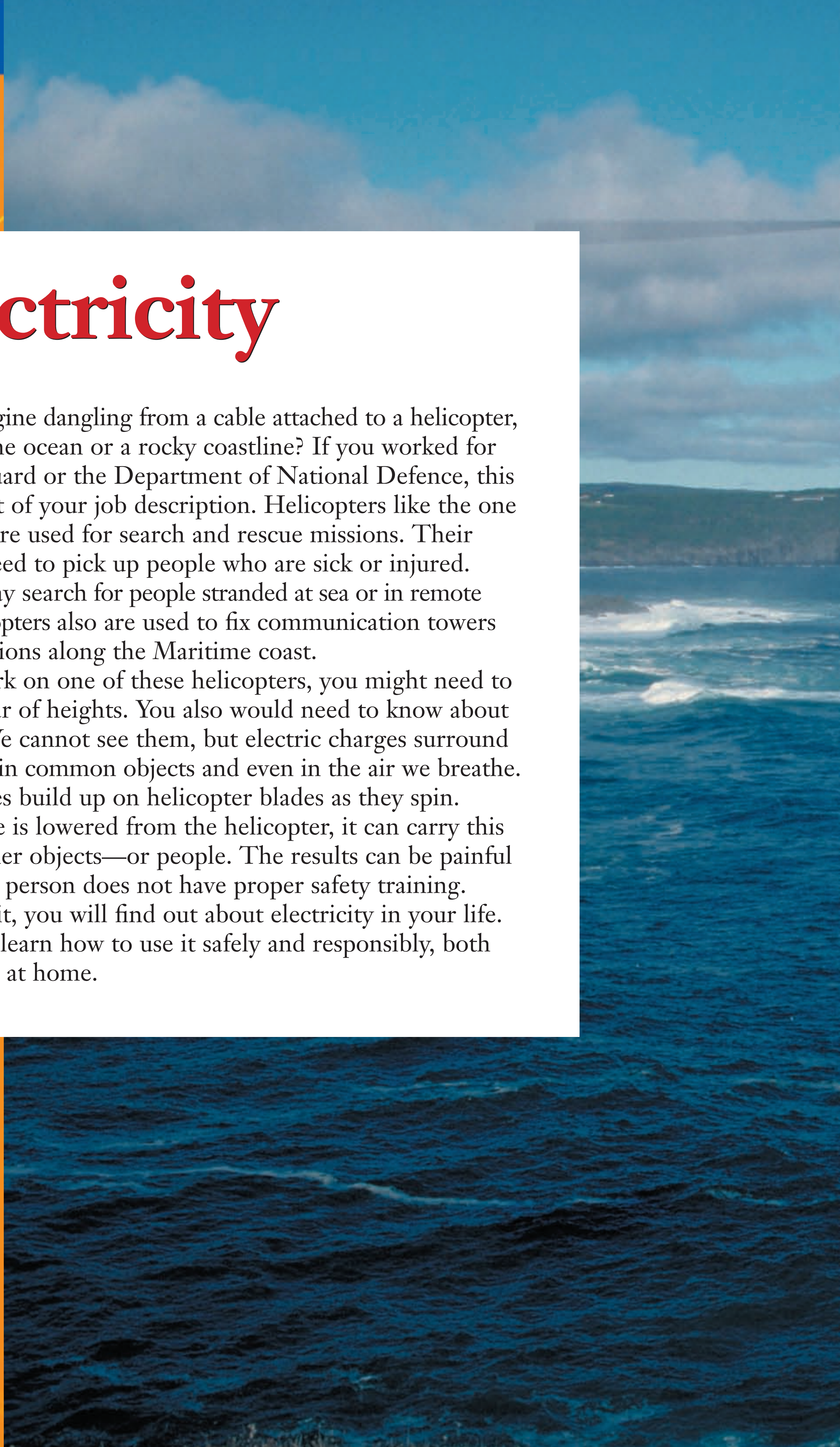
UNIT 1

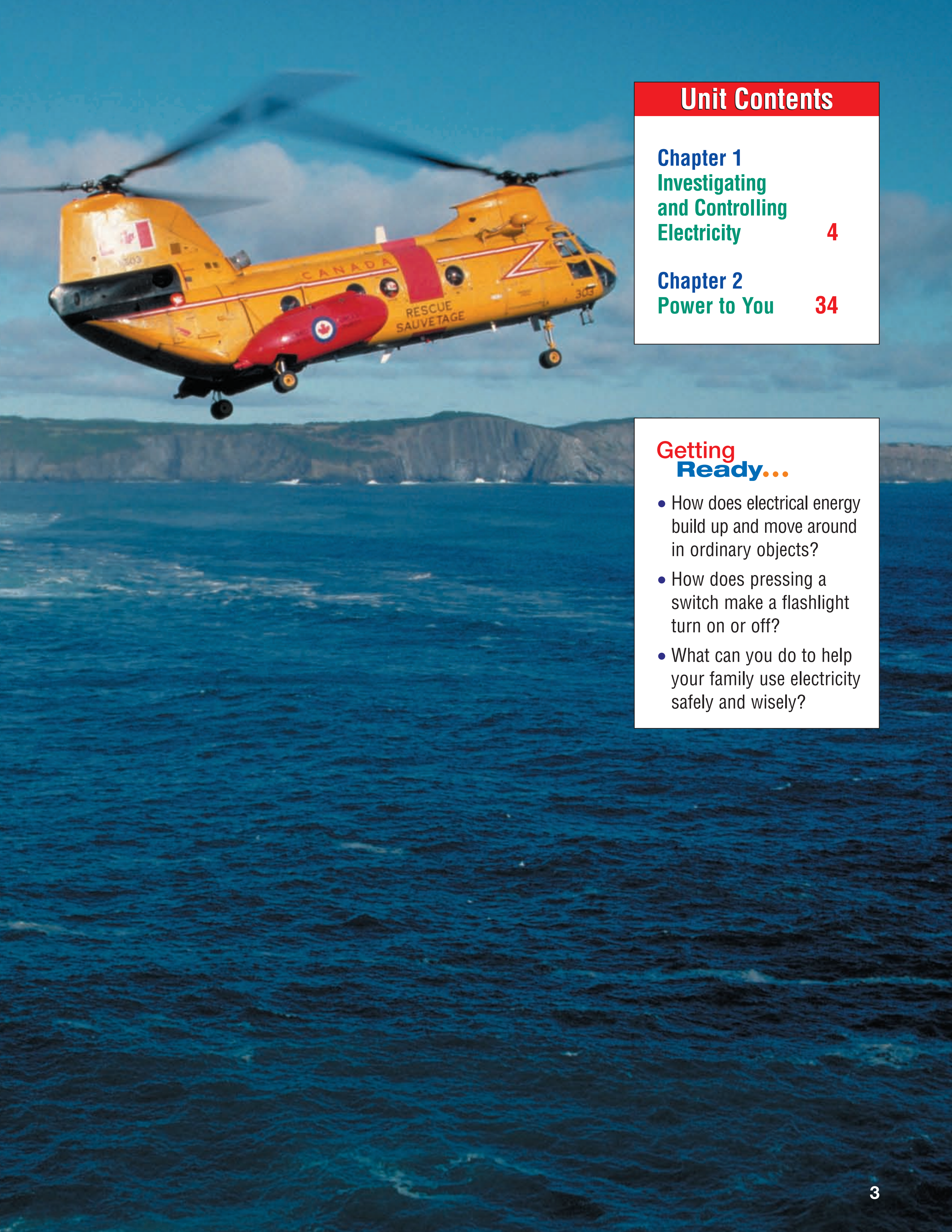
Electricity



Can you imagine dangling from a cable attached to a helicopter, high above the ocean or a rocky coastline? If you worked for the Coast Guard or the Department of National Defence, this might be part of your job description. Helicopters like the one shown here are used for search and rescue missions. Their crews may need to pick up people who are sick or injured. They also may search for people stranded at sea or in remote places. Helicopters also are used to fix communication towers and light stations along the Maritime coast.

