons moving from the carpet to your shoe? If you reach for a metal doorknob after walking on carpet, you might see a spark. Electrons moving from your hand to the doorknob cause the spark. How did those electrons move from your shoe to your hand?

What is a conductor?

Electrons can move more easily in some materials than in others. A **conductor** is material in which electrons can move easily. Your skin is a better conductor than your shoes. Electrons move from your shoes to your skin, spreading to your hands. The best electric conductors are metals. Atoms in metals have electrons that are able to move easily through the metal. Copper is one of the best conductors.

What is an insulator?

An **insulator** is a material in which electrons cannot move easily. In insulators, electrons are held tightly to atoms. The plastic coating around an electric wire keeps you from getting a dangerous electric shock when you touch the wire. Wood, rubber, and glass are other good insulators.

Think it Over

5. **Explain** why it is hard for electrons to move through an insulator.

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Charging Objects

Just like the clothes in the dryer, when two materials are rubbed together, electrons can be transferred between them. One object will have a negative charge. The other will have the same amount of positive charge. **Charging by contact** is the transfer of charges by touching or rubbing.

How can something be charged at a distance?

Remember, electric forces change when objects move closer together. If a charged object is moved near a neutral object, electrons on the neutral object will move around.

Think about the balloon that was charged by rubbing it on your hair. The charged balloon doesn't need to touch the hair to make the hair move toward it. The same is true if you hold the charged balloon close to a wall. The extra electrons on the balloon repel the electrons in the wall. The electrons in the wall move away from the balloon. Now there is a positively charged area on the wall. The negatively charged balloon is attracted to the positive area of the wall. **Charging by induction** is when a charged object causes the rearrangement of electrons on a nearby neutral object. The wall was charged by induction. The balloon will stick to the wall. An electric force holds it there.

What is lightning?

Have you ever seen lightning hit the ground? Lightning is a large static discharge—a transfer of charge between two objects. It happens if there is a buildup of static electricity.

A large amount of static electricity is formed when air moves around in thunderclouds. Areas of positive and negative charge build up. When enough charge builds up, there is a static discharge between the cloud and the ground. As the charges move through the air, they hit atoms and molecules and cause them to give off light.

What is thunder?

Lightning makes a bright light. It also creates powerful sound waves. Thunder is the sound that lightning makes. The electrical energy in lightning heats the air to 25,000°C. This rapid heating of the air causes sound waves you hear as thunder.

Think it Over

6. Analyze Why do you think a lightning rod is made of metal?

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Why is grounding important?

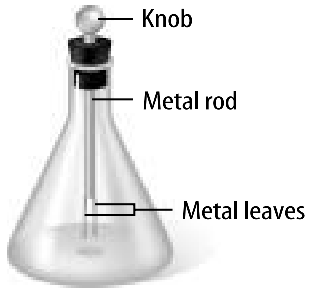
Lightning can cause damage and injury because it releases a great amount of energy. One way to avoid the damage is to make the charges flow to Earth's surface. Earth is a large, neutral conductor that can absorb a lot of excess charge. Grounding provides a path for electric charges to move to Earth. For example, a metal lightning rod on top of a building provides a path to move excess charges to Earth's surface.

Detecting Electric Charge

An electroscope can detect when an object has an electric charge. One type of electroscope is a glass beaker with a metal rod inside it, as shown. The metal rod connects to a knob at the top of the beaker. There are two metal branches, or leaves, at the bottom of the metal rod. The metal leaves hang down when there is no charge to the rod. When an object with a negative charge touches the knob, electrons travel down the rod to the leaves. Both leaves gain negative charges. When an object with a positive charge touches the knob, it attracts electrons that move up the rod. The leaves have a positive charge. When the leaves have a charge, they repel each other and spread apart.

