Lesson 3
How Does Electric Current Flow through Circuits?

Objectives

Students will

- describe the components of a circuit
- describe the role of switches in electric circuits
- compare series circuits with parallel circuits
- construct series and parallel circuits

Vocabulary

electric circuit—a closed path through which electrons can travel
parallel circuit—a circuit that has many paths through which electric current can flow
series circuit—a circuit in which the parts are connected in a single loop
short circuit—a spot where electric current is prevented from reaching an appliance
switch—a device that opens and closes a circuit

Structuring the Curriculum

If you need to save time, have students use the circuits they constructed in the previous lesson.

Preparation/Materials

Try This: Lemon Battery

√ lemons, one per team
√ brass thumbtacks, one per team
√ steel paper clips, one per team
√ insulated wire, two 20-cm lengths per team
√ scissors, one per team
√ flashlight bulbs, one per team

Demonstration: Glowing Steel Wool

√ battery holder and battery
√ steel wool
√ two lengths of wire

Let's Find Out: How Does a Switch Work?

√ insulated wires, three 30-cm lengths per team
√ battery holders and batteries, one per team
√ light bulbs and sockets, one per team
√ brass fasteners, two per team
√ steel paper clips, one per team
√ cardboard box lids, one per team

Let's Find Out: What Are Different Circuits Like?

√ battery holders and batteries, two per team

√ light bulbs and sockets, two per team

√ insulated wires, four 30-cm lengths per team

Activity: Will These Circuits Work?

√ materials from **Let's Find Out: What Are Different Circuits Like?**

√ activity sheet 1, one per student

Background

The electrical energy that we use comes to us via electric currents, in which electrons flow smoothly from one atom to another through a conducting material such as metal or water. Electrons flow smoothly and create an electric current only if they are connected in an electric circuit. A complete circuit consists of three parts: an energy source to get the electrons moving, a path along which the electrons can travel, and an appliance that uses the electrical energy. A simple circuit can be made with a battery (the energy source), two wires (the paths along which the electrons can travel), and a light bulb (the appliance that uses the electricity). If any part is missing or not connected properly, the circuit will not be complete, and electric current will not flow.

The electrical energy we use is usually created by a generator, a machine that converts mechanical energy into electrical energy. Mechanical energy sources for the generator may include turbines at hydroelectric dams, wind turbines, or steam turbines (the steam may originate with nuclear fission or the burning of fossil fuels). The energy flows through wires into buildings to power various appliances.

To reduce the risk of electrical fires, buildings are equipped with a fuse box or a circuit breaker. Both safety devices are connected to a building's circuit. The electric current entering a building flows through a fuse or circuit breaker before going to an appliance. A fuse is a tube or socket surrounding a strip of metal that melts easily when heated. If a circuit gets overloaded with too many appliances or by a short circuit, the fuse becomes hot and melts. A melted fuse opens the circuit and stops the flow of current. Fuses are designed with different melting points depending on the amount of current a circuit can safely carry. A proper fuse melts before the electrical wires in a house become hot enough to cause a fire.

Circuit breakers are similar to fuses. They are made of two strips of metal (two different kinds) welded together. When the circuit gets too hot, one metal strip expands faster than the other, causing the circuit breaker to bend and open the circuit.

Series circuits have more than one resistor (i.e. device that uses electrical energy to do work) but only one path for the charges to flow. Charges move from one resistor to the next. If one item in the circuit malfunctions, no charge will move through the circuit.

Parallel circuits have more than one resistor and have multiple paths for the charges to flow. If one item in the circuit is broken, no charges will move along that path, but charges can continue to move along the other paths. Parallel circuits are found in most household wiring.

Lesson 3 How Does Electric Current Flow through Circuits?

Think about watching a TV program, playing a video game, listening to music on the radio, or getting something out of the refrigerator. These activities all depend on electrical appliances. You use many electric appliances each day. Where does the electric current that powers these appliances come from? How does it reach your house, and how does it work when it gets there?

The electrons that make up an electric current flow smoothly through a system called an electric circuit. An **electric circuit** is a closed path through which electrons can travel. For a circuit to work, it must be a complete, closed loop. If the circuit is broken, the current can't flow through it, just as water can't flow through a cut hose. An electric circuit has three parts: an energy source, a conductor, and a load that is operated by the electrical energy. The energy source may be a battery or an electric power plant. The conductor is a wire. The load may be a lamp, a TV set, a computer, or any other appliance.

Intersection with Life Science

Electric Eels

Electric eels create an electric current in water. The body of an electric eel is made of 6,000 different parts arranged like a battery. Its head acts as the positive terminal, and its tail acts as the negative terminal. When the eel moves, it generates an electric current strong enough to stun a horse!

185

Try This

Lemon Battery

Stick a brass thumbtack into one side of a lemon and a steel paper clip into the other side. Cut 1 cm of plastic away from both ends of a 20-cm (8-inch) insulated wire. Do the same to a second wire of the same length. Twist one end of the first wire around the thumbtack and one end of the second wire around the paper clip. Hold the two free wire ends to the two bumps on the bottom of a small flashlight bulb. In your science journal, describe your observations. Write a paragraph explaining your observations.

This power plant at the Hoover Dam in Nevada uses the energy from falling water to generate electrical energy.

Power lines carry electrical energy safely from the power plant to homes and businesses.

The electrical energy that reaches your house is provided by a power plant, which uses another form of energy to generate the electrical energy. Power lines carry the electrical energy from the power plant to your house. In the walls, ceiling, and floors of your home are a maze of wires organized into a network. These wires form many circuits that direct the electric current to electric appliances, which convert the electrical energy into light, heat, sound, or the energy of motion.