If you work on one of these helicopters, you might need to conquer a fear of heights. You also would need to know about electricity. We cannot see them, but electric charges surround us. They are in common objects and even in the air we breathe. These charges build up on helicopter blades as they spin. When a cable is lowered from the helicopter, it can carry this charge to other objects—or people. The results can be painful or deadly if a person does not have proper safety training.

In this unit, you will find out about electricity in your life. You also will learn how to use it safely and responsibly, both at school and at home.



Unit Contents

Getting Ready...

- How does electrical energy build up and move around in ordinary objects?
- How does pressing a switch make a flashlight turn on or off?
- What can you do to help your family use electricity safely and wisely?

CHAPTER 1

Investigating and

Getting Ready...

- Where does electricity come from?
- What causes cotton socks to stick to a silk shirt, but not to each other?
- Is there a difference between the electricity in a storm cloud and the electricity in a flashlight?

Figure 1.1 The slow-moving Atlantic torpedo ray can catch fast-moving fish by stunning them with an electric shock.

Imagine that you are scuba diving in the ocean near Cape Breton. In the glow of your flashlight you see an Atlantic torpedo ray gliding through the water. Watch out! This electric ray can produce an electric shock strong enough to knock a full-grown person unconscious.

It might seem strange that an animal is able to produce electricity. But did you know that your own body is electrical? In fact, the same is true about every person and object around you. You probably know that you are using electricity when you turn on your flashlight. However, you don't usually see the effects of electricity in your body and the ordinary objects in your classroom or home.

In this chapter, you will find out about electricity. You will use objects in your classroom to study how electricity behaves. You will learn about two types of electricity, static and current, and will see how each can be used to perform useful tasks.

Controlling Electricity

What You Will Learn

In this chapter, you will learn

- how to charge objects with electricity
- how electric charges behave
- why some materials conduct electricity while others do not
- the difference between static electricity and current electricity
- the difference between series and parallel circuits

Why It Is Important

- You use electricity every day.
- When you understand what electricity is, you can learn to control and work with it.
- Understanding how electricity works will help you stay safe around it.

Skills You Will Use

In this chapter, you will

- observe what happens when an object is charged
- classify objects as insulators or conductors
- observe what happens when electric charges flow through a conductor
- design and compare series and parallel circuits

This lightning off the coast of Nova Scotia is a dramatic example of electricity in action.

Starting Point ACTIVITY 1-A

Static, Static, Everywhere

What to Do Group Work

1. Inflate a balloon and tie it off. With a marker, gently draw a face on it with the knot pointing up.
2. Using tape and string, hang the balloon from a door or a wall so it is at the same level as your head.
3. Walk slowly past the balloon without touching it. Record what happens in your science journal.
4. Rub the balloon's face with a wool cloth. Walk slowly past the balloon again without touching it. Record what happens.
5. Touch the face of the balloon several times with your hand. Make sure you touch the whole face. Now walk slowly past it and record your findings.
6. Inflate a second balloon and hang it close to the first one so they face each other. Rub both balloons with the wool cloth. Record how they behave.
7. Observe what happens when you rub other objects and bring them close together.

What Did You Find Out?

1. Where and when have you seen this type of "sticking" behaviour before? How might this activity be similar to the "sticking behaviour" that you have seen before?

Section 1.1 Static Electricity

Key Terms
- static electricity
- attract
- repel
- negative
- positive
- neutral
- like charges
- unlike charges

Figure 1.2 What causes some objects to stick together when they come out of a clothes dryer? What other objects are affected by this sticking effect?

It is a cold, dry winter day. You have just come home after playing your favourite winter sport, and you're feeling chilled. You jump onto the couch and wrap yourself in a cozy blanket. You stare absently at the carpet on the floor as you try to get warm under the blanket. Maybe a snack would warm you up faster. You step into your slippers, walk across the carpet, and reach for the doorknob. Ouch! The shock is so strong that you can see a spark in the dimly lit room.

The shocks you get from walking across a carpet and touching a metal doorknob look like tiny lightning bolts. In fact, that is exactly what they are! What could possibly be the same about a thunderstorm and walking across a carpet? How does rubbing create the condition that results in sparks?

Charging Materials with Static Electricity

In your Starting Point Activity, you rubbed a balloon against wool. Then you made it interact with your head, hand, and another balloon. When you rub different objects against each other, you change their properties and the way they behave. Sometimes the rubbed objects attract other objects. For instance, the rubbed balloon attracted your hair as you walked by it. Figure 1.2 shows ways that objects can attract each other after rubbing.

Scientists use the word "charged" to talk about objects that attract or repel other objects. Some objects become charged when they are rubbed with other objects. The charges on a rubbed object are electrical. The build-up of charges is referred to as **static electricity** because the charges are on the surface of an object. (*Static* means "not moving.")

Describing How Charged Objects Behave

Think again about what you observed in your Starting Point Activity. When you rubbed the balloon with wool cloth, you charged it with static electricity. After you charged the balloon, you saw that it behaved in certain ways.

- When you moved toward the balloon, the balloon moved toward you. Charged objects can **attract** (pull on) other objects. Figure 1.3 shows an example of attracting.
- When you put the charged balloon near a second charged balloon, the two charged balloons moved away from each other. Charged objects also can **repel** (push away) other objects. Figure 1.4 shows an example of repelling.

Is there a pattern to the way that objects behave when they are charged? When can you see objects repel? When can you see objects attract? You will explore more about how charged objects behave in Investigation 1-B on the next page.

READING Check

What are two ways that charged objects can behave?

Figure 1.3 The charged comb is attracting bits of paper. Where have you seen an effect like this before? What do you think might cause it to happen?

Figure 1.4 This machine creates a strong static electric charge on its dome. Each strand of hair on this student's head repels each of the other strands when she touches the charged dome.

SKILLCHECK
- Predicting
- Observing
- Controlling Variables
- Interpreting Observations

Get Ready, Get Set, Charge!

In this investigation, you will find out which types of objects can be charged, and you will observe what happens when charged objects are brought near uncharged objects and other charged objects. You also will see if you can change the strength of a charge.

Question

Which objects can be charged with static electricity, and how do charged objects behave?

Safety Precautions

- Small static shocks may occur.

Materials

2 plastic spoons
2 glass rods
piece of wool cloth
piece of silk
paper punches or confetti

Procedure

Part 1

1. Copy Table 1 into your science journal. Create a title.
2. Before you do each test, predict how the objects will behave. Record your predictions in Table 1 in your journal.
3. Put a small pile of paper confetti on your desk.
4. Rub the two plastic spoons together. Place them near the paper confetti. Record your observations as "Test 1" in your table.

Table 1

Test	Predictions	Observations
Test 1: Plastic rubbed with plastic and put near paper confetti		
Test 2: Glass rubbed with glass and put near paper confetti		
Test 3: Plastic rubbed with silk and put near paper confetti		
Test 4: Glass rubbed with silk and put near paper confetti		
Test 5: Two plastic spoons rubbed with silk and put near each other		
Test 6: Two glass rods rubbed with silk and put near each other		
Test 7: Plastic spoon rubbed with silk and put near glass rod rubbed with silk		

5. Rub the two glass rods together. Place them near the confetti. Record your observations as "Test 2" in your table.
6. Rub one of the spoons with a piece of silk. Place the spoon near the confetti. Record your observations as "Test 3" in your table.
7. Rub one of the glass rods with a piece of silk. Place the rod near the confetti. Record your observations as "Test 4" in your table.
8. Rub the bowl of each spoon with the silk. Do not touch the bowl of the spoon after you have rubbed it. Put one spoon down on your desk. Hold the other spoon by the handle and bring it close to the spoon on the desk. Record your observations as "Test 5" in your table.

