Building Electromagnets and Simple Motors

Summary

The students will be able to compare permanent magnets and electromagnets through a handson experience by building an electromagnet and a motor. They will also have the chance to try several experiments with an electromagnet that they create themselves!

Materials

Materials needed per group to make the electromagnets:

- One 6volt lantern battery
- Insulated wire cut in the following lengths: 30 cm. 50 cm, and 65 cm (Strip the insulation from both ends of the wires.)
- Large iron or steel nail
- 30 small paperclips
- Compass

Materials needed per student to make the motors:

- "D" cell battery
- 24gauge enameled magnet wire (30 cm or 6 ft.)
- Circular ceramic magnet
- Two large paperclips
- Masking tape
- Scissors or sandpaper

Books:

- Louis A. Bloomfield, *How Everything Works: Making Physics Out of the Ordinary* ISBN: 9780471 748175
- David P. Billington and David P. Billington Jr. *Power, Speed, and Form: Engineers and the Making of the Twentieth Century* ISBN: 9780691102924
- Clayton M. Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* ISBN: 9780875845852
- Charles Reginald Underhill, *Solenoids, Electromagnets and Electromagnetic Windings* ISBN: 978 1103576869

Background for Teachers

Science language that students should use: battery, complete circuit, incomplete circuit, current, conductor, insulator, pathway, power source, electromagnetism, magnetic force, attract, repel, compass, magnetic field, permanent magnet

Magnetism comes from the special arrangement of atoms in certain materials. Everything is made of atoms, and each atom has its own tiny, magnetic field. In materials such as rubber, paper, plastic, and ordinary rock, the atoms have no particular arrangement, so all the atomic magnetic fields cancel each other out and produce no overall magnetic quality. In iron, however, the individual atoms are magnetized strongly enough to line up in tiny groups called magnetic domains. Depending on how aligned these magnetic domains are with one another, iron can be nonmagnetized, strongly magnetized, or completely magnetized.

Students' confusion and misconceptions about magnetism must be carefully considered.

- It is difficult for students to accept that aluminum, a metal that seems very much like iron, is not attracted to a magnet.
- Materials such as a stack of paper, wood, plastic, and glass are tangible barriers, unlike air. It is difficult for students to accept that magnetic fields can penetrate these tangible barriers.

When a reference is made about the magnetic field as "transparent to magnetism," student confusion may be created. "Transparent" means "see through" to most students, and materials such as wood clearly do not have this property. This example also might seem to imply that magnetic properties can be seen.

The statement that magnetic lines of force "go through" materials may be difficult for many to accept.

Relating magnetic force, which acts at a distance, to a push or pull, where contact is required, may cause difficulty.

Labeling magnetic poles "north" and "south" is a little more unnatural to the first time learner than those familiar with magnetism may realize.

Separating electricity and magnetism initially, and then connecting them later (as with the electromagnet), may cause confusion if not handled carefully.

Understanding how an electromagnet works is very basic. By running electric current through a wire, you can create a magnetic field. A loop of wire that carries an electric current creates a magnetic field through the loop. You can increase the strength of this magnetic field by winding a lot of loops. The more loops, the stronger the magnet. An electromagnet may be constructed with enamelcoated wire wound around a large iron nail and connected to the poles of a battery. When this magnetic field is created it can be used to make motors, to read/write hard drives, to make stereo speakers, etc.

Intended Learning Outcomes

Use science processes and thinking skills.

Communicate effectively using science language and reasoning.

Understand the nature of science:

- Science is a way of knowing that is used by many people, not just scientists.
- Understand that science investigations use a variety of methods and do not always use the same set of procedures; understand that there is not just one "scientific method."

Instructional Procedures

Invitation to Learn:

Begin with a riddle.

Clues:

I have special properties that draw objects together.

I amaze, delight, and help people every hour, day after day.

I have a home in various places.

When the stereo is on, I am there.

When the doorbell buzzes, I am there.

I even turn up in nature. (Look amongst the rocks.)

You can't see or hear me. I am an invisible force.

I keep things going with my attraction and repulsion power.

I like to transfer my invisible power to other iron material.

Can you guess who I am? I'm Magnetism!

We will be studying magnetism through electromagnets for the next few weeks. First, let's assess what the students already know by creating a foldable for their journals called a KWLH chart.

It stands for:

What you already Know.

What you Want to find out.

What you Learned.

How you can learn more.

We will add new information to the chart throughout the unit.

Activity Connected to the Lesson:

Exploring Electromagnets

Show the students how to wrap a wire around the nail leaving 5 cm of wire unwrapped at each end.

Divide the students into 6 groups, the students should tightly wrap the 35 cm wire around the nail. While other students tightly wrap the 50 cm wire around the nail. As well as others tightly wrap the 65 cm wire around the nail. Provide 3 6Volt Lantern Batteries.

