

UNIT OVERVIEW

We use electricity and magnetism every day, but how do they each work? How are they related? The Electricity and Magnetism unit explains electricity, from charged particles at the atomic level to the current that flows in homes and businesses. There are two kinds of electricity: static electricity and electric currents. There are also two kinds of electric currents: direct (DC) and alternating (AC). Electricity and magnetism are closely related. Flowing electrons produce a magnetic field, and spinning magnets cause an electric current to flow. Electromagnetism is the interaction of these two important forces. Electricity and magnetism are integral to the workings of nearly every gadget, appliance, vehicle, and machine we use.

Certain reading resources are provided at three reading levels within the unit to support differentiated instruction. Other resources are provided as a set, with different titles offered at each reading level. Dots on student resources indicate the reading level as follows:

- low reading level
- : middle reading level
- : high reading level

THE BIG IDEA

Without electricity, we'd literally be in the dark. We'd be living in a world lit by open flame and powered by simple machines that rely on muscle power. Since the late 1800s, electricity has brightened our homes and streets, powered our appliances, and enabled the development of computers, phones, and many other devices we rely on. But people often take electricity for granted. Flip a switch and it's there. Understanding what electricity is and how it becomes ready for our safe use helps us appreciate this energy source. Meanwhile, without magnets, we couldn't generate electricity. Electricity and magnetism, and the relationship between the two, are fundamental to the workings of the modern world.

Other topics

This unit also addresses topics such as: Earth's magnetic field, electrical safety, electromagnets, electrical units of measure, the behavior of magnets, and means of generating and delivering electricity.

SPARK

The spark is designed to get students thinking about the unit's topics and to generate curiosity and discussion.

Materials

- small, unused foam tray or container
- two small rubber bands
- tape
- clean aluminum pie tin
- wool fabric (optional)



Activity

In advance of leading the activity, ask an employee at a grocery store meat department or deli for an unused foam tray, or ask a restaurant employee for a foam takeout container and remove the lid.

Place students in small groups. Have them tape the two rubber bands to opposite sides of the rim of the pie tin to provide nonmetallic handles.

Rub the bottom of the foam tray or container back and forth on a piece of wool fabric or on a student's hair for several seconds.

Set the foam tray or container on a table or desk with the rubbed side facing up. Carefully use the rubber-band handles to pick up the pie tin and lower it onto the foam. It's important that you do not touch the tin and that the tin touches only the foam. Release the handles. Ask a volunteer to touch a finger to the tin. He or she should experience a tiny spark. Advise the student not to touch the foam, or the demonstration won't work.

Have another student pick up the tin using the rubber-band handles and raise it off the foam. He or she may notice that the foam tends to stick to the tin. By shaking the pie tin by the handles, the foam should fall off. Now let another student touch the tin again, just once. He or she may experience a small spark.

This process can be repeated several times. If the sparks diminish, students can recharge the foam by rubbing it on the wool or on hair again.

Below are questions to spark discussion.

What caused the spark you got when you touched the tin?

Why did this demonstration require that we rub the foam on something first?

Why do you get a spark when you touch the pie tin after it's been set on the foam?

Why do you get a spark when you touch the tin after lifting it off the foam?

Why did the foam and tin stick together?

Use this activity to begin an introductory discussion about electricity. Explain that the spark that was produced was an example of static electricity. That's the same kind of energy that sometimes shocks students when they walk across a carpet and then touch something metal. Throughout the unit, students will learn more about electricity as well as magnetism, a force closely related to electricity.

After completing this unit, revisit the spark activity to allow students to apply what they learned about electricity to reflect on the demonstration. Explain that rubbing the foam caused electrons to build up on it. Some of those electrons transferred to the pie tin, and when a student touched it, the excess electrons jumped to his or her finger. When the student lifted the tin away from the foam and touched it again, the tin had fewer electrons, so electrons from his or her finger jumped back to the tin. The attraction of charged particles is also what caused the foam and tin to pull toward each other, just as the foam pulled hair toward it when it was rubbed on a student's head.

Many of the unit's vocabulary terms are related to the spark activity and can be introduced during the spark. For vocabulary work, see the Vocabulary section in this *Unit Guide*.

