8. Introduction to Magnetics

Name:______________________________ Section:_________________________

Objectives

1. To use a compass to determine the presence and direction of magnetic fields.
2. To observe the interaction between stationary charge and magnetic fields.
3. To use the idea of a solenoid or inductor to create a voice coil.
4. To construct a speaker using a voice coil, magnetic, and a Styrofoam plate.

Equipment

1. Power Supply (5V, 12V, -5V, etc…)
2. Clear coloured compass,
3. Ruler,
4. Solenoid (outer coil),
5. Bar magnet (silver with north and south marked),
6. Two 2Ω power resistors, 25W,
7. PVC pipe
8. Wool cloth
9. Paper clip
10. 3m length of enameled wire
11. Styrofoam plate
12. 2 Neodymium magnets
13. Scotch tape (1 per set of benches)
14. Scissors (1 pair per set of benches)
15. Hot Glue Gun (two for the lab)

Experiment

1. Given the current carrying conductor in Figure 1, indicate the direction of the magnetic field, B, by drawing an arrowhead on the dashed circle.

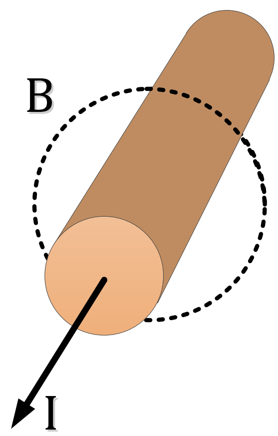


Figure 1: Current carrying wire with its induced magnetic field

2. Wire up the circuit in Figure 2 and use your compass to confirm the direction of the magnetic field. The resistors are 2Ω power resistors and they can become quite hot, so be careful. Use a long banana lead as the wire in Figure 2. You will need a variable power supply, which has been provided, but they are in limited number and must be shared between lab benches. You will probably only get about 3 Amps of current from the supply. You can observe the magnetic field by holding the wire over the compass and moving the wire around. **Sketch in the orientation of the compass needle next to the wire on both sides, the current flowing through the wire, and the direction of the induced magnetic field around the wire.**

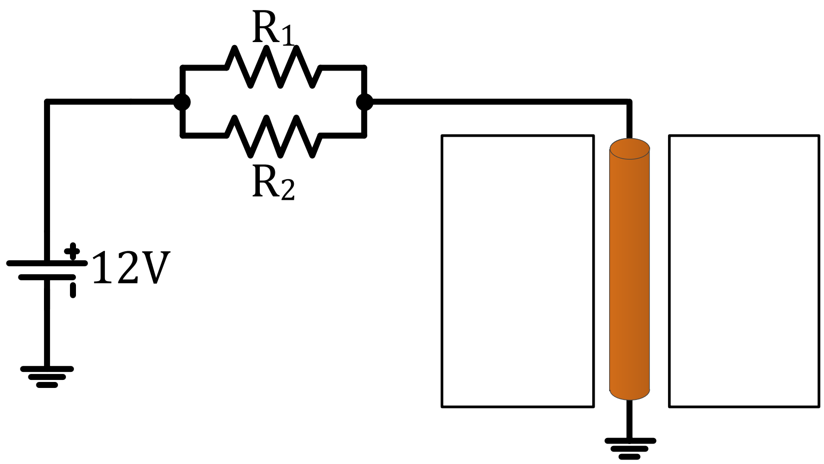


Figure 2: Experimental setup to measure the magnetic field around a current carrying conductor.

3. Indicate **the direction of the magnetic field**, B, inside the coil for the configuration in Figure 3.

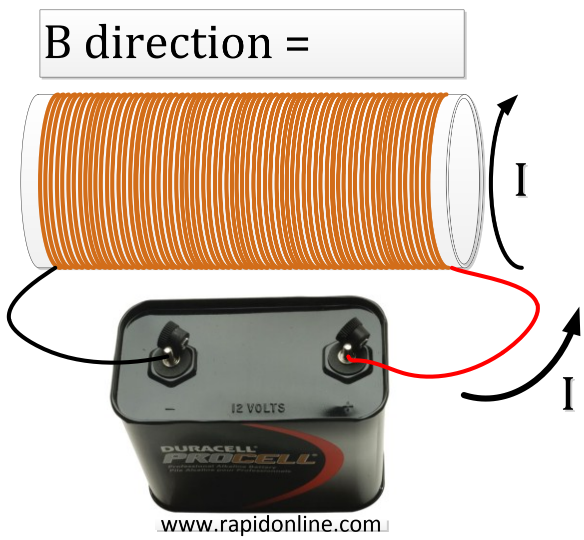


Figure 3: Solenoid Configuration.

4. The magnitude of the magnetic field inside a solenoid is given by

$$|\vec{B}| = \mu_0 \mu_r \frac{NI}{length}$$

Where B is the magnetic field, μ_0 is free space permeability, μ_r is relative permeability, N is the number of turns, I is the current in the conductor, and *length* is the length of the solenoid.

A coil is provided for you at your lab bench. It is 11 cm long and has, let's say, 1200 turns; calculate the **magnitude of the magnetic field** that would be induced with a current of 5 Amps. ($\mu_0 = 4\pi \times 10^{-7}$ T·m/A)

5. Wire up the coil in place of the wire from the circuit of Figure 2. Use the compass provided to determine the the following items and sketch them on the cross section of Figure 4.

   a. The orientation of the compass needle inside the coil.

   b. The orientation of the compass needle outside of the coil.

   c. The direction of the current flow.

   d. The direction of the induced magnetic field.

Note, if the compass seems unaffected when used to measure a field, than it is responding to the Earth's magnetic field only. Indicate this by writing 'unaffected" in the circle. Also, the magnetic field can be altered by materials near the coil that can become magnetized.