9. Rub the ends of both glass rods with the silk. Do not touch the ends after you have rubbed the rods. Put one rod down on your desk, making sure that it cannot roll off. Bring the second glass rod close to the first. Record your observations as "Test 6" in your table.

10. Rub one glass rod and the bowl of one spoon with the silk. Put the spoon down on your desk and bring the glass rod close to it. Record your observations as "Test 7" in your table.

11. Try using other rubbing materials (like paper towel, plastic bags, wool fabric, hair) and other objects (like a plastic comb, a penny, a paper cup, a plastic drinking straw, aluminum foil, a wood stick). Create a table to record your observations.

Part 2

1. Copy Table 2 into your science journal. Give it a descriptive title.

Table 2

Test	Observations
Test 1: 10 rubs	
Test 2: 30 rubs	

2. Rub one plastic spoon with a piece of wool 10 times and put it near the paper confetti. Record your observations under "Test 1" in your table.

3. Rub the spoon with the wool 30 times and put it near the confetti. Record your observations under "Test 2" in your table.

4. Clean up your work area and return all your objects to your teacher.

Analyze

1. How many different types of effects did you observe in Part 1? Describe each type of effect.
2. Which tests in Part 1 did not show the effect of an electric charge? Explain why there was no electric charge.
3. How did the number of rubs affect the charging effects you observed in Part 2?

Conclude and Apply

4. Write a few sentences, and draw and label a diagram that explains your observations when
   - **(a)** you rubbed silk on glass and held the glass near the paper confetti.
   - **(b)** you rubbed glass on glass and held the glass near the paper confetti.
5. If you wash cotton socks and put them in the dryer, will they cling to one another? What would happen if you put a silk shirt into the dryer with the socks? Give a reason for your answer.
6. When you brush your hair, your hair sometimes stands on end and is attracted to your brush. Will brushing your hair for a longer time help to settle it? Explain.
7. In Part 2, what do you think happens to the wool in each test? Explain.

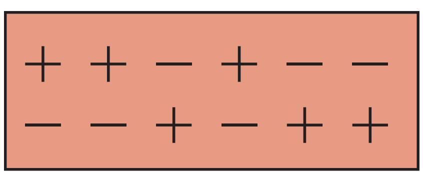
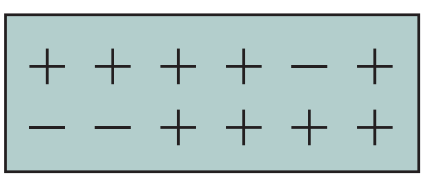
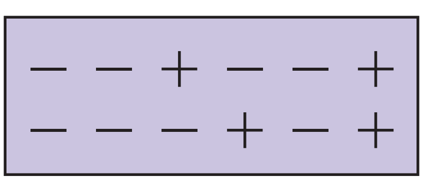
Types of Charges

You have been collecting a lot of information about charged objects and static electricity. Think about what you have seen. For instance:

- You have seen that two different charged objects can attract each other.
- You have seen that two charged objects of the same kind can repel each other.
- You have seen that a charged object can attract an object that is not charged (an uncharged object).

Hundreds of years ago, scientists observed the same things about charged objects that you did. They concluded that there are two types of charge. They called one type of charge **negative**, and they used a minus sign (−) to refer to it. They called the other type of charge **positive**, and they used a plus sign (+) to refer to it. Objects that do not have a charge are called **neutral**. Figure 1.5 shows how you can use plus signs and minus signs to describe charged and uncharged objects.

Figure 1.5 The charge that an object has depends on the balance between positive charges (plus signs) and negative charges (minus signs) in the object.

A 	**A neutral object** • six positive charges • six negative charges • number of positive charges equals number of negative charges • no overall charge
B 	**An object with positive charge** • nine positive charges • three negative charges • number of positive charges is greater than number of negative charges • overall positive charge
C 	**An object with negative charge** • four positive charges • eight negative charges • number of positive charges is less than number of negative charges • overall negative charge

How Charges Interact

Two charges of the same type (both positive or both negative) are alike. They are called **like charges**. Two charges that are different (one type positive and one type negative) are not alike. They are called **unlike charges**. When charged objects and uncharged objects interact, there are three ways they can behave. These three ways are listed below and shown in Figure 1.6.

1. Unlike charges attract.
2. Like charges repel.
3. Charged objects attract uncharged (neutral) objects.

INTERNET CONNECT

www.mcgrawhill.ca/links/ns+science6

The charge that an object has depends on the tiny particles that make up all matter. You might know that these tiny particles are called atoms. If you want to know more about atoms and how they affect static charge, go to the above web site and click on **Web Links** to find out where to go next.

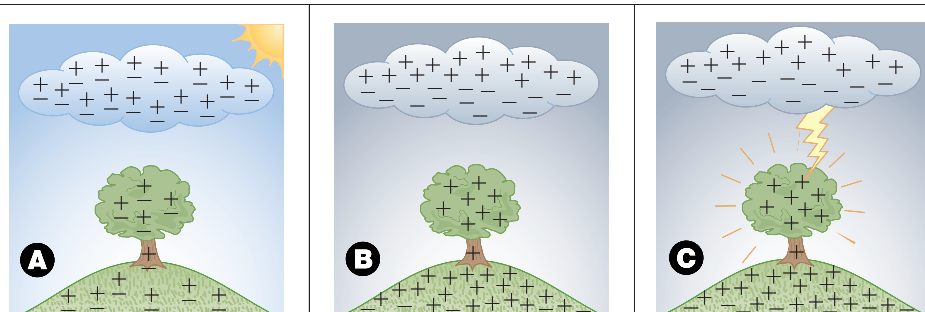
Figure 1.6 Which of these photos shows like charges repelling? Which shows unlike charges attracting? Which shows a charged object attracting a neutral object?

Figure 1.7 An average bolt of lightning is about 10 km long. The temperature of the air near a lightning bolt can reach as high as 33 000°C!

The Danger of Lightning

A family in Stellarton, Nova Scotia was watching a thunderstorm from their front porch when their whole house was shaken by a blast. Lightning had struck their chimney, sending bricks falling to the ground. Charges travelled down the chimney pipe to the furnace, causing soot to shoot out into their home. Lightning strikes at two neighbouring homes passed through telephone and electrical lines, damaging phones, TVs, and computer equipment. How can lightning be such a destructive, natural event?

Scientists are still studying the mysteries of lightning. They believe that, during a thunderstorm, air currents cause water droplets and ice particles to collide and rub together inside a thundercloud. This action causes negative charges to move to the bottom of the cloud, while positive charges stay near the top. Static electricity is released, or discharged, in the form of lightning (Figure 1.8).



A	B	C
• cloud and ground are neutral before the storm • positive and negative charges are evenly mixed	• strong negative charge from cloud repels negative charges on Earth's surface • ground (and trees or buildings) under cloud become positively charged	• gigantic spark leaps from cloud to ground • many sparks travel between cloud and ground, appearing as a single flash of lightning

Figure 1.8 Charges that build up during a thunderstorm are released as lightning.

A lightning strike usually will take the shortest route between the negatively charged side of the cloud and the positively charged area of ground. This is the reason why lightning tends to strike tall buildings and trees. In the next activity, you will find out facts and fiction about lightning. You also will learn how to protect yourself from lightning.

At Home ACTIVITY 1–C

How Shocking!

You may have heard the saying "lightning never strikes twice in the same place." Or maybe someone has told you that you can tell whether a thunderstorm is moving toward you or away from you just by listening to it. But are these ideas really true? In this activity, you will collect information about lightning and then sort fact from fiction.

Some people try to protect themselves during a rain or lightning storm by taking cover under tall trees. Is this a good idea?

What to Do

1. Talk with friends and members of your family to find out what they know and believe about lightning. Make a list of all the "facts" you hear from them.
2. Use library or Internet resources to investigate which of the statements on your list are true, and which are not.
3. As you do your research, add more statements to your list. Try to collect statements that are true and statements that are false. For every false statement you collect, write a true statement to correct it.