Picture This

7. Draw On the figure, draw what the leaves would look like if they had a charge.



After You Read

Mini Glossary

charging by contact: transferring charges by touching or rubbing

charging by induction: when electrons on a neutral object are moved by a charged object

conductor: a material in which electrons can move easily

insulator: a material in which electrons cannot move easily

law of conservation of charge: charge can be transferred from one thing to another, but it cannot be created or destroyed

static electricity: the buildup of electric charges on an object

1. Read the definitions of an insulator and a conductor in the Mini Glossary above. Use the words in a sentence that shows that you understand them.

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2. Column 1 lists some of the concepts you learned about in this section. Column 2 gives a fact about each concept. Write the letter of the fact on the line next to the concept that matches it.

Column 1	Column 2
______ **1.** transferring charge	**a.** static electricity is discharged between a cloud and the ground
______ **2.** conservation of charge	**b.** electrons cannot move easily in some materials
______ **3.** insulator	**c.** electrons can move from one object to another
______ **4.** lightning	**d.** charge cannot be created or destroyed

3. You highlighted the main points to help you understand electric charge. How did you decide what the main points were?

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End of Section

chapter 13 Electricity

section ● Electric Current

What You'll Learn
- what makes current flow
- how batteries work
- what causes electrical resistance
- what Ohm's law says

Before You Read

Have you noticed that one end of a battery is marked with a plus sign and the other end with a minus sign? What happens if you put the batteries in a flashlight in the wrong direction?

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Mark the Text

Identify Details Use one color to highlight each question heading. Then use another color to highlight the answer to the question.

Read to Learn

Current and Voltage Difference

You have read about the ways electric charges move. One example is the spark that can jump between your hand and a metal doorknob. **Electric current** is the net movement of electric charges in one direction.

To understand net movement, consider the movement of electrons in all materials. In all materials, electrons move in every direction. Since the electrons are not moving in the same direction, there is no electric current. When electric current flows in a wire, the electrons still move in all directions, but they also drift in the direction that the current flows. The drifting of the electrons is the net movement in one direction.

Electric current is measured in units called amperes. Amperes are also called amps. The symbol for amperes is the letter A. Amperes measure the electrons that flow past one point. One ampere is equal to 6,250 million billion electrons moving past a point every second. ☑

Reading Check

1. **Explain** How many electrons must move past a point every second to equal one ampere of electric current?

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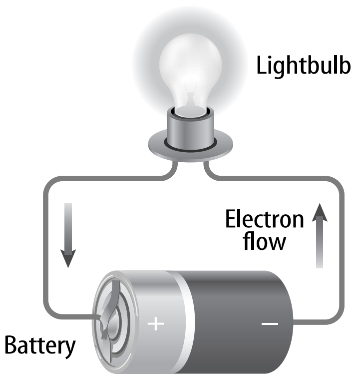
What is voltage difference?

Even though the electrons are moving in all directions, an electric force acts on the charges to make them flow in one direction. Voltage is the electric force that makes charges move.

Voltage is also like the force that acts on water in a pipe. Water flows from higher pressure to lower pressure. In the same way, electric charge flows from higher voltage to lower voltage. A **voltage difference** is related to the force that makes electric charges flow. Voltage difference is measured in units called volts. The symbol for volts is V.

What is an electric circuit?

Look at the figure. It shows an electric current doing work by lighting a lightbulb. Electric current must have a closed "loop-like" path to follow. If there is no closed path to follow, the current stops. A **circuit** is a closed path that electric current follows. If the circuit in the figure is broken by taking away one part, such as the battery or the lightbulb, current will not flow. It will also not flow if a wire is broken or cut. The lightbulb will not light.



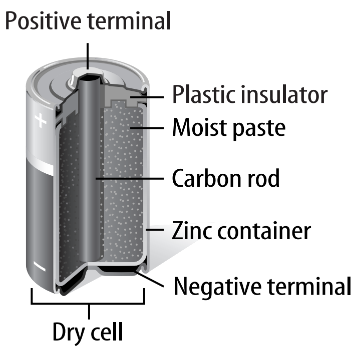
Batteries

A circuit needs a voltage difference to keep electric current flowing in it. A battery can provide the voltage difference that keeps electric current flowing. Look at the figure of the circuit again. The positive end and the negative end of a battery are called the terminals. When a closed path connects the terminals, the current will flow.