Have you ever wondered why electric cords have two prongs on the plug? Each prong attaches to a different wire inside the cord. One wire carries electrons to the appliance, and the other carries them back into a wire in the wall. The wire in the wall leads back to the power lines and power plant, completing the circuit. The plugs of most larger appliances have a third prong. This is a safety feature that prevents dangerous shocks if a wire comes loose in the appliance.

186

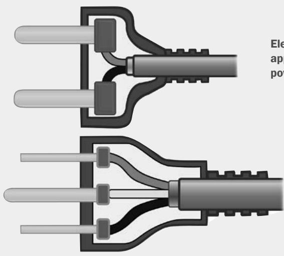
Discover

1. Have students complete **Try This: Lemon Battery** (page 186) in the student text.
   Batteries contain liquids or chemical pastes called electrolytes that react to produce an electric current, and the two electrodes carry the current in and out of the battery. Lemons contain natural electrolytes; the brass tack and steel paper clip act as the two electrodes.

2. **Demonstration: Glowing Steel Wool**
   Review the following safety precautions with students before the activity.
   - √ Don't allow anyone to touch the steel wool while it is hot.
   - √ Work with the steel wool on a heat-resistant surface.

   Pull a long strand of filaments from a ball of steel wool, and lay the strand where all students can see it. Connect two wires to the electrodes of a battery. Turn off the lights, and touch the two wires to opposite ends of the steel wool strand. The steel wool will glow bright red. The electric current has difficulty passing through the thin strands of steel. This causes excess heat, which makes the strands glow bright red. A powerful battery will melt the steel wool, breaking the circuit. Explain that fuses work in a similar way to break a circuit when the wires get too hot.

3. Try the activity "**Connecting an Electric Circuit**" from page 325 if you did not do this for Lesson 2. If your students completed the circuits activities from Lesson 2, review these with the class.



Electric current flows out of one wire, through the appliance, into the other wire, and back to the power source to complete the circuit.

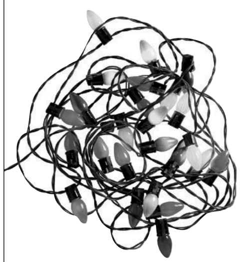
Many electrical supply systems have a third wire—the ground wire. It is connected to a metal rod in the ground to ensure that exposed parts never cause shocks.

The different wires in a circuit are kept separate by their coating of insulation. If the insulation came off and two wires touch, a short circuit results. A **short circuit** is a spot where electric current is prevented from reaching an appliance. Because the flowing electrons near a short circuit are not using their energy to power an appliance, they heat up the wires through which they are traveling. Hot wires caused by short circuits often cause fires.

If the plastic insulator of the electric cord breaks, the two wires inside may touch each other. Such contact allows the electrons to flow from one wire to the other instead of first traveling through the appliance. This can heat up the wires enough to cause a fire.

A simple circuit is made up of one source of electrons (such as a battery), wires, and one electric device (such as a light bulb). Most of the electric current that flows through the wires in houses, schools, and other buildings

187



travels on circuits that have more than one power source and more than one appliance. The two basic kinds of simple circuits are the series circuit and the parallel circuit.

A **series circuit** is a circuit in which the parts are connected in a single loop. The electric current moves through each part of the series to get to the next part. Some Christmas lights are wired together in a series circuit. When one bulb goes out, the circuit is broken. Without the flow of electric current, all of the bulbs go out. Then you have to replace each bulb until you find the one that has burned out.

Wiring appliances in series may seem to have many disadvantages, but series circuits can be helpful. When two batteries are wired together in a series circuit with one light bulb, the bulb burns twice as brightly. Two 1.5-volt batteries in series produce 3 volts of electricity. Many flashlights have a series circuit made of two batteries and one bulb.

Way Back When

Oh, Christmas Tree

The first Christmas lights were used in the 1600s by people living in Scandinavian countries. They attached candles to tree limbs using wax or pins. Edward Johnson (a friend of Thomas Edison) first made Christmas tree lights using electric circuits in 1882. In 1896 the town of Westmont, Quebec, displayed one of the first electrically lighted Christmas trees.

How Do Scientists Make Christmas Lights Blink?

Simple blinking Christmas lights have one blinker bulb in a strand of lights that are connected in a series circuit. The blinking bulb has an extra strip of metal at the top that the electric current must flow through. When this extra metal strip gets hot, it bends, stopping the flow of current. Because all of the bulbs are in a series circuit, they all go out when the blinker light goes out. As soon as the metal strip cools again, it bends back and reconnects the circuit, turning the lights back on. As this cycle repeats itself, the lights blink on and off. More complicated blinking lights can blink with interesting patterns.

188

Develop

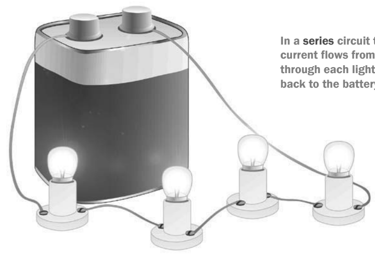
1. Have students complete **Let's Find Out: How Does a Switch Work?** (page 192) in the student text.

   Review the following safety precautions with students before the activity.

   - √ Avoid contact with bare wires that are attached to an electric current source such as a battery.
   - √ Never insert wires into electric outlets or sockets.
   - √ Never handle batteries that have openings in their outer casings.
   - √ Complete a circuit only long enough to make observations because the metal components, the bare wire ends, and the light bulb can become hot if the current is left on.

   The paper clip acts as a switch. When the paper clip is in contact with both fasteners, a complete circuit forms, and the bulbs lights up. When the paper clip switch is disconnected, the circuit is broken, causing the light to go out.

2. Have students complete **Let's Find Out: What Are Different Circuits Like?** (page 190) in the student text. Demonstrate how to draw a representation of a circuit using the symbols from the text.



