Section 1

Electric Charge and Static Electricity

Objectives

After this lesson, students will be able to

N.2.1.1 Explain how electric charges interact.

N.2.1.2 Explain what an electric field is.

N.2.1.3 Describe how static electricity builds up and transfers.

Target Reading Skill

Previewing Visuals Explain that looking at the visuals before they read helps students activate prior knowledge and predict what they are about to read.

Answers

Sample questions and answers:

What are three ways that static electricity can be transferred? *(Charging by friction, charging by conduction, and charging by induction.)* **Why does an object become charged?** *(An object becomes charged when electrons are transferred from one location to another.)*

All in One Teaching Resources

- Transparency N12

Preteach

Build Background Knowledge

L2

Experience With Static Electricity

Before class, rub together a piece of polyester fabric and nylon socks so that they stick together. Show students the fabric and sock sticking to each other. Ask: **Would you expect to find glue or some other form of matter between these two fabrics?** *(No)* **What do you think holds these fabrics together?** *(Students might suggest "static cling" or some kind of electricity.)* Explain that students will learn more about the forces that hold two fabrics together as they explore electric charges.

Section 1

Electric Charge and Static Electricity

Reading Preview

Key Concepts

- How do electric charges interact?
- What is an electric field?
- How does static electricity build up and transfer?

Key Terms

- electric force
- electric field
- static electricity
- conservation of charge
- friction
- conduction
- induction
- static discharge

Target Reading Skill

Previewing Visuals Before you read, preview Figure 4. Then write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

Transferring Static Electricity

Q.	What are three ways static electricity can be transferred?
A.	
Q.	

Lab zone Discover Activity

Can You Move a Can Without Touching It?

1. Place an empty aluminum can on its side on the floor.
2. Blow up a balloon. Then rub the balloon back and forth on your hair several times.
3. Hold the balloon about 2 to 3 centimeters away from the can.
4. Slowly move the balloon farther away from the can. Observe what happens.
5. Move the balloon to the other side of the can and observe what happens.

Think It Over

Inferring What happens to the can? What can you infer from your observation?

You're in a hurry to get dressed for school, but you can't find one of your socks. You quickly head for the pile of clean laundry. You've gone through everything, but where's your matching sock? The dryer couldn't have really destroyed it, could it? Oh no, there it is. It's sticking to the back of your blanket. What makes clothes and blankets stick together? The explanation has to do with tiny electric charges.

Why do these clothes stick together? ▶

Lab zone Discover Activity

Skills Focus Inferring L1

Materials empty aluminum can, balloon

Time 10 minutes

Tips Make sure students rub the balloon vigorously. Avoid doing this activity on a damp or rainy day.

Expected Outcome The can follows the balloon in either direction

Think It Over Sample answer: The can follows the balloon in either direction. Some force is attracting the can to the balloon.

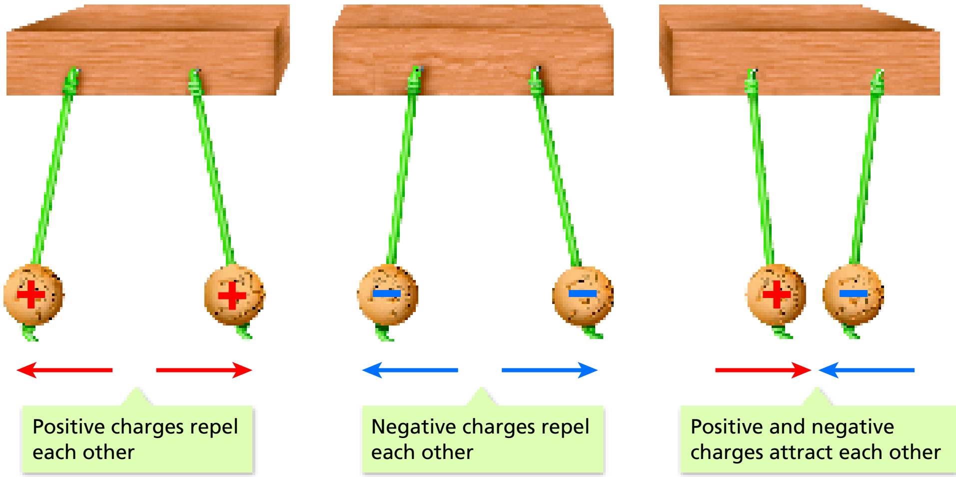


FIGURE 1
Repel or Attract?
The two types of charge, positive and negative, react to one another in specific ways.
Interpreting Diagrams *Which combinations of charges repel each other?*

Electric Charge

Recall that the charged parts of atoms are electrons and protons. When two protons come close together, they push one another apart. In other words, the protons repel each other. But if a proton and an electron come close together, they attract one another.

Why do protons repel protons but attract electrons? The reason is that they have different types of electric charge. Electric charge is a property of electrons and protons. Protons and electrons have opposite charges. The charge on a proton is called positive (+), and the charge on a electron is called negative (−). The names *positive* and *negative* were given to charges by Benjamin Franklin in the 1700s.

The two types of electric charges interact in specific ways, as you see in Figure 1. **Charges that are the same repel each other. Charges that are different attract each other.** Does this sound familiar to you? This rule is the same as the rule for interactions between magnetic poles. Recall that magnetic poles that are alike repel each other, and magnetic poles that are different attract each other. This interaction between magnetic poles is called magnetism. The interaction between electric charges is called electricity.