PRIOR KNOWLEDGE



Invite students to explain their understanding of what electricity and magnetism are. Ask them to explain whether the two are related and, if so, how they are related.

Probing Questions to Think About

Use the following questions to have students begin thinking of what they know about electricity and magnetism.

- What is electricity?
- Why is electricity important in our lives?
- How do atoms relate to electricity?
- What kind of electricity shocks you when you touch a doorknob after walking across a carpet?
- What kind of electricity flows into your home?
- What is magnetism?
- When do two magnets attract each other? When do they repel each other?
- What is an electromagnet?
- Can electricity produce magnetism? If so, how?
- Can magnets produce electricity? If so, how?
- How does electricity reach our homes and schools?

Tell students they will learn more about these topics soon.

UNIT MATERIALS

Each unit provides a wide variety of resources related to the unit topic. Students may read books and other passages, work in groups to complete hands-on experiments and investigations, discuss science ideas as a class, watch videos, complete writing tasks, and take assessments.

Resources are available for printing or projecting, and many student resources are also available for students to access digitally on **Kids A-Z**.

Selected unit resources are available in more than one language.

For a complete list of materials provided with the unit, see the Electricity and Magnetism unit page on the Science A–Z website.

VOCABULARY



Use the terms below for vocabulary development throughout the unit. They can be found in boldface in the *Nonfiction Book*, the *Quick Reads*, and/or other unit resources. These terms and definitions are available on *Vocabulary Cards* for student practice. Additional vocabulary lists are provided in the teaching tips for *Investigation Packs* and *FOCUS Books*.

Core Science Terms

These terms are crucial to understanding the unit.

alternating current (AC)	an electric current in which electrons move rapidly back and forth
amperes (amps)	a measure of the amount of current in a wire
atoms	the smallest parts of an element
charge	the property of matter that causes it to be electrically positive or negative, caused by losing or gaining electrons
circuit	a closed path along which an electric current travels
conductor	a material, usually a metal, that transmits electricity
direct current (DC)	an electric current in which electrons move in one direction
electric current	the movement of electrons through matter
electricity	a form of energy made when tiny parts move around in an atom; energy that can power many devices
electromagnet	a magnet that can be turned on or off and is made by sending electricity through metal
electromagnetism	a combined force of electricity and magnetism
electrons	particles in an atom that orbit the nucleus and have a negative electrical charge
insulator	a material, such as rubber or plastic, that does not transmit electricity
ion	an atom that has gained or lost electrons and has an electrical charge
magnetic field	an area around a magnet where magnetic force can be felt
magnetism	a force that pushes and pulls certain metals

neutrons	particles in the nucleus of an atom that have no electrical charge
protons	particles in the nucleus of an atom that have a positive electrical charge
static electricity	electricity caused by a buildup of negative charges in one place and positive charges in another
volts	a measure of the amount of push that gets an electric current moving
watts	a measure of the rate at which electrical energy is being used

Other Key Science Terms

The following vocabulary is not essential for comprehending the unit but may enrich students' vocabulary.

attract	to pull something closer
compass	a tool with a needle that always points north, used for showing direction
generator	a machine that turns motion into electricity
hydroelectric plant	a power plant that produces electricity from moving water that turns turbines connected to generators
lines of force	invisible lines of magnetic force that flow through and around a magnet, forming a magnetic field
north pole	the end of a magnet where lines of force flow out
nuclear power plant	a factory that makes electricity by splitting or joining atoms, usually those of radioactive materials such as uranium
permanent magnet	a material that is always magnetic
power plant	a factory that makes electricity
repel	to push something away
shock	a sharp jolt experienced when an electric current touches or travels through a person's body
solar power plant	a factory that makes electricity from the Sun's heat and light
south pole	the end of a magnet where lines of force flow in
temporary magnet	a material that is magnetic only while in the magnetic field produced by an electric current or a permanent magnet

transformer	a device that reduces or increases the voltage of an electric current
transmission lines	power cables that carry high-voltage electricity over long distances
turbine	a fan-shaped machine that captures the motion of water, wind, or steam to create an electric current

Vocabulary Activities

You may choose to introduce all the terms that will be encountered in the unit before assigning any of the reading components. *Vocabulary Cards* with the key science terms and definitions are provided. Dots on the cards indicate the reading levels of the *Nonfiction Book* or the *Quick Reads* in which each term can be found. If all level dots appear, the term may come from another resource in the unit. Students can use these cards to review and practice the terms in small groups or pairs. The cards can also be used for center activity games such as Concentration.

