ACTIVITY 10

A Different Kind of Magnet

OBJECTIVES

Students are introduced to the fundamental relationship between electricity and magnetism by investigating the interaction between a compass and a simple electrical circuit.

The students

- observe the effect that a wire with electric current flowing through it has on a compass
- infer a relationship between electric current and magnetism

SCHEDULE

About 40 minutes

VOCABULARY

electromagnetism

MATERIALS

All materials will be ready in the lab.

*provided by the teacher

~~PREPARATION~~ Done!

1. ~~Make a copy of Activity Sheet 7 for each student.~~
2. ~~Use scissors to cut one piece of enamel-coated wire about 2.1 m (7 ft) in length for each team of four students.~~
3. ~~Each team of four students will need a battery, a battery holder with two clips, the piece of enamel-coated wire, a square of emery cloth, and a compass.~~

BACKGROUND INFORMATION

In the years leading up to the eighteenth century, many people spent their lives trying to solve the mystery of magnetism. Then Danish physicist Hans Christian Oersted made a puzzling discovery: a connection between magnetism and electricity—***electromagnetism!***

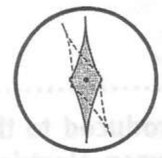
It is worth noting that Oersted was not working in a laboratory when he made his famous discovery. Rather, he was teaching at the time, trying to prove to his students that magnetism and electricity were not related. As a classroom demonstration, he placed a compass next to an electrical circuit and switched on the current. To everyone's surprise, the compass needle moved.

A magnetic field is created when electric current flows through a wire. This activity focuses on detecting this magnetic field using a compass.

▼ **Activity Sheet 7**

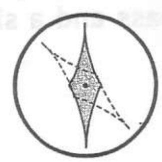
A Different Kind of Magnet

1. Draw the direction and amount of deflection of the compass needle with one loop of wire.



Deflection may be in opposite direction.

2. Draw the direction and amount of deflection of the compass needle with 11 loops of wire.

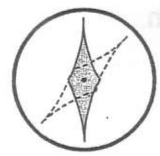


Deflection may be in opposite direction.

3. Why did the compass needle deflect farther?

As more loops of wire were added to the coil, the magnetic field around the coil got stronger.

4. Reverse the battery in the battery holder. Draw the direction and amount of deflection of the compass needle.



Deflection may be in opposite direction.

Guiding the Activity

Additional Information

1 Place all the materials on a centrally located distribution table. Divide the class into teams of four, and invite one member from each team to come up and get a length of enamel-coated wire, a battery, a battery holder and two clips, a square of emery cloth, and a compass.

Have the students use the emery cloth to sand off about 2.5 cm (1 in.) of the enamel coating from each end of the wire.

2 Have the students form a loop in the center of the enamel-coated wire by wrapping it once around their finger. Tell them to place the compass on the edge of a nonmetallic table so that the compass needle is perpendicular to the edge of the table.

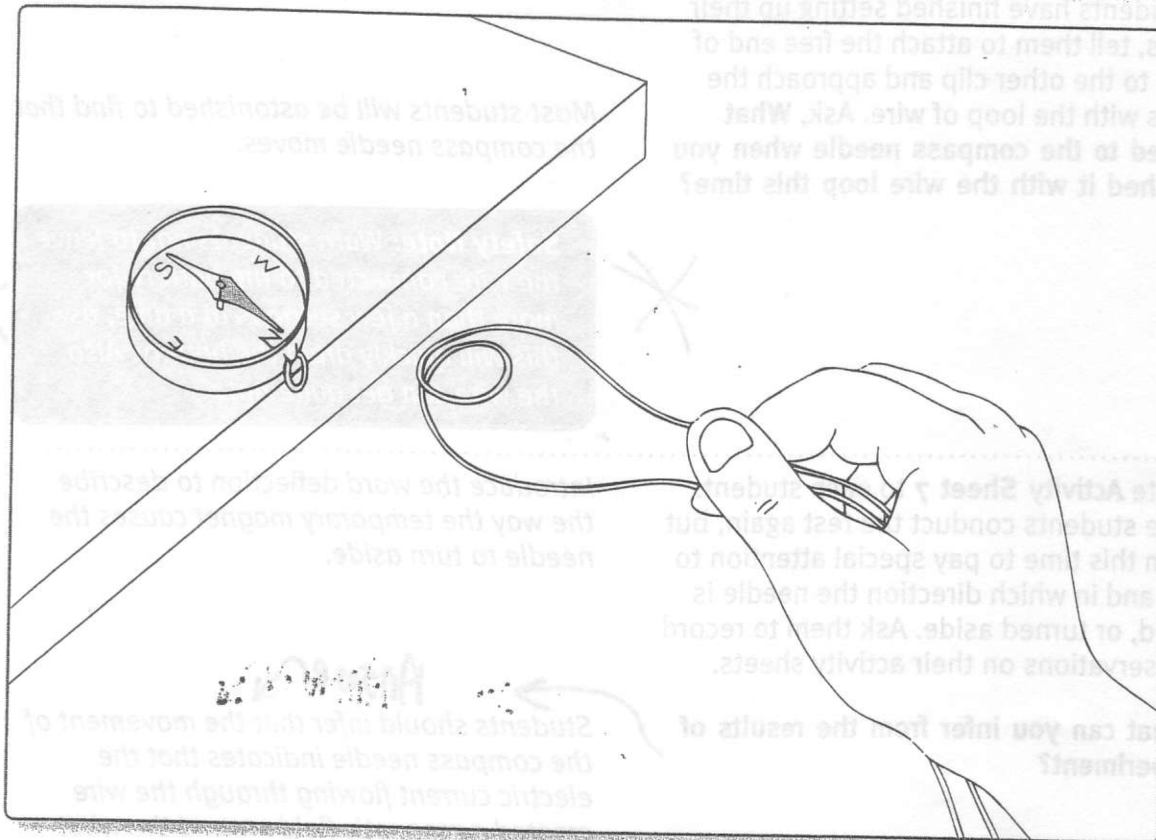
(see next page)