There is one important difference between electric charges and magnetic poles. Recall that magnetic poles cannot exist alone. Whenever there is a south pole, there is always a north pole. In contrast, electric charges can exist alone. In other words, a negative charge can exist without a positive charge.

Reading Checkpoint **What is one important difference between magnetism and electricity?**

Lab zone Skills Activity

Drawing Conclusions

1. Tear tissue paper into small pieces, or use a hole punch to cut circles.
2. Run a plastic comb through your hair several times.
3. Place the comb close to, but not touching, the tissue paper pieces. What do you observe?

What can you conclude about the electric charges on the comb and the tissue paper?

Instruct

Electric Charge

Teach Key Concepts L2

Types of Electric Charge

Focus Tell students that there are two types of charge, positive charge and negative charge.

Teach Have students recall their understanding of magnetic poles. Ask: **What is the rule about the attraction or repulsion of like and unlike magnetic poles?** *(Like poles repel, and unlike poles attract.)* Explain that electric charges are similar. Ask: **How do the two types of electric charges interact?** *(Charges that are alike repel each other. Charges that are unlike attract each other.)*

Apply Have students examine the three ways electric charges interact shown in Figure 1. Ask students to point their two index fingers downward to represent the suspended objects in one of the diagrams. Then ask them to model with their index fingers the three interactions shown in the figure, as you read the annotations. Students will spread their fingers out to model positive charges repelling and negative charges repelling, and bring their fingers together to model positive and negative charges attracting. **learning modality: kinesthetic**

All in One Teaching Resources
- Transparency N13

Independent Practice L2

All in One Teaching Resources
- *Guided Reading and Study Worksheet: Electric Charge and Static Electricity*

Student Edition on Audio CD

Lab zone Skills Activity

Skills Focus Drawing conclusions L2

Materials tissue paper, hole punch, plastic comb

Time 10 minutes

Tips Avoid performing this activity on a damp or rainy day. The tissue paper should be attracted to the comb.

Expected Outcome Students should conclude that the comb and tissue paper are unlike—the tissue paper is neutral (it has no charge).

Extend Have students find out what happens if they run a comb through their hair several times and then hold it a short distance from their hair. **learning modality: kinesthetic**

Monitor Progress L2

Writing Have students write a paragraph that describes the types of electric charges and the kinds of interactions between them.

Answers

Figure 1 Positive charges repel each other, and negative charges repel each other.

Reading Checkpoint Magnetic poles cannot exist alone, but electric charges can exist alone.

Electric Force

Teach Key Concepts L2

Attraction or Repulsion

Focus Tell students that charged objects exert a force through a region called an electric field.

Teach Ask: **What is an electric field?** *(A region around a charged object where the charged object's electric force is exerted on other charged objects)* Explain that an electric field can be represented by electric field lines. Ask: **How is the strength of an electric field represented by field lines?** *(The closer the lines, the stronger the field is that the lines represent.)*

Apply Ask: **Suppose a negatively charged object is placed in the electric field of a positively charged object—will it be attracted or repelled?** *(The negatively charged object will be attracted to the positively charged object.)* **learning modality: verbal**

All in One Teaching Resources

- Transparency N14

Lab zone Teacher Demo L1

Electric Field Exerts a Force

Materials inflated balloon, wool cloth, faucet

Time 5 minutes

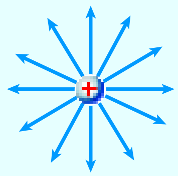
Focus Tell students that an electric field around a charged object is where the object's electric force is exerted.

Teach Vigorously rub the balloon with the wool cloth, and then turn on the faucet so that water flows in a steady narrow stream. Bring the charged balloon near the stream of water. Have students observe how the water bends toward the balloon.

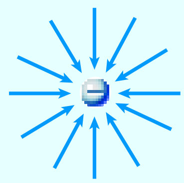
Apply Ask: **What causes the water to bend toward the balloon?** *(The water is attracted to the balloon because it must have an opposite charge.)* **learning modality: visual**

FIGURE 2
Electric Charges and Fields
The lines in each diagram represent an electric field. The stronger the field, the closer together the lines are.

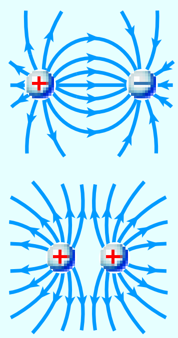
A The electric field around a positive charge points outward.



B The electric field around a negative charge points inward.



C The electric fields around charged particles are combined when they are brought near each other.



Electric Force

You may think of force as a push or pull on an object. For example, the force of gravity pulls objects toward the ground. You have learned that magnetic force is the attraction or repulsion between magnetic poles. In electricity, **electric force** is the attraction or repulsion between electric charges.

Electric Field Just as magnetic poles exert their forces over a distance, so do electric charges. Recall that a magnetic field extends around a magnet. Similarly, an **electric field** extends around a charged object. **An electric field is a region around a charged object where the object's electric force is exerted on other charged objects.**

When one charged object is placed in the electric field of another charged object, it is either pushed or pulled. It is pushed away if the two objects have the same charge. It is pulled toward the other charged object if their charges are different.

Electric Field Around a Single Charge An electric field is invisible, just like a magnetic field. You may recall using magnetic field lines to represent a magnetic field in Chapter 1. In a similar way, you can use electric field lines to represent the electric field. Electric field lines are drawn with arrows to show the direction of the electric force. The electric force always points away from positive charges, as shown in Figure 2A. Notice in Figure 2B that the electric force always points toward negative charges.