The *Word Work* activity sheets offer fun puzzles and practice with key vocabulary terms from the unit. For further vocabulary practice and reinforcement, you can choose from the vocabulary *Graphic Organizers*. To build customized vocabulary lessons with terms related to the topic, see *Vocabulary A-Z*.

Students can use the *Word Smart* vocabulary *Graphic Organizer* to organize information on the science terms. You may want to assign each student one to three words to share his or her *Word Smart* knowledge with classmates. Students who have the same word should first compare their *Word Smart* sheets with each other and then report to the larger group.

The science terms can be used in oral practice. Have students use each term in a spoken sentence.

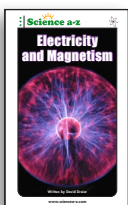
As students read, encourage them to create a science dictionary by recording new vocabulary terms and definitions in their *SAZ Journal*.

BACKGROUND AND MISCONCEPTIONS

Use this section as a resource for more background knowledge on unit content and to clarify the content for students if misconceptions arise. Refer to Using the Internet below for more ways to extend the learning.

Q: *Do atoms become positively charged because they gain protons?*

A: No. Atoms become positively charged because they lose electrons, which leaves them with more positively charged protons than negatively charged electrons. The number of protons in an atom doesn't change.



Q: How does an atom gain or lose electrons, and where do “lost” electrons go?

A: Different elements have different tendencies to gain or lose electrons. This fact explains why some elements are better conductors of electricity than others. Friction, such as from scuffing your feet on a carpet, can strip electrons from atoms, causing negatively charged electrons to build up. Negatively charged electrons repel one another, so some of them “leap” to positively charged atoms to balance out. When electrons “leap” from your finger to a metal doorknob, you feel a shock and may see a spark. When electrons move from one atom to another in a wire, they produce an electric current. So electrons are not lost but rather are exchanged among atoms.

Q: Does electricity flow through the hollow inside of a wire?

A: No. The wire is solid metal. The flow of electric current is created when electrons move among atoms within the solid metal wire.

Q: Is an insulator meant to keep a wire warm or cool, much like the insulation in a house?

A: No. In electrical wiring, an insulator is used to prevent electric current from flowing outside the wire, which would cause an electric shock if someone touched it. Rubber and plastic are commonly used as electrical insulators.

Q: Are electricity and magnetism the same thing?

A: No, but the two are related. Magnetism and electricity are fundamentally two manifestations of the same force—electromagnetism. But in practice, they behave differently. Magnetism is a force that can help generate electricity. When magnets spin around wires, they cause charged particles to flow through the wires. This process generates an electric current. Other wires carry the current to homes and businesses. Meanwhile, electricity can also create magnetic fields. If you wrap a wire around a piece of metal and pass an electric current through it, a magnetic field forms. If you turn off the electricity, the field disappears. While electricity and magnetism work together and are aspects of the same force, they are not the same thing.

Q: Can anything other than metal be turned into a magnet?

A: Yes. Magnets made of metal are by far the most common, but the electrons in certain other materials can be rearranged to make them magnetic. Examples include plastic, rubber, and ceramic magnets. However, it takes special circumstances for nonmetallic items to be magnetized, so these types of magnets are unlikely to occur in everyday life.

Q: Are bigger magnets stronger than smaller ones?

A: Generally yes, but not always. A larger magnet made from the same material and shaped in the same way as a smaller one will be stronger. But magnets made of different materials have differing degrees of magnetic force. For example, “super magnets” are made from neodymium, boron, and iron. A smaller super magnet has a stronger pull than a much larger common magnet. Additionally, an electromagnet may be stronger than a regular magnet of similar size.

Q: Are the poles of magnets named after Earth’s North and South Poles?

A: No. In each case, the north and south ends are called *poles* because that term refers to two points at opposite ends of an object. But Earth and magnets do have something in common. Earth has a huge magnetic field with a north and a south pole, just as any magnet does.

Q: What is the difference between Earth’s two kinds of north poles? Which one does a compass needle point to?

