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Science Unit: *Concepts in Electricity*
Lesson 5: *Magnets and Iron Filings Art*

Summary: Students use **iron filings** spread on a paper plate to **visualize magnetic fields**. They then move the magnets until the filings create a unique pattern, spray the filings with vinegar and allow the filings to rust. The rust marks will stain the paper in an interesting pattern.

School Year: 2013/2014

Developed for: Lord Selkirk Elementary School, Vancouver School District

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Grade level: Presented to grade 6; appropriate for grades 5 – 7 with age appropriate modifications

Duration of lesson: 1 hour and 05 minutes

Notes: The main activity associated with this lesson is the visualization of magnetic fields (because they are easier to manipulate), whereas the lesson is on electric fields. Students should be asked to explore electric fields at home, using the PhET “Electric Field Hockey” before the lesson. Students should also have an understanding of the interdependence of electricity and magnetism.

Objectives

Students will be able to:

1. Explore the field—action at a distance—concept.
2. Develop a working model of a field. Compare and contrast different types of fields.
3. Observe a magnetic field (and, by their interdependence, understand what an electric field looks like).

Background Information

As children grow, they become very accustomed to contact forces; but an action-at-a-distance force upon first observation is quite surprising. Action-at-a-distance forces are sometimes referred to as *field forces*. The concept of a field force is utilized by scientists to explain this rather unusual force phenomenon that occurs in the absence of physical contact.

While all masses attract when held some distance apart, charges can either repel or attract when held some distance apart.

An alternative to describing this action-at-a-distance affect is to simply suggest that there is something rather strange about the space surrounding a charged object. Any other charged object that is in that space feels the affect of the charge.

A charged object creates an electric field - an alteration of the space in the region that surrounds it. Other charges in that field would feel the unusual alteration of the space. Whether a charged object enters that space or not, the electric field exists.

Space is altered by the presence of a charged object. Other objects in that space experience the strange and mysterious qualities of the space.



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Vocabulary

- Magnet: A material that produces a magnetic field
- Magnetic field: The magnetic influence of electric currents and magnetic materials. The magnetic field at any given point has both a direction (attraction or repulsion) and a magnitude (a relative strength).

Materials (per group)

- 2 - 4 bar magnets
- sheet of paper
- paper cup
- iron filings
- spray bottle of white vinegar
- paper plates

In the Classroom

Introductory Discussion

1. Brief analogy of fields to capture students' attention: a stinky field.
 - Anyone who has ever walked into a room with an infant with a soiled diaper has experienced a stinky field. There is something about the space surrounding an infant's soiled diaper that exerts a strange influence upon other people who enter that space. When that little stinker needs a diaper change, you can't help but notice it. When you walk into a room with such a diaper present, your detectors (i.e., the nose) begin to detect the presence of a stinky field.
 - As you move closer and closer to the infant, the stinky field becomes more and more intense. And of course the worse the diaper, the stronger the stinky field becomes.
 - It's not difficult to imagine that a soiled diaper could exert a smelly influence some distance away that would repel any nose that gets in that area. The diaper has altered the nature of the surrounding space and when your nose gets near, you know it. The stinky diaper has created a stinky field. (We could get students to draw the stinky field in their science notebooks.)
2. Ask students to come up with other action-at-a-distance forces (charged balloons repel, or magnets attract), as well as contrast examples where the action does not happen at a distance (cars colliding, or balls bouncing on the floor).
3. Make an explicit comparison (and contrast) to gravitational fields:
 - If a test mass is placed near a large mass, what will happen to the test mass?
 - What causes the test mass to move?
 - How do students know about the path along which the test mass will move?
 - What is a main difference between a gravitational field and an electric or magnetic field? (A gravitational field is always attractive.)
4. Briefly describe safety guidelines. **Keep iron filings away from the eyes, nose and mouth. Vinegar can also cause an irritation if it contacts the eyes.**



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Science Activity

Activity Title: Magnetic Field Art

Purpose of Activity: To make visible what is otherwise invisible. To capture a student created magnetic field in an artistic fashion.

Experimental Observations: The effects of magnets and their relative position to one another and the fields they generate will be observed separately.

Prediction or Hypothesis: Before making your prediction (or hypothesis), it helps to start with a question, or make observations and then ask a question. Use your prior knowledge of magnets and fields to predict what you think will happen when the magnets are positioned as outlined in the instructions below. Record your prediction based on the following question: What do you think the magnetic field will look like when the magnets are placed as such...?

Methods and Instructions:

Set-up prior to experiment: Add info.

Brief description of how students will work in groups or pairs.