The strength of an electric field is related to the distance from the charged object. The greater the distance, the weaker the electric field is. The strength of an electric field is represented by how close the electric field lines are to each other. The electric field is strongest where the lines are closest together. Since the strength of the electric field is greatest near the charged object, that's where the lines appear closest together. Farther from the charged object, the lines appear more spread out because the magnetic field is weaker.

Electric Field Around Multiple Charges When there are two or more charges, the shape of the electric field of each charge is altered. The electric fields of each individual charge combine by repelling or attracting. Figure 2C shows the interaction of the electric fields from two pairs of charges.

Reading Checkpoint What is electric force?

Differentiated Instruction

Gifted and Talented L3
Researching Fabric Softeners Have students investigate why sheets of fabric softener added to the dryer with clothes reduces "static cling." Have them prepare a presentation for the class complete with labeled diagrams that show the processes involved. **learning modality: verbal**

Special Needs L1
Modeling How Objects Are Charged
Place three blue marbles in a jar. Explain that the jar is an atom, and the blue marbles are protons. Give students six red marbles, and tell them the red marbles are electrons. Then have students model how to make the atom neutral, negatively charged, and positively charged by adding marbles.
learning modality: kinesthetic

Static Electricity

Most objects normally have no overall charge, which means that they are neutral. Each atom has an equal number of protons and electrons. So each positive charge is balanced by a negative charge. As a result, there is no overall electric force on an atom.

Some objects, however, can become charged. Protons are bound tightly in the center of an atom, but electrons can sometimes leave their atoms. In materials such as silver, copper, gold, and aluminum, some electrons are held loosely by the atoms. These electrons can move to other atoms. As you see in Figure 3, an uncharged object becomes charged by gaining or losing electrons. If an object loses electrons, it is left with more protons than electrons. Therefore, the object has an overall positive charge. If an object gains electrons, it has more electrons than protons and has an overall negative charge.

The buildup of charges on an object is called **static electricity.** *Static* means "not moving or changing." **In static electricity, charges build up on an object, but they do not flow continuously.**

Go Online SCI LINKS NSTA
For: Links on static electricity
Visit: www.SciLinks.org
Web Code: scn-1421

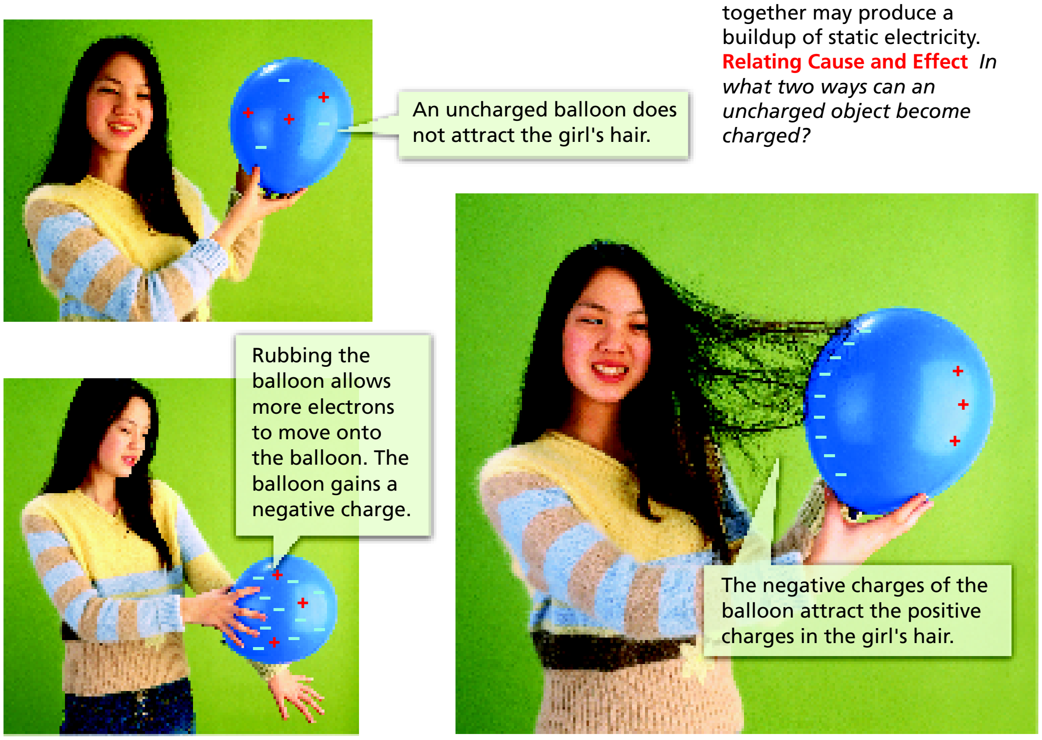


Figure 3
Charging by Friction
Rubbing two objects together may produce a buildup of static electricity.
Relating Cause and Effect *In what two ways can an uncharged object become charged?*

Static Electricity

Teach Key Concepts L2

A Buildup of Charges

Focus Tell students that objects can become charged as electrons move from atom to atom.

