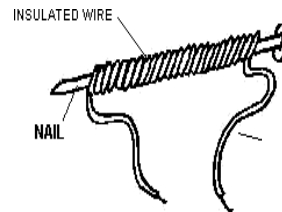


# Electromagnetic Power!



## Lesson Overview

Students will investigate the characteristics of electromagnetism and then use what they learn to plan and conduct an experiment on electromagnets.

## Suggested Grade Levels: 3-8

## Standards for Lesson

Content Standard A: Science as Inquiry

Content Standard B: Physical Science

VA SOL:

3.1 a, c, g, j; 4.1 a, b, c, f, h, 4.3 e; 5.1 e, f, g, h;

6.1 e, f, g, h, i; LS.1 a, b, f, g, i;

PS.1 a, g, h, i, k, l, m; PS.11 a, b, c

## Time Needed

This lesson takes several class periods. Sample schedule:

Day One: Complete the **Engage, Explore** and **Explain** portion of lesson

Day Two: Complete the **Elaborate** and **Evaluate** portion of the lesson

## Materials for Lesson

- Battery (D cell)
- Wire (4-6 feet of 18 gauge)
- Iron nail
- Paper clips
- Tape

# Content Background

## Information for teacher:

Magnets are materials that will attract objects made of iron, steel, cobalt, and nickel. Many scientists believe that magnetism is due to the spinning movement of electrons as they travel around the nucleus of the atom. Each electron acts as a magnet. Non-magnetic materials have atoms in which half the electrons spin in one direction and the other half spin in the opposite direction. This cancels their magnetic effect. In atoms of magnetic materials, more electrons spin in one direction than in the other. This leaves each atom with a slight magnetic pull. These magnetic atoms group together in large clusters, called “domains.” These domains line up so that all of the north-seeking poles face one direction and all the south-seeking poles face the other.

The following Web site contains an explanation of magnetism with some diagrams that may be helpful to students: <http://www.wcsscience.com/magnet/magnetism/page.html>.

Materials can be made magnetic by exposing them to one of two things: a magnet or an electric current. When current flows through a wire it creates a magnetic field surrounding that wire. If a material that can be magnetized is placed into this field, it will become magnetic. When the electric current is turned off, the magnetic field is also ended, and the previously magnetized material will slowly revert to a non-magnetic state.

Wrapping a wire around certain iron-bearing metals (iron nail) and creating a closed circuit is an example of a simple electromagnet. Soft iron is used as the core of electromagnets because it is magnetized quickly and it easily loses its magnetism when removed from the current. Electromagnets can be made stronger by increasing the number of turns of wire around the core or by increasing the current flowing through the wires.

One of the most dramatic examples of the use of an electromagnet is in the salvage industry. Incredibly strong electromagnets are used to pick up metal objects to be moved. When the object, such as an entire car, has been moved, the current is shut off and it falls from the magnet.

## Engage

**SIMULTANEOUS RALLY TABLE:** Access prior knowledge of electricity and magnetism by having students create a list of what they know. Students work with a partner. One student writes electricity at the top of the page. The other writes magnetism. On your signal, each student will list one thing that he/she knows about the topic. Students then switch papers and write one thing about the other topic. Students continue switching papers until you tell them to stop.

**GIVE ONE GET ONE:** Divide the class in half. One half will be magnetism; the half will be electricity. Student will mingle among their half of the class and find a partner. Partners each share on item about their topic from the list generate by Simultaneous Rally Table. Students add to their list

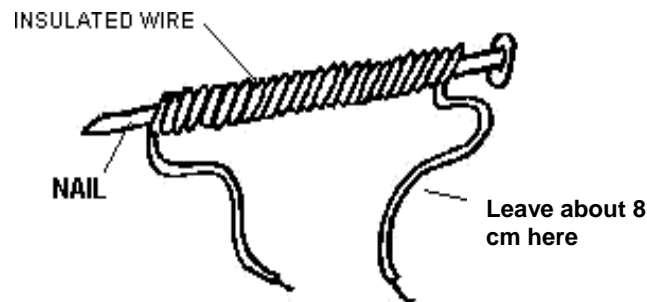
any new information. They then thank their partner and find a new partner. Continue until students don't seem to be "getting / giving" new information. Discuss as whole class.

Tell the students that today they will use the magnetic field around a wire to create an electromagnet, using layers of wire and a battery. Ask them what they think will happen. Give them a few minutes to discuss this question in groups and make a group prediction.

## Explore

Distribute the materials for the electromagnet (nail, copper wire) to each group. Have each group tightly wrap the wire around the nail, starting at the nail point and making sure that about 8 cm of wire is left free at the end for connection to the battery.

If they have wrapped the wire up the length of the nail all the way to the tip, have them start another layer on top of the one just completed.



Spread the paper clips out on a table or other flat surface.

Have students connect and tape one loose end of the wire to the positive battery terminal and the other end to the negative terminal.

Have students try to pick up as many paper clips as they can at the end of the nail. Give them 5 minutes to play with the electromagnet.

*Safety Note: When touching the wire to the battery, students should not touch the bare portion of the wire. The current being used is low and not dangerous, but the wire will heat up. It is also important that students not keep the circuit connected too long.*

# Explain

Ask students what they discovered about electromagnets. Discuss the magnetic field created in an electromagnet. Ask students how they think the electromagnet can be strengthened.

# Elaborate

Tell the students that they are going to design an experiment using the 4-Question Strategy to determine what strengthens an electromagnet.

- a. What does an electromagnet do?
- b. What materials are available for conducting an experiment on electromagnets?
- c. How could you change each material (nail, wire, battery) to affect what the electromagnet does?
- d. How could you measure or describe the response of the electromagnet to what you changed?