In a **series** circuit the electric current flows from the battery, through each light bulb, and back to the battery.

Imagine that all of the wires in your house were arranged in a series circuit. If you turned off one light, all of the other lights and appliances in your house would also turn off! So houses are wired in parallel circuits. A **parallel circuit** is a circuit that has many paths through which electric current can flow. Think of a group of people moving down one or more paths. Can they move more easily down one path or ten paths? If they are moving down ten separate paths, even though one person is slow, nine people can still move quickly. If two have to stop, eight can keep moving. Each person can go as fast as the path allows.

The appliances in your house are connected in parallel circuits. Appliances connected in parallel are like ten people on ten different paths. Electric current can move more easily through the side-by-side paths of a parallel circuit than down one path in which everything is connected in a row, as with a series circuit. If you turn the blender off, the TV stays on. If a light bulb burns out, the toaster still works. Each appliance is a separate part of the circuit, allowing each one to work independently of the others.

In a **parallel** circuit the electric current flows from the battery to each light bulb separately and then back to the battery.

189

Let's Find Out

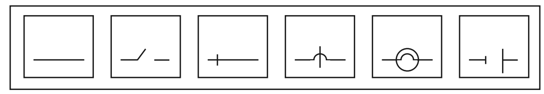
What Are Different Circuits Like?

You will need

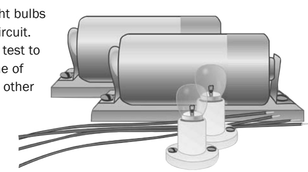
- ✓ two battery holders and batteries
- ✓ two light bulbs and sockets
- ✓ four 30-cm lengths of insulated wire

Do this

1. Use one battery and battery holder, two light bulbs and sockets, and wire to make a series circuit. When you are finished making the circuit, test to see if it is a series circuit by removing one of the light bulbs. What should happen to the other light if you have made a series circuit?
2. Using the circuit symbols from the information below, sketch a diagram of your series circuit in your science journal. Write a paragraph explaining how you know that it is a series circuit.



3. Add another battery to your series circuit. What change do you observe? Write your observations in your science journal.
4. Use one battery and battery holder, two light bulbs and sockets, and wire to make a parallel circuit. When you are finished making your circuit, test to see of it is a parallel circuit by removing one of the light bulbs. What should happen to the other light if you have made a parallel circuit?
5. Using the circuit symbols from the chart, sketch a diagram of your parallel circuit in your science journal. Write a paragraph explaining how you know that it is a parallel circuit.
6. Add another battery to your parallel circuit in parallel with the first battery. What change do you observe? Write your observation in your science journal.



190

Review the following safety precautions with students before the activity.

- √ Avoid contact with bare wires that are attached to an electric current source such as a battery.
- √ Never insert wires into electric outlets or sockets.
- √ Never handle batteries that have openings in their outer casings.
- √ Complete a circuit only long enough to make observations because the metal components, the bare wire ends, and the light bulb can become hot if the current is left on.

In a series circuit disconnecting any one part of the setup disconnects the circuit, causing the light to go out. In a parallel circuit one part of the setup can be disconnected, causing one light bulb to go out but the other bulb to stay lit because it is still part of an unbroken circuit.

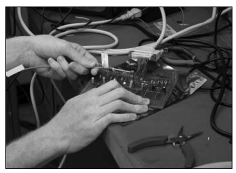
When a second battery is added to the series circuit, the light bulb should burn brighter because the voltages of the two batteries are combined to create more current. The bulb does not burn brighter when two batteries are added to the parallel circuit because the current can travel in more than one path.

Unlike sources connected in series, sources connected in parallel do not produce more voltage. Two 1.5-volt batteries connected in parallel produce only 1.5 volts, not 3 volts.

Many circuits are combinations of parallel and series circuits. These combinations are called complex circuits. Most of the circuits in your house are complex circuits.

Imagine that the only way to turn off a lamp, TV, CD player, or toaster was to unplug it. It would be inconvenient to have to plug in an appliance whenever you wanted to use it. Fortunately, the many circuits in your house can be completed (turned on) or broken (turned off) by switches. A **switch** is a device that opens and closes a circuit. Switches prevent electric current from flowing to an appliance all of the time. If you have ever seen a drawbridge over a river, you can picture how a switch works.

Focus On
Electrical Engineers



Engineers design buildings, machines, and many other products. An electrical engineer is a person who uses the principles of electricity to make and test electrical equipment. Electrical engineers work on all the parts of a circuit. They work with sources of electrical energy—generators that are run by water, coal, oil, wind, moving water, or other energy sources. They also work with the conductors—power lines, wiring in houses, and appliance cords. And they work with the things that use electricity. For example, engineers design electric motors and electrical systems for airplanes and cars. They work with television sets, DVD players, radios, and vacuum cleaners, trying to make these appliances better. Many electrical engineers work with computers, designing machines to do specific jobs. So electrical engineers have a major effect on your life!

191

Let's Find Out

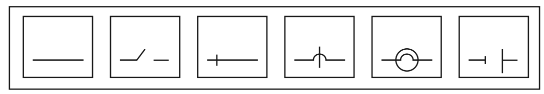
How Does a Switch Work?