Now have them approach the compass with the loop of wire, as shown in Figure 10-1. Ask, **Does the compass react to the loop of wire?**

The compass needle will not react to the wire.

Guiding the Activity

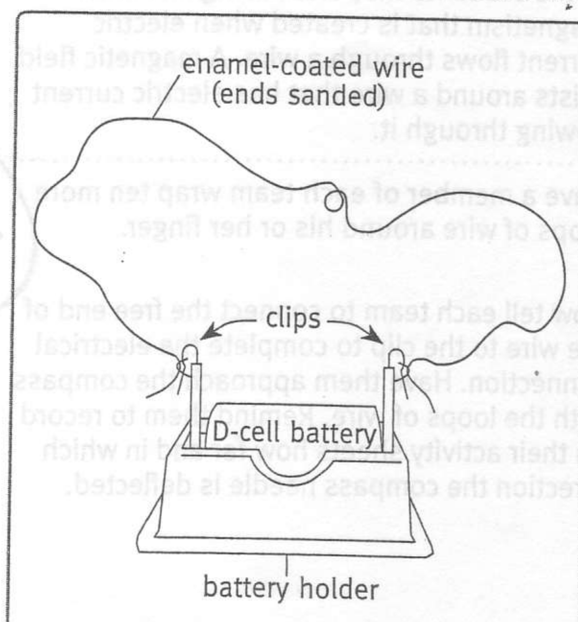
Additional Information



▲ *Figure 10-1. Approaching the compass with a loop of wire.*

3 Now tell students that they will experiment to see what happens when the wire is attached to a battery.

Show students how to set up their batteries by placing a battery in a battery holder and inserting the clips between each end of the battery and the battery holder, as shown in Figure 10-2. Press on one clip and insert one sanded end of the wire into the resulting loop. When the clip is released, the wire will stay in place. The section of wire that had the insulation sanded off must make contact with the metal loop of the clip.



▲ *Figure 10-2. Setting up the battery.*

Guiding the Activity

Additional Information

4 After students have finished setting up their batteries, tell them to attach the free end of the wire to the other clip and approach the compass with the loop of wire. Ask, **What happened to the compass needle when you approached it with the wire loop this time?**

Most students will be astonished to find that the compass needle moves.

Safety Note: *Warn students not to leave the wire connected to the battery for more than a few seconds at a time, as this will quickly drain the battery. Also, the wire can get quite hot.*

5 Distribute **Activity Sheet 7** to each student. Have the students conduct the test again, but tell them this time to pay special attention to how far and in which direction the needle is deflected, or turned aside. Ask them to record their observations on their activity sheets.

Introduce the word deflection *to describe the way the temporary magnet causes the needle to turn aside.*

Ask, **What can you infer from the results of this experiment?**

Answer

Students should infer that the movement of the compass needle indicates that the electric current flowing through the wire created a magnetic field around the wire.

Write *electromagnetism* on the board. Explain to the students that **electromagnetism** is magnetism that is created when electric current flows through a wire. A magnetic field exists around a wire that has electric current flowing through it.