What Did You Find Out?

1. How much of what you heard in the past about lightning was true?
2. Will any of the things you learned about lightning change how you and your family behave during a thunderstorm? Explain.
3. Using the information you have collected, prepare a poster or a presentation that will communicate accurate information about lightning. Include safety tips that will help people protect themselves from lightning both indoors and outdoors.
4. Share this information with your family and friends at home.

Section 1.1 Summary

In this section, you learned that rubbing together objects made of different materials can create a static electric charge on them. Since these charges stay in one place on the surface of the charged objects, they are referred to as static electricity.

When charged objects and uncharged objects interact, one of three things can happen.

1. Unlike charges attract each other.
2. Like charges repel each other.
3. Charged objects attract uncharged objects.

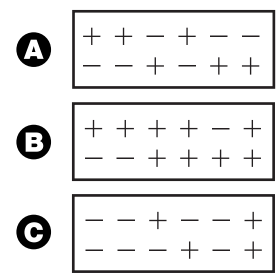
Lightning is a dangerous release of electricity that happens when charges build up in a thundercloud during a thunderstorm. Lightning tends to strike tall trees and buildings because the discharge usually takes the shortest route between the cloud and the ground.

Key Terms

static electricity
attract
repel
negative
positive
neutral
like charges
unlike charges

Check Your Understanding

1. The diagram shows the charge on three different objects, A, B, and C.



(a) Is object A positively charged, negatively charged, or uncharged?
(b) What will happen to object B if object C is brought close?
(c) What would have to be done to object C to make it uncharged?

2. You rub two identical wool cloths together, and then hold them close together (but not touching). What would you expect to observe? Explain.

3. **(a)** Two balloons are hanging from the ceiling. The balloon on the left has the same charge as the balloon on the right. Draw how the balloons look.
(b) Two balloons are hanging from the ceiling. The balloon on the left has the opposite charge of the balloon on the right. Draw how the balloons look.
(c) Two balloons are hanging from the ceiling. The balloon on the left is charged. The balloon on the right is neutral. Draw how the balloons look.

4. Do you think it is safe to carry an umbrella during a lightning storm? Explain.

Section 1.2 Making Connections

Electricity on the Move

In Section 1.1, you learned about static electricity. Static electricity is the accumulation of electric charges on an object. It can occur when charges move from one object to another, such as when they are rubbed together. Much of your daily life depends on another kind of electricity called **current electricity**. Current electricity is when charges move *through* an object. What do you think is needed to make charges flow through an object? How is current electricity a part of your daily life?

Key Terms

- current electricity
- conductors
- insulators
- ground

Find Out ACTIVITY 1-D

Put It Together

Can you make electricity flow?

What You Need

1 D-cell battery (1.5 V) in a holder
2 aluminum foil strips
(10 cm long × 1 cm wide)
1 small flashlight bulb
additional items provided by your teacher (these could include copper wires with alligator clips, additional D-cell batteries, buzzers, and switches)

What to Do

1. Try to connect the materials supplied so the bulb lights up. When it lights up, electricity is flowing.
2. Draw a sketch of each arrangement that you try. Label each part and say whether or not the arrangement worked.
3. Use the other items from your teacher to make connections that let electricity flow. How can you tell if the connection is successful?
4. When your teacher tells you to stop, clean up your work area, and return all items.

What Did You Find Out?

1. Which arrangements worked to light the bulb in step 1?
2. Did you make electricity flow in step 1? How do you know?
3. Which connections did not work in steps 1 and 3? Explain why you think they did not work. Then explain what you think would make them work.

CONDUCT AN

INVESTIGATION 1-E

SKILLCHECK
- Controlling Variables
- Observing
- Interpreting Observations
- Communicating

Lighten Up!

An electric current is the flow of charges through an object. Charges can pass through some types of materials and not others. In this investigation, you will study different types of materials to see which ones allow the flow of charges and which ones do not.

Question

How can you tell that charges are flowing through some materials and not others?

Safety Precautions

- Do not connect more than one battery.
- Do not touch the metal part of the alligator clips.

Materials

1 D-cell battery (1.5 V)
1 battery holder
3 copper wires with an alligator clip on each end
1 small flashlight bulb
1 light holder
4 small plastic containers
spoon

Solid test materials:
glass rod
piece of silk
piece of wood
a penny coin
a nickel coin

Liquid test materials:
tap water
lemon juice
salt-water solution
baking soda solution

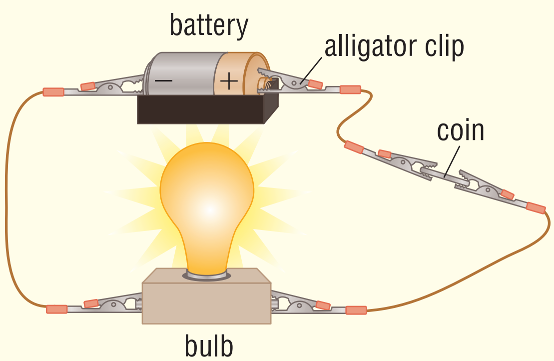
Procedure

1. Copy the table below into your science journal. Give it a title. Predict whether each material will allow electricity to flow.

	Solid Test Materials						Liquid Test Materials			
	No item	Glass	Silk	Wood	Penny	Nickel	Tap water	Lemon juice	Salt-water solution	Baking soda solution
Prediction										
Results										

2 Put the battery into the battery holder. Attach the end of one wire to one terminal (or end) on the light holder, and the other end of the same wire to one terminal on the battery holder. Attach one end of the second wire to the other terminal on the light holder. Attach one end of the third wire to the other terminal on the battery holder. You should now have two alligator clips available. Attach the two clips together, making sure that your fingers touch only the plastic on the clips, not the metal. Record your observations in your table under "No item."

3 Attach one of the solid test items between the two available alligator clips. Make sure the metal part of each clip touches the test item. Record your observations in your table.



4 Repeat step 3 for each of the solid test items.

5 Test each of the liquid items by placing the alligator clips into a beaker containing the liquid. Make sure the clips do not touch each other. Wipe the clips clean and dry them between each test. Record your observations in your table.

6 Clean up your work area and return all materials to your teacher.

Analyze

1. What is the purpose of doing step 2 with no items?
2. Which items allowed the electricity to flow through them? How could you tell?
3. Which items did not allow electricity to flow through them? How could you tell?
4. What was the reason for cleaning the alligator clips between tests of the liquids?

Conclude and Apply

5. Write a paragraph or draw and label a diagram that shows how charges flowed through the wires
   (a) when you put a penny between the two alligator clips
   (b) when you put wood between the two alligator clips
6. Do you think you can create a static charge (that is, one that stays in one place) on a type of object that allows electricity to flow through it? Explain.

READING Check

What is the difference between a conductor and an insulator?

Conductors and Insulators

Some materials let charges flow through them easily. These materials are called **conductors**. Metals such as copper are good conductors. An electric charge at one end of a metal object will spread over the whole object.

Other materials block the flow of charges. These materials are called **insulators**. Rubber and wool are both insulators. An electric charge on one part of an insulator is static. In other words, it will stay in one place. You can build static electricity only on objects that are insulators.

A In humid areas such as many parts of Nova Scotia, a static charge will flow away into the air instead of building up on the surface of an object.

B It is much easier to create static electricity on an object in drier areas of the East Coast or in the dry prairies of western Canada (shown above).

Figure 1.9 Humid air is a good conductor of electricity, while dry air is not.

Some materials let charges flow through them, but not very well. These materials are called *fair conductors*. Table 1.1 shows some examples of good conductors, fair conductors, and insulators.