Teach Ask: **What does it mean that most objects are neutral?** *(Most objects normally have no overall charge.)* **How does an uncharged object become charged?** *(By gaining or losing electrons)* **What is the buildup of charges on an object called?** *(Static electricity)*

Apply Have students analyze the buildup of charges in Figure 3. Ask: **What causes the uncharged balloon to become charged?** *(Rubbing the balloon on the student's sweater)* **Why does the balloon become negatively charged?** *(Electrons move from the sweater to the balloon.)* **Why is the student's hair attracted to the balloon?** *(Positive charges in the hair are attracted to the negatively charged balloon.)* **learning modality: visual**

Go Online SCI LINKS NSTA
For: Links on static electricity
Visit: www.SciLinks.org
Web Code: scn-1421
Download a worksheet that will guide students' review of Internet sources on static electricity.

Monitor Progress L2

Oral Presentation Call on students to describe an electric field around a single charge and an electric field around multiple charges.

Answers

Figure 3 An uncharged object can be charged by gaining electrons or by losing electrons.

Reading Checkpoint The attraction or repulsion between charges

Transferring Charge

Teach Key Concepts L2

Three Methods of Transfer

Focus Tell students that charges can be transferred from object to object by three methods.

Teach Ask: **What is the law of conservation of charge?** *(Charges are neither created nor destroyed. If one object gives up electrons, another object gains those electrons.)* Emphasize that this law of conservation of charge holds true for all three methods of transfer.

Apply Ask: **Suppose a positively charged object touches a neutral object and gains electrons. By which method was the neutral object charged?** *(Charging by conduction)* **Is there a way in which the neutral object could have been charged without touching the charged object?** *(Yes, by induction)* **learning modality: verbal**

Address Misconceptions L2

Relatively Few Electrons Transfer

Focus Many students may think that charging by friction involves most or all of the atoms in the rubbing objects. Explain that only a very small fraction of atoms of a substance give up electrons.

Teach Ask: **Do all the atoms in a substance give up electrons when another object rubs against it?** *(Many students will think that all atoms are involved.)* Explain that even if a billion atoms give up electrons, an object is normally made up of many trillions of atoms. In fact, only about one in a trillion atoms loses electrons during the process of charging by friction.

Apply Have students look again Figure 3. Ask: **What method of transfer is shown?** *(Charging by friction)* **Do most of the sweater's atoms lose electrons in the process?** *(No. Only a small fraction of atoms lose electrons.)* **learning modality: verbal**

Transferring Charge

An object becomes charged only when electrons are transferred from one location to another. Charges are neither created nor destroyed. This is a rule known as the law of **conservation of charge.** If one object gives up electrons, another object gains those electrons. **There are three methods by which charges can be transferred to build up static electricity: charging by friction, by conduction, and by induction.**

Charging by Friction When two uncharged objects rub together, some electrons from one object can move onto the other object. The object that gains electrons becomes negatively charged, and the object that loses electrons becomes positively charged. Charging by **friction** is the transfer of electrons from one uncharged object to another by rubbing. In Figure 4, when the girl's socks rub the carpet, electrons move from the carpet onto her sock. This causes an overall negative charge on the sock. Clothing that sticks together when it is taken out of the dryer is another example of charging by friction.

Charging by Conduction When a charged object touches another object, electrons can be transferred between the objects. Electrons transfer from the object that has the more negative charge to the one that has the more positive charge. For example, a positively charged object will gain electrons when it touches an uncharged object. Charging by **conduction** is the transfer of electrons from a charged object to another object by direct contact. In Figure 4, charges are transferred from the girl's feet to the rest of her body because of charging by conduction.

Charging by Induction In charging by friction and by conduction, electrons are transferred when objects touch one another. In charging by induction, however, objects do not touch when the charges transfer. Charging by **induction** is the movement of electrons to one part of an object that is caused by the electric field of a second object. The electric field around the charged object attracts or repels electrons in the second object. In Figure 4, for example, the negative charges in the girl's fingertip produce an electric field that repels the electrons on the surface of the doorknob. The electrons on the doorknob move away from the finger. This movement produces an induced positive charge on the doorknob.

Reading Checkpoint **What is the difference between charging by induction and charging by conduction?**

Lab zone **Try This Activity**

Sparks Are Flying

Lightning, as you will learn on page 41, is the result of static electricity. You can make your own lightning.

1. Cut a strip 3 cm wide from the middle of a foam plate. Fold the strip to form a W. Tape it to the center of an aluminum pie plate as a handle.

2. Rub a second foam plate on your hair. Place it upside down on a table.
3. Use the handle to pick up the pie plate. Hold the pie plate about 30 cm over the foam plate and drop it.
4. Now, very slowly, touch the tip of your finger to the pie plate. Be careful not to touch the foam plate. Then take your finger away.
5. Use the handle to pick up the pie plate again. Slowly touch the pie plate again.

Inferring What did you observe each time you touched the pie plate? How can you explain your observations?

Lab zone **Try This Activity**

Skills Focus Inferring L2

Materials 2 foam plates, scissors, tape, aluminum pie plate

Time 10 minutes

Tips You may want to prepare the plates in advance. Perform this activity on a dry day, and, if possible, in the dark.

Expected Outcome Students should observe that each time they touch the pie plate, a spark is seen. The spark is a transfer of a tiny amount of electrons , and is safe. Sample answer: When the pie plate is first put onto the foam, electrons in the foam repel electrons in the plate. Touching the plate causes a spark as electrons jump from plate to hand. Touching it again causes a spark as electrons jump back from hand to plate. **learning modality: kinesthetic**

FIGURE 4
Transferring Electrons
Static electricity involves the transfer of electrons from one object to another. Electrons can be transferred by friction, conduction, or induction.
Interpreting Photos *How can charges on the carpet induce a charge on the doorknob?*

A Charging by Friction
Electrons are rubbed from the carpet to the girl's sock. The charges are distributed evenly over the sock.

