VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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Electromagnetism

Fall 2012

8th grade

(Adapted from Student Guide for Electric Snap Circuits by Elenco Electronic Inc.)

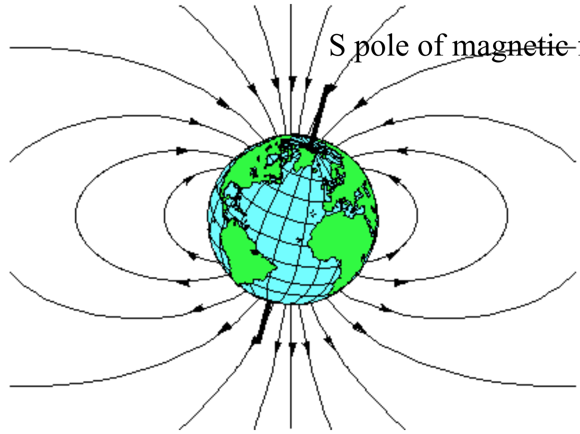
Materials
16 compasses
16 cases Iron fillings
16 paper clips
16 circuit boards with:
- 4 # 2 snaps
- 1 # 1snap
- 1 # 3 snaps
- 1 electromagnet
- 1 switch
- 1 red and 1 black lead
- 1 voltmeter/ammeter
- 1 motor

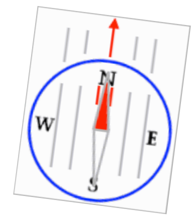
1 magnet
1 red spinner (blade)
1 iron rod and grommet
Observation sheet

Divide class into 16 pairs.

I. Investigating Magnets and Compasses

1. Pick up the compass and notice the direction the needle (red arrow) is pointing.
2. Turn the compass around and look at the direction of the needle.
3. Look at the compass of the students across and next to you and notice the direction of the needles.





http://www.ssec.honeywell.com/magnetic/magpics/earth.gif

The red pointer on the compass is called the **needle** and is a weak magnet. The needle (red arrow) always points to *magnetic north* (near geographic north), which is actually the *south pole* of Earth's magnetic field. The needle will always point north because it is aligned with the Earth's magnetic field (remember that opposites attract, so $N_{compass} \rightarrow S_{magnetic\ pole}$. The Earth is thus similar to a bar magnet. Also, the region of space that is affected by the Earth's magnetic field is called the **magnetosphere**.

4. Take your magnet and hold it above the paper clip. What happens?
5. Now place the magnet in the center of the *Observation sheet* with the red-painted end at the top. Place the compass in the circle above the red (N) end of the magnet and draw an arrow above the circle to show which way the needle on the compass is pointing.
6. Repeat the procedure above (5) for each of the remaining circles.

Your Notes:

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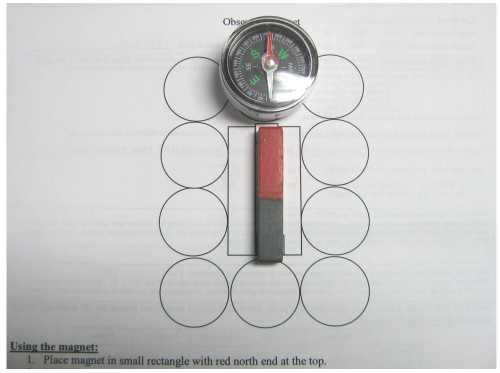


Magnets can attract certain metals such as iron, cobalt and nickel. The needle in the compass is attracted to (the South end) or repelled by (the North end) of the bar magnet. The needle changes direction as it is moved around the magnet, but the red-painted end of the needle always points in the same direction as the North end of the magnet. The magnetic force exerted by a magnet acts around that magnet in all directions (think 3-D).

All magnets have the same properties:

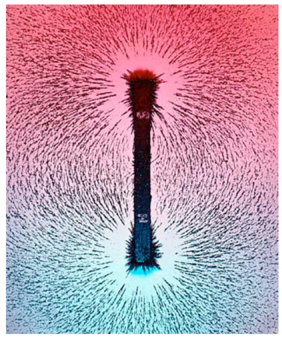
- All magnets have 2 magnetic poles. The poles are the places where its magnetism is strongest. The poles in the bar magnet are at the ends. One is labeled **N** (this end is attracted to the earth's north magnetic pole) and the other **S** (points south).
  - If the **N** pole is brought close to the **N** pole of a second magnet they will repel each other, the same is true for 2 **S** poles brought together. Additionally, if the **N** pole of one magnet is brought close to the **S** pole of another magnet, they will attract each other.
- All magnets have a magnetic field, which can be visualized using iron filings (see image below)

Ask the students: Suppose I gave you two magnets, one that is labeled with **N** and **S** (show them the magnet with the painted red end), and one that is not labeled or painted. How could you figure out which pole is **N** and which pole is **S** on the bar magnet without labels?