You will need

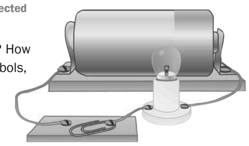
- ✓ three 30-cm lengths of insulated wire
- ✓ battery holder and battery
- ✓ light bulb and socket
- ✓ two brass fasteners
- ✓ one steel paper clip
- ✓ cardboard box lid

Do this

1. Connect the end of one wire to one battery terminal and the end of a second wire to the other battery terminal. Connect the free end of one of the wires to one side of the light bulb socket. Connect a free end of the third wire to the other side of the socket. Insert the light bulb into the socket.
2. Insert one brass fastener through the paper clip. Then insert the brass fastener through the box lid.
3. Insert the other brass fastener through the box lid. Make sure that the paper clip from the first fastener can touch the second fastener. Do not put the second fastener through the paper clip.
4. Wrap the free end of one wire around the fastener with the paper clip, and wrap the free end of the wire around the second fastener.
5. Move the paper clip so that it touches both fasteners. What happens to the light bulb? Now move the paper clip away from the fastener. What happens to the light bulb?
6. Sketch the circuit you have made in your science journal using the following circuit symbols. Write a paragraph in your science journal describing your observations of what happened to the lamp when you used the paper clip. Explain how the paper clip is like a switch.



7. Could you make a circuit with more than one switch? How would this circuit work? Using the correct circuit symbols, sketch a diagram of a circuit with more than one switch.



192

Reinforce/Assess

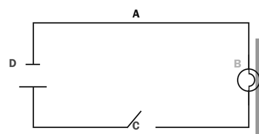
1. **Activity: Will These Circuits Work?** Have each student use the materials from **Let's Find Out: What Are Different Circuits Like?** to construct a series circuit and a parallel circuit. Alternatively, have students draw a labeled diagram of series and parallel circuits. Have students complete **activity sheet 1**.

2. Have students read **How Does Electric Current Flow through Circuits?** (page 185) in the student text and answer the **Think Back** questions (page 193).
   1. *How does electric current reach your house? (It travels from a power plant to the house through wires—through a circuit.)*
   2. *Describe how the circuit that turns on your TV works. (One prong of the plug is connected to a wire that carries electrons to the appliance. The other prong is attached to a wire that carries electrons back to the power lines leading to the power plant to complete the circuit.)*
   3. *Why are short circuits dangerous? (They don't allow electricity to reach an appliance. This causes wires to heat up and become a fire hazard.)*
   4. *Why are switches used to turn electric appliances on and off? (Switches allow an individual circuit to be broken to turn off an appliance when it isn't being used.)*
   5. *Describe the difference between a series circuit and a parallel circuit. (A series circuit has only one path for electric current to follow; a parallel circuit has many paths for electric current to follow.)*
   6. *What type of circuit would you use to invent a more powerful flashlight? Explain your answer. (A series circuit, because it allows the overall voltage of batteries to be added together.)*

When the drawbridge is open, cars can't cross over the bridge; they have to stop. Lowering the bridge allows traffic to move forward on the road. A switch is like a drawbridge. When a switch is open, electrons can't flow through a wire, and the appliance is turned off. Closing the switch allows electrons to flow through the wire again.

There are two basic types of switches: snap switches and pushbutton switches. Snap switches are the kind that you use to turn lights or the radio on and off. Flipping the switch one way opens the circuit; flipping the switch the other way closes the circuit. Once you open the circuit, it stays open until you close it again. Pushbutton switches are the kind used on doorbells. When you push on the switch, you press down a spring that closes the circuit, and the doorbell rings. When you release the button, the spring flies back to open the circuit, and the doorbell stops ringing.

When the drawbridge is open, cars can't travel across it. In the same way, when a circuit is open, electrons can't flow through it.



A. Wire
B. Bulb
C. Switch
D. Battery

Think Back

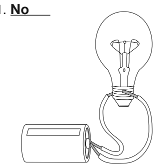
1. How does electric current reach your house?
2. Describe how the circuit that turns on your TV works.
3. Why are short circuits dangerous?
4. Why are switches used to turn electric appliances on and off?
5. Describe the difference between a series circuit and a parallel circuit.
6. What type of circuit would you use to invent a more powerful flashlight? Explain your answer.

193

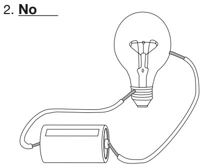
Will These Circuits Work?

Some of these circuits will make a bulb light up; some will not. Study each circuit. If the circuit will make the bulb light up, write yes; if not, write no.

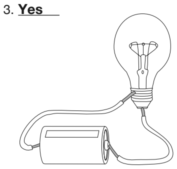
1. **No**



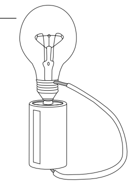
2. **No**



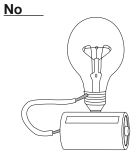
3. **Yes**



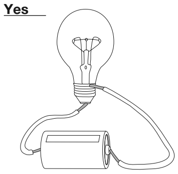
4. **Yes**



5. **No**



6. **Yes**



Unit 5, Lesson 3/1

651

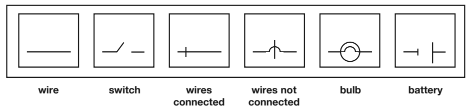
Extend

- Have students complete **activity sheet 2**.
- Have students touch a silver spoon and a piece of aluminum foil together and then touch both to their tongue. Their saliva completes the circuit, causing a tingly taste. This is the "taste of electricity."
- Have students use a galvanometer to test circuits. Make one circuit by suspending a strip of copper and a strip of zinc from copper wires in a glass of vinegar. Have them try other solutions and other metals to see which ones produce a current.

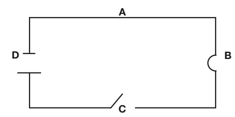
Electric Symbols

People who work with electric circuits use symbols for circuit parts to communicate information.

1. Study these common electric symbols.



2. Label the parts of this drawing.



A. **Wire**

B. **Bulb**

C. **Switch**

D. **Battery**

3. Use the symbols to draw a series circuit with batteries, a light bulb, and wires.

Answers will vary.

4. Now draw a parallel circuit.

Answers will vary.

5. Ask a team member to try to assemble your circuits to see if they will work.

Lesson 3

How Does Electric Current Flow through Circuits?