How do dry-cell batteries work?

The batteries used in a flashlight are called dry-cell batteries. Look at the figure below of a dry-cell battery. The battery has two electrodes. One electrode is a carbon rod. The other electrode is a zinc container.

Around the electrodes is a moist paste. The paste is called an electrolyte. The electrolyte contains chemicals that are conductors. The electrolyte lets charges move from one electrode to the other electrode. This kind of battery is called a dry cell because the electrolyte is a paste, not a liquid.



Picture This

2. Describe Look at the figure of a circuit. Which direction do electrons flow in the circuit, away from the negative terminal or away from the positive terminal?

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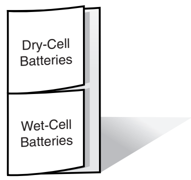
FOLDABLES™

Build Vocabulary
Make a Foldable as shown. Write the definitions under the tabs and add information as you read this section.



Think it Over

3. Describe when the chemical reaction occur in a dry-cell battery.

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Picture This

4. Compare What two things are shown in both the figure of the dry-cell battery and the figure of the wet-cell battery?

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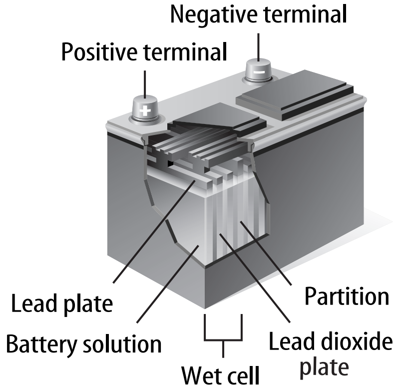
Making Electricity When the two terminals of a dry-cell battery are connected in a circuit, there is a reaction between the zinc and the chemicals in the electrolyte. Electrons move between some of the compounds in this chemical reaction. The carbon rod become positive. The positive terminal is marked with a plus sign (+). Electrons build up on the zinc, making it the negative terminal. The negative terminal is marked with a minus sign (–). The voltage difference between the terminals cause current to flow through a closed circuit.

How do wet-cell batteries work?

Another kind of battery is the wet-cell battery shown below. A wet cell has two connected plates made of different metals. The metals are in a conducting solution. Chemical reactions transfer electrons from the lead plates to the lead dioxide plates. This battery is called a wet cell because the conductor is a liquid. A wet-cell battery contains several wet cells that are connected. Together the cells give a larger voltage difference than each of the cells alone.



What is a lead-acid battery?

Lead-acid batteries are wet-cell batteries. They are usually used in cars. A lead-acid battery has six separate wet cells that are connected. The cells are made of lead and lead dioxide plates. The plates are in a sulfuric acid solution. A chemical reaction gives a voltage difference of about 2 V in each cell. There are six cells, so the total voltage difference is 12 V.

How are electric outlets different from batteries?

Electric outlets, such as wall sockets, also give a voltage difference. This voltage difference usually is much higher than the voltage difference a battery gives. Most wall sockets give a voltage difference of 120 V. Some outlets have a voltage of 240 V that is needed for large appliances, such as electric ovens and clothes dryers.

Resistance

Flashlights use dry-cell batteries to make the current that lights up the lightbulb. What makes a lightbulb glow? Part of the circuit is a thin wire in the bulb. The wire is called a filament. The electrons in the current flow through the filament. As they move, they bump into the metal atoms in the filament.

The electrons bump into the metal atoms, turning some of their electrical energy into thermal energy. The metal filament gets hot enough to glow. The radiant energy lights up the room. ☑

How do materials resist current?

Electric current loses energy when it moves through material because of resistance. **Resistance** is the tendency for a material to oppose, or go against, the flow of electrons. Resistance turns electrical energy into thermal energy and light.

Almost all materials have electrical resistance. Materials that are electrical conductors have less resistance than materials that are electrical insulators. Resistance is in units called ohms(Ω).