6 Have a member of each team wrap ten more loops of wire around his or her finger.

Tell students to be sure that the wire is wrapped in the same direction as the original loop.

Now tell each team to connect the free end of the wire to the clip to complete the electrical connection. Have them approach the compass with the loops of wire. Remind them to record on their activity sheets how far and in which direction the compass needle is deflected.

Guiding the Activity

Ask, **Was the needle deflected farther this time?**

Ask, **What do you think might happen if the electric current suddenly began flowing in the opposite direction?**

Additional Information

Students should be able to see the relationship between the number of wire loops and how far the needle is deflected.

Suggest that teams find out what happens by experimenting with a change in the direction of current flow.

7 Tell the students to change the direction of the electric current by disconnecting the wires from the clips and turning the battery and battery holder 180°. One team member should hold the wire steady to ensure that it does not get rotated or reversed in the process. Have the students reconnect the wires and conduct the experiment again, noting the direction and the amount of deflection of the compass needle this time. Have them record their observations on their activity sheets.

Each end of the wire should now be attached to a different end of the battery.

Ask, **What happened when you reversed the battery?**

Students should notice that the compass needle was deflected about as far as before, but in the opposite direction.

Tell students that in the next activity they will continue to explore the connection between electricity and magnetism.

Reinforcement

If students are still skeptical that electric current creates a magnetic field, have them compare how the compass reacted in this activity with how the compass reacts to one of the magnets from the kit.

Science Journals

Have students place their completed activity sheets in their science journals.

Cleanup

Disconnect the wires from both ends of the batteries, but leave the remaining battery setups for use in Activity 11. Return the emery cloths to the kit.

ACTIVITY 11

Making an Electromagnet

Part 2

OBJECTIVES

The students apply what they have learned about electromagnetism to build an electromagnet. They also investigate factors that affect the strength of their electromagnet.

The students

- construct an electromagnet using a battery, a nail, and coils of wire
- use an electromagnet to attract magnetic materials
- vary the strength of their electromagnet

SCHEDULE

About 45 minutes

VOCABULARY

electromagnet
ferrous

MATERIALS

For each student

1	Activity Sheet 8

For each team of four

1	circuit (battery setup and wire from Activity 10)
1	compass
1	nail, iron
25	paper clips

PREPARATION

1. Make a copy of Activity Sheet 8 for each student.
2. Each group of four students will need the circuit (battery setup and wire) from Activity 10, a compass, an iron nail, and twenty-five paper clips.

BACKGROUND INFORMATION

An ***electromagnet*** usually consists of wire wound around a ***ferrous*** (iron-containing) core. When electric current passes through the wire, the ferrous core becomes a magnet, complete with poles and a magnetic field. The strength of an electromagnet depends upon the amount of electric current and the number of coils of wire wrapped around the core. The more coils, the stronger the electromagnet.

Because the ferrous core loses its magnetic field when the electric current stops flowing (when the circuit is turned off), electromagnets can be used in relays, switches, and motors. Because of their strength and the fact that they can be turned on and off, electromagnets play an extremely important role in a wide range of technological devices.

▼ **Activity Sheet 8**

Making an Electromagnet

Number of coils	Number of clips picked up
10	Possible answers: 1
20	1
30	1
40	3
50	5
60	8
70	10
80	12
90	14
100	16

Guiding the Activity

1 Review what students have learned by discussing how an electric current produces a magnetic field around a wire. Ask, **If electromagnetism can move the needle of a compass, what else could we expect it to do?**

2 Write *electromagnet* and *ferrous* on the board. Explain to the students that an **electromagnet** consists of an iron-containing—or **ferrous**—object inserted into coils of wire that have electric current flowing through them. *Ferrous* means "iron-containing."

Tell the students that they will construct an electromagnet and investigate its ability to pick up paper clips.

Additional Information

Students will probably identify tasks similar to those accomplished with magnets, such as picking up objects.

Point out that the ferrous object for this activity is an iron nail.

