Electric Circuits

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CHAPTER 1 Electric Circuits

Lesson Objectives

- Identify the parts of an electric circuit.
- Define electric power, and state how to calculate electrical energy use.
- Identify electric safety features and how to use electricity safely.

Lesson Vocabulary

- electric circuit
- electric power
- parallel circuit
- series circuit

Introduction

Look at the battery and light bulb in **Figure** 1.1. The light bulb works and it's connected to the battery, but it won't light. The problem is the loose wire on the left. It must be connected to the positive terminal of the battery in order for the bulb to light up. The reason? Electric current can flow through a material such as a wire only if the material forms a closed loop. Charges must have an unbroken path to follow between the positively and negatively charged parts of the voltage source, in this case, the battery.

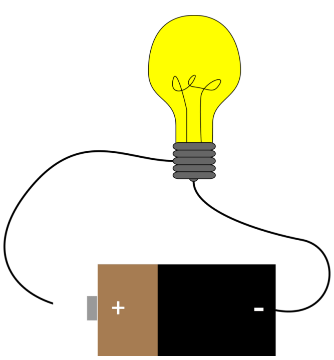


FIGURE 1.1
Electric current cannot flow through an open circuit.

Electric Circuit Basics

A closed loop through which current can flow is called an **electric circuit**. In homes in the U.S., most electric circuits have a voltage of 120 volts. The amount of current (amps) a circuit carries depends on the number and power of electrical devices connected to the circuit. But home circuits generally have a safe upper limit of about 20 or 30 amps.

Parts of an Electric Circuit

All electric circuits have at least two parts: a voltage source and a conductor.

- The voltage source of the circuit in **Figure** 1.2 is a battery. In a home circuit, the source of voltage is an electric power plant, which may supply electric current to many homes and businesses in a community or even to many communities.
- The conductor in most circuits consists of one or more wires. The conductor must form a closed loop from the source of voltage and back again. In **Figure** 1.2, the wires are connected to both terminals of the battery, so they form a closed loop.

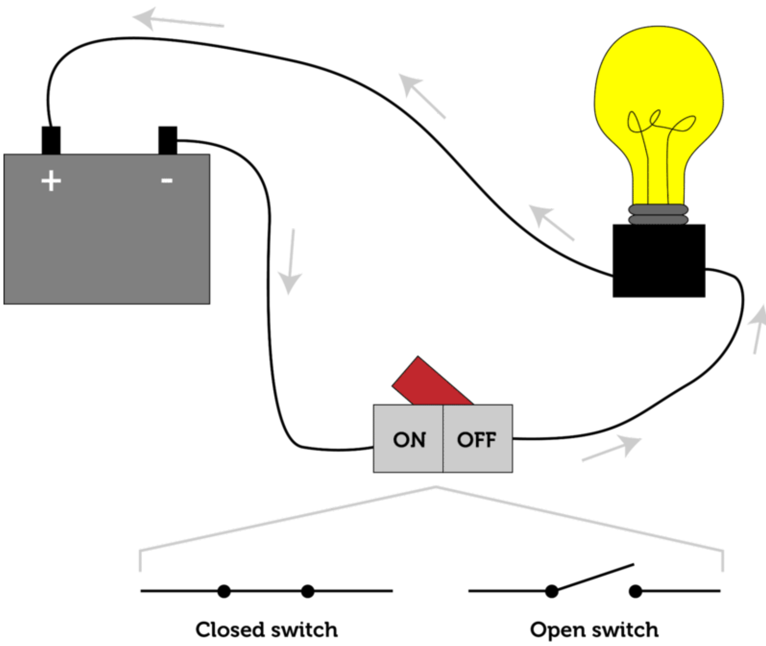


FIGURE 1.2

A circuit must be closed for electric devices such as light bulbs to work. The arrows in the diagram show the direction in which electrons flow through the circuit. The current is considered to flow in the opposite direction.

The circuit in **Figure** 1.2 also has two other parts: a light bulb and a switch.

- Most circuits have devices such as light bulbs that convert electric energy to other forms of energy. In the case of a light bulb, electricity is converted to light and thermal energy.
- Many circuits have switches to control the flow of current through the circuit. When the switch is turned on, the circuit is closed and current can flow through it. When the switch is turned off, the circuit is open and current cannot flow through it.

Circuit Diagrams

When a contractor builds a new home, she uses a set of plans called blueprints that show her how to build the house. The blueprints include circuit diagrams that show how the wiring and other electrical components are to be installed in order to supply current to appliances, lights, and other electrical devices in the home. You can see an example of a very simple circuit diagram in **Figure** 1.3. Different parts of the circuit are represented by standard symbols, as defined in the figure. An ammeter measures the flow of current through the circuit, and a voltmeter measures the voltage. A resistor is any device that converts some of the electricity to other forms of energy. It could be a light bulb, doorbell, or similar device.