Table 1.1 Conductors and Insulators

Good Conductors	Fair Conductors	Insulators
aluminum	carbon	cotton
copper	Earth	rubber
gold	human body	glass
iron	humid air	dry air
nickel	salt water	wool

Grounding an Electric Charge

"You're grounded!" Those words are not usually ones you want to hear. But when you are using electricity, being grounded can be very important. It can even save your life. To **ground** an object means to connect it through a conductor to the ground, or Earth. Grounding is a way to prevent electric charges from building up on an object, or to get rid of electric charges. Extra charges can flow into the ground so that the object is uncharged again. As shown in Figure 1.10, Earth is so large that it can accept or give up charges without any noticeable change in its overall charge.

Grounding works for big charges like lightning, but it also works for smaller charges. Remember that you can charge an insulator such as a balloon by rubbing it with wool. If you touch the balloon with your hand, you ground the static charge. Figure 1.11 shows another example of grounding for smaller charges.

Figure 1.10 Earth can absorb even big electric charges, the same way the ocean absorbs a cup of water. The overall effect is so small it cannot be measured.

READING Check

How does grounding help keep people safe?

Figure 1.11 Static electric charges can damage sensitive electric equipment like computers. The arrow points to a special ground wire often worn by computer technicians to get rid of static electricity.

Creating an Electric Current

In Investigation 1-B, you charged different insulators with a static charge. If you touch a conductor such as a metal wire with that charged object, the static electricity can be turned into an electric current. Why can't you use static electricity to power your television? When static electricity is released, it produces only a one-time burst of electric current. You need a steady (continuous) electric current for most objects that use electricity. In the next activity, you will use a lemon to make a steady electric current.

Find Out ACTIVITY 1-F

Electric Lemon

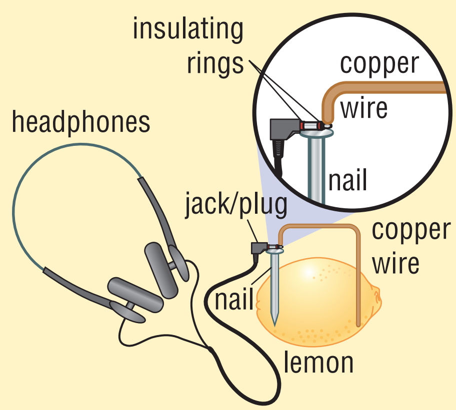
You can use a static charge to start an electric current, but that is not always very useful. Chemical reactions also can create electric currents. In this activity, you will find out how to make charges flow *without* first building a static charge.

What You Need

1 pair of headphones
1 galvanized nail
1 piece of copper wire (heavy gauge)
1 lemon

What to Do

1. Stick the copper wire down into one end of the lemon. Push it almost all the way through.
2. Stick the nail down into the other end of the lemon. Again, push it almost all the way through.
3. Bend the top of the wire so that it is almost touching the nail.
4. Put on the headphones. Hold the plug end of the headphones on the top of the nail. Observe what you hear.
5. With your other hand, touch the copper wire to the plug as shown in the illustration. Make sure that the plug is touching both the nail and the wire.
6. Wait one to two minutes. Observe what you hear.



What Did You Find Out?

1. Did you hear anything in step 4? How did it differ from what you heard in step 6?
2. How do you know that electricity is flowing?

Section 1.2 Summary

In this section, you learned the following:
- Current electricity is the flow of charges.

Charges can move easily through some materials and not others:
- A conductor is a material that allows the flow of charge.
- An insulator is a material that blocks the flow of charge.
- A fair conductor is a material that allows the flow of small amounts of charge (for example, your body or salt water).

One way to get rid of an electric charge is to ground the charged object. Grounding an object means connecting it through a conductor to Earth. Earth is so big that it can give up or accept enough charges to neutralize even a very big electric charge.

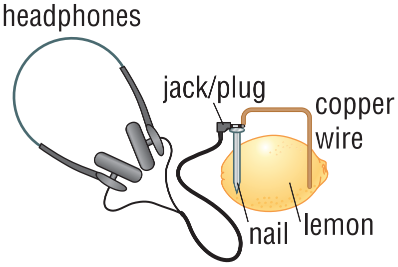
To use electricity effectively, you should know the following:
- The electric devices we use every day require a steady electric current instead of a sudden release of charges.

Key Terms

current electricity
conductors
insulators
ground

Check Your Understanding

1. If an object is a good conductor, what characteristics does it have?
2. List three examples of fair conductors. What do these three examples have in common?
3. Explain how grounding a charged object neutralizes the charge on that object.
4. Think of lightning and the electric shocks you may get when you rub your feet across a carpet. What makes the "flash" of a lightning strike larger than that of a carpet shock?
5. When the headphones are connected to the lemon in the arrangement below, you can hear the electricity flow.
   (a) What does this tell you about the properties of lemon juice?
   (b) What would happen if you injected pure water into the lemon while you were listening to the headphones? Explain.



Section 1.3 Electrical Circuits

Key Terms
- circuit
- source
- load
- closed circuit
- open circuit
- switch
- hazard
- short circuit
- series circuit
- parallel circuit

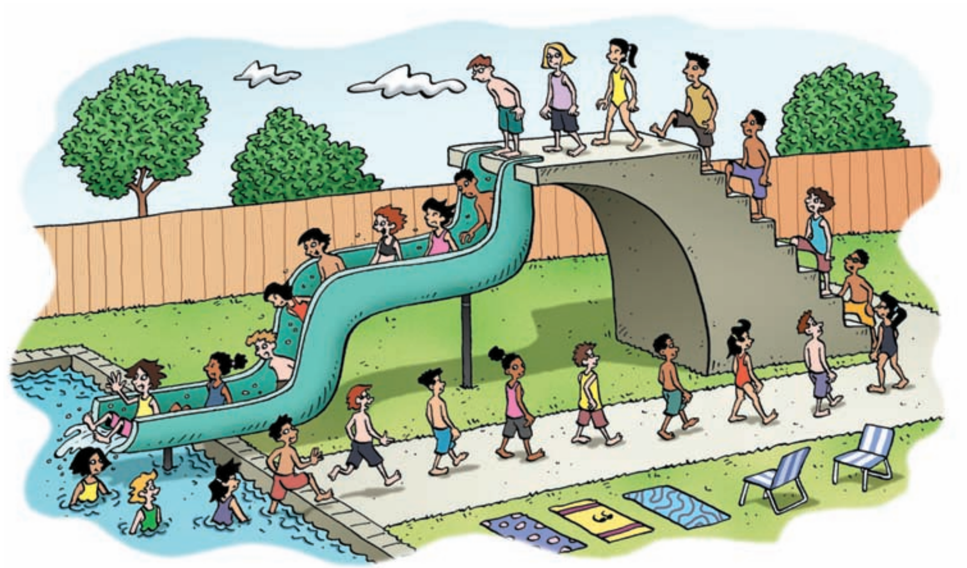


Figure 1.12 Each person who climbs the stairs must move along the same pathway to move down the slide. What will happen if a person stops on the stairs or on the slide? How will this affect the movement of people along the pathway?

Electricity Flows in a Circuit

Everyone who uses the water slide in Figure 1.12 must follow the same pathway. There is a steady movement of people along this pathway. In Section 1.2, you connected components, or parts, to make charges flow. Your system allowed the steady movement of charges around a specific pathway. You built a working electric **circuit**. A circuit is a complete pathway for the flow of electricity.

Every electric circuit has three basic components:

- A **source** of electrical energy: The source provides the "push" that causes charges to move through the circuit. In the electric circuit you built, the source was the battery.
- A conductor to carry electricity: In an electric circuit, a conductor is usually the wire or wires that carry electricity. Most circuits use a wire made of copper that is wrapped in an insulating material.
- A **load**: The load is any component along the circuit that uses the electricity. In simple circuits, the load is often a light bulb or a buzzer.

Closed and Open Circuits

In Section 1.2, you found that a circuit works only when it is complete. The bulb lights up only when there is a complete and unbroken pathway to carry the electricity from the battery to the light and back to the battery. This is called a **closed circuit**. If there is a gap or break anywhere along the path, electricity does not flow. A circuit with a gap in it is called an **open circuit**. Figure 1.13 shows the difference between an open and closed circuit.