What can affect resistance?

The temperature, length, and thickness of a material can affect the electric resistance of the material. Usually, the hotter something is, the more resistance it has. The resistance of an object also depends on its length and thickness. The longer the circuit is, the more resistance it has. Resistance also increases as the wire gets thinner.

A lightbulb filament is a thin piece of tungsten wire made into a short coil. The uncoiled wire is about 2 m long and very thin. Tungsten is a good conductor, but since the wire is so long and thin, it has resistance. The resistance makes the filament glow. The more resistance a filament has, the brighter it glows. ☑

The Current in a Simple Circuit

A simple electric circuit has three main parts. First, it has a source of voltage difference, such as a battery. Second, it has a device that has resistance, like a lightbulb. Third, it has conductors, such as wires. The conductors connect the resistance device to the battery terminals. When the wires are connected to the battery terminals, the path is closed and current flows.

Two electric circuits are shown in the figures on the next page. Each circuit is a battery connected to a lightbulb by wires and a rod. The circuit on the right is shorter because the wires are closer together on the rod. That circuit has less resistance.

Reading Check

5. **List** the three types of energy needed to make a lightbulb in a flashlight glow.

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Reading Check

6. **Recognize Cause and Effect** How does the resistance of a filament affect its glow?

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Picture This

7. Compare In which circuit will the light be brighter, the one on the left or the one on the right?

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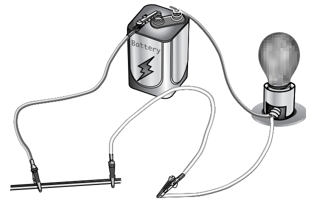
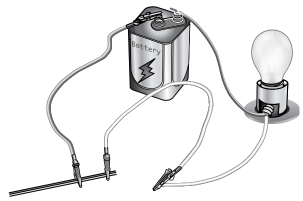
More resistance



Less resistance



The voltage difference, current, and resistance in a circuit are related. If the voltage difference stays the same as the resistance decreases, the current in the circuit increases. If the wire is short, the lightbulb will be brighter. If the resistance doesn't change, increasing the voltage difference increases the current. If you use a larger battery, the lightbulb will be brighter.

What is Ohm's law?

There is a relationship between voltage difference, current, and resistance in a circuit. **Ohm's law** states that the current in a circuit equals the voltage difference divided by the resistance. If *I* stands for electric current, Ohm's law can be written as:

$$\textbf{current} \text{ (in amperes)} = \frac{\textbf{voltage difference} \text{ (in volts)}}{\textbf{resistance} \text{ (in ohms)}}$$

$$\boldsymbol{I = \frac{V}{R}}$$

Ohm's law also can be used to measure resistance. Change the equation so that resistance, *R*, is alone on one side. Do this by multiplying both sides of the equation by *R*. The new equation is:

$$\boldsymbol{R = \frac{V}{I}}$$

Suppose a current of 0.5 A flows in a 75-W lightbulb. The voltage difference between the ends of the filament is 120 V. Find the resistance of the filament.

$$R = \frac{V}{I}$$

$$= \frac{120}{0.5}$$

$$= 240$$

The resistance is 240 Ω.

Applying Math

8. Solve the equation to show how $I = \frac{V}{R}$ becomes $R = \frac{V}{I}$. Show your work.

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After You Read

Mini Glossary

circuit: a closed path that electric current follows

electric current: the rate at which electric charges move in one direction past one point

Ohm's law: the current in a circuit equals the voltage difference divided by the resistance

resistance: the tendency for a material to oppose the flow of electrons, changing electric energy into heat and light

voltage difference: something related to the force that makes electric charges flow

1. Read the terms and definitions of resistance in the Mini Glossary above. Rewrite the definition of resistance in your own words on the lines below.

2. Complete the table below to describe a simple circuit. The first column lists the parts of a circuit. In the second column, give an example of each part of a circuit. Under the heading *Function*, write a short description of what job each part does in the circuit.