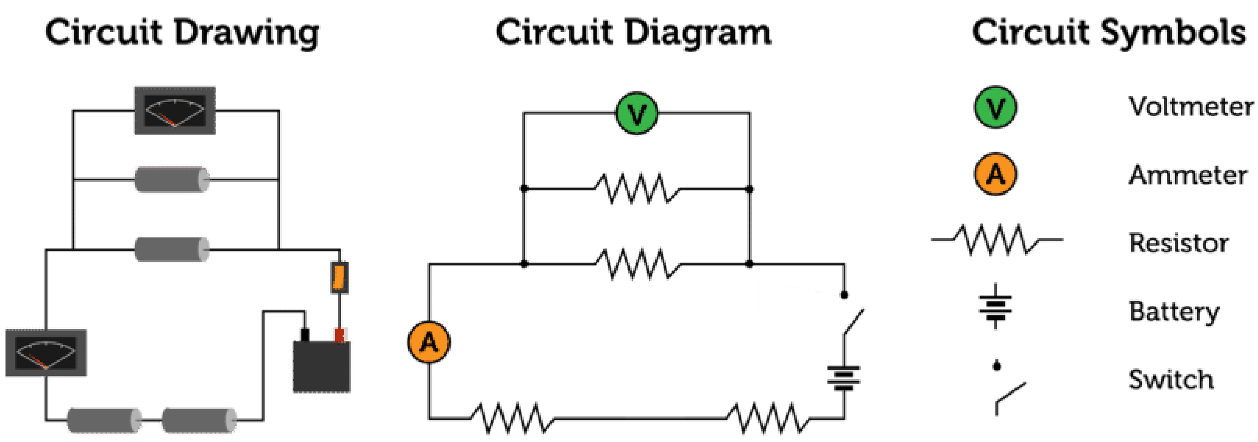


FIGURE 1.3
The circuit diagram on the right represents the circuit drawing on the left. To the right are some of the standard symbols used in circuit diagrams.

Series and Parallel Circuits

There are two basic types of electric circuits, called series and parallel circuits. They differ in the number of loops through which current can flow. You can see an example of each type of circuit in **Figure** 1.4.

- A **series circuit** has only one loop through which current can flow. If the circuit is interrupted at any point in the loop, no current can flow through the circuit and no devices in the circuit will work. In the series circuit in **Figure** 1.4, if one light bulb burns out the other light bulb will not work because it won't receive any current. Series circuits are commonly used in flashlights. You can see an animation of a series circuit at this URL: http://regentsprep.org/regents/physics/phys03/bsercir/default.htm .
- A **parallel circuit** has two (or more) loops through which current can flow. If the circuit is interrupted in one of the loops, current can still flow through the other loop(s). For example, if one light bulb burns out in the parallel circuit in **Figure** 1.4, the other light bulb will still work because current can by-pass the burned-out bulb. The wiring in a house consists of parallel circuits. You can see an animation of a parallel circuit at this URL: http://regentsprep.org/regents/physics/phys03/bsercir/default.htm .

Electric Power and Electrical Energy Use

We use electricity for many purposes. Devices such as lights, stoves, and stereos all use electricity and convert it to energy in other forms. However, devices may vary in how quickly they change electricity to other forms of energy.