B Charging by Conduction
When the negatively charged sock touches the skin, electrons are transferred by direct contact. Electrons are then distributed throughout the girl's body.

C Charging by Induction
Electrons on the girl's fingertip produce an electric field that repels negative charges and attracts positive charges on the doorknob. An overall positive charge is induced on the edge of the doorknob.

Use Visuals: Figure 4 L2

Transferring Electrons

Focus Ask: **What are three methods by which electrons can be transferred to build up static electricity?** *(Charging by friction, charging by conduction, and charging by induction)*

Teach As students look at the images in the figure, question them about the transfer of electrons by each of the three methods. Ask: **By what method did electrons move from the carpet to the girl's sock?** *(Charging by friction)* **Which object lost electrons, and which gained electrons?** *(The carpet lost electrons, and the socks gained electrons.)* **By what method were electrons transferred to her foot?** *(Charging by conduction)* **Which object lost electrons and which gained electrons?** *(The sock lost electrons, and the foot gained electrons.)* **By what method did the doorknob become a positively charged object?** *(Charging by induction)* **What caused the doorknob to become positive?** *(The girl's fingertip was negative, and its electric field repelled negative charges and attracted positive charges in the doorknob.)*

Apply Have students predict what the girl will likely feel as her hand gets closer to the doorknob. *(Sample answer: The shock of static electricity.)* **learning modality: visual**

All in One Teaching Resources
- Transparency N15

Monitor Progress L2

Skills Check Ask students to make a compare/contrast table listing and describing the three methods by which charges can be transferred to build up static electricity.

Students can keep their tables in their portfolios.

Portfolio

Answers

Figure 4 Electrons from the carpet are transferred through the sock to the skin. These electrons are distributed throughout the girl's body. The electrons on her fingertip produce an electric field. When her finger is close to the doorknob, the electric field induces a positive charge on the doorknob.

Reading Checkpoint Charging by conduction occurs by direct contact, while charging by induction occurs without direct contact.

All in One Teaching Resources

- Transparency N16

Static Discharge

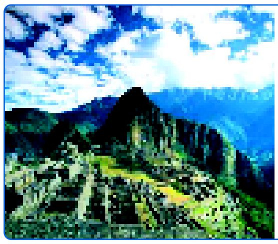
Teach Key Concepts L2

The Loss of Static Electricity

Focus Tell students that static electricity on an objects doesn't last forever.

Teach Ask: **What is static discharge?** *(The loss of static electricity as electric charges transfer from one object to another)* Explain that lightning is an example of static discharge as electrons transfer from an area of negative charge to an area of positive charge.

Apply Ask: **When lightning occurs, what is the area of negative charge and what is the area of positive charge?** *(The bottom of storm clouds is an area of negative charge, while the surface of Earth is an area of positive charge.)* **learning modality: verbal**



Discovery Channel School Video Field Trip

Electricity

Show the Video Field Trip to let students experience the dramatic static discharge of lightning. Discussion question: **Describe how the top and bottom of a thundercloud become oppositely charged.** *(Fast-moving winds cause water crystals in thunderclouds to be in constant motion, resulting in lots of tiny collisions. These collisions cause some particles to lose electrons. The electrons gather at the bottom of the cloud so that the bottom of the cloud has a negative charge, while the top of the cloud acquires a positive charge.)*

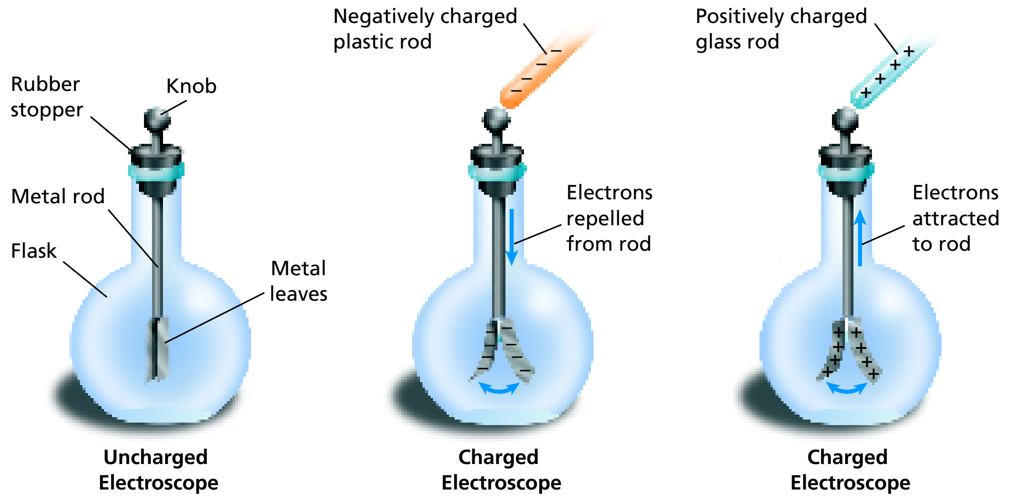


FIGURE 5
An Electroscope
An electroscope can be used to detect the presence of a charge, but it does not tell you whether the charge is positive or negative.
Relating Cause and Effect *Why do the leaves of the electroscope move apart when a charged object touches the knob?*

Discovery Channel School

Electricity

Video Preview
▶ Video Field Trip
Video Assessment

Detecting Charge Electric charge is invisible, but it can be detected by an instrument called an electroscope. A typical electroscope, shown in Figure 5, consists of a metal rod with a knob at the top and two thin metal leaves at the bottom. When the electroscope is uncharged, its metal leaves hang straight down. When a charged object touches the knob, electric charge travels by conduction into or out of the leaves. Since the charge on both leaves is the same, the leaves repel each other and spread apart. The leaves move apart in response to either negative charge or positive charge. Therefore, you cannot use an electroscope to determine the type of charge.

