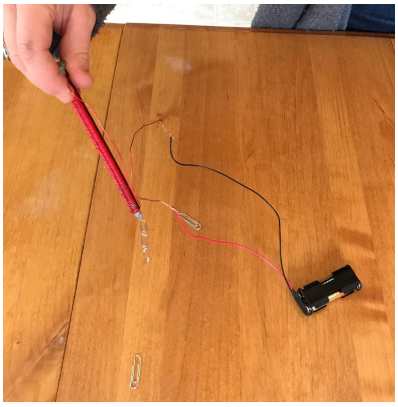
Lesson 7: Making a Temporary Magnet

Summary

Students review their understanding of permanent magnets and magnetism, and then observe and explain how temporary magnets work.

Like the static electricity lesson, this lesson also creates a bridge between electricity and magnetism, and hints at the interconnectedness of the two phenomena.



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Students observe the behaviors of two temporary magnets, one created using a permanent magnet and the other using electromagnetism. **Unit Anchoring Phenomenon Connection:** Students discuss the interplay between energy and matter in electromagnetism, and are challenged to create a new model of Earth's magnetic field that incorporates their understanding of electromagnetism. It turns out that this additional cause of magnetism—produced by circular electric currents—is most likely responsible for the Earth's magnetic field. The idea is broached in this lesson and used later when students solve the mystery of the Earth's magnetic field.

Goal: Students use cause and effect thinking while observing the creation of temporary magnets. They then construct explanations for what is happening to produce these electromagnets and induced magnets.

Vocabulary

electromagnet/electromagnetism/electromagnetic
electric current

Materials

Per class, for the demo:

- ★ copper wire, 3 m length (22 gauge, lightly coated; sometimes sold as "magnet wire")
- ★ battery (1.5 V, e.g., AA or AAA)
- ★ non-galvanized iron or steel nail (2 inch or longer)

- ★ sandpaper, fine grain
- ★ *recommended:* battery holder with red and black lead wires

Per group:

- ★ strong bar magnets
- ★ iron nails
- ★ paper clips

Preparation:

Practice creating the temporary magnets in the Explore section (this will ensure that you have the procedures down accurately for your specific materials).

- To magnetize a nail using a strong bar magnet, touch *only one end* of the magnet to the nail, and move the magnet repeatedly *in only one direction* along the nail; the stroking motion must not be too fast or too slow. It may take 20 or more strokes to magnetize the nail; and the larger the nail, the more strokes will be needed for it to pick up a paper clip.
- To magnetize a nail using an electric current, wrap copper wire around the length of the nail. Sand off the coating on both ends of the wire. Place the battery in the battery holder, and then attach both ends of the wire around the nail to the lead wires of the battery. Test the electromagnet by picking up a few paper clips. Disconnect the wires to prevent the battery and wire from becoming too hot. (See the Lesson 7 resource Electromagnet & Paper Clips Video)

Set up the electromagnet demonstration so it will be visible to the whole class.

(Save the electromagnet assembly for use in later lessons.)

Engage (10 min.)

➔ Students evaluate a model of the Earth's magnetic field. Later, at the end of the lesson, they will evaluate another model that includes the concept of induced magnetic fields. This will act as the assessment at the end of the lesson.

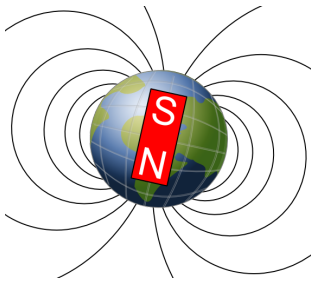
OPENER

- ❖ Suppose someone says, "The Earth has a dipole magnetic field because there is a large bar magnet inside it." Draw a model of this hypothesis. Drawings will vary. They will show dipole magnetic field lines around Earth, and a large bar magnet oriented north-south inside Earth.
- ❖ Do you think this hypothesis could be correct? Explain. Answers will vary; students are not expected to know the correct answer at this

point. They may recall that discussions of the Earth's interior in the Earth Systems Unit did not include anything about a large bar magnet.

➔ *Engaging in Argument from Evidence:* Lead a class discussion on this question: If there were a giant bar magnet inside the Earth, how would it be oriented? Guide students in using evidence to support their answers, particularly by drawing on data from demos and experiments in the lessons that used a compass.