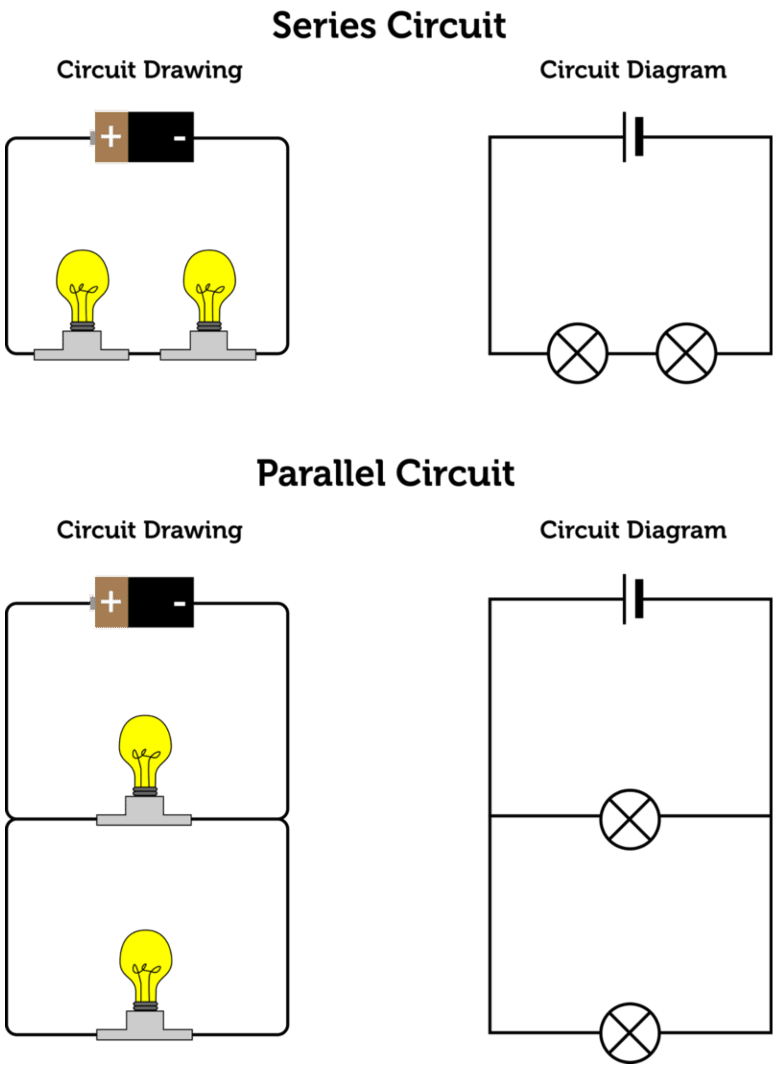


FIGURE 1.4
Series and parallel circuits differ in the number of loops they contain.

Electric Power

The rate at which a device changes electric current to another form of energy is called **electric power**. The SI unit of power—including electric power—is the watt. A watt equals 1 joule of energy per second. High wattages are often expressed in kilowatts, where 1 kilowatt equals 1000 watts. The power of an electric device, such as a microwave, can be calculated if you know the current and voltage of the circuit. This equation shows how power, current, and voltage are related:

$$\text{Power (watts)} = \text{Current (amps)} \times \text{Voltage (volts)}$$

Consider a microwave that is plugged into a home circuit. Assume the microwave is the only device connected to the circuit. If the voltage of the circuit is 120 volts and it carries 10 amps of current, then the power of the microwave is:

$$\text{Power} = 120 \text{ volts} \times 10 \text{ amps} = 1200 \text{ watts, or } 1.2 \text{ kilowatts}$$

You Try It!

Problem: A hair dryer is connected to a 120-volt circuit that carries 12 amps of current. What is the power of the hair dryer in kilowatts?

Electrical Energy Use

Did you ever wonder how much electrical energy it takes to use an appliance such as a microwave or hair dryer? Electrical energy use depends on the power of the appliance and how long it is used. It can be represented by the equation:

$$\text{Electrical Energy} = \text{Power} \times \text{Time}$$

Suppose you use a 1.2-kilowatt microwave for 5 minutes ($\frac{1}{12}$ hour). Then the energy used would be:

$$\text{Electrical Energy} = 1.2 \text{ kilowatts} \times \frac{1}{12} \text{ hour} = 0.1 \text{ kilowatt-hours}$$

Electrical energy use is typically expressed in kilowatt-hours, as in this example. How much energy is this? One kilowatt-hour equals 3.6 million joules of energy. Therefore, the 0.1 kilowatt-hours used by the microwave equals 0.36 million joules of energy.

You Try It!

Problem: A family watches television for an average of 2 hours per day. The television has 0.12 kilowatts of power. How much electrical energy does the family use watching television each day?

Electric Safety

Electricity is dangerous. Contact with electric current can cause severe burns and even death. Electricity can also cause serious fires. A common cause of electric hazards and fires is a short circuit.

How a Short Circuit Occurs

An electric cord contains two wires. One wire carries current from the outlet to the appliance or other electric device, and one wire carries current back to the outlet. Did you ever see an old appliance with a damaged cord, like the one in **Figure** 1.5? A damaged electric cord can cause a severe shock if it allows current to pass from the cord to a person who touches it. A damaged cord can also cause a short circuit. A short circuit occurs when electric current follows a shorter path than the intended loop of the circuit. For example, if the two wires in a damaged cord come into contact with each other, current flows from one wire to the other and bypasses the appliance. This may cause the wires to overheat and start a fire.

Electric Safety Features

Because electricity can be so dangerous, safety features are built into electric circuits and devices. They include three-prong plugs, circuit breakers, and GFCI outlets. Each feature is described and illustrated in **Table** 1.1. You can learn more about electric safety features in the home by watching the video at this URL: http://www.dailymotion.com/video/x6fg5i_basics-of-your-home-s-electrical-sy_school .

