Synopsis: Electromagnetic Challenge

In this activity we will perform a multivariate study to determine what factors impact the strength of an electromagnet. We are going to pool our findings to make a tailored electromagnet.

Standards

4th Grade

1c. Students know electric currents produce magnetic fields and know how to build a simple electromagnet.

1d. Students know the role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.

6c. Formulate and justify predictions based on cause-and-effect relationships.

6d. Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.

6e. Construct and interpret graphs from measurements.

6f. Follow a set of written instructions for a scientific investigation.

9-12th Grade

5f. *Students know* magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

Driving Questions

1.) How do we know current produces a magnetic field?
2.) How does an electromagnet work?

Learning Objectives

1.) Students will learn how to build a better electromagnet.
2.) Students will discover what variables impact the strength of an electromagnet.
3.) Students will learn how to carry out a multivariate study to accurately characterize a process or object.

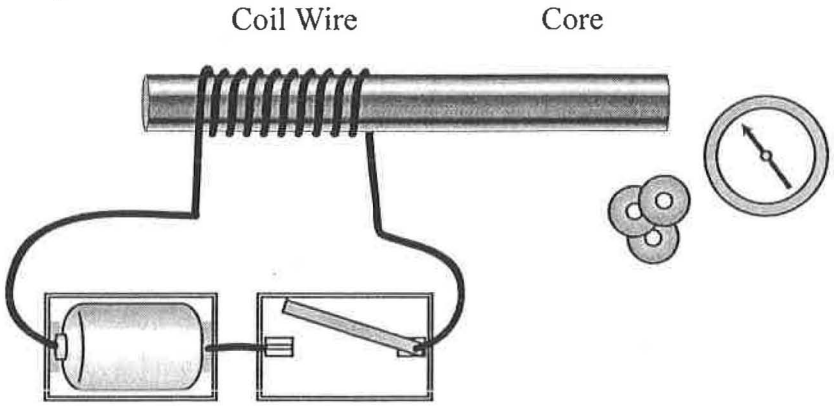
Electromagnetic Challenge

Procedure

Work in groups of two.

This series of activities will investigate the impact of four variables in the construction of an electromagnet:

- Type of Core Material
- Width of Core Material
- Thickness of Coil Wire
- Number of Loops in Coil Wire



Each group of two should investigate at least two variables, one Core variable and one Coil wire variable. Before moving on to the challenge component of this activity, all the groups will share their findings.

All of the electromagnets we make will look something like the figure above. You will be able to estimate field strength by either:

- Measuring the number of washers the magnet picks up.
- Measuring the distance at which the magnet will affect a compass.

Part A: Type of Core Material

Make sure you have the following:

- Four potential core materials, they should all be roughly ½ inch in diameter:
  - Wood
  - Plastic
  - Aluminum
  - Steel
- One long jumper with alligator clips
- One short jumper with alligator clips
- Switch
- Two battery holder with D Cell batteries
- Washers of various size
- A compass
- Ruler

For each core material (in sequence):

1.) Make a 10 turn coil using a long jumper with alligator clips. The coil should be confined to one end of the core.
2.) Tape the coil in place.
3.) Attach a battery and switch to the ends of the coiled jumper (see diagram above).
4.) Close the switch and measure the magnetic field produced in the core material. Use the end of the core opposite the coil. Either measure the number of washers the end of the core will pick up or measure the distance at which the end of core will affect a compass. Record your observations in your notebook.
5.) Make a bar graph to represent your findings.

Part B: Width of Core Material

Make sure you have the following:

- Four steel carriage bolts with various widths (~4 inches long)
- One long jumper with alligator clips
- Two battery holder with D Cell batteries
- Washers of various size
- A compass
- Ruler

For each core width (in sequence):

1. Measure the width of the test core. Record the widths in your notebook.
2. Make a 10 turn coil using a long jumper with alligator clips. The coil should be confined to the threaded end of the carriage bolt.
3. Tape the coil in place.
4. Attach a battery and switch to the ends of the coiled jumper.
5. Close the switch and measure the magnetic field produced in the core material. Use the end of the core opposite the coil. Either measure the number of washers the end of the core will pick up or measure the distance at which the end of core will affect a compass. Record your observations in your notebook.