1. Arrange 2 magnets end to end, on the table, with their north poles about 5 cm apart. (see Figure 1)
2. Draw this configuration of magnets into your science notebook. Then draw your prediction of the magnet fields that you think exist about these two magnets.
3. Cover the magnets with a sheet of paper. Take the paper cup with iron filings and carefully sprinkle some of them over the part of the paper that is covering the magnets.
4. Observe the pattern that is formed by the filings on the paper. Draw the actual pattern into your science notebook and compare it to your predicted pattern.
5. Carefully pour your iron filings back into your paper cup.
6. Rearrange the magnets so that the north pole of the first magnet is about 5 cm away from the south pole of the second magnet. Draw this configuration of magnets into your science notebook. Then draw your prediction of the magnet fields that you think exist about these two magnets. (see Figure 1)
7. Cover the magnets with the second sheet of paper and, as before, carefully sprinkle some of them over the part of the paper that is covering the magnets.
8. Observe the pattern that is formed by the filings on the paper. Draw the actual pattern into your science notebook and compare it to your predicted pattern.
9. On a paper plate, position several magnets into the pattern of your choosing. In your science notebook, draw your configuration of magnets and make a prediction about the pattern that you think will result.
10. Use a bit of tape to keep the magnets from slipping around. Cover up the magnets with a second paper plate.
11. Now sprinkle iron filings over the surface of the paper plate. Gently tap the paper plate with your finger and the filings will form a pattern of the force around the magnets.
12. Use a spray bottle to cover the paper plate with a fine mist of white vinegar. Allow the paper plate to remain undisturbed for several hours (preferably, overnight) – enough time for the iron filings to rust. Later, turn the paper plate over and brush off the rusty filings.
13. The rust marks will remain on the paper to record the shapes of the magnetic fields around each magnet. (see Figure 2)

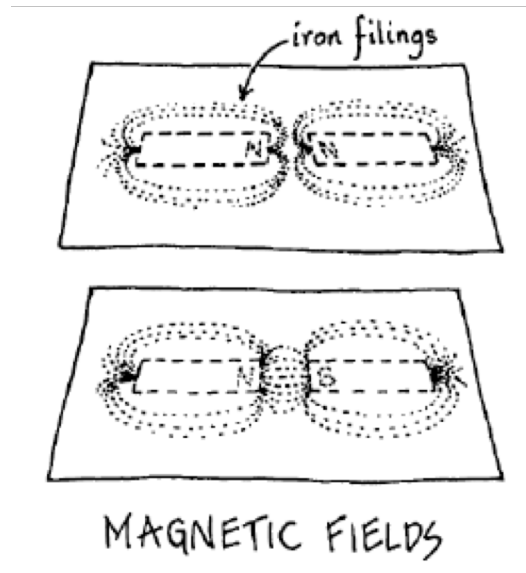


Figure 1: The field patterns that result when bar magnets are placed north-to-north pole (above) and north-to-south pole (below).



Figure 2: Capturing the magnetic fields.

Closure Discussion

1. Would placing the south poles end to end produce a different pattern?
2. Would laying the magnets side by side change the pattern of the filings?
3. Does the shape of the magnet affect the patterns of the filings?



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References

1. <http://www.physicsclassroom.com/class/estatics/u8l4a.cfm>
2. <http://www.indigo.com>
3. <http://coraifeartaigh.wordpress.com/2010/02/27/what-is-a-field/>
4. <http://phet.colorado.edu/en/simulation/electric-hockey>

Extension of Lesson Plan

1. Read about Michael Faraday, a 19th-century English scientist who was the first person to make it possible to visualize magnetic lines around a magnet.



Pre-lesson Reading Magnetic Fields

What is a field?

A field is a physical quantity that has a value for each point in space and time. For example, in a weather forecast, the wind velocity is described by assigning a vector (you can imagine that a vector is just a little arrow) to each point in space. Each vector represents the speed (say, the length/thickness of the arrow) and direction (say, which way the arrow is pointing) of the movement of air at that point.

As an example, look at the wind map below. You can probably tell which way the winds are blowing and where they are blowing the strongest. That is a field!





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What does this have to do with electricity?

Well, electric charges create electric fields. You may recall that like charges repel, while unlike charges attract. These attract/repel forces are relatively familiar. However, the concept of force isn't all that useful if one wants to know the effect of a given electric charge (call it "A") on the rest of the world. We can, though, draw pictures of the field due to "A", simply by drawing arrows representing the direction in which an electric charge will move. (In reference to our wind analogy, we can create our wind field by drawing arrows representing the direction in which a small kite will move.) The usual thing in science is that we draw the direction a positive "test charge" will move. This "test charge" is like our "small kite" in the wind. Given that like charges repel and unlike charges attract, a single positive charge or single negative charge would create the following fields.