Guiding the Activity

Additional Information

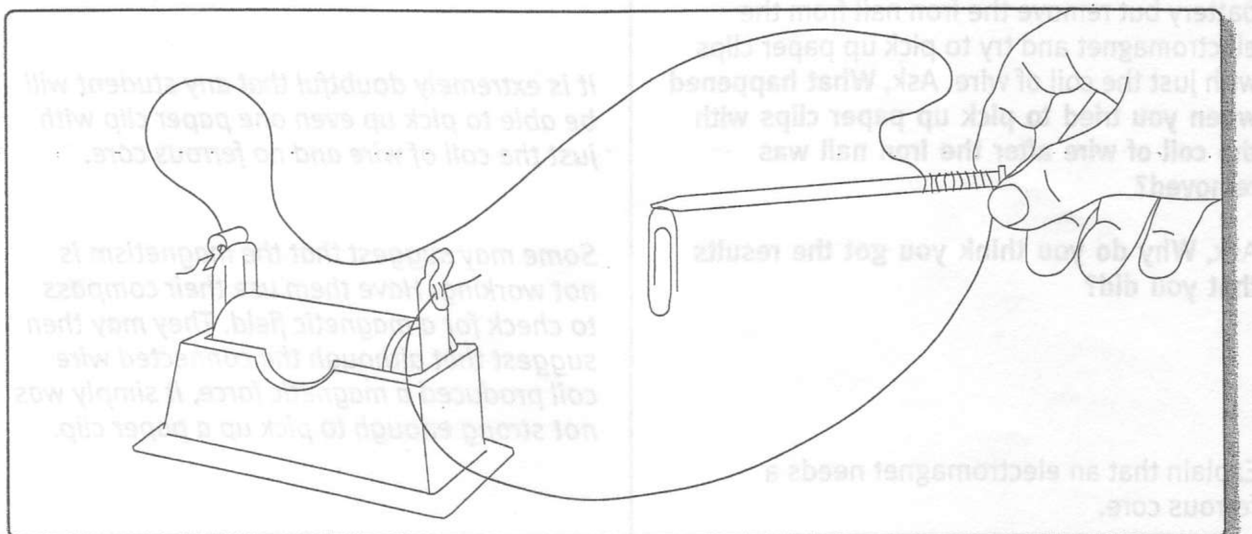
3 Divide the class into teams of four and distribute a battery setup and wire, an iron nail, a compass, and 25 paper clips to each team. Have the students construct their electromagnet by wrapping 10 coils of wire around the iron nail.

Begin wrapping the wire about 20 cm (8 in.) from one end of the wire, leaving enough wire to connect to the battery. The wire should be wrapped in the same direction, and the coils should not overlap.

4 Distribute a copy of **Activity Sheet 8** to each student. Tell the students to connect the ends of the wire to the battery and to begin testing the electromagnet (see Figure 11-1). Remind them to record on the activity sheet the number of paper clips their electromagnet picked up.

Tell students not to hook any clips over the tip or the head of the nail. Remind them not to keep the electromagnet connected to the battery for more than a minute.

Be safe!!



▲ *Figure 11-1. Picking up paper clips with an electromagnet.*

5 Tell students to disconnect one end of the wire from the battery, increase the number of wraps of wire around the nail to 20, and repeat the experiment to see how many paper clips can be picked up now. Remind them to record their data on their activity sheets.

Tell them to continue adding wraps of wire in groups of 10 until they have a total of 100. Remind them to record their observations after each trial.

Tell students to slide the coils toward the nail head, squeezing them together to make room for 100 coils.

Ask, **Is there a relationship between the strength of an electromagnet and the number of coils of wire?**

Yes. As the number of coils increases, the strength of the electromagnet also increases.

Guiding the Activity

		Additional Information
6	Now instruct the students to disconnect the wire from the battery. Ask, **What happens to the nail?**	*When the electric current stops flowing through the wire coil, the nail loses its magnetism and the paper clips are no longer attracted to the nail.*
7	Have the students turn the current on and off several times by alternately connecting and disconnecting the wire and battery, and have them observe what happens to the nail's ability to pick up paper clips. Then ask, **How does an electromagnet differ from the other magnets we have studied?**	*Students should realize that an electromagnet has magnetic properties only when electric current is flowing through the wire coils.*
8	Have the students reconnect the wire to the battery but remove the iron nail from the electromagnet and try to pick up paper clips with just the coil of wire. Ask, **What happened when you tried to pick up paper clips with the coil of wire after the iron nail was removed?**	*It is extremely doubtful that any student will be able to pick up even one paper clip with just the coil of wire and no ferrous core.*
	Ask, **Why do you think you got the results that you did?**	*Some may suggest that the magnetism is not working. Have them use their compass to check for a magnetic field. They may then suggest that although the connected wire coil produced a magnetic force, it simply was not strong enough to pick up a paper clip.*
	Explain that an electromagnet needs a ferrous core.	
9	Tell students that combining a ferrous core and an electric current to make a magnet that can be turned on and off has had an important impact on our society. Give students a moment to think of what they might be able to do with a magnet that can be turned on and off. Then explain to them that the on/off combination of a magnet and electric current is the basis of the electric motor found in the many appliances they use every day.	Good real world connection