Think about watching a TV program, playing a video game, listening to music on the radio, or getting something out of the refrigerator. These activities all depend on electrical appliances. You use many electric appliances each day. Where does the electric current that powers these appliances come from? How does it reach your house, and how does it work when it gets there?

The electrons that make up an electric current flow smoothly through a system called an electric circuit. An **electric circuit** is a closed path through which electrons can travel. For a circuit to work, it must be a complete, closed loop. If the circuit is broken, the current can't flow through it, just as water can't flow through a cut hose. An electric circuit has three parts: an energy source, a conductor, and a load that is operated by the electrical energy. The energy source may be a battery or an electric power plant. The conductor is a wire. The load may be a lamp, a TV set, a computer, or any other appliance.

Intersection with Life Science

Electric Eels

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Try This

Lemon Battery

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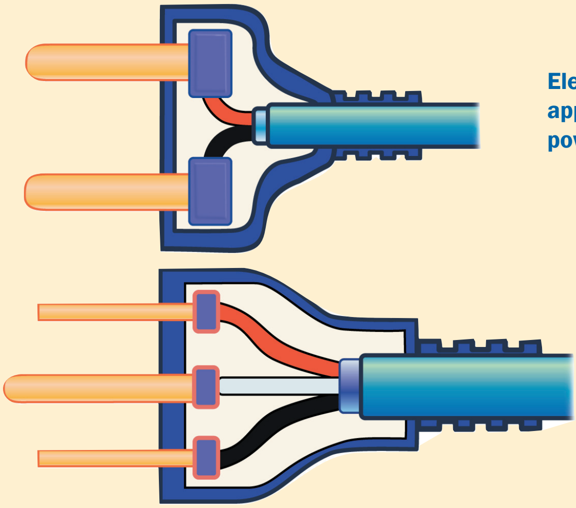
The electrical energy that reaches your house is provided by a power plant, which uses another form of energy to generate the electrical energy. Power lines carry the electrical energy from the power plant to your house. In the walls, ceiling, and floors of your home are a maze of wires organized into a network. These wires form many circuits that direct the electric current to electric appliances, which convert the electrical energy into light, heat, sound, or the energy of motion.

Have you ever wondered why electric cords have two prongs on the plug? Each prong attaches to a different wire inside the cord. One wire carries electrons to the appliance, and the other carries them back into a wire in the wall. The wire in the wall leads back to the power lines and power plant, completing the circuit. The plugs of most larger appliances have a third prong. This is a safety feature that prevents dangerous shocks if a wire comes loose in the appliance.

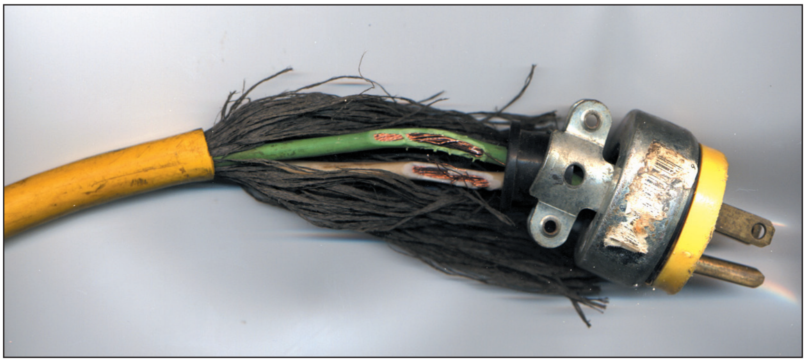
Power lines carry electrical energy safely from the power plant to homes and businesses.



Electric current flows out of one wire, through the appliance, into the other wire, and back to the power source to complete the circuit.

Many electrical supply systems have a third wire—the ground wire. It is connected to a metal rod in the ground to ensure that exposed parts never cause shocks.

The different wires in a circuit are kept separate by their coating of insulation. If the insulation came off and two wires touch, a short circuit results. A **short circuit** is a spot where electric current is prevented from reaching an appliance. Because the flowing electrons near a short circuit are not using their energy to power an appliance, they heat up the wires through which they are traveling. Hot wires caused by short circuits often cause fires.



If the plastic insulator of the electric cord breaks, the two wires inside may touch each other. Such contact allows the electrons to flow from one wire to the other instead of first traveling through the appliance. This can heat up the wires enough to cause a fire.

A simple circuit is made up of one source of electrons (such as a battery), wires, and one electric device (such as a light bulb). Most of the electric current that flows through the wires in houses, schools, and other buildings

travels on circuits that have more than one power source and more than one appliance. The two basic kinds of simple circuits are the series circuit and the parallel circuit.

A **series circuit** is a circuit in which the parts are connected in a single loop. The electric current moves through each part of the series to get to the next part. Some Christmas lights are wired together in a series circuit. When one bulb goes out, the circuit is broken. Without the flow of electric current, all of the bulbs go out. Then you have to replace each bulb until you find the one that has burned out.

Wiring appliances in series may seem to have many disadvantages, but series circuits can be helpful. When two batteries are wired together in a series circuit with one light bulb, the bulb burns twice as brightly. Two 1.5-volt batteries in series produce 3 volts of electricity. Many flashlights have a series circuit made of two batteries and one bulb.

