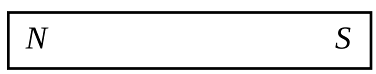
Introduction

This material corresponds with Hecht, Chapter 19. In this lab you will focus on the concepts of magnetism and magnetic fields. It is a good idea to read all the steps in each part before you start. Note that there is only one setup for Experiments C and D. Make sure you make time to visit that station during the course of your lab period. Make sure that everyone in the group has a chance to play with the hands-on item at each station.

Pre-Lab Homework

1. Find two refrigerator magnets (preferably the rectangular flat ones).
   (a) Does the orientation (rotation, flipping, etc) of the magnet affects whether it is attracted to your refrigerator?
   (b) What materials are the magnets attracted to? (Try various metals such as iron, stainless steel, aluminum, etc.)
   (c) Do the two magnets attract each other? With the magnetic sides facing each other, slide one magnet over the other. Do you notice anything strange? Now, rotate one of the magnets 90° and slide them over each other again. Is there a difference in the strength of the magnetic interaction after the rotation? Can you explain your observations?

2. For the permanent magnet shown below, draw the resulting magnetic field lines.



   What happens to the North and South poles if you break the magnet in half? Label the appropriate North and South ends for each half. What if you break each piece in half again? And again and again until you get to what the Greeks called 'the indivisible' or the atom? Can each atom act as a magnet? Use an arrow → to represent the magnetic dipole pair *S-N*. Sketch the atomic dipoles inside your original unbroken magnet.

3. For ferromagnetic materials, such as iron or steel, explain the difference on an atomic level between momentary attraction and a more permanent magnetized state. (An example of momentary attraction is getting a bit of iron to "stick" to a permanent magnet and returning to a non-magnetic state when the permanent magnet is removed. An example of a permanent magnetized state is when a permanent magnet has been used to magnetize some iron, so even when the original magnet is removed, the iron still acts a magnet with other metals.)

4. A long wire carrying a current of 1 Amp is stretched horizontally at 30° East of North where the Earth's magnetic field is 0.5×10^{-4} Tesla. What is the direction of the magnetic field due to the current-carrying wire below the wire? A small compass is placed 1 cm below the wire. Determine the equilibrium direction (i.e., angle) of the compass needle. (Hint: This is just a vector addition problem where you need to find the angle of the resultant vector.)

Experiment A: Magnet and Iron Filings

Materials:

- A plastic sheet
- A container of iron filings
- A few magnets (bar, circular, and flat)

Procedure:

1. Place the bar magnet under the plastic sheet.
2. Sprinkle some iron filings on the plastic sheet. You may need to tap the sheet a bit to move the filings toward the magnet.

Questions:

A1. Draw a sketch of what you see with the magnet and iron filings.
A2. Is there a pattern to what you see? What do you think causes this?
A3. Why do you use a plastic sheet?
A4. Find a circular magnet and a refrigerator magnet at your table. Place each of these under the plastic sheet and sketch what you observe.

Experiment B: Oersted's Law

Materials:

- Compass
- Battery in battery holder with wires attached to the battery holder

Procedure:

1. Move any magnets away from the compass, and line up the compass needle due North.
2. Place the battery in the battery holder, but *unclip* the wires so they are not connected.
3. Stretch the wire over the compass so that the wire is running from North to South.

Questions:

B1. With the wire over the compass, do you see any significant change in the position of the compass needle? If so, what is the new position?
B2. Now, clip the wires together to complete the circuit. Connect the wires briefly since this will generate a large current and drain the battery quickly. Do you see any change in the position of the compass needle when the current flows? If so, what is the new position?
B3. Lift the wire up further away from the compass. Again, clip the wires together to complete the circuit. Do you see any change in the position of the compass needle? If so, how does the position of the compass needle change as you lift the wire away from the compass?
B4. Put the compass *on top* of the wire and connect the wires together. Do you see any change in the position of the compass needle when the current flows? Does it deflect in the same direction as B2?
B5. What caused the needle to deflect from the North?

Experiment C: Magnetic "Toys"

1. At this station, there are several common "toys" involving magnetism. Look at each and explain how each toy works.
2. This station also contains a sample of a ferrofluid in a beaker. Holding various magnets on the outside of the container, observe and describe the properties of ferrofluid.

Experiment D: "Newton's Folly" and 3-D Magnetic Fields

1. There are two separate items at this station. The first is a clear plastic block, with a cylindrical opening through it, is filled with a viscous fluid and iron filings. There is also a bar magnet that fits through the opening.
2. The second item at this station is "Newton's Folly."

Questions:

Examine the two setups and for each give a brief description of the following:

- What you observe happening
- The physics that is occurring