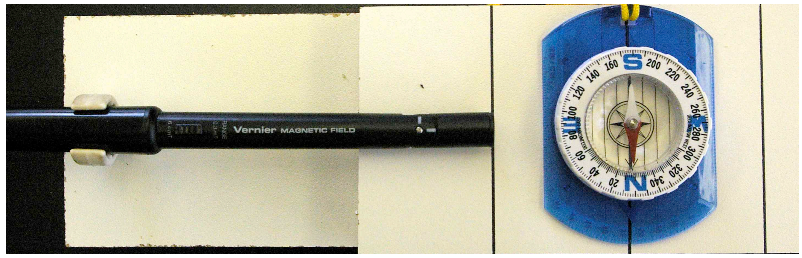
# Magnetism Experiments

## Experiment 1 - Magnetic Field Strength, Bar Magnet

This experiment is designed to allow you to determine how the strength of the magnetic field due to a pole of a bar magnet varies with the distance from the pole.




In this experiment, you will measure the strength of the magnetic field at varying distances from the north pole of the bar magnet, allowing you to determine the relative strength of its magnetic field.

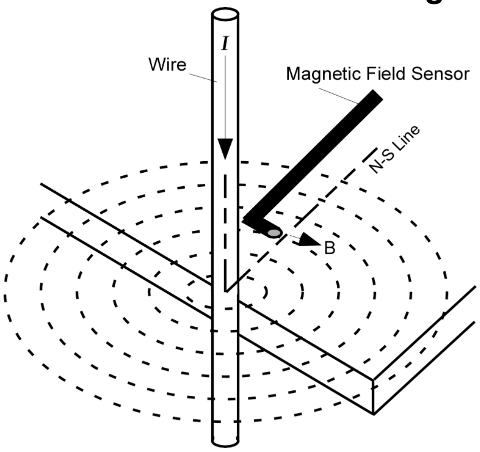
Place the apparatus on the table at a location that is unlikely to be affected by ferrous materials like steel table or chair legs or frames, and away from any electrical wires that might be carrying currents. You should use the compass to determine the N-S line of the earth's magnetic field and align the apparatus so that it is perpendicular to this line. The

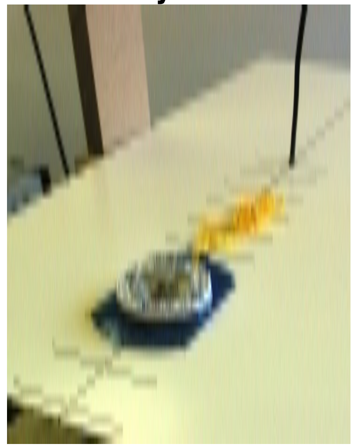
photo above shows the appropriate orientation of the apparatus. The white dot on the end of the magnetic field sensor marks the position of the actual sensing mechanism. You should place the magnetic field sensor at your zero position and check to see that the sensitivity switch on the sensor is set to 6.4 mT. Open the file ***Magnetic Field of a Bar Magnet***. With the magnet far away from the sensor, ZERO the force sensor. After you have zeroed the sensor, and move the north pole of the magnet to a position 10.0 cm from the sensor, perpendicular to your north-south line, and parallel to the body of the sensor as shown below.

Hit the COLLECT button. Then hit the KEEP button. The computer will collect data for 10 s, average the readings, and then prompt you to enter the distance that the magnet is from the sensor. Enter this value (in meters). When the computer has accepted the data point, move the magnet 5.0 cm further from the north pole of the magnet to a position of 15.0 cm. Hit the KEEP button again and record the distance away. Continue this process until the north pole of the magnet is 40.0 cm away from the sensor. After entering the last distance reading, hit STOP.

This process will generate a data table with magnetic field strength readings and distance readings. Save the file with a different name (including your name) in the DOCUMENTS folder and on your flash drive. Set up the graph(s) and perform the appropriate mathematical analysis of the data to determine the relationship between the magnetic field strength of the bar magnet and the distance from it.

## Experiment 2 - The Magnetic Field of a Long Straight Wire--
## How does the Magnetic Field vary with Distance from the wire?