6.) Make a bar graph to represent your findings.

Part C: Thickness of Coil Wire

Make sure you have the following:

- A carriage bolt
- A series of long jumper with different wire widths and alligator clips
- Two battery holder with D Cell batteries
- Washers of various size
- A compass
- Ruler

For each coil width (in sequence):

1. Measure the width of the test wires. Record the widths in your notebook.
2. Measure the width of the carriage bolt. Record the width in your notebook.
3. Make a 10 turn coil using a long jumper with alligator clips. The coil should be confined to the threaded end of the carriage bolt.
4. Tape the coil in place.
5. Attach a battery and switch to the ends of the coiled jumper.
6. Close the switch and measure the magnetic field produced in the core material. Use the end of the core opposite the coil. Either measure the number of washers the end of the core will pick up or measure the distance at which the end of core will affect a compass. Record your observations in your notebook.

7.) Make a bar graph to represent your findings.

Part D: Number of Coil Loops

Make sure you have the following:

- A carriage bolt
- A long jumper with alligator clips

- Two battery holder with D Cell batteries
- Washers of various size
- A compass
- Ruler

You are going to make 5 electromagnets with: 2, 6, 10, 14 and 18 loops.

For each coil (in sequence):

1. Measure the width of the test wire. Record the width in your notebook.
2. Measure the width of the carriage bolt. Record the width in your notebook.
3. Make a N loop coil using a long jumper with alligator clips. The coil should be confined to the threaded end of the carriage bolt.
4. Tape the coil in place.
5. Attach a battery and switch to the ends of the coiled jumper.
6. Close the switch and measure the magnetic field produced in the core material. Use the end of the core opposite the coil. Either measure the number of washers the end of the core will pick up or measure the distance at which the end of core will affect a compass. Record your observations in your notebook.
7. Make a bar graph to represent your findings.

Follow up to Parts A-D:

1. Make a white board for two of your experiments.
2. Share white boards with group.
3. Summarize all the data on the board.

Part E: Electromagnetic Challenge

If time permits. . .
Your challenge is to use the data we have collected to make a tailored magnet. You will get three attempt to design and make an electromagnet that will:

(Challenges will be announced in class and will vary)

Design 1

Describe:
Results:
Trouble shoot:

Design 2

Describe tweaks:
Results:
Trouble shoot:

Design 3

Describe tweaks:
Result:

Practical Application Extension questions:

How are electromagnets (and the interaction between magnetic poles) used to effectively move bullet trains in Japan?

Instructor Notes: Electromagnetic Challenge

You will want to set the electromagnet challenge after the groups have collected their data.

Safety
This activity has little to no risk associated with it.

Materials

Part A: Type of Core Material

- Four potential core materials, they should all be roughly ½ inch in diameter:
  - Wood
  - Plastic
  - Aluminum
  - Steel
- One long jumper with alligator clips
- One battery holder with D Cell battery
- Washers of various size
- A compass
- Ruler

Part B: Width of Core Material

- Four steel carriage bolts with various widths (~4 inches long)
- One long jumper with alligator clips
- One battery holder with D Cell battery
- Washers of various size
- A compass
- Ruler

Part C: Thickness of Coil Wire

- A carriage bolt
- A series of long jumper with different wire widths and alligator clips
- One battery holder with D Cell battery
- Washers of various size
- A compass
- Ruler

Part D: Number of Coil Loops

- A carriage bolt
- A long jumper with alligator clips
- One battery holder with D Cell battery
- Washers of various size
- A compass
- Ruler

Notes