Parts of a Simple Circuit		
Part	**Example**	**Function**
Voltage difference		
Source of resistance		
Conductors		

3. As you read this section, you highlighted the question headings and their answers. Why was using two colors helpful?

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End of Section

chapter 13 Electricity

section ● Electrical Energy

What You'll Learn
- the difference between series and parallel circuits
- why circuit breakers and fuses are important
- how electric power is calculated

Before You Read

Do adults ever remind you to turn off the lights when you leave a room? Like many things we use, electricity is not free. How does the electric company know how much electric energy you use?

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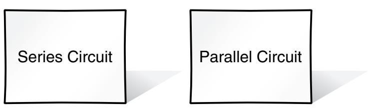
Study Coach

Create a Quiz As you read this section, think of five quiz questions. Write them down. After you read the section, answer the quiz questions you wrote.

FOLDABLES

Gather Information Use two quarter-sheets of notebook paper to organize information about series circuits and parallel circuits. Include terms and calculations.



Read to Learn

Series and Parallel Circuits

Think of your home. How many things are plugged into electric outlets? You might think of lamps, stereos, televisions, and clocks.

As you read in the last section, a circuit includes three parts. The first part is something that provides a voltage difference. It can be a battery or an electric outlet. The second part is something that uses electric energy and provides resistance. Lightbulbs and hair dryers are two examples. The third part is a conductor that connects the other parts. An example of a conductor is a wire. These three parts form a closed path for the electric current to travel on.

Think about using a hair dryer. The dryer needs to be plugged into an electric outlet. A generator at a power plant produces the voltage difference that ends up at the wall outlet. The voltage difference makes electric charges move when the circuit is complete. The dryer and the circuit in your house have conducting wires. The wires carry the current.

Closing the Circuit When you turn on the hair dryer, you close the circuit. The hair dryer turns electrical energy into thermal energy and mechanical energy. Mechanical energy is the energy that moves the fan in the hair dryer.

Opening the Circuit When you turn the hair dryer off, you open the circuit. This breaks the path of the current. To use electrical energy, you need a complete circuit. There are two kinds of circuits, series circuits and parallel circuits.

What is a series circuit?

One kind of circuit is called a series circuit. In a **series circuit**, the current has only one loop to flow through. Series circuits are used in flashlights.

Reading Check

1. **Identify** How many loops does a series circuit have?

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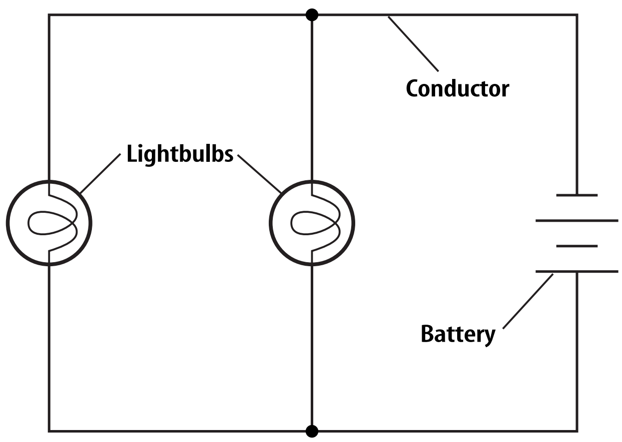
How does an open circuit affect a series circuit?

Some older strings of holiday lights will not work if just one lightbulb is burned out. The lights are connected in a series circuit. In a series circuit, the parts are wired one after another. The amount of current is the same through every part. When any part of a series circuit is disconnected, no current flows through the circuit. This is called an open circuit. One burned-out bulb makes the string of lights an open circuit.

Where are parallel circuits used?

What would happen if your home were wired in a series circuit? If you turned off one light, the circuit would be open. All the other lights and appliances in your house would go off. This is why houses are wired with parallel circuits. **Parallel circuits** have at least two paths for current to move through.

Look at the parallel circuit in the figure. The parallel circuit divides the current into two paths. This lowers the resistance. Remember Ohm's law from the last section. More current flows through the paths that have lower resistance.