**PAIRED HEADS TOGETHER:** For each question, have students brainstorm the answers on their own and record on the form. Then students **RALLY ROBIN** with their shoulder partners. If their partner says an idea on their list, they check it off. If it is not on their list, they add the idea. After one minute, students share with their face partners.

2. **POPCORN SHARE:** One at a time, students pop up from chair to share an answer. As a class, choose one idea to change in the experiment (the number of times the wire is wrapped around the nail). Or have each group decide which idea they would like to test and allow them time to do so.
3. **TEAMMATES CONSULT:** To complete the experimental design, students put pencils down. Teammates discuss each step of the lab report (does not have to be completed in order. Variables may be recorded before hypothesis). Everyone should contribute ideas, but everyone does not have to agree on the answer to the question. When everyone is ready with an answer, all team members pick up their pencils and **SILENTLY** write their answers. When each teammate is finished, the team repeats the steps with the next step.
4. Once all have completed experimental design portion of lab report, students may begin experimentation. Remind students of safety concerns with electricity.

## *Observations and Conclusions*

1. Assign lab roles: Principal Investigator who directs others to follow procedures; Materials Manager who does experiment; Reporter who records data; Timekeeper / Clean Up Captain who keeps time and helps clean up. Allow students to conduct experiment.
2. Students collect data and record observations. Tell students to do multiple trials and to find the average for each number of strands.
3. Demonstrate for the student a stronger electromagnet. Let each group examine the magnet and draw conclusions about how it was strengthened.

4. Ask students why it is useful to have a magnet that can be turned on and off. Electromagnets are in doorbells, speakers, telephones, and almost every motor, but many people do not understand how such everyday devices work.

## Evaluate

- Students write conclusion including three key parts:
  - Make a **CLAIM**: Statement saying if the results support or do not support the hypothesis.
  - Provide **EVIDENCE** for the **CLAIM**: Summary of the results and data
  - Provide **REASONING** that links the **EVIDENCE** to the **CLAIM**: Explanation of results
- **ALL WRITE ROUND ROBIN**: Students create a list of what they learned about electromagnets. In teams of 4, one student announces what was learned. All students write on their own list. Repeat until all students have stated what was learned.
- Have students find an electromagnet in an everyday machine or gadget and explain in their science journals where it is and what it does

### *Extension:*

- Allow students to create other tools using items they bring from home. These tools may be compound machines.

# HOW TO MAKE AN ELECTROMAGNET

To make an electromagnet, you need electricity (usually supplied by a battery or a larger power source) and something for that electricity to flow through (wire coils, for example). Sometimes, the wire of an electromagnet is wound around a metal rod to increase the magnetic field strength.

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Try this -- *build your own electromagnet!*

Materials:

- battery (a 1.5 volt, D cell works great)
- wire (4-6 feet of 18 gauge)
- iron nail
- paper clips

Procedure:

1. Wrap the wire around the metal rod, leaving about three inches of wire on each end for connection to the battery.
2. Spread the paper clips out on a table or other flat surface.
3. Now connect one end of the wire to the positive battery terminal and the other to the negative terminal.
4. See how many paper clips you can pick up at the end of the nail.

## Questions:

What did you observe about your electromagnet? (Thinking question: What did you see when you put the nail towards the paper clips?)

What conclusions can you make from your observations?



3. How could you change each material to affect what the electromagnet does?


4. How could you measure or describe the response of the electromagnet to what you changed?

The purpose of this experiment is to determine the effect of

\_\_\_\_\_ on \_\_\_\_\_.  
(Independent Variable from question #3 above) (Dependent Variable from question #3 above)

## ELECTROMAGNET PLANNING SHEET

My testable question is

What will happen to the magnetic field of a nail if you wind more and more wire connected to a battery around it?

My hypothesis is

If \_\_\_\_\_, then

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### MATERIALS

nail  
piece of insulated wire 1 meter long  
D battery  
masking tape

What **one** thing will I change on purpose? Scientists call this the **independent variable** or the **manipulated variable**

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How will I know if the one thing I changed on purpose made any difference? (How I will measure, observe, and collect data in the experiment). Scientists call this the **dependent variable** or the **responding variable**

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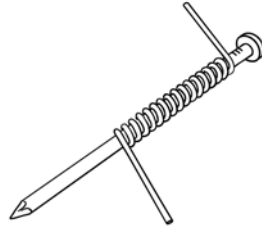
What things will I need to keep exactly the same in order to conduct a fair test? (Constants)

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## PROCEDURE

1. Follow these steps to collect data:
  - a. Leaving about 10 cm of wire free to connect to the battery, wrap the wire around the nail 10 times, starting at the flat end. Use this drawing as an example.



- b. Hold the ends of the wires so they touch the ends of the battery, making a circuit.
    - c. Collect data with 10 winds of wire around the nail .
    - d. Repeat Step c for 20 turns, 30 turns, 40 turns, and 50 turns.

## My Data

<b>IV: Number of Winds</b>	<b>DV: Number of paperclips</b>			<b>Average</b>
	<b>Trial 1</b>	<b>Trial 2</b>	<b>Trial 3</b>	
<b>0 winds</b>				
<b>10 winds</b>				
<b>20 winds</b>				
<b>30 winds</b>				
<b>40 winds</b>				
<b>50 winds</b>				

**What I learned (My Conclusion)**

Consider the following questions in your conclusion:

1. Was your hypothesis supported by the data? Use your data to explain.

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2. Why is it important to keep the nail in the same position each time when making measurements of the magnet's strength?

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My Conclusion:

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