A: The geographical poles represent the ends of the vertical axis around which the planet rotates. The magnetic poles are the ends of the vertical axis through Earth’s magnetic field. Earth’s geographical poles do not change much, but its magnetic poles are constantly on the move. (In fact, Earth’s so-called North Pole is currently a south magnetic pole, based on the flow of the magnetic lines of force.) Over many years, the magnetic poles can migrate and have even been known to switch places. Scientists determine their historical locations based on geological research into the alignment of electrons in magnetic rocks.

To accurately use a compass, it is important to account for the difference between the present location of magnetic north and Earth’s geographical North Pole. While a compass always points to magnetic north, people are likely more interested in knowing which way true (geographical) north is, in order to set a course on a map or toward a known destination. (Earth’s migrating magnetic poles have been known to cause problems for airports. Runways have had to be relabeled because pilots rely on Earth’s magnetic field to navigate in the proper direction during landings.)

Q: Is a magnetic field really just a group of lines? Could a magnetic item “dodge” the magnetic force if it were placed between some of those lines?

A: While magnetic fields are often shown in diagrams as being made up of lines, they actually encompass a continuous area surrounding a magnet. When iron filings position themselves in lines around a magnet, we see how the magnetic field affects the filings. It turns each filing into a tiny magnet, and because of the way magnets are attracted to opposite poles and can repel one another, the filings line up. But the actual magnetic field is just that—a field. The term *lines of force* helps describe the field and the direction of force.

EXTENSION ACTIVITIES



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Using the Internet


Most search engines will yield many results when you input the term *electricity* or *magnetism*. You can also search for information on a specific use of magnets or electricity. Be aware that some sites may not be educational or intended for the elementary classroom. More specific inquiries are recommended, such as:

- positive and negative ions
- alternating vs. direct current
- amperes, voltage, wattage
- What is static electricity?
- diagram of electric generator
- magnetic north pole
- magnetic field
- inside an electric motor

Projects and Activities



- **Math:** Ask students to calculate and compare the amount of energy used by incandescent lightbulbs of different wattages over various periods of time. The example in the *Nonfiction Book Electricity and Magnetism* (a 60-watt bulb uses 1.5 times more energy than a 40-watt bulb) can provide a starting point. Common wattages of lightbulbs are 25, 40, 60, 75, and 100.
- **Physical Education:** Get students moving by having them represent the current in a circuit. Have them stand in a circle with hands at their sides. One student acts as the generator and controls the on/off switch that completes the circuit. (For this game, the “generator” should move along with the “current.”) When the generator calls out “AC” or “DC” and shouts “on” or “off,” the other students all join hands and move in a certain way. If DC, students sidestep in the same direction while the generator is on. If AC, students shift three steps to the right, then three steps to the left, continuing back and forth. If the generator says “off,” or if any part of the circuit becomes disconnected, students stop where they are and drop their hands.

- **Field Trip:** Tour a power plant to see electric generators—and the magnets that get the current flowing—in action.
- **Guest:** Invite an electrician or someone who repairs appliances to use tangible models to explain how magnets generate electricity inside motors.
- **Community Service/Research:** Have students research methods of conserving electricity, which help society by reducing pollution and lowering costs. Then have students write an action plan proposal for their class, school, family, or city.
-  **Social Studies/Technology:** Have students learn about Nikola Tesla and Thomas Edison and their battle over AC versus DC. Students can conduct research and produce a report about the rivalry between these two inventors. Encourage students to use images, audio, video, and other technologies to produce their reports.
- **Literature:** Recommended books for independent student reading include *Awesome Experiments in Electricity and Magnetism* by Michael A. DiSpezio, *Electricity* by Steve Parker and Laura Buller, *Electricity and Magnetism* by Peter Adamczyk and Paul-Francis Law, and *Electricity and Magnetism* by Steve Parker.
- **Research:** Help students conduct research into electric cars. How are electric cars powered differently from traditional cars? What are the advantages and disadvantages of using electricity versus gasoline? Students can learn more on the websites of specific automakers that produce electric cars.
- **Research/Home Connection:** Students can conduct research as a family/home project or in the library/media center to extend the learning about a topic in one of the *Quick Reads* or other unit resources.