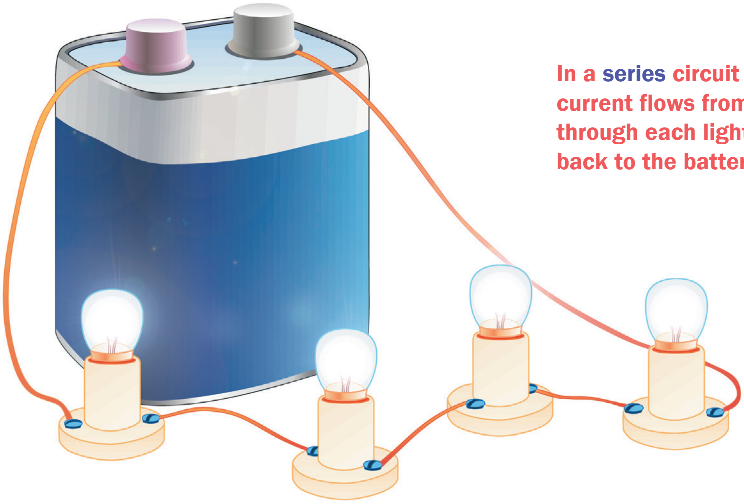
Way Back When

Oh, Christmas Tree

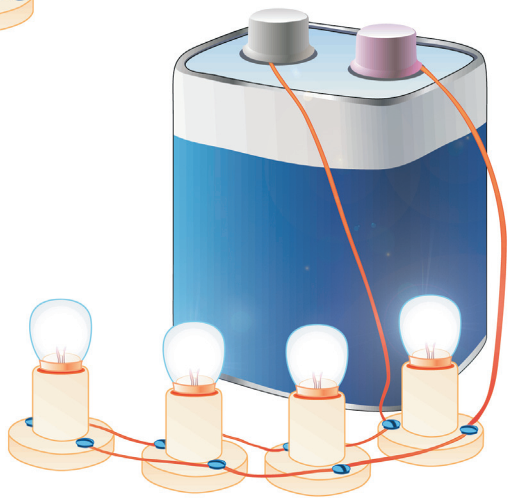
The first Christmas lights were used in the 1600s by people living in Scandinavian countries. They attached candles to tree limbs using wax or pins. Edward Johnson (a friend of Thomas Edison) first made Christmas tree lights using electric circuits in 1882. In 1896 the town of Westmont, Quebec, displayed one of the first electrically lighted Christmas trees.

How Do Scientists Make Christmas Lights Blink?

Simple blinking Christmas lights have one blinker bulb in a strand of lights that are connected in a series circuit. The blinking bulb has an extra strip of metal at the top that the electric current must flow through. When this extra metal strip gets hot, it bends, stopping the flow of current. Because all of the bulbs are in a series circuit, they all go out when the blinker light goes out. As soon as the metal strip cools again, it bends back and reconnects the circuit, turning the lights back on. As this cycle repeats itself, the lights blink on and off. More complicated blinking lights can blink with interesting patterns.



In a series circuit the electric current flows from the battery, through each light bulb, and back to the battery.



In a parallel circuit the electric current flows from the battery to each light bulb separately and then back to the battery.

Imagine that all of the wires in your house were arranged in a series circuit. If you turned off one light, all of the other lights and appliances in your house would also turn off! So houses are wired in parallel circuits. A **parallel circuit** is a circuit that has many paths through which electric current can flow. Think of a group of people moving down one or more paths. Can they move more easily down one path or ten paths? If they are moving down ten separate paths, even though one person is slow, nine people can still move quickly. If two have to stop, eight can keep moving. Each person can go as fast as the path allows.

The appliances in your house are connected in parallel circuits. Appliances connected in parallel are like ten people on ten different paths. Electric current can move more easily through the side-by-side paths of a parallel circuit than down one path in which everything is connected in a row, as with a series circuit. If you turn the blender off, the TV stays on. If a light bulb burns out, the toaster still works. Each appliance is a separate part of the circuit, allowing each one to work independently of the others.

Let's Find Out

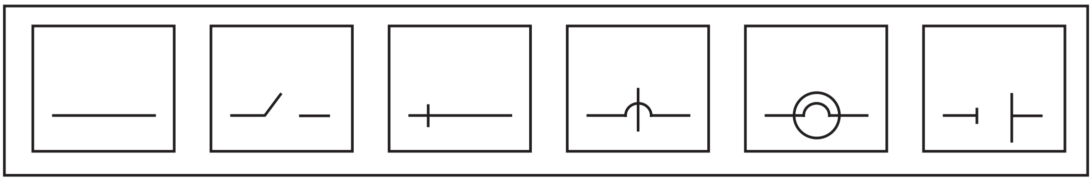
What Are Different Circuits Like?

You will need

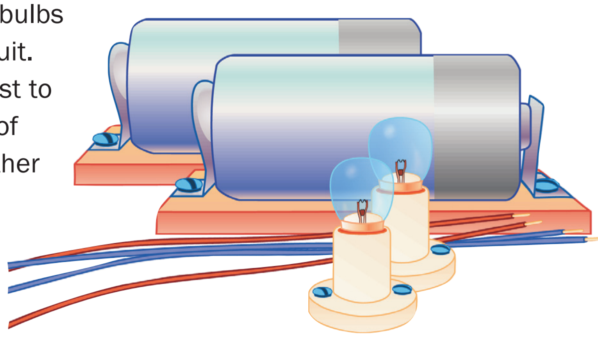
- ✓ two battery holders and batteries
- ✓ two light bulbs and sockets
- ✓ four 30-cm lengths of insulated wire

Do this

1. Use one battery and battery holder, two light bulbs and sockets, and wire to make a series circuit. When you are finished making the circuit, test to see if it is a series circuit by removing one of the light bulbs. What should happen to the other light if you have made a series circuit?
2. Using the circuit symbols from the information below, sketch a diagram of your series circuit in your science journal. Write a paragraph explaining how you know that it is a series circuit.



3. Add another battery to your series circuit. What change do you observe? Write your observations in your science journal.
4. Use one battery and battery holder, two light bulbs and sockets, and wire to make a parallel circuit. When you are finished making your circuit, test to see of it is a parallel circuit by removing one of the light bulbs. What should happen to the other light if you have made a parallel circuit?