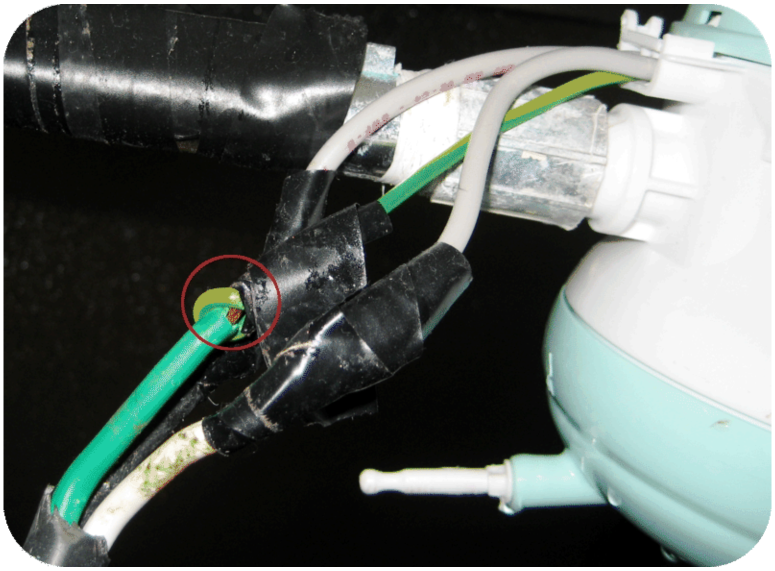
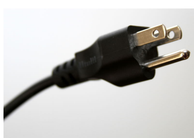
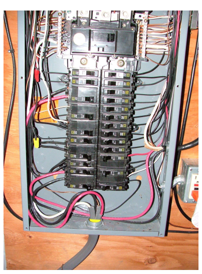


FIGURE 1.5
A damaged electric cord is a serious hazard. How can it cause an electric short?

TABLE 1.1: Can you find one or more examples of these electric safety features in your home?

Electric Safety Feature	Description
Three-Prong Plug 	A three-prong plug is generally used on metal appliances. The two flat prongs carry current to and from the appliance. The round prong is for safety. It connects with a wire inside the outlet that goes down into the ground. If any stray current leaks from the circuit or if there is a short circuit, the ground wire carries the current into the ground, which harmlessly absorbs it.
Circuit Breaker 	A circuit breaker is a switch that automatically opens a circuit if too much current flows through it. This could happen if too many electric devices are plugged into the circuit or if there is an electric short. Once the problem is resolved, the circuit breaker can be switched back on to close the circuit. Circuit breakers are generally found in a breaker box that controls all the circuits in a building.
GFCI Outlet 	GFCI stands for ground-fault circuit interrupter. GFCI outlets are typically found in bathrooms and kitchens where the use of water poses a risk of shock (because water is a good electric conductor). A GFCI outlet contains a device that monitors the amounts of current leaving and returning to the outlet. If less current is returning than leaving, this means that current is escaping. When this occurs, a tiny circuit breaker in the outlet opens the circuit. The breaker can be reset by pushing a button on the outlet cover.

Using Electricity Safely

Even with electric safety features, electricity is still dangerous if it is not used safely. Follow the safety rules below to reduce the risk of injury or fire from electricity.

Lesson Summary

- An electric circuit is a closed loop through which electric current can flow. A circuit must include a source of voltage and conductors such as wires to carry the current from the source of voltage and back again. Types of circuits are series and parallel circuits.
- Electric power is the rate at which an electric device changes electric current to another form of energy. It is measured in watts or kilowatts and equals current (amps) times voltage (volts). The electrical energy used by a device is measured in kilowatt-hours and equals the power of the device (kilowatts) times the amount of time (hours) the device is used.
- Electricity is dangerous. Electric shorts can be hazardous and start fires. Electric safety features include three-prong plugs, circuit breakers, and GFCI outlets. Even with electric safety features, it's important to use electricity safely

Lesson Review Questions

Recall

1. Identify the parts of an electric circuit.
2. What is electric power?
3. What variables determine the amount of electrical energy an appliance uses?
4. Identify an electric safety feature and describe how it works.
5. List three tips to reduce the risk of injury or fire from electricity.

Apply Concepts

6. Draw a simple electric circuit that includes a battery, light bulb, and switch. Use arrows to show the flow of electrons through the circuit.
7. What is the power of an electric device that is connected to a 12-volt battery if the circuit is carrying 3 amps of current?

Think Critically

8. Compare and contrast series and parallel circuits.
9. Explain how a short circuit occurs.

Points to Consider

In this lesson, you read that electric devices convert electrical energy to other forms of energy. For example, a microwave oven converts electrical energy to electromagnetic energy in the form of microwaves. A blender converts electrical energy to sound energy and the kinetic energy of the whirring blades.

- Do you think all electric devices convert electrical energy to other forms of energy?
- Computers are familiar electric devices. Do you know how they use electric current?

References

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