Static Discharge

Charges that build up as static electricity on an object don't stay there forever. Electrons tend to move, returning the object to its neutral condition. Consider what happens when two objects with opposite charges touch one another. **When a negatively charged object and a positively charged object are brought together, electrons transfer until both objects have the same charge.** The loss of static electricity as electric charges transfer from one object to another is called **static discharge**.

Often, a static discharge produces a spark. As electrons transfer between objects, they heat the air around the path they travel until it glows. The glowing air is the spark you see. The tiny spark you may have seen when you touch a doorknob or metal object is an example of static discharge.

Lightning is a dramatic example of static discharge. You can think of lightning as a huge spark. During thunderstorms, air swirls violently. Water droplets within the clouds become electrically charged. To restore a neutral condition in the clouds, electrons move from areas of negative charge to areas of positive charge and produce an intense spark. You see that spark as lightning.

Some lightning reaches Earth because negative charges at the bottom of storm clouds may cause the surface of Earth to become positively charged by induction. Electrons jump between the cloud and Earth's surface, producing a giant spark as they travel through the air. This is possible because of charging by conduction.

Reading Checkpoint How is lightning formed?

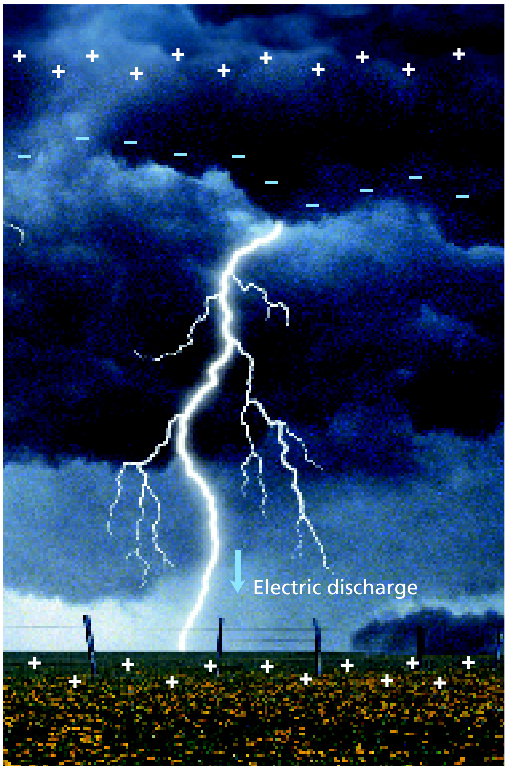


FIGURE 6
Static Discharge
Lightning is a spectacular discharge of static electricity. Lightning can occur within a cloud, between two clouds, or between a cloud and Earth.

Section 1 Assessment

Target Reading Skill **Previewing Visuals** Refer to your questions and answers about Figure 4 to help you answer Question 3 below.

Reviewing Key Concepts

1. a. **Identifying** What are the two types of electric charge?
   b. **Explaining** How do objects with the same charge interact? How do objects with opposite charges interact?
   c. **Comparing and Contrasting** How are electric charges similar to magnetic poles? How are they different?
2. a. **Defining** What is an electric field?
   b. **Interpreting Diagrams** What do the lines represent in an electric field diagram?
3. a. **Reviewing** What is static electricity?
   b. **Describing** How is static electricity transferred during charging by conduction?
   c. **Applying Concepts** What role does induction play when lightning strikes Earth?

Lab zone At-Home Activity

TV Attraction Rub a balloon against your hair and bring the balloon near one of your arms. Observe the hair on your arm; then put down the balloon. Then bring your other arm near the front of a television screen that is turned on. Ask a family member to explain why the hairs on your arms are attracted to the balloon and to the screen. Explain that this is evidence that there is static electricity present on both the balloon and the screen.

Monitor Progress L2

Answers

Figure 5 Electrons move between the rod and the electroscope, leaving the electroscope charged either positively or negatively. Because the leaves have the same net charge, they repel each other.

Reading Checkpoint Lightning forms when electrons travel through the air between clouds and Earth.

Assess

Reviewing Key Concepts

1. a. Positive charge and negative charge **b.** Objects with like charge repel. Objects with unlike charge attract. **c.** Electric charges that are alike repel each other. Similarly, magnetic poles that are alike repel each other. Unlike charges attract each other, and poles that are unlike attract each other. However, electric charges can exist alone, while magnetic poles must exist in pairs.
2. a. An electric field is the region around a charged object in which the object's electric force is exerted on other charged objects. **b.** Electric field lines show the direction and strength of the electric force.
3. a. Static electricity is the buildup of charges on an object. **b.** During charging by conduction, electrons move from a charged object to another object by direct contact. **c.** Induction can cause the surface of Earth to become positively charged. Then, lighting can occur when electrons jump between negatively charged clouds and Earth's positive surface.

Reteach L1

Use Figure 3 to reteach the three methods by which electrons can be transferred.

Performance Assessment L2

Drawing Have students make a labeled drawing of how an electroscope works.

