



Electricity and Magnetism, Part 3 Supplemental and Background Information For Teachers and Volunteers

Rationale:

According to the new California Science Standards, electricity and magnetism are important science concepts for 4th grade students. While the new science standards have not yet been implemented in most schools, these modules were designed to complement these standards. Specific science standards addressed in this *Electricity and Magnetism* lesson plan are:

3rd grade:

- Students are asked to predict the outcome of a simple investigation and compare the result with the prediction.
- Students are asked to collect data in an investigation and analyze the data to develop a logical conclusion.

4th grade:

- Students know how to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field.
- Students know electric currents produce magnetic fields and know how to build a simple electromagnet.

Disclaimer: Some of the procedures for the activities contained in the lessons have been adapted from various resources listed throughout the module. Ideas for extension activities can be found in these resources as well.

Part 3: Connecting Electricity and Magnetism

Objectives:

After participating in the program *Electricity and Magnetism, Part 3*, students will be able to:

- describe how to determine the north or south pole of a magnetic object
- report that a current in a wire generates a magnetic field
- recognize that this magnetic field can be turned on and off with the current
- describe how the direction of this magnetic field depends on the direction of the current
- discuss how a magnetic field generated by a current in a coil can do work
- explain that an iron-containing object can be magnetized by the magnetic field from a current in a coil
- discover the direction of the magnetic field produced by a current in a coil

Vocabulary:

induced magnetism - magnetism produced in an object when it is exposed to the influence of an electric field

electromagnet - an object placed inside a coil of wire that becomes a temporary magnet when a current is made to flow through the wire



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Lesson Notes:

1. How can we determine which end of the induced magnet is the N or S pole? Consider this question if neither a magnet nor a compass were available. (We solve this problem by suspending the magnetized nail from a support (students now have a compass). Depending on the orientation of the magnet during the magnetization process, the head or point of the nail will point north. This is the north end of the temporary magnet.)

2. When using the test circuit, it is important to limit the time the current flows. One student will be in charge of limiting the current flow to 10 seconds (to preserve battery life as well as to prevent overheating of wires and battery contacts). The straw is used to make handling the wire easier. Students should notice that holding the wire near the "compass needle" causes the "needle" to deflect when current is allowed to flow. (Discussion with the class should lead to the conclusion that a current flowing in a wire induces a magnetic field which deflects the "needle". This is called induced magnetism. The direction of the magnetic field will depend on the direction of the current flow, which in turn depends on the battery connections, and the placement of the wire with respect to the nail. This effect can be subtle if using D cell batteries, so just noting a deflection is enough at this point.)

3. To increase this effect, wire is coiled around a straw. It is again important to monitor the length of time the current is allowed to flow. When the iron-containing object is introduced into one end of the coil, the object is sucked into the coil by the magnetic field⁸. Does battery polarity matter? (No, reversing the polarity of the battery produces the same result. The students should be able to realize and state that work has been done by the magnetic field produced by the current in the coil.)

4. To increase the effect even further, the wire is wound around a large iron-containing nail. Again, watch the time the current is allowed to flow. Can the magnetic field produced by a current in the wire be used to magnetize the nail? (Yes, the students have made an electromagnet.) How can the students prove or disprove that the nail is magnetized? (Hopefully they will suggest seeing if the nail can pick up paper clips.) What happens when the circuit is opened? Do the paper clips fall off? (Yes. When the current is switched off, the magnetic field goes away, and the nail is no longer a magnet. Sometimes, the nail will drop most, but not all of the paper clips. In this case, the nail has become a very weak temporary magnet due to the induced magnetic field from the current in the wire. Some of the magnetic domains that lined up while the current was on did not return to random orientations after the current was switched off.)

What are the potential uses of a magnet that can be turned on and off with a switch? (Students may suggest applications that they are familiar with or some that are purely inventive.)

5. Repeat the "compass" deflection experiment with the nail and coil. (Students should notice that the magnetic field is much stronger now. In fact, it is strong enough to easily see that changing the battery polarity (or the direction of current flow) changes the direction of deflection of the "compass needle".)



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Students should try two or three different orientations of the nail/coil with respect to the “compass needle”, with both battery polarities, and record the results in their worksheet. (These last observations allow us to conclude that the current direction is directly related to the direction of the magnetic field produced.)

6. An activity to do between this and the next visit, would be to think about some different ways this relationship between magnetism and electricity may be used.

Answers to the worksheet are located in the file:

E&M_3_wksht_key.

References and Extension Ideas:

The following resources were used in developing this lesson plan. Some of the activities were adapted from these sources. Many ideas for extension activities can be found in them as well.

1. *The Thomas Edison Book of Easy and Incredible Experiments*, Thomas Alva Edison Foundation, John Wiley & Sons, Inc., New York, 1988.
2. www.beakman.com
3. Foss Magnetism and Electricity Module
4. www.freeweb.pdq.net/headstrong/mag.htm
5. www.freeweb.pdq.net/headstrong/mag2.htm
6. www.pausd.palo-alto.ca.us/k6science/electric/e_tips.html
7. www.edtech.kennesaw.edu/web/electric.html
8. *Exploratorium Science Snackbook* or www.exploratorium.edu/snacks/
9. www.pbs.org/ktca/newtons/12/electric.html
10. www.pbs.org/wgbh/nova/teachersguide/lightning/lightning_sp1.html
11. www.pbs.org/wgbh/nova/specialfx/fxguide/fxmshtr2.html
12. www.pbs.org/saf/4_class/45_pguides/pguide_605/4565_image.html
13. www.pgs.org/saf/4_class/45_pguides/pguide_604/4564_shark.html
14. www.pgs.org/saf/4_class/45_pguides/pguide_602/4542_storm.html
15. www.chss.montclair.edu/~pererat/pertel.html
16. www.chss.montclair.edu/~pererat/perbuild.html
17. www.chss.montclair.edu/~pererat/perwirls.html
18. *The Science Teacher*, October 1999, “Electromagnetic/Mechanical Resonator”, pp. 56-58.