5. Using the circuit symbols from the chart, sketch a diagram of your parallel circuit in your science journal. Write a paragraph explaining how you know that it is a parallel circuit.
6. Add another battery to your parallel circuit in parallel with the first battery. What change do you observe? Write your observation in your science journal.

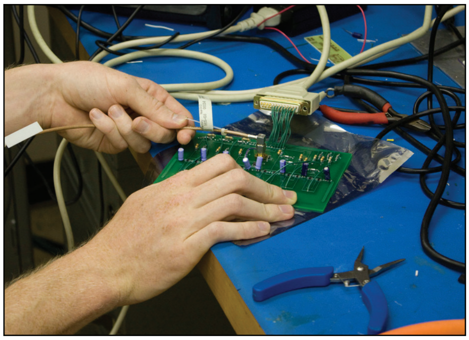
Unlike sources connected in series, sources connected in parallel do not produce more voltage. Two 1.5-volt batteries connected in parallel produce only 1.5 volts, not 3 volts.

Many circuits are combinations of parallel and series circuits. These combinations are called complex circuits. Most of the circuits in your house are complex circuits.

Imagine that the only way to turn off a lamp, TV, CD player, or toaster was to unplug it. It would be inconvenient to have to plug in an appliance whenever you wanted to use it. Fortunately, the many circuits in your house can be completed (turned on) or broken (turned off) by switches. A **switch** is a device that opens and closes a circuit. Switches prevent electric current from flowing to an appliance all of the time. If you have ever seen a drawbridge over a river, you can picture how a switch works.

Focus On

Electrical Engineers



Engineers design buildings, machines, and many other products. An electrical engineer is a person who uses the principles of electricity to make and test electrical equipment. Electrical engineers work on all the parts of a circuit. They work with sources of electrical energy—generators that are run by water, coal, oil, wind, moving water, or other energy sources. They also work with the conductors—power lines, wiring in houses, and appliance cords. And they work with the things that use electricity. For example, engineers design electric motors and electrical systems for airplanes and cars. They work with television sets, DVD players, radios, and vacuum cleaners, trying to make these appliances better. Many electrical engineers work with computers, designing machines to do specific jobs. So electrical engineers have a major effect on your life!

Let's Find Out

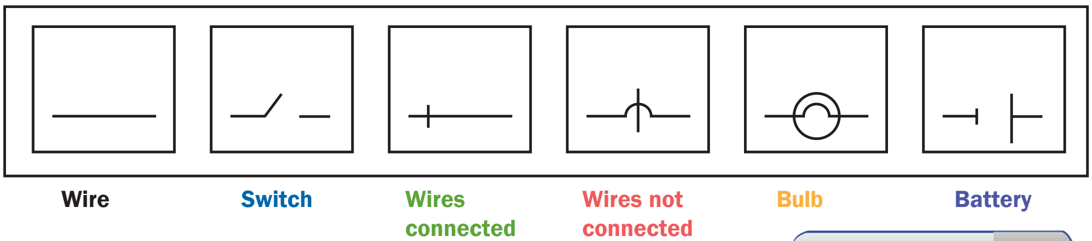
How Does a Switch Work?

You will need

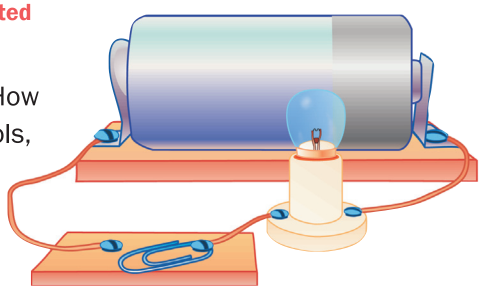
- ✓ three 30-cm lengths of insulated wire
- ✓ battery holder and battery
- ✓ light bulb and socket
- ✓ two brass fasteners
- ✓ one steel paper clip
- ✓ cardboard box lid

Do this

1. Connect the end of one wire to one battery terminal and the end of a second wire to the other battery terminal. Connect the free end of one of the wires to one side of the light bulb socket. Connect a free end of the third wire to the other side of the socket. Insert the light bulb into the socket.
2. Insert one brass fastener through the paper clip. Then insert the brass fastener through the box lid.
3. Insert the other brass fastener through the box lid. Make sure that the paper clip from the first fastener can touch the second fastener. Do not put the second fastener through the paper clip.
4. Wrap the free end of one wire around the fastener with the paper clip, and wrap the free end of the wire around the second fastener.
5. Move the paper clip so that it touches both fasteners. What happens to the light bulb? Now move the paper clip away from the fastener. What happens to the light bulb?
6. Sketch the circuit you have made in your science journal using the following circuit symbols. Write a paragraph in your science journal describing your observations of what happened to the lamp when you used the paper clip. Explain how the paper clip is like a switch.



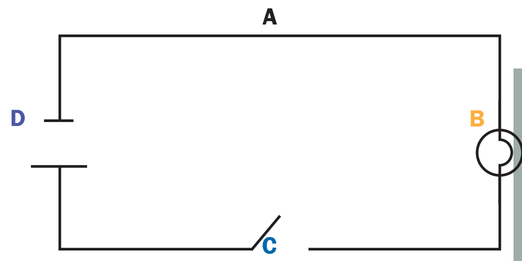
7. Could you make a circuit with more than one switch? How would this circuit work? Using the correct circuit symbols, sketch a diagram of a circuit with more than one switch.



When the drawbridge is open, cars can't cross over the bridge; they have to stop. Lowering the bridge allows traffic to move forward on the road. A switch is like a drawbridge. When a switch is open, electrons can't flow through a wire, and the appliance is turned off. Closing the switch allows electrons to flow through the wire again.