READING Check

What is the difference between a closed circuit and an open circuit?

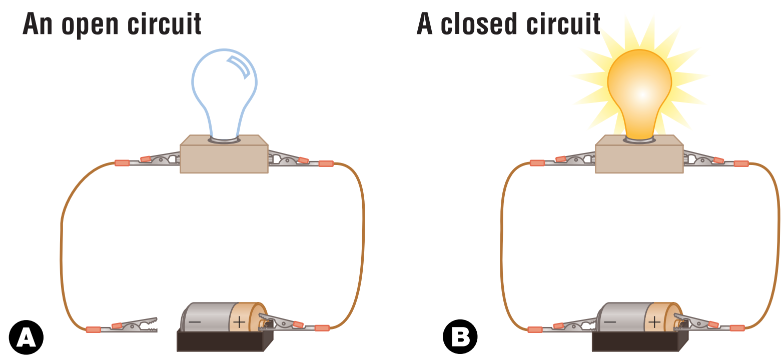


Figure 1.13 Electricity can flow only when there is an unbroken pathway.

Opening and closing an electric circuit is a way to control the flow of the current. Most useful electric circuits have a fourth component: a switch. A **switch** is a device that closes or opens the circuit to start or stop the flow of electricity. Figure 1.14 shows how an ordinary light switch works to turn a light on or off.

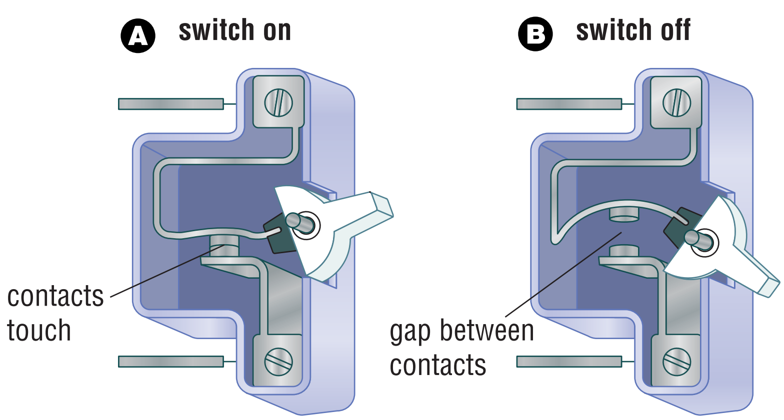


Figure 1.14 An inside view of a light switch. What is the difference between A and B?

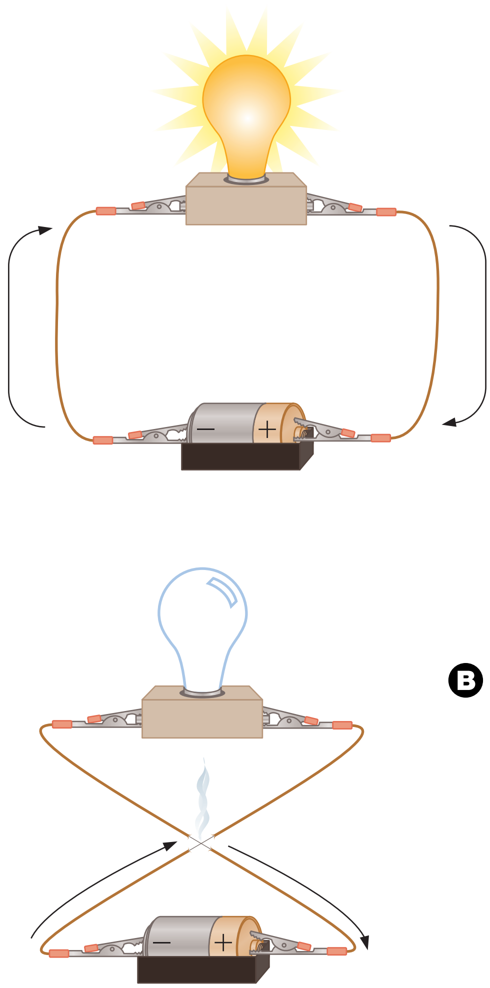
Pause & Reflect

Where can you find switches at home? How many kinds can you find? What do you think happens to a circuit when you turn a switch on or off? Discuss your ideas in class.

Short Circuits Are Dangerous

Sometimes electricity can flow through a closed circuit in a way that is not controlled or safe. We call this danger a **hazard**. A closed circuit that does not have a useful load is called a **short circuit**. If you do not include a useful load, the conductor itself becomes the load. The electrical energy flowing through the circuit is enough to heat up the conductor. In some short circuits, as shown in Figure 1.15B, the current follows a different path instead of flowing through the intended load.

A hot or smoking conductor is one sign of a short circuit. Other short circuits can be much more dangerous than the one you just made—especially if *you* become the load! Watch out for short circuits whenever you are working with electricity.



A This closed circuit is safe to work with.

B In this circuit, the insulation around the wires is damaged where the wires cross. The charges travel through the uninsulated wires back to the source without going through the light. This is a dangerous short circuit. Why is it dangerous?

Figure 1.15 Arrows show the flow of charges through each circuit.

A Series Circuit Is a Single Pathway

In Activity 1-D and Investigation 1-E, you built series circuits. A **series circuit** provides a single pathway for charges to travel from the source(s) through the load(s). That single pathway then continues through the load(s) to the source(s). Figure 1.16 shows that a series circuit can have more than one load and more than one source, all connected in one continuous loop. Charges flow from the negative terminal of the battery through the circuit components to the positive terminal of the battery. In the next pages, you will take a closer look at series circuits.

Pause & Reflect

If the insulation on the wires in Figure 1.15B was not damaged, would electricity still flow from one wire to the other where they cross?

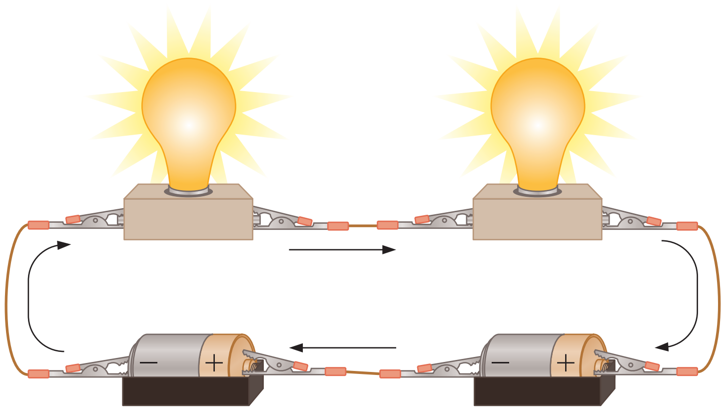


Figure 1.16 A series circuit can have many loads (lights) and sources (batteries). Charges have only one path to follow (shown by arrows) through the entire circuit.

Find Out ACTIVITY 1–G

It's the Only Way to Go

A flashlight is an example of a series circuit.

What to Do Group Work

1. Carefully take apart a flashlight and draw a diagram to show how the parts fit together inside.
2. Using a coloured pencil or marker, draw arrows on your diagram to show the flow of charges from the battery through the circuit.

What Did You Find Out?

1. How does your diagram compare to the diagrams drawn by others in your class?
2. Which parts of a flashlight do you think are needed for it to work?
3. What role do the other parts of the flashlight play?

CONDUCT AN

INVESTIGATION 1-H

SKILLCHECK

- Observing
- Controlling Variables
- Interpreting Observations
- Making Inferences

In Series

In a series circuit, charges travel along a single pathway through all of the components. In this investigation, you will build and test a series circuit. As you change some components, you will affect other parts of the circuit.

Question

How can you make a light bulb burn more dimly or more brightly?

Safety Precautions

- Connect the load first.
- Disconnect the battery first.

