Electricity and Magnetism, Part 2

Rationale: According to the California State Science Content Standards, electricity and magnetism are important concepts for 4th grade students.

Disclaimer: Some of the procedures for the activities contained in the lessons have been adapted from various resources listed throughout the module.

Part 2: Magnetism
introductory explorations with magnetism

Activity Summary:

- Preliminary observations with magnets Part 2 Worksheet Item 1
- Introduction of magnetic poles, field lines, and force Part 2 Worksheet Item 2
- Magnetic field line visualization Part 2 Worksheet Item 3
- Test for magnetism Part 2 Worksheet Item 4
- Permeability test
- Magnetic domains
- Magnetize an object
- Problem: how to determine the N end of a magnet

File Summary:

- E&M_doc_2
- E&M_2_teachers
- E&M_2_wksht
Part 2: Magnetism

Objectives:
After participating in the program *Electricity and Magnetism, Part 2*, students will be able to:

- recognize that some materials exhibit magnetism and others do not
- restate that magnetic objects have a north pole and a south pole
- explain that like poles repel each other while opposite poles attract each other
- describe magnetism as a force with force lines extending from an object into space
- recognize that most magnetic objects contain iron (some other less common elements are also magnetic)
- demonstrate that iron-containing objects can be magnetized
- explain how induced magnetism can be destroyed
- restate that magnetic field lines can pass unaffected through some materials and are gathered in by others

Vocabulary:
- **permanent magnet** - a magnet, usually of hard steel, which keeps most of its magnetism after it has once been magnetized
- **repulsion** - the mutual action by which bodies or particles of matter tend to push each other apart
- **attraction** - the mutual action by which bodies or particles of matter tend to draw together
- **magnetic force** - the attracting or repelling force between a magnet and a magnetic object
- **magnetic field lines** - imaginary lines in a region of space in which there is an appreciable magnetic force
- **magnetic poles** - either pole of a magnet, where the magnetic lines of force seem to be concentrated
- **north pole** - that end of a straight magnet that points north when the magnet hangs free
- **south pole** - that end of a straight magnet that points south when the magnet hangs free
- **magnetic domain** - microscopic regions in an object in which magnetic dipoles (north and south poles) tend to align parallel to each other
- **temporary magnet** - an object whose magnetism is not permanent
- **permeable** - a material which interacts with a magnetic force passing into it
- **nonpermeable** - a material which does not interact with a magnetic force passing into and through it

Lesson Plan:

Materials:
For each group:
- bag of materials to test for magnetism (paper, plastic, paper clip, aluminum, aluminum foil, marble, mylar, glass, steel button, wood, nail containing iron, silicon chunk, penny)
- small baggie with paper clips
- string (sewing thread) about 12" long
- permeability tester (cardboard and straws)
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- suspension system (two wood end pieces and dowel, tape)

For each student:
- worksheet
- permanent magnet
- iron filings in sealed bags

Volunteer/Teacher Preparation:
1. Make the iron filing demos. Refer to Figure E&M_2_1 during the construction of these demo materials. Try to pick sturdy paper plates so that the students can handle them easily without destroying them. Chinet® plates work well. If the plates do not fit inside the resealable plastic baggies, cut the rim off so that they do. Place the plate inside the baggie and add about ¼ tsp of iron filings. Close the baggie and seal with electrical or duct tape. You will have to caution the students to be careful when using the filing demos as it is very easy to make tiny holes in the plastic bags. In that case, some of the filings will get out and coat the magnets or otherwise make a mess.

2. Make the permeability test cells. Cut two pieces of cardboard into 4” x 6” rectangles for each tester you are making. Cut drinking straws in 6” lengths, two per tester. The straws act as spacers to create a space between the two pieces of cardboard. Tape the straws and cardboard pieces in place as shown in Figure E&M_2_2.

3. Make suspension systems. See Figure E&M_2_3 for the details. For each system, cut two pieces of ¼” wood or particle board into triangles about 7” high. The base of the triangles should be about 5”. Drill a hole near the top of the triangle that will allow the dowel to be inserted somewhat snugly. Cut one 7” piece from a 3/8” wooden dowel for each suspension system. Students can assemble this system in class by inserting each end of the dowel into the holes of the two triangles.

Time:
- activity 1: 10 minutes
- activity 2: 15 minutes
- activity 3: 10 minutes
- activity 4: 10 minutes
- activity 5: 10 minutes
- activity 6: 10 minutes
- activity 7: 15 minutes
- activity 8: 5 minutes

Activities:
1. (10 minutes)
   - Give out magnets and have pairs of students work together to discover some of the properties of two (permanent) magnets interacting.
   - Students should record their observations and conclusions in the worksheet.

