Magnetic Fields
Spring 2017

Introduction

The purpose of this experiment is to observe the magnetic fields of a bar magnet, a coil of current-carrying wire, and a straight current-carrying wire.

Experiment

1. The \( \vec{B} \) field of a permanent bar magnet.
   a. Use the large horseshoe magnet to find the orientation of your compass (Figure 1), taking care not to get the compass too close to the magnet.
   b. Note that the red bar magnets have a ‘bump’ on one end. Use your compass to determine if this is the north or south pole of the magnet. Explain how you determined the magnet polarity. Note that the magnets in the lab may not be oriented the same!
   c. Your instructor will show you how to use a teslameter to measure the \( \vec{B} \) field at each end of your bar magnet (units = Tesla). Also measure \( \vec{B} \) for both poles of the large horseshoe magnet.
   d. Locate the sheet of paper on which there are an arrangement of compasses. Place your magnet in the center of the page, being careful not to disturb the arrangement of compasses. Draw a large sketch like Figure 2 that shows your magnet (label the north and south poles!), the compasses and the direction each compass needle points. Note that there may be more compasses on the page than represented in Figure 2; your sketch should show the actual number of compasses! Keep in mind that each compass needle represents the direction of \( \vec{B} \) at that location.
   e. Rotate your magnet 180° on the page, and note the effect on the compass needle directions.

2. The \( \vec{B} \) field of current carrying coils.
   a. Locate the small vertical coil, surrounded by compasses. With the switch open (no current flowing through the coil), note the direction that each compass points. Close the switch, which will supply a small amount of direct current through the coil. Draw a large sketch of the coil and compasses (Figure 3), the direction of current through the coil side facing you and the direction of each compass. Don’t leave the switch closed too long; the coil will get very warm! Compare the magnetic field around the coil to your sketch of the field around the bar magnet. Open the switch when you’re finished.
   b. Locate the large coil (a solenoid). Use the teslameter to measure the maximum strength of the \( \vec{B} \) field at one end of this coil. Draw a large sketch of the solenoid (Figure 4 – note the direction the wire wraps around the core), including the direction of the current flow in the coil, and the \( \vec{B} \) field.
c. The magnitude of $\vec{B}$ at the end of a solenoid is:

$$B = \frac{\mu_0 NI}{2\ell}$$

where $\mu_0$ is a constant ($12.57 \times 10^{-7}$ N m/A^2), $N$ is the number of turns in the solenoid ($N = 560$ for this solenoid), $I$ is the current (measured on the ammeter; units: A), and $\ell$ is the length of the coil (units: m).

Record $I$, measure $\ell$ (the length of the coiled wire; don’t include the plastic end supports) and calculate $B$ (units: Tesla). Compare this value of $B$ with the value you just measured in step (2b).

d. Algebraically solve the equation above for $I$ and then calculate the amount of current you would have to pass through the solenoid in order to produce the same $\vec{B}$ as: i) the strongest pole measured on your bar magnet; ii) the strongest pole of the horseshoe magnet as measured in step (1b).

*Something to consider:* Is a large amount of current through the solenoid required to create the equivalent magnetic field strength as these permanent magnets? As a comparison, a current of 0.2 A is fatal, and a typical room air conditioner can draw up to 8 A – a considerable amount. How do the currents you just calculated compare with a typical air conditioner?

3. *The $\vec{B}$ field of a current carrying straight wire.* In this part you will summarize your observations with a simple sketch (a top view, Figure 5) and a few words. Use the symbols in Figure 6 to represent current direction in the wire, into or out of the page.

a. Turn the knob on the power supply down to zero. Several compasses are arranged on the platform of the apparatus around the vertical wire. Observe their direction when no current flows through the wire.

b. Note the direction the current will be traveling through the wire, and use the right hand rule to predict the direction of the magnetic field when current passes through the wire.

c. Turn the knob up to 4 on the power supply. Note the pattern indicated by the compass needle directions to see if your prediction is correct.

d. When finished with your observations set the power supply to zero so that the wires won't heat up!

4. *Fun with magnetism!* Here are a few other pieces of equipment for you to experiment with:

a. There is a clear container with iron filings suspended in silicon oil. Hold this container in various positions near the horseshoe magnet, noting the path of the field lines.

b. *Your instructor will help you with this one!* Place a wire between the poles of the horseshoe magnet. Use the right-hand rule to predict the direction the wire will “jump” when current passes through it (out of the page in Figure 7). *Briefly* press the tap switch, and see if your prediction was correct! Create a sketch showing the correct orientation of the magnet, the $\vec{B}$ field, the current and the force exerted on the wire.

c. An old computer has been placed in the lab. Take your bar magnet, move it around in front of the monitor, and observe the effect. Don’t try this with the other lab computers, or your own computer!

**Discussion**

- Summarize what you have learned about the direction of magnetic fields in permanent magnets, wires and coils.
- Compare the magnetic fields for the various objects studied, and discuss the right hand rule, as it applies.