Lab zone At-Home Activity

TV Attraction L1 Tell students to avoid doing the activity on a humid day. Students should readily feel the hairs of their arm attracted to the television screen or observe that their hair is attracted. They may even feel very tiny sparks jump from the screen.

Lab zone Chapter Project

Keep Students on Track By this point, students should have chosen an event that will close a switch on the alarm circuit. For students who are having trouble, suggest an event, such as an object falling or a container filling with salt water.

All in One Teaching Resources

- Section Summary: *Electric Charge and Static Electricity*
- Review and Reinforce: *Electric Charge and Static Electricity*
- Enrich: *Electric Charge and Static Electricity*

Lab zone Skills Lab

The Versorium

L3

Prepare for Inquiry

Key Concept

An uncharged object—the versorium—is attracted to a charged object.

Skills Objectives

After this lab, students will be able to:

- predict the behavior of both the aluminum tent and the paper tent
- observe the behavior of the aluminum tent and the paper tent
- classify the process that explains observed behaviors of materials

Prep Time 20 minutes
Class Time 30 minutes

Advance Planning

On the day of the lab, test the plastic foam plates and wool to be sure they develop adequate static charge. To save time, cut the 3-cm by 10-cm strips of aluminum foil and paper in advance. Buy wool fabric at fabric or craft stores.

Alternative Materials

Any set of materials that develops a static charge will work. Examples: wool fabric and balloon; plastic bag and plastic foam plate; acetate transparency and plastic foam plate; fur and balloon.

Safety

Be sure that students avoid pushing the sharpened pencil into their skin. Review the safety guidelines in Appendix A.

All in One Teaching Resources

- Lab Worksheet: *The Versorium*

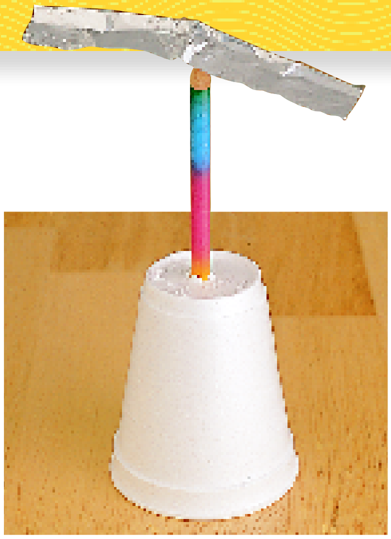
Guide Inquiry

Introduce the Procedure

Balance a meter stick on a thumbtack on a table in front of the class, and rub a balloon on your sweater or hair. Ask: **What is the charge on the meter stick?** *(No charge)* Bring the balloon close to the meter stick, and students will observe that the meter stick is attracted to the balloon. Ask: **What causes the attraction?** *(Some students may know that the electric charge on the balloon is attracting oppositely charged particles on the meter stick.)*

Lab zone Skills Lab

The Versorium



Problem

A versorium is a device that was first described in 1600 by Sir William Gilbert. Why does a versorium turn?

Skills Focus

observing, predicting, classifying

Materials

- foam cup
- plastic foam plate
- pencil
- aluminum foil
- wool fabric
- paper
- scissors

Procedure

PART 1 Aluminum Foil Versorium

1. Cut a piece of aluminum foil approximately 3 cm by 10 cm.
2. Make a tent out of the foil strip by gently folding it in half in both directions.
3. Push a pencil up through the bottom of an inverted cup. **CAUTION:** *Avoid pushing the sharpened pencil against your skin.* Balance the center point of the foil tent on the point of the pencil as shown.
4. Make a copy of the data table.
5. Predict what will happen if you bring a foam plate near the foil tent. Record your prediction in the data table.
6. Predict what will happen if you rub the foam plate with wool fabric and then bring the plate near the foil tent. Record your prediction.
7. Predict what will happen if you bring the rubbed wool near the foil tent. Again record your prediction.
8. Test each of your three predictions and record your observations in the data table.

PART 2 Paper Tent Versorium

9. What might happen if you used a paper tent versorium instead of aluminum foil? Record your prediction for each of the three tests.
10. Test your prediction and record your observations in the data table.

Data Table

	Unrubbed Foam Plate	Rubbed Foam Plate	Rubbed Wool Fabric
Aluminum Tent: Prediction			
Aluminum Tent: Observation			
Paper Tent: Prediction			
Paper Tent: Observation			