Picture This

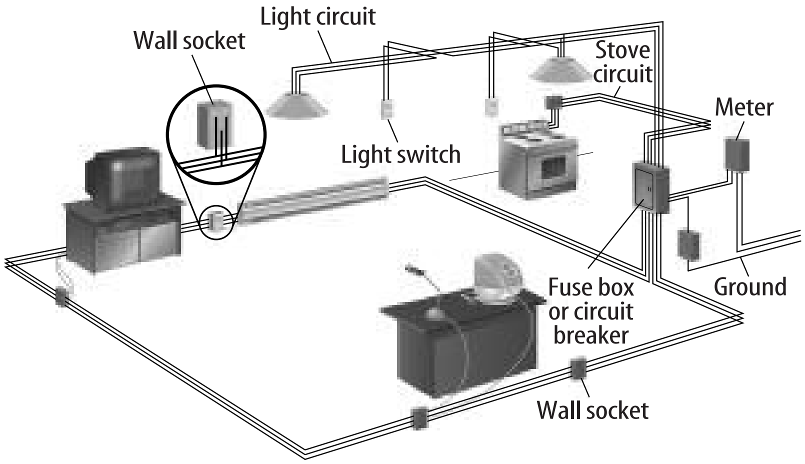
2. **Illustrate** In the space below, draw a parallel circuit that has three branches. Label the parts of the circuit.

Houses, cars, and most electric systems use parallel circuits. When one path is opened, the current still flows through the other paths. One part can be turned off without turning off the whole circuit.

Household Circuits

Many things in your house use electric energy. You don't see all the wires, because they are hidden behind the walls, ceiling, and floors. The wiring is mostly a combination of parallel circuits. The circuits are connected in an organized and logical way.

Look at the figure below showing the wiring in a house. There is a main switch and a circuit breaker or fuse box. These are like the electric headquarters for the house. Parallel circuits branch out from the circuit breaker or fuse box. The circuits run to wall outlets, appliances, and lights.



Picture This

3. **Highlight** In the figure, use a highlighter to trace a path of a circuit from the meter to the wall socket on the far side of the room.

In a house, many appliances use current from the same circuit. If more appliances are plugged in on a circuit, more current will flow through the wires. As more current flows through the wires, more heat is produced in the wires. If the wires get too hot, the insulation can melt. The bare wires can touch, get hot, and cause a fire. To keep the wires from getting too hot, household circuits include either a fuse or a circuit breaker. ☑

Reading Check

4. **Describe** What happens to the current flow in a circuit when more appliances are added to the circuit?

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What are fuses?

A fuse is a safety device that stops the wires from getting too hot. A fuse is a small glass tube with a piece of metal inside. If the current is too high, the metal melts. When it melts, it breaks the flow in the circuit. The current stops. To get the current to flow again, you need to replace the old fuse with a new one.

Before you replace the fuse, you should turn off or unplug some of the appliances on the circuit. Using too many household appliances at the same time is the main cause for a blown fuse.

How does a circuit breaker work?

A circuit breaker is another device that keeps a circuit from overheating. A house usually has a metal box, called a breaker box, which contains many circuit breakers. A circuit breaker is a switch, like a light switch, that has a piece of metal inside. If the current in the circuit is too high, the metal warms up and bends. When the metal bends, it flips the switch and opens the circuit. The flow of current stops before the wires get too hot.

You can usually reset the circuit breaker by flipping the switch inside the breaker box back to its original position. But, before you flip the switch, you should turn off or unplug some of the appliances on the circuit. Otherwise, the circuit breaker will flip the switch off again if too many appliances are using the current in the circuit.

Electric Power

Electrical energy is useful because it is easy to change into other kinds of energy. For example, it can be changed to thermal energy in a hair dryer. It can also be turned into light, or radiant energy, in a lamp or mechanical energy in a fan. **Electric power** is the rate at which electrical energy is changed into another form of energy.