Then, the students attach the wire ends to the different ends of the battery. (Be careful, some heat is given off.)

The students hold the pointed end of the nail in the pile of clips and lift.

Create a chart to record information. (It's a great use of student journals.)

They record the number of paperclips picked up.

Discuss how students changed variables to increase or reduce the strength of the electromagnet (tighter or looser coils, larger or smaller nail, larger or smaller battery).

Write a reflection, in their journals, of the student learning. Students use graphs, diagrams to show their understanding. Then have the students share their findings.

Magnetism. You can magnetize a conductor of electricity, such as a nail, by running current through the conductor. The more coils of wire that are wrapped around the nail, the stronger the electromagnet will become. The smaller the battery, the less magnetism will be produced. An electric current has a magnetic field around it. This magnetic field is seen in the construction of an electromagnet, which is made by wrapping a wire, the pathway, into coils.)

Using Electromagnets to make a Motor (Allow 30 minutes for this activity)

Begin by asking the following introductory questions: "What things in your home use an electric motor?" (An electric mixer, telephone, computer, refrigerator, electric drill, copy machine, stereo, speakers, hair dryer, etc.) Then ask: "What are the parts of an electric motor?" (A magnet, wire, and a power source or electricity.) "How does a motor work?" (A coil moves in a magnetic field.)

Wrap the enameled wire around the battery tightly to make a coil. Use the entire length of wire, making approximately 610 wraps around the battery. Leave two inches of wire off each side of the coil. Secure with two wraps of the wire.

Scrape all the enamel from both ends of the wire so only copper shows.

Bend each paperclip to create an "S" shape.

Tape paperclips to each end of the battery. (Be careful, because heat is generated.)

Place the magnet under the battery. If the battery has a metal coating, the magnet will adhere to it.

Place wire coil in the loops of the paperclips.

Adjust the paperclips, moving the coil up and down until the coil is affected by the magnetic field. This will be evidenced by a wobble in the coil. It will start to move back and forth.

Spin the coil slightly and the coil should start spinning by it. The electric motor should now operate.

Troubleshooting is very exciting, as well as frustrating, because the students will determine what needs to be adjusted. (Some problems that students could adjust include scraping all the enamel off the wire; a loose wire coil; not enough coil wraps; or having the paperclips too far from the coil.)

You can turn this into an experiment students generate in their journals using the scientific method. Write a conclusion, in their journals, of the student learning. Students use graphs, diagrams to show their understanding.

1. Question

   : How do I make a motor work best?

2. Hypothesis
   : If I use the magnetic field of an electromagnet,
3. Procedure
   : Students list the steps used to create a motor. (I give them a typed list of procedures to tape into their journals.)
4. Data Collected
   : Students create a data chart of their observations from a variety of attempts to get the motors to work. Discuss the variables that the students could change to see if the motor works better. (Change battery size, change paperclip size, change type of tape used to attach the paperclip, use different magnets, different ways to hold the motor, etc.) Then they can create a question that will utilize the scientific method more appropriately.
5. Conclusion
   : Students address their hypothesis and information learned from the data collected to respond to the question of how the motor worked.

Lesson and Activity Time Schedule:

Each lesson is 55 minutes.
Each activity is 30 minutes.
Total lesson and activity time is 90 minutes.

Extensions

Increasing/decreasing the amount of electric current moving through the nail will vary the strength of the magnetic field in the nail. Have the students experiment with the number of wraps around the nail and the battery power. Have them record the results in some sort of graphic organizer. Have the students try other variables like uniformity of the wrapping, wire thickness, etc. Warn the students that some wires may become hot when connected to the batteries.

Put the students in research teams and have them report on the way motors are used. Use the web site mentioned below (How Stuff Works) as a reference.

Family Connections:

Magnetism and electricity are so closely related that scientists call this force by just one name: electromagnetism. Students can teach their families about the electromagnets they made in school.

For a family activity, students can find all the items at home that utilize this special force. Electromagnets are used in doorbells and telephones, as well as large metal moving machines (i.e., every telephone, computer, video game, spark plug, light bulb, heat lamp, radio, flashlight, compass, hair dryer, airplane radar, walkie-talkie, movie projector, copy machine, burglar alarm, and garbage disposal depends on our understanding of electromagnetism to work).

Students teach their parents how the motor works. At home, students use different size batteries to show which battery works best.

Students visit the Foss Web Magnets site. Can students find all the magnets in the picture? Take the challenge.

Assessment Plan

List the items a student would need to create an electromagnet.

Create a data chart for the experiment that two students would use if they made an electromagnet by winding copper wire around a steel nail, then attached it to a battery. How would it look if they wrapped 20 coils, 40 coils, or 80 coils around the nail?

Explain how a motor demonstrates good use of an electromagnet.

Make a chart of where in life people would use magnets.

Authors

Janeen Graham