2. (15 minutes)
   - Lead the students through a discussion of magnetic poles. (Each magnet has a north and a south pole. No matter how small the magnet is, it will have both poles. Introduce the idea of a compass which can be used to tell directions.)
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• Show students how a magnet interacts with the iron filing display in order to visualize the magnetic field lines of the magnetic force.
• Have students play with their iron filing demo and their magnets to learn about the magnetic field lines. Students should try two different orientations of the magnet with respect to the iron filing demo.
• Ask them to draw the field line pattern in their worksheets for each case.

3. (10 minutes)
• Ask students to replace the iron filing demos in their box and collect the magnets.
• Distribute the bags of materials and have the students sort the objects into magnetic and nonmagnetic items based on their intuition.
• Have them place checkmarks on their worksheets beside the objects they believe are magnetic.

4. (10 minutes)
• Get students to propose how they would test the objects for magnetic behavior.
• Return the magnets and let the students test the objects and record the results in their worksheets.
• Go over the results of the magnetism test.
• Were there any materials that fooled the students? What do all the magnetic objects have in common? (They are made of metals that contain iron.)

5. (10 minutes)
• Will magnetic force go through matter and/or air? How can we test this?
• Define permeable and non-permeable.
• Students may construct a test cell or use the one provided. (See the Teacher/Volunteer Preparation section for instructions if the students are to make the test cells.)
• Materials are tested by inserting the object between the two cardboard pieces. The magnet(s) are placed on top of the cardboard during the test. Test various materials for permeability and record results in worksheet.

6. (10 minutes)
• Ask students why iron-containing objects are attracted to magnets? Does it matter which pole of the magnet? What happens inside the material when it is exposed to a magnetic field?
• Talk about the magnetic domains inside aligning with the magnetic field of the permanent magnet.

7. (15 minutes)
• Can you turn an iron-containing object into a (temporary) magnet?
• Have students take a small nail from the material bag and show them how to stroke the nail with the permanent magnet (use two
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magnets together if your magnets are fairly weak). See Figure E&M_2_4 for directions on how to magnetize a nail.

- How can they prove that the nail is now magnetized? (Let them propose methods such as having the nail pick up paper clips.)
- Can this induced magnetism be destroyed? (Yes, by heating or by dropping several times.)

8. (5 minutes)

- Leave the students with a problem to think about for the next session. How can we determine which end of the temporary magnet is the N or S pole?
- If there is to be no further session with this group of students, continue with the brainstorming to find a solution to this problem.
  - If using a compass or known magnet is suggested, ask for them to consider the case when neither of these items were available.
  - Lead them to the solution of suspending their nail with a string and seeing how it hangs (they now have a compass).
  - Suspend one group’s magnetized nail with the suspension setup as a demo to illustrate how the N and S ends of the nail can be determined.

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.

2. [www.beakman.com](http://www.beakman.com)
3. Foss *Magnetism and Electricity* Module
4. [www.freeweb.pdq.net/headstrong/mag.htm](http://www.freeweb.pdq.net/headstrong/mag.htm)
5. [www.freeweb.pdq.net/headstrong/mag2.htm](http://www.freeweb.pdq.net/headstrong/mag2.htm)
6. [www.pausd.palo-alto.ca.us/k6science/electric/e_tips.html](http://www.pausd.palo-alto.ca.us/k6science/electric/e_tips.html)
7. [www.edtech.kennesaw.edu/web/electric.html](http://www.edtech.kennesaw.edu/web/electric.html)
8. *Exploratorium Science Snackbook* or [www.exploratorium.edu/snacks/](http://www.exploratorium.edu/snacks/)
9. [www.pbs.org/kcta/newtons/12/electric.html](http://www.pbs.org/kcta/newtons/12/electric.html)
11. [www.pbs.org/wgbh/nova/specialfx/xfguide/xfmshtr2.html](http://www.pbs.org/wgbh/nova/specialfx/xfguide/xfmshtr2.html)
15. [www.chss.montclair.edu/~pererat/pererat.html](http://www.chss.montclair.edu/~pererat/pererat.html)
16. [www.chss.montclair.edu/~pererat/perbuild.html](http://www.chss.montclair.edu/~pererat/perbuild.html)
17. [www.chss.montclair.edu/~pererat/perwirls.html](http://www.chss.montclair.edu/~pererat/perwirls.html)
E&M_2_1. Illustration of iron filing demo construction.

a) Place plates and iron filings in bag:

b) Seal with tape:
E&M_2_2. Illustration of permeability tester.

a) Construction:

b) Operation:

Place magnet(s) on top of the tester:

Pick up paper clips:

Insert test object between the pieces of cardboard in the space created by the straws:
E&M_2_3. Suspension system construction.

a) Detail of pieces:

- cut two: ¼" wood or particle board
- 3/8" dowel
- 7"

b) Assembly:

c) with magnetized nail:
E&M_2_4. Magnetizing a nail.

To produce N/S in the direction of the nail body, rub the magnet along the length of the nail as shown below.

OR

BUT NOT

OR