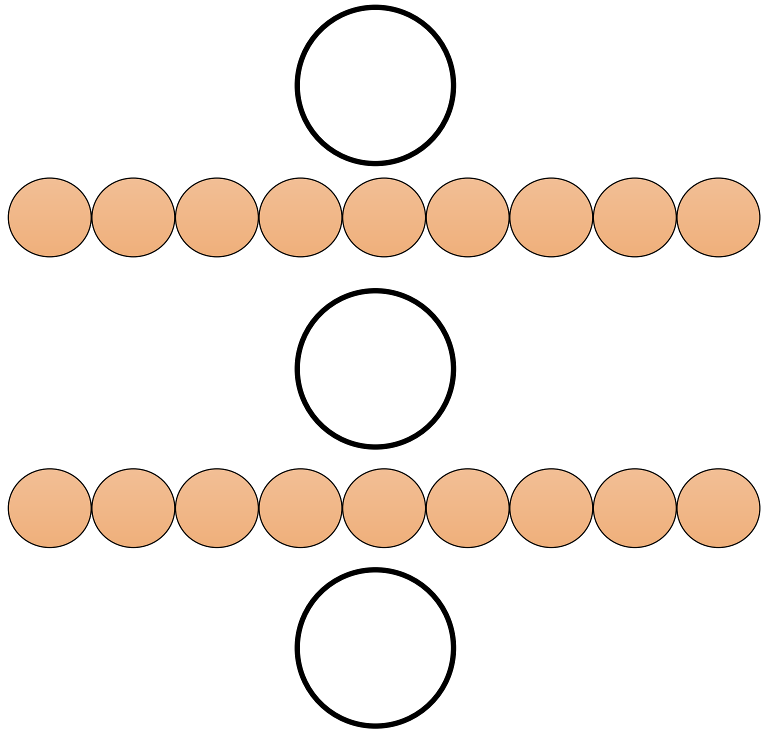


Figure 4: Solenoid cross section. Smaller circles represent current carrying conductor cross sections and the larger circles represent the compass.

6. Take your PVC pipe and use a wool cloth to charge the pipe. Bring the pipe close to the **clear coloured** compass. Explain your observations when the pipe is stationary and when it is moving. **Note, the black compasses will not work.**

Stationary:
Moving:

7. Take your bar magnet and bring the North end near a paper clip. Does it attract or repel the paperclip?

8. Take your bar magnet and bring the South end near a paper clip. Does it attract or repel the paperclip?

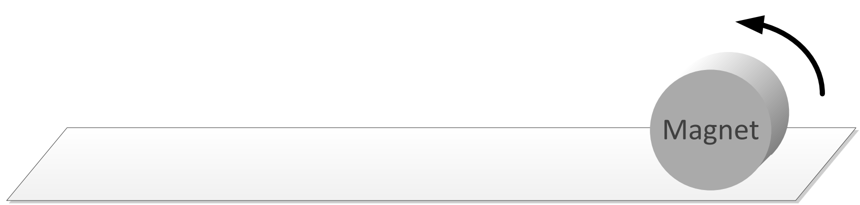
9. The paperclip is said to become magnetized in the presence of the magnetic field of the bar magnet. What other effect have you previously observed that is similar (think of how insulators behave near charge)?

Application - Speakers

There is a fully constructed speaker in the lab for you to reference as you create your own speaker.

1. Take a sheet of 8 ½ x 11 inch paper and cut two strips 17 mm wide by 280 mm long (11 in.).

2. Wrap one of your strips around the circumference of the magnet and secure it with Scotch tape.

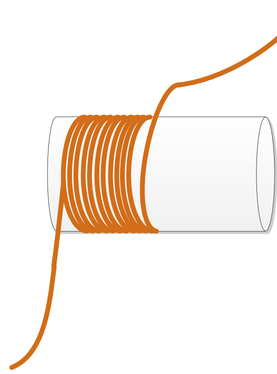


3. Remove the magnet from the center of the paper cylinder you have created.

4. Wrap a second strip of paper around the circumference of the first strip and secure it with Scotch tape.

5. Take a piece of Scotch tape and wrap it sticky side out around the paper cylinder. This will allow you to wrap your wire onto the cylinder without it falling off.

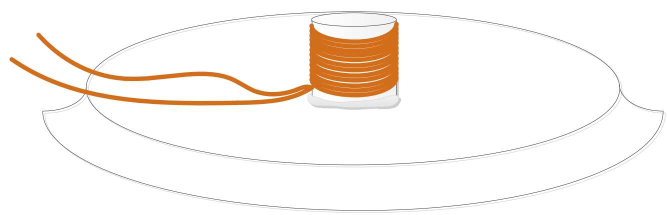
6. Take your length of enameled wire, leaving about 25 cm free. Begin wrapping it around the paper cylinder. The tape will hold the wire onto the cylinder. Keep the turns tight together while you wrap. Keep making turns until about 25 cm of wire is left. When you are done wrapping the solenoid, secure the windings with a piece of Scotch tape.



7. Remove the inner paper strip from the cylinder.

8. Trim the cylinder so that there is no excess paper. Careful, don't cut the wire!

9. Take the styrofoam plate and hot glue the cylinder onto the back of the plate **as close to the center as possible**.



10. Take a look at a sample speaker and see how the business cards are supporting the plate when it is inverted with the coil on the bottom. Take the business card provid-ed at your bench and cut some strips that can be folded to support the plate.

11. Hot glue these supports to the back of the plate opposing each other and offset half way between the center and one side.

Take your speaker to the lab instructor to test it.

Instructor or TA signature ______________________________