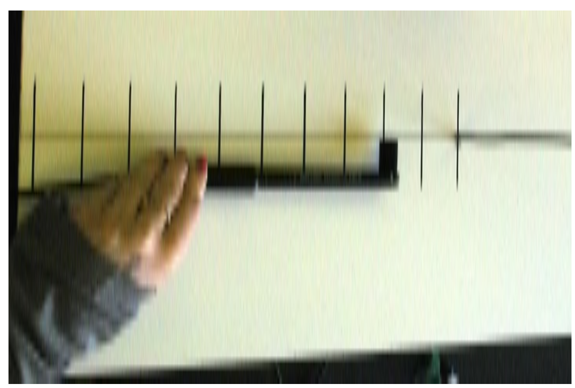


In this experiment you will attempt to determine how the magnetic field created by a current carrying wire varies with the distance from the wire. The magnetic field due to a wire encircles the wire as shown in the diagram above left.

The magnetic field sensor will be placed along the north-south line of the earth's magnetic field. Since the magnetic field around the wire is circular, if the body of the sensor is placed along the N-S line but with the sensor head rotated perpendicular to the line, the earth's field and that of the wire will be perpendicular to each other. With this arrangement, the magnetic field of earth will have little effect on the magnetic field sensor, so we will be primarily looking at the magnetic field due to the current carrying wire. Be sure to orient the apparatus so that the main line on the whiteboard is oriented along the north south line.

Set the equipment up as shown to in the photo above right. Be sure that the wire is vertical in the apparatus, and stretched fairly tight. Set the apparatus on the edge of the table as far away from current carrying wires and ferromagnetic materials as possible. For this experiment the power supply, ammeter, and rheostat (variable resistor) will be connected in series with the long wire. Set the rheostat to the highest resistance value. Use the digital ammeter set at the 20.0 A setting and make sure that the leads are connected to the 20 A and COM ports on the meter.



You will place the magnetic field sensor at varying distances from the wire. The horizontal whiteboard platform is marked with a north-south line, with perpendicular marks in increments of 3.0 cm from the wire. The tip of the sensor should point in the direction of the field that will be created by the current in the wire.

Set the switch on the sensor to the 0.3 mT position. Open the file ***Magnetic Field vs. Distance***. Place the sensor at the 3 cm mark and ZERO the sensor before turning on the power supply. Turn on the power supply and vary the voltage of the power supply until the current in the wire is 5.00 amperes (or the maximum value your power supply will allow if it won't reach 5 A). To minimize the heating of the wire and rheostat, *the power supply should only be turned on when you are collecting data*. Once the current is set with the sensor at the 3 cm position, hit the COLLECT button. Then hit the KEEP button. It is important that you hold the sensor and the platform very still during the data collection process. The computer will collect data for 10 s, average the readings, and then prompt you to enter the distance that the sensor is away from the wire. Enter this value (in meters). When the computer has accepted the data point, move the magnet 3.0 cm farther from the wire to a position of 6.0 cm. Hit the KEEP button again and record the distance away. Continue this process until the sensor is 24.0 cm away from the sensor. After entering the last distance reading, hit STOP.

This process will generate a data table with magnetic field strength readings and distance readings. Save the file with a different name (including your name) in the DOCUMENTS folder and on your flash drive. Set up the graph(s) and perform the appropriate mathematical analysis of the data to determine the relationship between the magnetic field strength around a wire and the distance from it.

## Experiment 3 - The Magnetic Field of a Long Straight Wire--
### How does the Magnetic Field vary with the Current in the Wire?

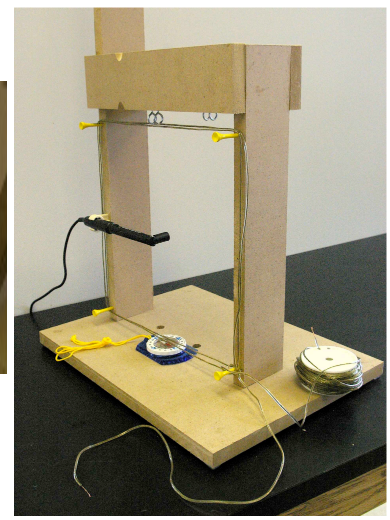
This experiment uses the same apparatus and setup as experiment 2. Open the file ***Magnetic Field vs. Current***. In this experiment, you will keep the distance from the sensor to the wire constant at 3.0 cm and vary the current in the wire in increments of 0.50 A, from zero to 5.00 A (or as close as you can get if your power supply won't reach 5 A).

Set the magnetic field sensor to the 0.3 mT setting. Place the magnetic field sensor so that the tip of the sensor points in the direction of the field that will be created by the current in the wire, at a distance of 3.0 cm from the wire. ZERO the sensor before turning on the power supply.

After you have zeroed the sensor, hit the COLLECT button. Then hit the KEEP button. The computer will collect data for 10 s, average the readings, and then prompt you to enter the value of the current in the wire. Enter zero. When the computer has accepted the data point, turn on the power supply and change the potential difference so that the current becomes 0.50 A. Hit the KEEP button again and record the current. Continue this process, increasing the current in increments of 0.50 A until the current in the wire is 5.00 A. After entering the last current reading, hit STOP.