- To support the use of evidence, project a student's model, and ask the class to indicate which way a compass needle would point. The north pole (N) of the compass needle points north, which means it is attracted to what would be the south pole (S) of the hypothesized large bar magnet inside the Earth.
- A large bar magnet inside the Earth would have its south magnetic pole at the north end of the rotational axis (North Pole) and its north magnetic pole at the south end of the rotational axis (South Pole).



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➔ *Cause and Effect.* **Ask:** How is this model similar to the real Earth? How is this model different from the real Earth? The Earth does have a magnetic field like this one. But, from the Earth Systems unit, we know that the interior of the Earth is too hot to be completely solid all the way through; as such this simple model cannot be correct.

- Reinforce student answers by pointing out that they need to learn more about the cause of the Earth's magnetic field even though they have correctly modeled its effect (its dipole structure).
- Let students know they will have more opportunities to explain how the Earth's magnetic field is created as the unit continues. This lesson will show them a couple of other ways that a magnetic field can be created.

EL Refer to previously introduced frames and add:

The dipole structure is the effect of _____.

*Earth's magnetic field is caused by*_____.

*A magnetic field is created when*_____.

Explore (15 min.)

Demo/Activity: Temporary Magnet Using Stroke Method

- ➔ *Cause and Effect:* Describe how to make a temporary magnet using the stroke method: To magnetize a nail using a bar magnet, touch only one end of the magnet to the nail, and move the magnet repeatedly in only one direction along the nail. The stroking motion must not be too fast or too slow, and may need to be repeated 20 or more times.
- ➔ ***PS2.B** Types of Interactions:* Hand out materials to groups. Have them make the nail into a temporary magnet. They can demonstrate that the nail is magnetized by using it to pick up paper clips.
- ➔ Point out that the nail eventually demagnetizes. It can also be demagnetized by tapping it with something, or dropping it repeatedly on the floor.
- ➔ **Ask:** What did the permanent magnet do to the nail to make it temporarily behave like a magnet? Have groups construct explanations for what they think happened to the nail; then have students share their ideas with the class. Accept all ideas at this point.

Demo: Electromagnet

- ➔ Create an electromagnet using an electrical circuit. In this case, an electric current generates the magnetic field that magnetizes the nail.
- ➔ Before connecting the wires to the leads of the battery holder, show students that the nail will not pick up a paper clip.
- ➔ Attach the sanded copper-wire ends to the battery holder leads, and show students that the nail will now pick up a few paper clips.
- ➔ Detach the wire from the battery leads, and show students that the nail can no longer pick up a paper clip.
- ➔ **Ask:** What did the electrical circuit do to the nail to make it temporarily behave like a magnet? Accept all ideas at this point.

Demo/Activity: Temporary Magnet Using Stroke Method

1. What did the permanent magnet do to the nail to make it temporarily behave like a magnet? Students might guess that the magnet pulled some of the free electrons to one end of the nail, creating a positive and negative end—which is not exactly right but is a reasonable guess based on what they know so far.

Demo: Electromagnet

2. What did the electrical circuit do to the nail to make it temporarily behave like a magnet? Answers will vary but might allude to the attracting/repelling properties of objects with static electricity, or guess at some connection between electricity and magnetism.

Explain/Elaborate (10 min.)

- ➔ *Constructing Explanations:* Debrief the first demo/activity. Have students create explanations for how they think the stroke method magnetizes a nail in their group or with a partner, and then share their ideas with the class. They might say the magnet pulls some electrons to one end of the nail, creating positive and negative poles in the magnet. This isn't exactly right but may be OK at this stage. What is really happening is that the atoms in the nail are tiny dipoles due to the spin of their electrons; students might be able to grasp this after this next discussion of electromagnetism. Those dipoles are lining up mostly facing the same way. (Note: If any of the compasses in earlier lessons pointed south instead of north, they probably got magnetized by a strong magnet while they were being stored. You can use the stroke method to remagnetize them in the correct orientation.)

- ➔ When we connect the wire to the two ends of the battery, it creates an electric current in the wire. **Ask:** What do you think an electric current is? How is it different from static electricity? Electric current consists of charges running through a wire (as opposed to staying in one location, as they did with static electricity in the balloon).

- ➔ Define electric current. Help students think about what *current* means. It means *running*. It means that electric charges (in this case electrons) are running through the wire.