Materials

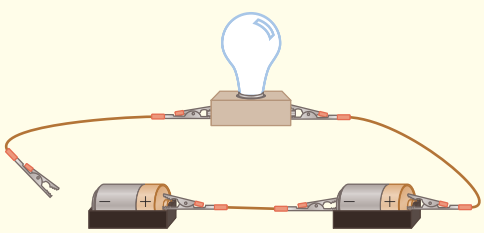
2 D-cell batteries in holders (1.5 V)
2 small flashlight bulbs in holders
4 copper wires with an alligator clip on each end
1 switch

Procedure

Group Work

Part 1: Sources in Series

1. You will use two wires for this step. Join one alligator clip from each wire to each terminal on the light bulb holder. Then join the other end of each wire to the terminals on the battery holder. Record your observations.
2. Add a second battery to the circuit. To do this, disconnect the wire from the negative terminal of the battery holder in the circuit. Use a new wire to connect the positive terminal of this battery holder to the negative terminal of the second battery holder. Your open circuit should look like the illustration below.



Working Safely with Electric Circuits

Electricity can be dangerous. Without special equipment, it is not always possible to tell when there is a current in a wire. Never conduct experiments using electric circuits without the supervision of an adult who is trained to work safely with electricity.

Always follow these guidelines when you work with electric circuits:

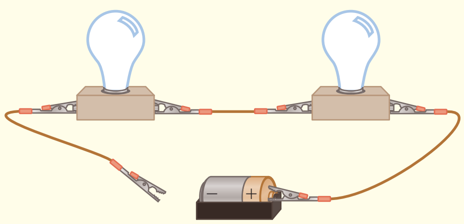
- Inspect your equipment before you begin. Watch out for and replace damaged wires, leaky batteries, broken bulbs, or damaged clips.
- Make sure your work area is clean, dry, and uncluttered.
- Remove metal jewellery that could conduct electricity.
- Handle wires by holding the plastic (insulated) coating or clips.
- When connecting a circuit, *connect the wires to the load first,* before connecting them to the battery.
- When disconnecting a circuit, *disconnect the wires from the battery first,* before disconnecting them from the load.
- Check to make sure that the battery is not too powerful for your circuit. If you connect a battery of 6 V to a light of 1.5 V, you may “blow” the bulb.

3. Connect the available alligator clip to the negative terminal of the second battery holder to close the circuit. Record your observations.

Part 2: Loads in Series

4. Build an electric circuit like the circuit in step 1. Observe what happens.

5. Add a second light to the circuit. To do this, first open the circuit by disconnecting one of the wires from the battery holder. Then disconnect the other wire from the light holder. Connect this wire to the second light bulb. Use a new wire to connect the two light bulbs. Your open circuit should look like the illustration below.



6. Close your circuit by connecting the available alligator clip to the available battery terminal, and record your observations.

7. Unscrew one light bulb in the series circuit. Do not remove the wires from the bulb holder. What happens to the other light? Record your observations.

Part 3: Circuit with a Switch

8. Screw the light bulb back in to the circuit you built in Part 2.

9. Using a switch and the fourth wire, try to connect the switch to your circuit so that you can turn the lights on and off. Remember to always disconnect the battery first when you change your circuit.

10. Test various locations for the switch.

11. Draw diagrams of all arrangements. Identify the successful arrangements.

Analyze

1. What did you observe about the light bulb when you added a second battery in series? What can you infer about the flow of charges?

2. What did you observe about the light bulbs when you added a second light bulb in series? What can you infer about the flow of charges?

3. What did you observe about the light bulbs when you unscrewed one bulb? Explain your observation.

4. Were you able to turn the light bulbs on and off when you connected a switch to your circuit? Explain what you observed.

Conclude and Apply

5. Did the location of the switch affect the result in Part 3? Explain.

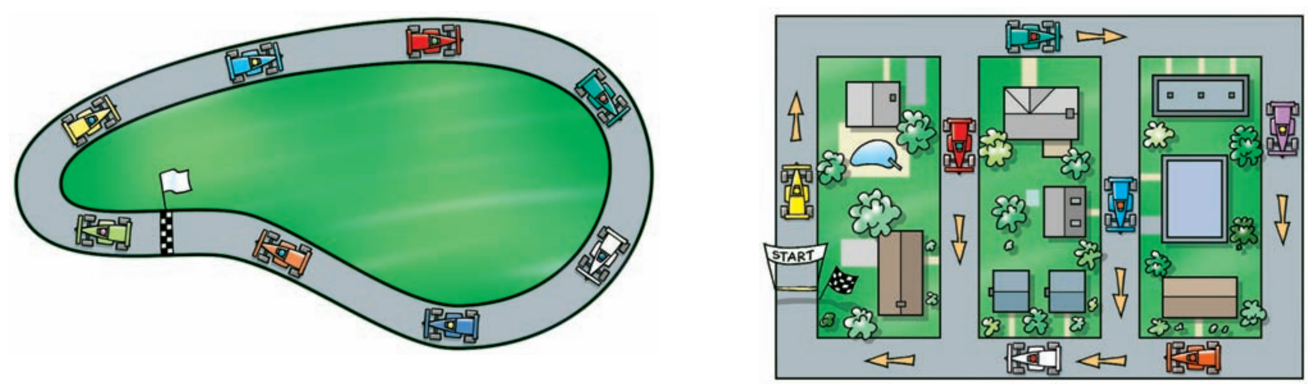
6. Draw a diagram to show the flow of electricity through a series circuit with two bulbs, one battery, and one switch. In what way is unscrewing a bulb like turning off the switch?

READING Check

What is the difference between a parallel circuit and a series circuit?

Parallel Circuits

In your home, many electric devices probably are connected together in a circuit. However, you can turn each of them on or off without affecting the others. Within this circuit, charges have more than one complete pathway to follow. This kind of circuit is called a **parallel circuit**. Figure 1.17 shows the difference between a single path and multiple pathways in circuits.



A Cars on a racetrack all travel the same path to return to the starting point.

B Cars on a road system can choose different routes to return to the starting point.

Figure 1.17 The difference between a series circuit and a parallel circuit is like the difference between a single-lane racetrack and a system of single-lane roads. In each case, what happens if one car stops and blocks the road?

Figure 1.18 shows several loads connected in parallel. If you turn off the lamp, you stop the current from flowing to the lamp by opening that part of the circuit. However, there are other closed paths for charges to follow. The circuits that connect the electric piano and the toaster to the source are still closed. Turning off the lamp does not affect the flow of current to these loads.

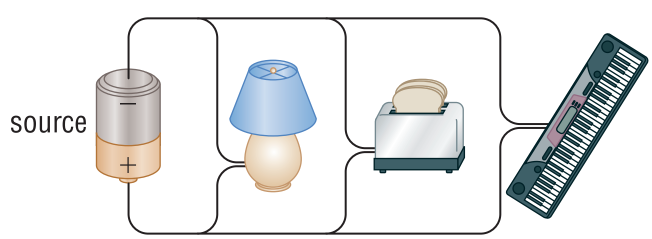


Figure 1.18 A parallel circuit. Each load can be turned on or off without affecting the others. Where could you place one switch to control all three loads?

At Home **ACTIVITY 1-I**

Current in Parallel and Series Circuits

You can use water as a model for the rate of movement of charges (current) through a parallel and a series circuit.

What You Need

2 glasses (filled with water)
4 drinking straws
clear adhesive tape

What to Do

1. Put all four straws into one glass of water. Put the other end of all four straws into your mouth.
2. Draw the water up the straws with your mouth. Observe how much water enters your mouth.
3. Tape the four straws end to end and put one end into the second glass of water.
4. Draw the water up the four connected straws with your mouth. Try to draw with the same force and for the same amount of time as in step 2. Observe how much water enters your mouth.

What Did You Find Out?

1. **(a)** Which arrangement of straws (the first or the second) provided more than one path for water to flow?
   (b) Was this similar to a series circuit or a parallel circuit?
2. Which arrangement of straws allowed you to draw up more water into your mouth?
3. After drawing up the water once, what was the difference in the water level in the glass for each arrangement?
4. What does this model tell you about the flow of current in each type of circuit?