This process will generate a data table with magnetic field strength readings and currents. Save the file with a different name (including your name) in the DOCUMENTS folder. Set up the graph(s) and perform the appropriate mathematical analysis of the data to determine the relationship between the magnetic field around the wire and the current in the wire.

## Experiment 4 - The Magnetic Field of a Coil of Wire--
### How does the Magnetic Field vary with the Current in the Wire?



The magnetic field inside of a coil of current carrying wire is perpendicular to the cross section of the coil. The direction of this field can be determined via the application of the right hand rule. Try this, and determine the direction of the field of the coil for both clockwise and counterclockwise currents.

Set up the equipment as shown in the photo to the right. Set the apparatus on the edge of the table as far away from current carrying wires and ferromagnetic materials as possible. Align the plane of the coil with the north-south line of the earth's magnetic field (as determined with a compass.

For this experiment the power supply, ammeter, and rheostat (variable resistor) will be connected in series with the long wire. Set the rheostat to the highest resistance value. Use the digital ammeter set at the 20.0 A setting and make sure that the leads are connected to the 20 A and COM ports on the meter.

Set the magnetic field sensor to the 0.3 mT setting. Open the file ***Magnetic Field vs. Current***. With no current in the coil, center the magnetic field sensor inside the coil with the tip of the sensor pointing perpendicular to the plane of the coil. Wind <u>three turns</u> of wire around the golf tees in a square pattern as shown. Set the rheostat to its maximum resistance. *The power supply should <u>only</u> be turned on while you are collecting data to avoid overheating the wires and rheostat*. After you have zeroed the sensor, hit the COLLECT button. Then hit the KEEP button. The computer will collect data for 10 s, average the readings, and then prompt you to enter the value of the current in the wire. Enter zero. Turn on the power supply and adjust the voltage of the power supply until the current reads 0.50 A. Then hit the KEEP button. The computer will collect data for 10 s, average the readings, and then prompt you to enter the value of the current in the wire. Enter this value. When the computer has accepted the data point, change the potential difference so that the current becomes 1.00 A. Hit the KEEP button again and record the current. Continue this process, increasing the current in increments of 0.50 A until the current in the wire is 5.00 A. After entering the last current reading, hit STOP.

This process will generate a data table with magnetic field strength readings and currents. Save the file with a different name (including your name) in the DOCUMENTS folder. Set up the graph(s) and perform the appropriate mathematical analysis of the data to determine the relationship between the magnetic field around the wire and the current in the wire.

## Experiment 5 - The Magnetic Field of a Coil of Wire-- How does the Magnetic Field vary with the Number of Turns of Wire?

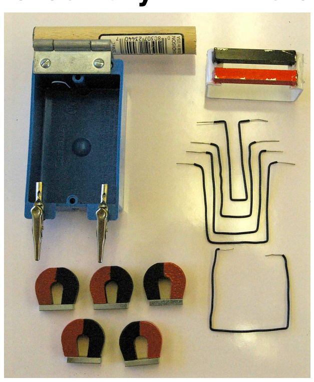
This experiment is essentially the same as experiment 4 except that you will keep the current in the wire constant and increase the number of turns of wire. The equipment should be set up as shown in the diagram. Once the apparatus is properly positioned with the sensor in the center of the coil wind <u>one turn of wire</u> around the frame. Zero the sensor, hit the COLLECT button. Turn on the power supply and adjust the potential difference of the power supply and the resistance of the rheostat until the current reads 2.00 A. Then hit the KEEP button. The computer will collect data for 10 s, average the readings, and then prompt you to enter the value of the current in the wire. Enter this value. When the computer has accepted the data point, add one wrap of wire to the frame. Repeat this procedure, each time adding 1 wrap of wire around the frame.  Continue until you reach 8 wraps. After entering the last current reading, hit STOP.