Your Notes:

Answer: *Using the labeled magnet; If the **N** end of the labeled bar magnet, is repelled by the pole of the unlabeled magnet then it is the **N** end of the unlabeled bar magnet, and so on.*

7. Gently shake the iron filings pack so that the filings are spread evenly and thinly
8. Place the magnet on top of the pack and notice how the filings produce a distinct pattern.



The pattern you see shows the magnetic field of the magnet. The field has areas of strong and weak magnetism.

II. Making an Electromagnet with Electricity

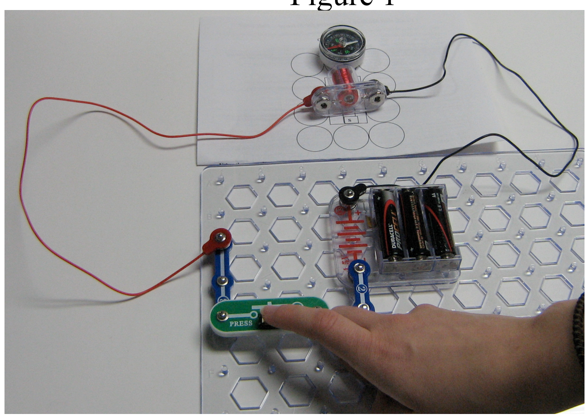
An electromagnet is made by wrapping copper (the metallic reddish-colored) wire around a coil. It generates a magnetic field when an electric current passes through it. An iron rod placed inside the coil will increase the magnetic force.
Important: Electromagnets differ from permanents magnets in that they have an inducible or **temporary** magnetic field. Their magnetic field can be turned off by removing the electric current.

1. Look at the electromagnet.
2. Build the circuit shown in **figure 1** below (The students can see it on the *Instruction sheet)*.
3. Make sure the switch is in the **OFF** position. Hold the paper clip close to the top of the iron rod in the electromagnet. Is there any magnetic attraction? *No.*
4. Turn the switch **ON** and repeat step 3. Is there any magnetic attraction? *Yes, the paper clip is attracted to the electromagnet.*

Your Notes:

5. Turn the switch **OFF** and notice what happens. *The paper clip is no longer attracted.*
6. Place the paper clip near the rod under the electromagnet and notice what happens when the switch is turned **ON**.
7. Place the electromagnet, on its side, in the center of the larger rectangle on the *Observation sheet*. The top of the electromagnet should be at the end labeled N.
8. Place the compass in the top circle and turn the switch **ON**. Record the direction of the needle.
9. Repeat at the different circles around the electromagnet and note that the needle changes direction.

Figure 1



How is the magnetic field around the electromagnet similar to that found around a magnet?

It looks the same.

*The electric current flows only when the switch is closed (**ON**). The electromagnet is magnetic only when the current is flowing.*

III. Making Electricity with Magnets

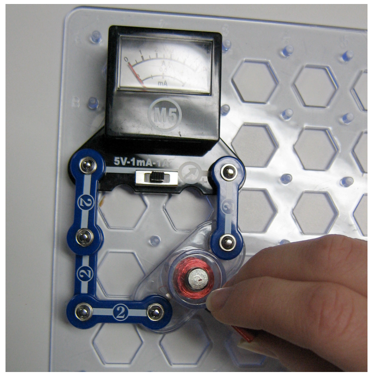
Show students the meter and tell them that it is capable of measuring both current and voltage.

Your Notes:

The 5V setting measures voltage, and the 1mA and 1A settings measure current.
Voltage is measured in volts (V).
Current is measured in amperes (A) or milliamps (mA, 1/1000 of an ampere).

Build the circuit shown in **figure 2** on the *Instruction sheet*. (Do not place the rod into the core yet.)

Figure 2



1. Set the meter to the middle setting, 1mA. (The current produced by the circuit you have built will be very small, and will not be detected with the 1A setting.)
2. Place the board flat on the table surface (you are going to be looking for small movements in the meter needle, so the board needs to be stable).
3. Hold the bar magnet against the coil (vertically or horizontally) and move it up and down or across back and forth (see **figures 3 & 4** below). Observe the meter needle while moving the magnet. Very small movements will be detected.
4. Place the iron core rod into the coil and repeat. The meter needle movement will be larger.
5. Place the magnet on the top of the rod and use it to move the rod up and down.

