chapter 6 Electricity

section 3 More Complex Circuits

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.

Read to Learn

Series and Parallel Circuits

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

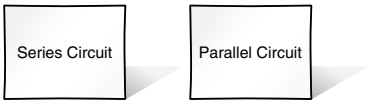
As you read in the last section, a circuit includes three parts. The first part is something that provides a voltage difference. It can be a battery or an electric outlet. The second part is something that uses electric energy and provides resistance. Lightbulbs and hair dryers are two examples. The 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 the hair dryer switch to the on position, you close the circuit and current flows. The hair dryer turns electrical energy into thermal energy to warm the air, and mechanical energy to run the fan.

FOLDABLES™

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



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?

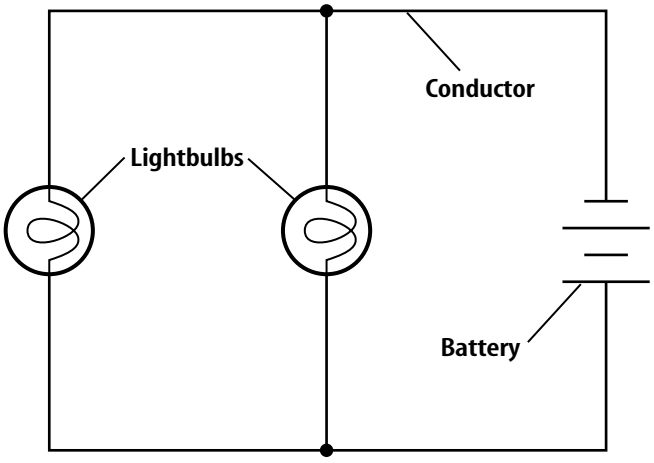
How does an open circuit affect a series circuit?

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.



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.

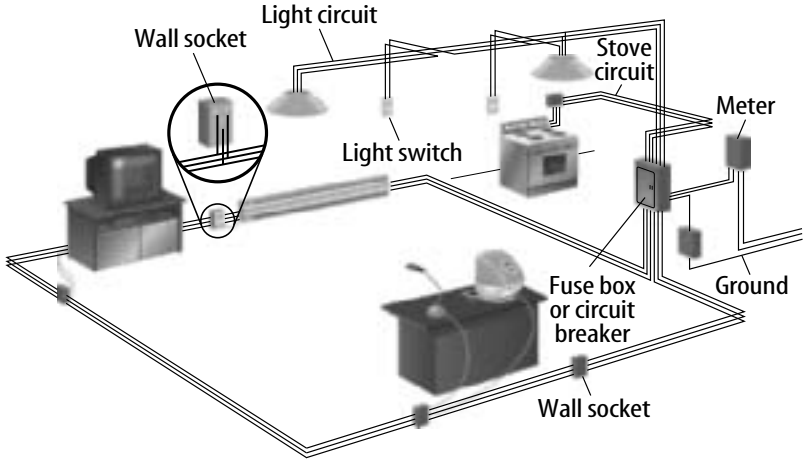
Picture This

2. **Illustrate** In the space below, draw a parallel circuit that has three paths. Label the parts of the 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, ceilings, 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 and Energy

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.

electric power (in watts) = **current** (in amperes) × **voltage difference** (in volts)

$$P = IV$$

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?

Applying Math

6. Calculate The current in an electric clothes dryer is 15 A when it is plugged into a 120-V outlet. How much power does the clothes dryer use? Show your work. Show your answer in kW.

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?

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:

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

$$E = Pt$$

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

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

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 \$0.15 per kWh was used in the calculations.

Picture This

8. **Observe** Which appliance has the greatest monthly cost?

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	\$0.15	\$0.15	\$0.15
Monthly cost	\$1.13	\$0.90	\$3.60

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 their 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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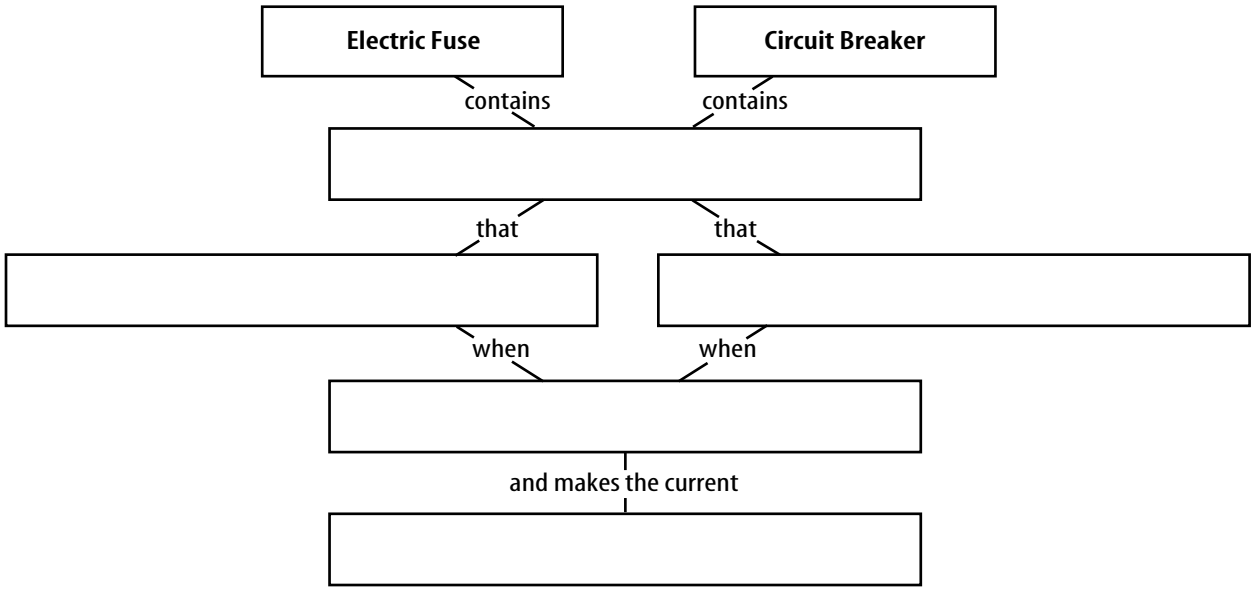
2. Complete the graphic organizer.



3. Study Coach 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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End of Section