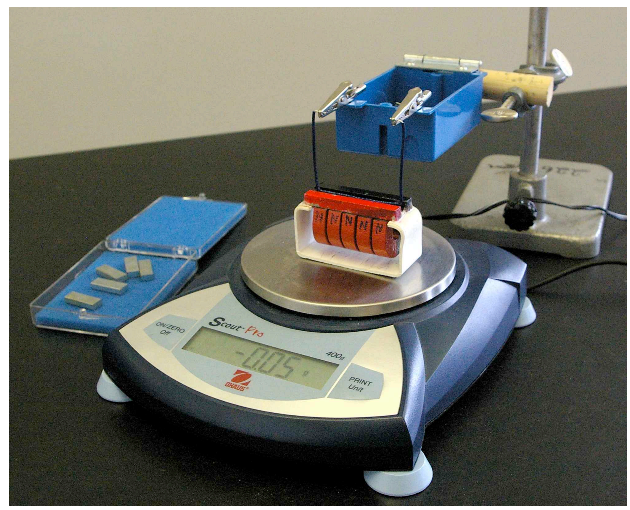
This process will generate a data table with magnetic field strength readings and currents. Save the file with a different name (including your name) in the DOCUMENTS folder. Set up the graph(s) and perform the appropriate mathematical analysis of the data to determine the relationship between the magnetic field around the wire and the number of wraps of wire on the frame.

Use your data to determine the relationship between the number of wraps of wire in a current carrying coil and the magnetic field in the coil.

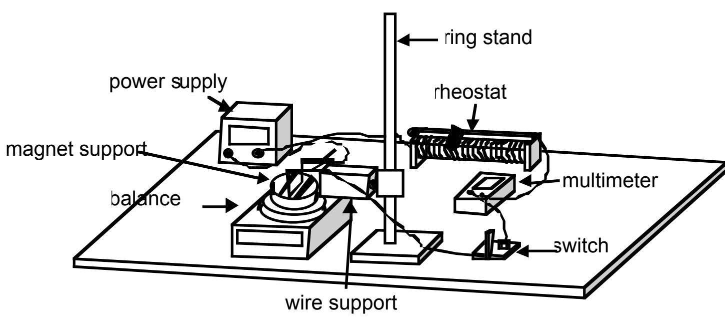
## Experiment 6 - Magnetic Force on a Current Carrying Wire in an External Magnetic Field-- How does the force vary with the current in the wire?

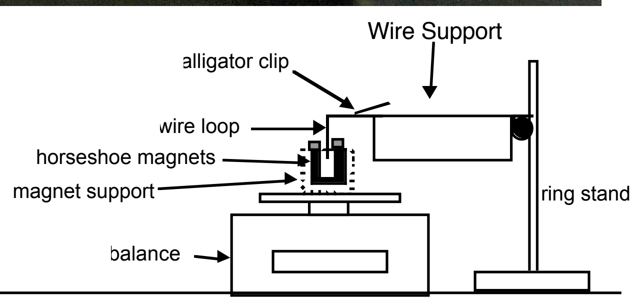
For this experiment, and each of the two that follow, the apparatus shown to the right will be used:
With this apparatus you will be able to control the current in the wire loop, the strength of the magnetic field that surrounds the wire, and the length of the wire that experiences the magnetic force.





You will use the apparatus shown below to test the effects of changing current, wire length, and magnetic field strength on the force experienced by a wire in a magnetic field.




In experiment 6, you should use 5 magnets and the longest wire loop. Be sure that the magnet bank is being forced <u>downward</u> by the current in the wire loop. Be sure to tare the balance <u>before</u> turning on the power supply. It works best if you turn on the balance before adding the magnet bank, and then tare the balance.

Vary the current in the circuit from 0 to 3.0 A in increments of 0.25 A.

## Experiment 7 - Magnetic Force on a Current Carrying Wire in an External Magnetic Field--How does the force vary with the length of the wire?

Vary the length of the loop from the shortest available loop to the longest. Keep the current at around 3.0 amperes and use five magnets. Plot Force vs. Length.

## Experiment 8 - Magnetic Force on a Current Carrying Wire in an External Magnetic Field--How does the force vary with the strength of the magnetic field?

Vary the number of magnets from 0 to 5 magnets. Keep the current at around 3.0 amperes. Use a loop that is one of the middle lengths.

## Writeup Notes:

Requirements for lab report:

1. A brief description of the purpose of <u>each</u> of the experiments
2. A <u>brief</u> description of the procedure for <u>each</u> experiment including the conditions for the experiment.
3. A schematic and physical diagram of the apparatus setup for each experiment. The physical diagrams may be taken (cut and paste) from the lab document if desired.
4. The data and graph(s) for <u>each</u> experiment. Make sure that you indicate the values that were held constant in each experiment. Make your data tables neat and easy to follow. Don't worry about the values of the slopes. We are looking for the general relationships in this set of experiments. We will deal with the constants of proportionality later.
5. A brief conclusion describing the relationships shown for <u>each</u> experiment.
6. An overall conclusion that summarizes and merges the major results of the experiments.