Current in a Parallel Circuit

Remember from Investigation 1-H that the current through a series circuit decreases as you add more loads to the circuit (the light bulbs got dimmer). In contrast, each time you add a new load to a parallel circuit, the total current through the system increases. In Activity 1-I, you used straws to model the flow of charges (current) through a parallel circuit and a series circuit. If you had added even more straws in parallel, more water would have been pulled up, and the glass of water would have been drained faster.

If a battery is your source, the battery will be drained more quickly as more loads are added in parallel. In your household electric system, as you add more loads, the total current can increase to a dangerous level.

READING Check

What happens to the total current flowing through a circuit as you add new loads in parallel?

CONDUCT AN

INVESTIGATION 1-J

SKILLCHECK

- Controlling Variables
- Observing
- Making Inferences
- Communicating (Reporting)

On Parallel Tracks

In a parallel circuit, charges can travel along more than one pathway through all of the components. In this investigation, you will build and test a parallel circuit. As you change some components, you will affect other parts of the circuit.

Question

How does electricity flow through a parallel circuit?

Safety Precautions

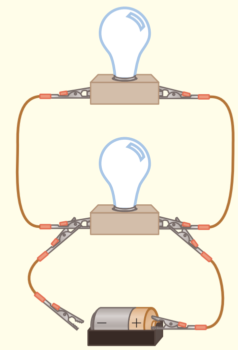
Materials

1 D-cell battery (1.5 V) in a holder
6 copper wires with an alligator clip on each end
2 small flashlight bulbs in holders
1 buzzer

Procedure

1. Using the wires, connect the battery holder and light holder in a simple circuit so that the light goes on. Observe the brightness of the light.

2. Add a second light in parallel with the first. To do this, open your circuit by disconnecting one of the wires from the battery holder. Then without disconnecting the first light, connect a new wire to each of the terminals on the first light holder. Connect each available end of each of these wires to a terminal on the second light holder. Your circuit should look like the illustration.



3. Close your circuit by reconnecting the battery holder. Observe the brightness of both lights. Record what happens in your science journal.

4. Using the same procedure as in step 2, add a buzzer in parallel with the two lights. Remember to disconnect the battery before you work with your circuit. Close your circuit and observe what happens.

5. Record your observations about what happens when you increase the loads in a parallel circuit. Then disconnect your circuit.

Analyze

1. What happened to the brightness of each light as more lights were added?

2. What happened to the lights when you added the sound buzzer?

3. From questions 1 and 2, what can you infer about the current in the parallel circuit?

Conclude and Apply

4. How do the results of adding more lights in parallel compare with adding more lights in series? (Hint: See Investigation 1-H.)

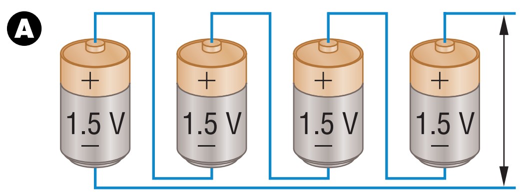
Sources Can Be Connected in Parallel

In Investigation 1-J, you found that you can add *bulbs* in a parallel circuit without changing the brightness of each bulb. The current increases as you increase the loads, but the "push" stays the same. In a parallel circuit, you can add or take away loads without affecting the strength of the current across other components of the circuit.

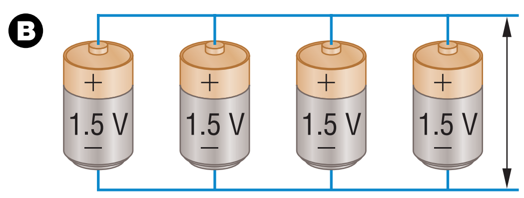
If you had added more *batteries* in parallel, you would have seen that the brightness of the light does not change in this situation either. The strength of the current in the circuit does not increase when you add batteries in parallel. Although the lights are not any brighter, the batteries will *last* longer because there are more of them. Figure 1.19 shows how the amount of "push" exerted by batteries is affected when they are wired in series and in parallel. (The amount of "push" is measured in units called volts.)

READING Check

Does the current in a circuit change as you add identical batteries in parallel?



Series circuit
- four batteries, each 1.5 V
- charges flow through one battery after another
- the "push" of all the batteries adds up
- total "push" = 1.5 V + 1.5 V + 1.5 V + 1.5 V = 6 V



Parallel circuit
- four batteries, each 1.5 V
- smaller amount of charge flows through each battery
- total "push" = 1.5 V

Figure 1.19 More than one battery is usually used in a device. Batteries can be grouped together either in series to produce a stronger "push" of charges, or in parallel to provide the "push" of charges for a longer time.

Section 1.3 Summary

In this section, you learned that an electric circuit is a pathway for the flow of electricity. For the circuit to be useful, it needs

- a source to "push" charges through the circuit.
- a conductor to carry electric current.
- a load that responds in some way to the current.
- a switch to control the electric current.

Circuits can be closed or open. A closed circuit allows the flow of electricity. An open circuit does not allow the flow of electricity. A short circuit is closed and allows the flow of electricity but does not have a useful or intended load. It can be quite dangerous.

A circuit can be arranged either in series or in parallel.

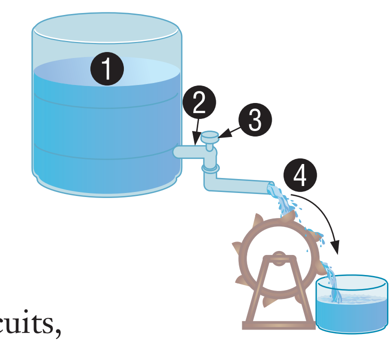
- A series circuit connects all components in a single pathway, while a parallel circuit has more than one pathway for charges to follow.
- Removing any device from a series circuit (or turning the device off) opens the circuit.
- Adding more loads to a series circuit increases the "push" of charges. Adding loads to a parallel circuit does not change the amount of current flowing through other loads.

Key Terms

circuit
source
load
closed circuit
open circuit
switch
hazard
short circuit
series circuit
parallel circuit

Check Your Understanding

1. How can you stop the flow of current around a circuit?
2. What are the four basic components that make up all circuits? Describe the role each component plays in the circuit.
3. Are short circuits dangerous? Explain.
4. In the water system shown in the illustration, which one of the numbered elements is like the conductor in an electric circuit? Explain your answer.



5. From what you know about series circuits, explain whether you think it would be a good idea to wire a string of decorative lights in series.
6. Question 4 compared a water system to an electric circuit. Name one characteristic that makes this water system *not* like an electrical circuit.

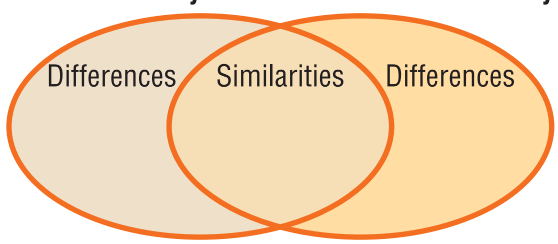
Prepare Your Own Chapter Summary

Summarize this chapter by doing one of the following:

- Create a graphic organizer such as a concept map.
- Produce a poster.
- Write a summary to include the key chapter ideas.

Here are a few ideas to use as a guide:

- Make a Venn diagram, as shown, to explain the similarities and differences between static electricity and current electricity.



- Draw or collect pictures of items that will conduct electricity and others that will not. Label each one as a conductor or insulator. Provide a definition of conductors and insulators that could be understood by younger children.
- Write a set of instructions for charging a balloon with static electricity. Include labelled diagrams to show what is happening to the charges.
- Describe how electric circuits work. Include the following terms: source, load, switch, and current.
- Explain what the term "grounding" means and how it relates to the unit opener on pages 2 and 3.
- Use diagrams to demonstrate the difference between series and parallel circuits.