Troubleshooting the Experiment

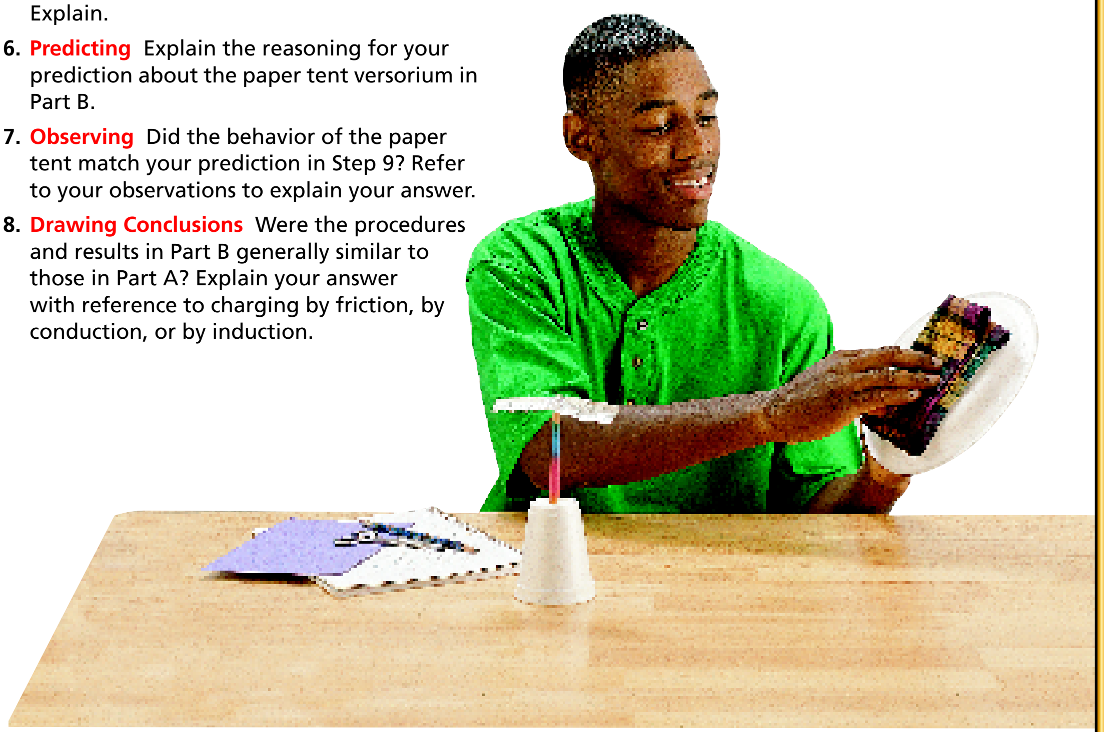
- Show students how to make the versorium. The tent has to turn freely.
- Remind students to slowly bring the plastic foam plate or wool fabric near—but not touching—the top of the tent.
- Humidity may affect the static charge.
- Demonstrate that the tent must be approached from the side.

Analyze and Conclude

1. **Inferring** At the beginning of the lab, is the foil negatively charged, positively charged, or uncharged? Use your observations to explain your answer.
2. **Predicting** Refer to the predictions you recorded in Steps 5, 6, and 7. Explain the reasoning behind those predictions.
3. **Observing** Did the behavior of the foil match each of your predictions in Steps 5, 6, and 7? Refer to your observations to explain your answer.
4. **Classifying** Did the effect of the foam plate differ in Steps 5 and 6? If so, identify which process—charging by friction, by conduction, or by induction—produced that change.
5. **Classifying** In Step 7, which process—charging by friction, by conduction, or by induction—explains the behavior of the foil when you brought the rubbed wool near it? Explain.
6. **Predicting** Explain the reasoning for your prediction about the paper tent versorium in Part B.
7. **Observing** Did the behavior of the paper tent match your prediction in Step 9? Refer to your observations to explain your answer.
8. **Drawing Conclusions** Were the procedures and results in Part B generally similar to those in Part A? Explain your answer with reference to charging by friction, by conduction, or by induction.
9. **Controlling Variables** During this lab, why is it important to avoid touching the foam plate or the wool with other objects before testing them with the versorium?
10. **Communicating** Another student who did this lab says that the versorium can show whether an object has a positive or negative charge. Write an e-mail to that student giving your reasons for agreeing or disagreeing.

Design an Experiment

What other materials besides foam or wool might have an effect on the versorium? What other materials could you use to make the versorium tent? Design an experiment to test specific materials and see how they respond. *Obtain your teacher's permission before carrying out your investigation.*



Analyze and Conclude

1. Sample answer: Uncharged. If the foil had been charged, it would have been attracted to the unrubbed foam plate.
2. Students' predictions may vary. Students should support each prediction with reasoning that shows an understanding of how the wool and the foam plate both became charged by friction, as well as how the tent was either repelled or attracted to the charged materials and became charged by induction.
3. Sample answer: Yes. My observations matched my predictions.
4. Sample answer: Yes. In Step 6, the foam plate became negatively charged by friction when it was rubbed with wool.
5. Sample answer: Charging occurred by induction when the positively charged wool caused electrons in the foil to travel to the near end of the versorium. Thus, the negative end was attracted to the wool.
6. Sample answer: In Part 2, I predicted that the paper tent would be attracted to both. Even though electrons are not able to move freely in the paper, they might cluster on the sides of the paper molecules toward or away from the charged materials.
7. Sample answer: Yes. My observations in Step 10 matched my predictions.
8. Sample answer: Yes. The foam plate and wool became charged by friction, just as in Part 1. Because the paper tent was attracted to both the rubbed foam plate and the rubbed wool, it became charged by induction.
9. Sample answer: If allowed to touch other objects, the charged foam plate and charged wool will become uncharged because of transfer by conduction.
10. Sample e-mail: I disagree with your assertion. The device cannot detect the sign of the charge because induction causes the tent to be attracted equally to both positively charged and negatively charged objects.

Expected Outcome

The foam plate that is not rubbed with wool fabric should cause no change, because the plate is neutral. Both the foil tent and the paper tent should be attracted both to the rubbed foam plate and rubbed wool fabric. Friction charges the plate and the wool; the versorium tent is then charged by induction when charged material comes near.

Extend Inquiry

Design an Experiment Students may want to try materials such as inflated balloons, plastic rulers that have been rubbed with plastic sandwich bags, or objects charged with a Van de Graff generator, if available. Other materials for the versorium tent might be plastic, wood, or other metal foils.