Name _____
Recitation 8:30 11:00 12:30
You can earn up to 20 points based on your participation and written work.

Magnets -- Fields, and the Right Hand Rule.

Warning -- be careful not to let iron filings touch the magnets. They stick really well! You may wish to use the iron filings on the floor instead of your desk.

Activity 1 -- Drawing a magnetic field.
Equipment: magnet, compass, paper, iron filings

Step 1.0 -- Orientation.

The easiest magnet to keep track of during this experiment is the earth. A compass is a magnet, suspended so it can swing around. With your compass far from other magnets, determine which end of the compass needle points north. This is the north pole of the compass. (It may, or may not, be the end with the "N", and the end that points north may be changed by close proximity to stronger magnets, so you may wish to re-check this later on!)

Question 1.0 -- Is the earth's geographic north pole a magnetic north pole, or is it a magnetic south pole? Briefly explain your reasoning.

Step 1.1 -- More Orientation.

Use the compass to find your magnet's north and south poles. *(You may use a piece of tape to mark the north pole, but be sure to remove the tape before you return the magnet.)* Use a couple pictures to describe your technique.

Step 1.2 -- Drawing magnetic field lines.

Place your magnet on the table and cover it with a piece of paper. Trace the outline of the magnet on the paper so you know how it is oriented. Sprinkle a modest amount of iron filings on the paper so you can see a pattern form. It may help to lightly tap the paper.

Quickly sketch the shape of the pattern formed by the iron filings in the space below. Remove the paper and use it as a funnel to pour the iron filings back into their storage container. Repeat this for one of the small segments of your magnet.

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Question 1.2 -- Is there any way to tell, from the iron filings, the difference between a north and a south pole?

Step 1.3 -- Adding direction to the magnetic field lines.

It is conventional to draw magnetic field lines with arrows that point in the same direction as the north pole of a compass placed in the field. Label the poles of the magnets in your sketches, and add arrows as appropriate.

Question 1.3 -- Do field lines begin near the magnet's north pole, or end near it (which)? Do they begin or end near the magnet's south pole?

Activity 2 -- Forces on moving charges in a magnetic field (aka "thinking through a Right Hand Rule")

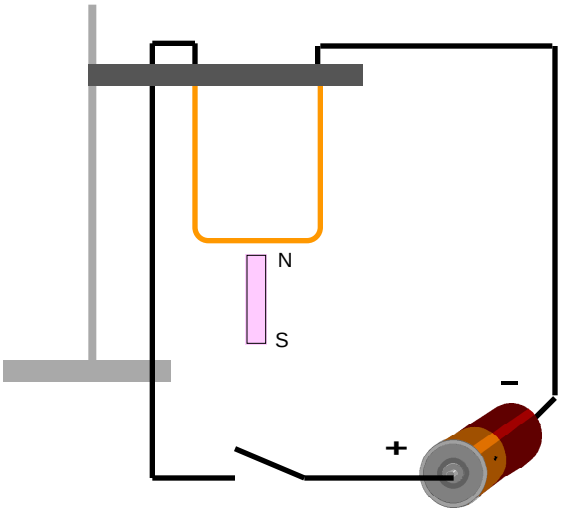
Equipment: 6-V Battery set, Large bar magnet, Compass, Support stand, U-shaped wire with plastic support rod, Key switch, Banana leads

Question 2.0 -- Does the magnet attract or repel the copper wire?

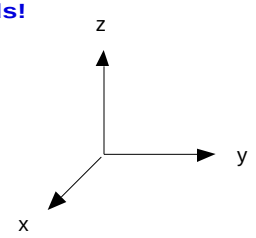
Step 2.0 -- Build the circuit pictured here.

Be sure that the key switch is part of the circuit. Hold the magnet vertically directly under the U-shaped wire, with the north pole pointed up.

Step 2.1 -- When the wire is hanging without swinging, briefly close the key switch and describe what happens. *(HINT: You may be able to develop a "rhythm" to make the effect easier to observe!)*



The switch should only be closed for a couple of seconds!



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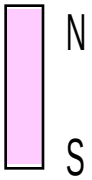
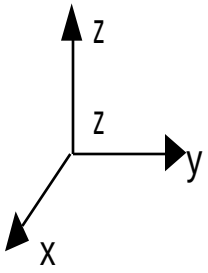
Step [redacted]n below, add appropriate magnetic field lines for this magnet. Add a "+" and a "-" to [redacted]de of the wire is attached to the positive terminal of the batteries and which is attac[redacted]e terminal. Indicate the direction of the force acting on the wire.





Step 2.3 -- Inside the wire, negative charges (electrons) are moving from regions of low potential to regions of higher potential. Indicate on the drawing above the direction of the electron flow $\vec{v}$ in the wire when the switch is closed. (Note! the electrons flow in the opposite direction to the "current" I. This confusing contradiction can be traced back to Ben Franklin, who assumed--incorrectly--that it was moving *positive* charges that make an electrical current.)

Step 2.4 --Using the + and - x, y, and z directions shown in the diagram, identify the directions of the following vectors:

- Magnetic field $\vec{B}$
- Force on wire $\vec{F}$
- Velocity of electrons $\vec{v}$.

Step 2.5 -- **Repeat** this experiment with the south pole of the magnet closest to the wire. Describe what happens. Make a sketch and identify the directions of the following vectors: Magnetic field $\vec{B}$, Force on wire $\vec{F}$, and Velocity of electrons $\vec{v}$.

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Scientists often talk about the right-hand rule when it comes to describing the relation between the directions of the magnetic field, velocity of a charged particle, and the resultant force vectors. One common text book suggests:

> *To find the direction of force, place the fingers of your open right hand in the direction of* $\vec{B}$ *and point your thumb in the direction of the velocity* $\vec{v}$. *The force* $\vec{F}$ *on a positive charge is directed out of the palm of your hand.*

Step 2.6 -- Compare your data from the Exploration to this right-hand rule. Do they agree? If not, why not? How can you ***modify*** the rule to agree with your data? Write out a complete statement of your modified right-hand rule.

Step 2.7 -- Use your rule to predict what would happen if you held the magnet *inside* the wire loop, with the North pole pointing up.

Bonus Activity (worth up to five points if all the activities above are finished) -- Use the compass to explore the magnetic field surrounding the wire loop with no other permanent magnet nearby and describe what you find.

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