Different appliances use different amounts of electric power. Appliances are usually marked with a power rating. The power rating tells how much power the appliance uses. Appliances that have electric heating elements, such as ovens and hair dryers, usually use the most power.

How is electric power calculated?

The amount of electric power something uses depends on the voltage difference and the current. You can use the following equation to calculate electric power.

$$\underset{\text{(in watts)}}{\textbf{electric power}} = \underset{\text{(in amperes)}}{\textbf{current}} \times \underset{\text{(in volts)}}{\textbf{voltage difference}}$$

$$P = IV$$

The unit for power is the watt. The abbreviation for watt is W. The watt is a small unit of power. Because of this, electric power usually is measured in kilowatts. *Kilo-* means "thousand." One kilowatt equals 1,000 watts. The abbreviation for kilowatt is kW. You may see this symbol, or something similar, if you look at an electric bill.

Think it Over

5. **Apply** Think about the circuits in your house. Why is it a good idea to have circuit breakers and fuses?

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Applying Math

6. **Calculate** The current in an electric clothes dryer is 15 A when it is plugged into a 240-V outlet. How much power does the clothes dryer use? Show your work. Show your answer in kW.

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Think it Over

7. Infer Why do you think electric companies charge by the amount of electric energy used as opposed to the amount of electric power used?

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How is electrical energy calculated?

Using electric power costs money. However, electric companies charge by the amount of electrical energy used, not the amount of electrical power. Electrical energy usually is measured in units of kilowatt hours. The abbreviation for kilowatt hours is kWh. Kilowatt hours can be calculated using this equation:

$$\underset{\text{(in kWh)}}{\textbf{electrical energy}} = \underset{\text{(in kW)}}{\textbf{electric power}} \times \underset{\text{(in hours)}}{\textbf{time}}$$

$$\boldsymbol{E = Pt}$$

How much does it cost to use electric energy?

You can figure out how much it costs to use an appliance. You do this by multiplying the electric energy used by the cost of each kilowatt hour. Suppose you leave a 100-W lightbulb on for 5 h. The amount of electric energy it uses is

$$E = Pt = (0.1\ \text{kW})\ (5\ \text{h}) = 0.5\ \text{kWh}$$

If the power company charges $0.10 per kWh, the cost of using the light for 5 h is

$$\begin{aligned}\text{cost} &= (\text{kWh used})\ (\text{cost per kWh})\\ &= (0.5\ \text{kWh})\ (\$0.10/\text{kWh}) = \$0.05\end{aligned}$$

So, in this example, it costs five cents to use a 100-W lightbulb for 5 h.

The cost of using some household appliances is given in the table. The cost of $0.09 per kWh was used in the calculations.

Cost of Using Home Appliances

Appliance	Hair Dryer	Stereo	Color Television
Power rating	1,000	100	200
Hours used daily	0.25	2.0	4.0
kWh used monthly	7.5	6.0	24.0
Cost per kWh	$0.09	$0.09	$0.09
Monthly cost	$0.68	$0.54	$2.16

Picture This

8. Observe Which appliance has the greatest monthly cost?

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After You Read

Mini Glossary

electric power: the rate at which electric energy is changed into another form of energy

parallel circuit: a circuit with at least two paths for current to move through

series circuit: a circuit with just one loop for current to move through

1. Read the terms and definitions in the Mini Glossary above. On the lines below, write a sentence that shows your understanding of the difference between a series circuit and a parallel circuit.