Your Notes:

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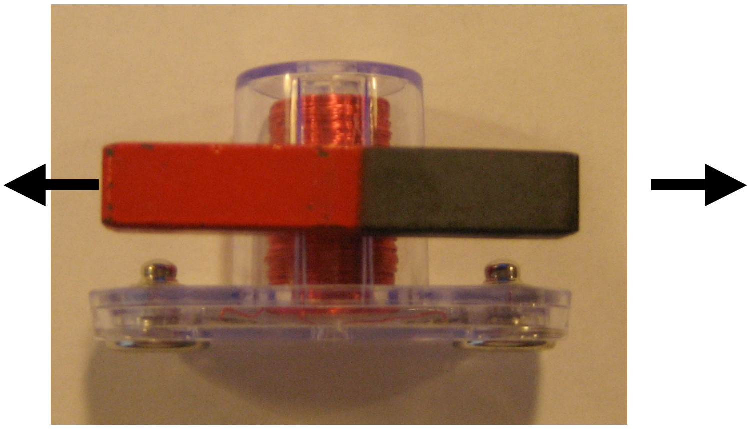

Figure 3

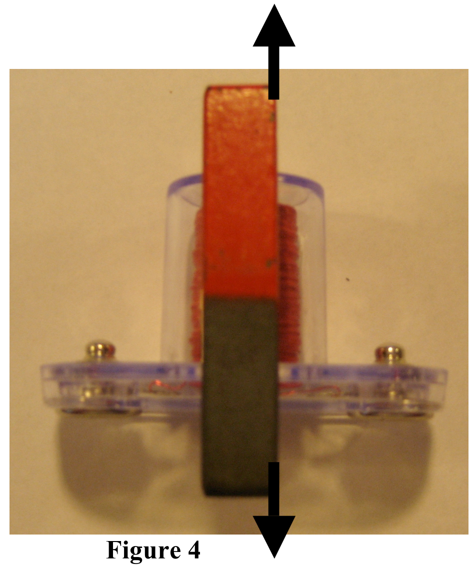

Figure 4

- The movement of the meter needle indicates that a small current is being produced.
- Remember that NO batteries are being used – the electric current has been induced by the movement of the bar magnet and copper wire coil.
    - This occurs because electric fields and magnetic fields always occur together, hence electromagnetic spectrum (EM spectrum).
    - Since electric and magnetic fields always occur together, altering or inducing one will cause a change in the other.
    - EM spectrum refers to the range of energy waves known to man, which range from Gamma to visible light to radio waves, just to name a few.
- Moving the bar magnet changes the magnetic field around the coil. This change produces an electric current. Alternatively, the coil could be moved instead of the magnet, and an electric current would still be produced.

IV. Using a Motor to Make a Generator

Electric motors utilize the principles of electromagnetism to operate.

1. Build the circuit shown in **figure 5** in the *Instruction sheet*.
    - Note how the positive and negative sides of the motor are oriented.
2. Set the meter to 1mA (you will be detecting small currents).

Your Notes:

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3. Turn the motor (gently) clockwise with the tip of a finger and observe the movement of the meter needle.
4. Now spin in the opposite direction, and note the movement of the needle.

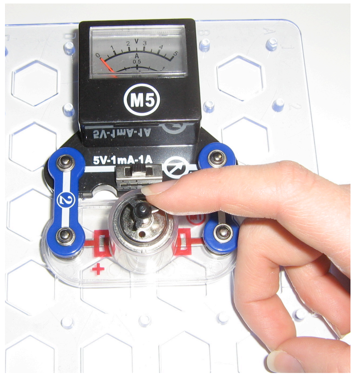

Figure 5

The needle wants to move in the opposite direction. The motor needs to be flipped around to measure current if the motor is turned in a counter-clockwise direction.

Generators are used to produce electric current by changing magnetic fields. They can be small to produce electricity for a single house, or large to create electricity for cities. Hydroelectric power plants use turbines (acts like a giant water-wheel) to turn coils, or magnets, in generators. Turbines are turned by flowing water (at dam sites), rising steam (at coal burning sites), wind (windmill farms), or other sources.

The electricity is produced by converting **mechanical energy** (water moving the turbines) into **electrical energy.** Generators also typically produce alternating current, or AC, which is the same form of electricity that an electrical outlet in a house provides.

V. Using Electricity to Run a Motor

Your Notes:

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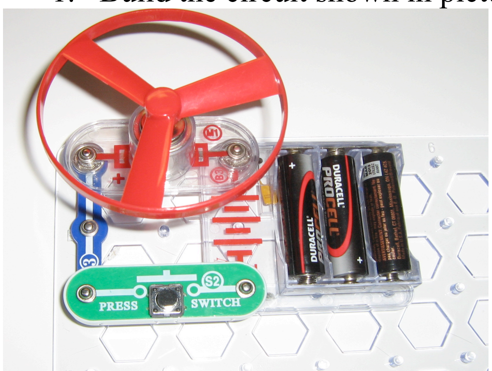
Motors are more commonly used to convert electricity to mechanical energy. Motors is the opposite of an electromagnet.

A motor has 3 parts.

1. A fixed magnet that cannot move (it is on the shell of the motor).
2. A coil of wire (an electromagnetic coil) attached to a moveable shaft.
1. Build the circuit shown in picture #6 in the *Instruction sheet*.



   a. Do not add the fan yet.
   b. Make sure the positive side of the motor is on the correct side.

2. Turn the switch **ON,** and note that the blade of the motor is turning.
3. Attach the blade to the motor and repeat. Turn the switch **OFF** when the motor reaches full speed.

Why does the blade float off in the air?

Your Notes: