# *IT'S MAGNETIC* (1 Hour)

**Addresses NGSS**
**Level of Difficulty: 4**
**Grade Range: 3-5**

## OVERVIEW

*In this activity, students will create a simple electromagnet using a nail, a battery, and copper wire. They will attempt to pick up nails and pins using the magnet, and they will investigate how different variables affect the strength of the magnet.*

**Topic: Magnetism, electricity**

### Real-World Science Topics

- An exploration of the force of magnetism
- An exploration of how electrical currents can induce magnetic fields

### Objective

Students will gain an understanding of magnetic fields and magnetic forces. They will also observe how electrical currents can create magnetic fields in certain materials.

### Materials Needed for Teacher Demonstration

- bar magnet
- iron nail

### Materials Needed for Student Teams

- thin gauge copper wire
- D-cell battery
- thick gardening gloves
- wire cutters
- tape
- iron nails of varying length
- paper clips and/or straight pins
- ruler
- battery holder (optional)
- alligator clips (optional)

### Teacher Preparation

Prior to the activity, cut the copper wire into 2-meter (approximately 6 feet) lengths. Cut the wire insulation down so that at least 2 centimeters (approximately 1 inch) of bare wire is exposed on each end. Each group will need one wire.

# STEPS FOR IT'S MAGNETIC

1. **Warm-up Activity:** Hold a bar magnet and an iron nail in front of the class. Ask students to identify and describe the objects. Then, tell students that in this activity, they will learn how to turn the nail into a magnet. Ask students to predict how this might happen. Give students time to brainstorm with a partner and fill in their answers to Question 1 on the **Student Handout**. Do not provide students with the correct answer to the question at this time, but do tell them that they will revisit the question, and their answers to it, later in the activity.
2. Divide students into teams, and pass out the materials, as shown below, to each student group.

If supplies are available, you may provide students with battery holders and alligator clips. This will make it easier for students to assemble the battery and wire circuits.

3. Explain to students that they are going to try to make the nail into a magnet that can pick up paper clips and pins. Have students experiment with different configurations of the battery, wire, and nail. (Do not explain the appropriate setup at this point.) If students are not using the battery holder and alligator clips, be sure that students wear gloves when connecting the wire to the terminals of the battery because these wire ends will heat up. Students may also use tape to secure the wire ends to the battery terminals, but students will find that the connection is much better when they apply additional pressure to the wire/terminal connection with their hands.

   Students can test their magnet configurations by moving a paper clip close to their setup. If the materials are set up appropriately, the paper clip will be attracted to the nail.

4. If students need additional support, you may walk them through the process of creating an electromagnet. First, instruct students to choose a nail. Then, have students wrap the copper wire many times around the nail. Instruct students to take care that the wires do not cross; the coils should all be going the same direction and should not overlap at any point. The coils should be wound tightly around the nail. There should be enough wire left over at either end to reach both ends of the battery. An example of this is shown below.

Instruct students to tape one end of the wire to each end of the battery. It does not matter which end of the battery they attach the wire to, but each terminal must have one end of the wire attached in order to complete the electrical circuit. If you are using a battery holder, students should attach the wires to each end of the battery holder. Again, instruct students to wear the gardening gloves when working with the wires and the battery, as the wires will start to get hot.

5. Next, instruct students to use the nail as a magnet and attempt to pick up the paper clips and/or straight pins. Students may need to wait up to a minute for the nail to begin acting as a magnet. Though the wires are taped to the ends of the battery, it is more effective if a student, wearing gardening gloves, presses the wires to the terminals of the battery. This improves the circuit connection. The image below shows the magnetized nail picking up straight pins.

6. Students should count both the number of coils on the nail and the number of paper clips and straight pins they were able to pick up, and record this information on Question 3 on the **Student Handout**.

7. Now, instruct student teams to choose one variable to manipulate. They will then repeat the activity at least three times, altering their chosen variable each time. Sample variables include:

   - Changing the size of the nail, but keeping the number of coils the same for each nail
   - Changing the number of coils on one nail
   - Working with different voltage batteries
   - Working with a wire of shorter or longer length

   Provide students with any additional material they may need to test their variables, and allow them time to work. Then, instruct them to complete Question 4 on the **Student Handout**, in which they create a table to display their results. If time allows, encourage students to test multiple variables.

8. Have students analyze their results and, within their groups, discuss the properties of the battery/wire/nail setup that maximized the number of paper clips picked up in each investigation. Based on these conclusions, have students design a "super magnet" that is designed to pick up the greatest number of paper clips possible.

9. **w rap-up Activity:** After teams design the "super magnet," explain to the class that they will compete with other teams to see which team's magnet can pick up the most paper clips in 30 seconds. Select two teams at a time to compete in a "heads up" competition to pick up paper clips from a pile at the front of the classroom. After teams have picked up as many paper clips as they can in 30 seconds, have them count their paper clips and report the number. Instruct the team with the fewer number of paper clips to return to their seats, and then invite the next team to compete with the winners from the previous round. Continue this process until all teams have competed.

   Have students observe and describe the properties of the winning electromagnet. Then, prompt students to draw conclusions about the strength of the magnetic force produced in this investigation. Have them discuss how the number of coils, voltage of the battery, length of wire, and length of the nail influenced the strength of the magnetic force. Explain to students that some magnets exist naturally in nature. Earth, for example, is a magnet with a north and south pole. Other magnets can be created using electrical currents. Explain that students enabled electrical current to flow through the copper wires in this activity when they touched both ends of the wires to the ends of the battery terminals. When this current flows around certain conductive materials, such as an iron nail, it causes the material to become magnetized.

### *It's Magnetic* extension Activity

1. Challenge students to create an electromagnet using different materials, such as tightly wrapped aluminum foil, pencils, pens, drinking straw, and so on. Have students examine how different materials affect the strength of the magnetic field and its ability to pick up small objects, such as paper clips.
2. Have students measure the strength and shape of different electromagnets using iron filings. Students should place the iron filings on a white sheet of paper or a paper plate. Then, they can move the electromagnet over the pile of filings to observe how the filings move in response to the nail's magnetic field. Students can sketch the pattern of the filings, and they should observe how modifications to the electromagnet (such as an increase in the number of coils or voltage of the batteries) affect the way in which the filings respond to the electromagnet.

## WHat is a magnet?

All materials contain electrons, negatively charged particles that are in constant spinning motion. Each spinning electron produces a small magnetic field with a north and south pole. In regular, un-magnetized materials, each electron spins in a random direction, and this essentially cancels out the magnetic field associated with each electron in the material. In a permanent magnet, however, each electron in the material spins in the same direction. This alignment of spins causes the material to have a north and south pole, thus creating a magnetic field. The north pole of a magnet will attract the south pole of another magnet. A bar magnet is an example of a permanent magnet. Earth is also an example of a permanent, naturally occurring magnet. The magnetic field associated with a magnet can exert an attractive or repulsive force on other magnets or moving charged particles.

## How can a battery turn an iron nail into a magnet?

Three things are needed to create a simple electromagnet: electricity, ferromagnetic material (such as iron), and copper wire. When the copper wire is attached to the positive and negative terminals of a battery, electric current flows through the wire. Electric current is a flow of charged particles. This flow of charged particles creates a magnetic field. If a ferromagnetic material, such as an iron nail, is placed in the middle of this magnetic field, the spin of electrons in the material will align and the material will become magnetized. This creates a temporary magnet that attracts other ferromagnetic materials for as long as the flow of electricity is present. When the electrical current is stopped, the electrons within the iron resume a more random alignment and the nail is no longer magnetized.

## What are some uses for electromagnets?

Electromagnets have a wide variety of uses, both in household and industrial applications. Electromagnets are used in motors to help things spin. Cars, vacuums, fans, and blenders all use electromagnets. Electromagnets are used to create giant magnets capable of moving massive loads, such as the magnets found at junkyards. Electromagnets are also becoming more common in the medical field, especially for magnetic resonance imaging, or MRI. Electromagnets have such a wide variety of uses because their magnetic fields are temporary and can be turned on and off with the presence or absence of electrical currents.

## Key vocabulary:

**battery:** a container that stores chemical potential energy

**electromagnet:** a material that becomes magnetized when electrical current passes around it

**magnet:** a material with a north and south pole

**1.** Draw a picture to show how you will set up your electromagnet. Label all of the parts.

*[Images will vary.]*

**2.** Describe the properties of your electromagnet:

- How long is the nail?
- How many coils of wire are wrapped around the nail?
- How long is the wire?
- What type of battery did you use?
- How many paper clips did your magnet pick up?

*[Sample answer: The nail is 6 cm long. We wrapped 40 coils around the nail. The wire is 45 cm long. The battery is a D battery. The magnet picked up 8 paper clips.]*

**3.** Decide which property of the magnet you will change in this investigation and list it below.

*[Sample answer: We varied the number of coils wrapped around the nail.]*

**4.** Create a table to show the variable you tested and the different results that occurred.

*[Sample table below.]*

| Variable: Number of Coils | Number of Pins |
|---|---|
| 40 coils | 8 |
| 60 coils | 12 |
| 80 coils | 20 |
| 100 coils | 31 |

**5.** Work with your group to brainstorm at least two uses for electromagnets.

*[Sample answer: Electromagnets can be used in junkyards to help pick up cars and move them. They can also be used in motors to help things spin.]*

# STUDENT HANDOUT *IT'S MAGNETIC*

Name:

Date:

**1.** Draw a picture to show how you will set up your electromagnet. Label all of the parts.

**2.** Describe the properties of your electromagnet:

- How long is the nail?
- How many coils of wire are wrapped around the nail?
- How long is the wire?
- What type of battery did you use?
- How many paper clips did your magnet pick up?

**3.** Decide which property of the magnet you will change in this investigation and list it below.

**4.** Create a table to show the variable you tested and the different results that occurred.

**5.** Work with your group to brainstorm at least two uses for electromagnets.