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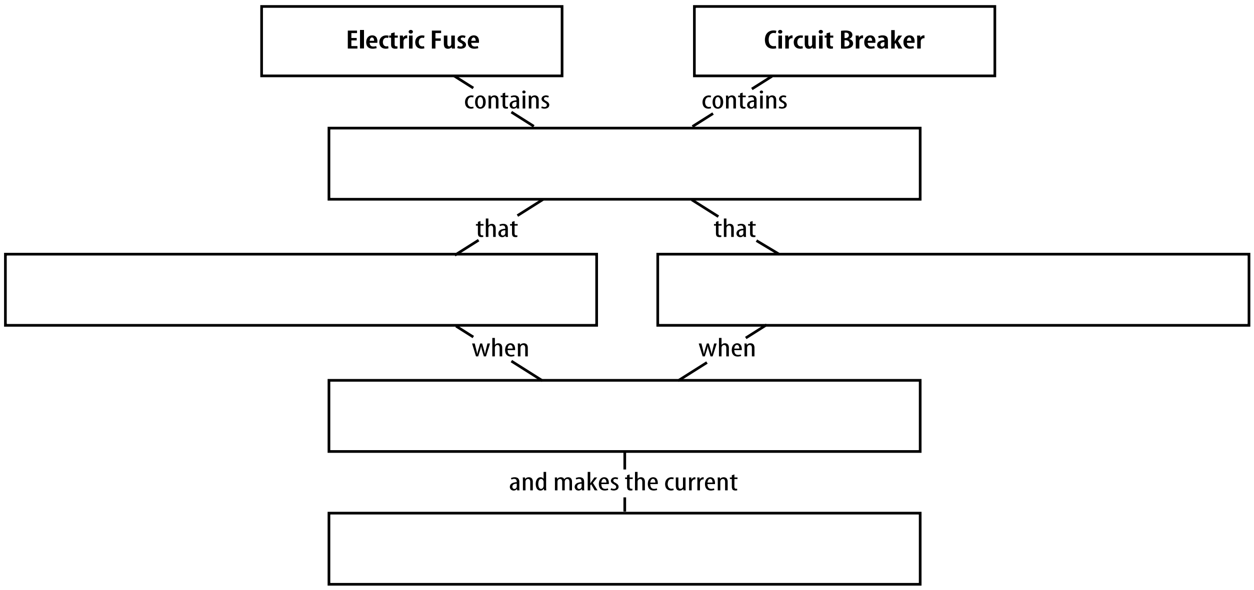
2. Complete the graphic organizer.



3. You used the create-a-quiz strategy as you read this section. Look at the quiz questions you wrote. How many of them can you answer correctly? Did this strategy help you understand and remember what you read?

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Science Online Visit **gpescience.com** to access your textbook, interactive games, and projects to help you learn more about electrical energy.

End of Section

chapter 14

Magnetism

section ● Magnetism

What You'll Learn

- how a magnet applies force
- how temporary and permanent magnets act
- magnetic materials and magnetic domains

Before You Read

Think about a magnet that you have used. Tell what it looked like and the kinds of materials it attracted.

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Study Coach

Discussion After reading this section, use an index card to write down the two most important things you learned. Put one idea on one side and the second idea on the back. Form a group of four students to discuss your topics.

Read to Learn

Magnets

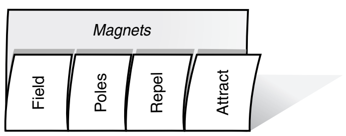
Magnets were discovered more than 2,000 years ago. Greeks discovered a mineral that could attract pieces of iron. This mineral is now called magnetite. About 1,000 years ago, Chinese sailors used magnetite to make compasses. Compasses are tools that can help you determine which direction you are traveling. Since then many items have been invented that use magnets. **Magnetism** refers to the properties of magnets and how magnets act when they are near each other, or interact.

What is a magnetic force?

Magnets exert a force on each other. These forces cause magnets to do one of two things. The magnets can attract, which means they pull together. Or the magnets can repel, which means they push each other away. How they react depends on which ends of the magnets are close together. Two magnets interact with each other even before they touch. As the magnets move closer together, the force between them increases. As the magnets move farther apart, the force decreases.

FOLDABLES™

● Organize Information Make the following Foldable to help you organize information about magnets.



What is a magnetic field?

The way magnetic forces interact with each other is caused by magnetic fields. The **magnetic field** exerts a force on other magnets and objects that are made of magnetic material. The magnetic force is strongest close to the magnet. The magnetic force becomes weaker as distance from the magnet increases.