When the drawbridge is open, cars can't travel across it. In the same way, when a circuit is open, electrons can't flow through it.

There are two basic types of switches: snap switches and pushbutton switches. Snap switches are the kind that you use to turn lights or the radio on and off. Flipping the switch one way opens the circuit; flipping the switch the other way closes the circuit. Once you open the circuit, it stays open until you close it again. Pushbutton switches are the kind used on doorbells. When you push on the switch, you press down a spring that closes the circuit, and the doorbell rings. When you release the button, the spring flies back to open the circuit, and the doorbell stops ringing.



A. Wire
B. Bulb
C. Switch
D. Battery

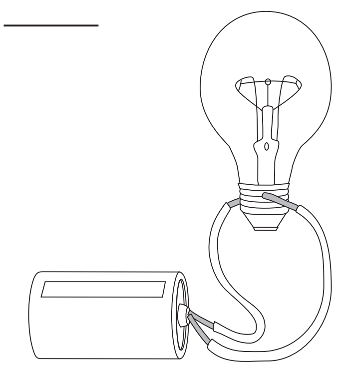
Think Back

1. How does electric current reach your house?
2. Describe how the circuit that turns on your TV works.
3. Why are short circuits dangerous?
4. Why are switches used to turn electric appliances on and off?
5. Describe the difference between a series circuit and a parallel circuit.
6. What type of circuit would you use to invent a more powerful flashlight? Explain your answer.

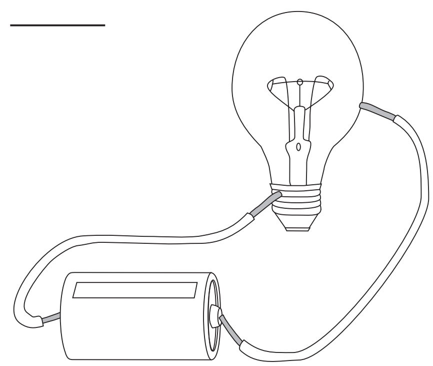
Will These Circuits Work?

Some of these circuits will make a bulb light up; some will not. Study each circuit. If the circuit will make the bulb light up, write yes; if not, write no.

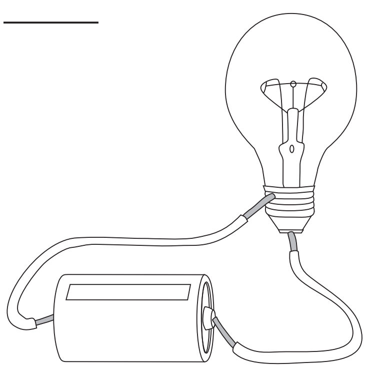
1. ______



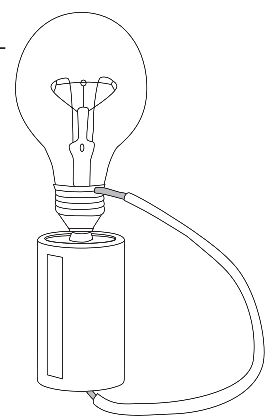
2. ______



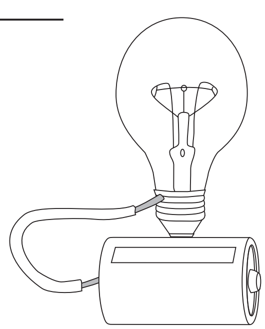
3. ______



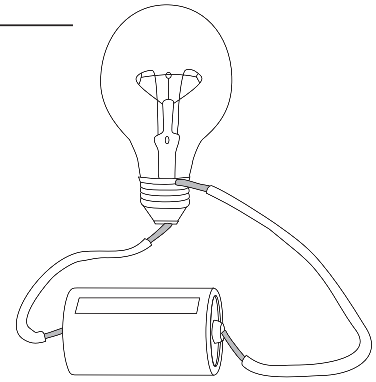
4. ______



5. ______



6. ______

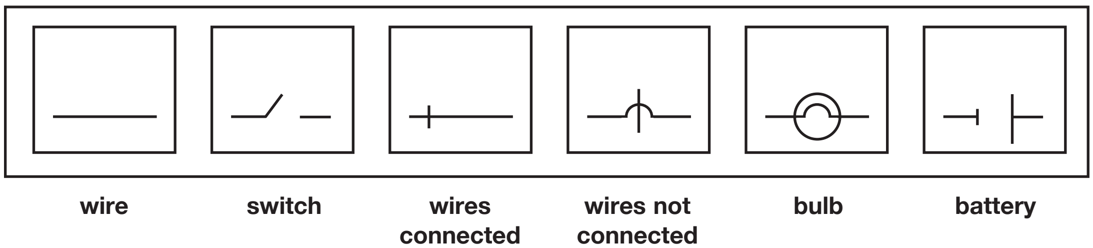


Unit 5, Lesson 3/1

Electric Symbols

People who work with electric circuits use symbols for circuit parts to communicate information.

1. Study these common electric symbols.



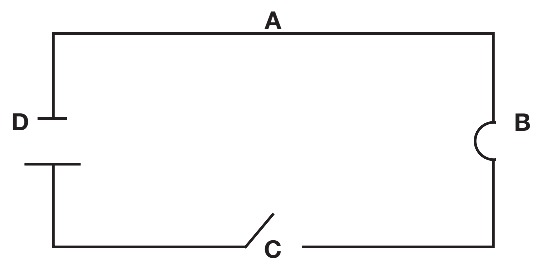
2. Label the parts of this drawing.

   A. ______________________

   B. ______________________

   C. ______________________

   D. ______________________



3. Use the symbols to draw a series circuit with batteries, a light bulb, and wires.

4. Now draw a parallel circuit.

5. Ask a team member to try to assemble your circuits to see if they will work.