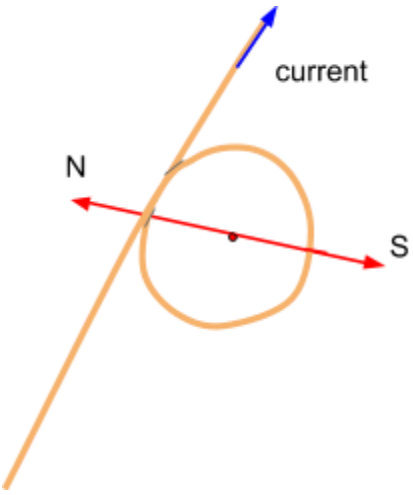
  EL Point out the similarity in the words *electron* and *electricity*.

- ➔ *Energy and Matter:* **Ask:** Is electricity a form of matter or a form of energy? It requires both. If charged particles build up on an object, it has static electricity and electric potential energy to discharge. If charged particles flow through an object, it has electric current and the potential to do work. So electricity is an interaction of energy and matter.

- ➔ *Constructing Explanations:* Have students construct explanations for how they think the circuit magnetizes the nail. **Ask:** What was the effect of static electricity? What do you think might be the effect of an electric current? Static

electricity makes the object attract or repel other objects. Similarly, an electric current produces a magnetic field around the wire.

When the wire makes a loop, the magnetic field overlaps at the center of the loop, perpendicular to the circle. Wrapping the wire into a coil intensifies this effect through the center of the coil, and can magnetize a nail inside the coil and turn it into a temporary dipole.



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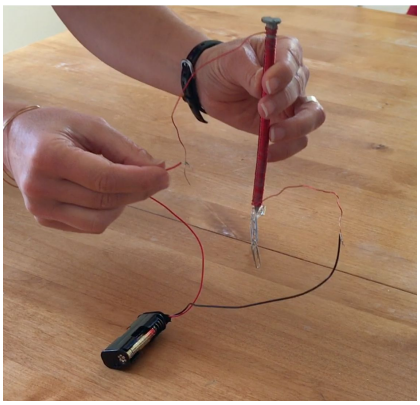
➔ Define electromagnet. Students should be able to break down the word and put together that it is a magnet created using electricity. This should also solidify the idea for students that electricity and magnetism are closely interrelated.



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EL Prior to the whole-group discussion, encourage students to co-construct an explanation with their partner using key vocabulary and previously introduced frames with demonstration or images.

SLD To engage kinesthetic learners, encourage students to co-construct their explanation using movement or sketching their explanation out then labeling it.

Extend

EXTENSION

- How does an electromagnet nail gun work?
- How does Magnetic Resonance Imaging (MRI) work, and when is it useful? When can it not be used?

Evaluate (10 min.)

EXIT CARD

- Suppose someone says, "The Earth has a dipole magnetic field because there is a large electrical current inside it." Draw a model of this hypothesis. Drawings will vary. They will show dipole magnetic field lines around Earth, and part of the Earth's interior with charged particles moving around. Some drawings may show the charged particles circling the rotational axis (parallel to the equator), which would show the induced magnetic field approximately aligned with the rotational axis.
- Do you think this hypothesis could be correct? Explain. Answers will vary; students are not expected to know the correct answer at this point.
- What are some major differences between this model and the one from the beginning of the lesson, showing a bar magnet inside Earth? Choose all that apply. Accept all answers that INCLUDE A and DO NOT INCLUDE C and D (answers B and E have not been explored by all students at this point in the unit). *Correct answers: A, B, E.*
    A. The structure of Earth's interior
    B. The material of Earth's interior
    C. The shape of the magnetic field
    D. The way the magnetic field affects objects (like a compass)
    E. The stability of the magnetic field over the history of the Earth

Homework

HOMEWORK

- How are electrons and electricity related? Electrons are negatively charged particles. Electric current consists of electrons moving through a wire (or other medium, such as the atmosphere or the ground as occurs during a lightning strike); and static electricity (as at the base of a storm cloud) is the result of many electrons gathered in one place.
- How can electrons and magnetic fields be related? When electrons move (as in a wire attached to a battery), they create a magnetic field, and a coiled wire with electrons running through it can generate a magnetic field similar to that of a bar magnet.