Magnetic Fields Lab

Learning objectives:

- Observe shape of a magnetic field around a bar magnet (Iron Filing and magnet)
- Observe that electric currents produce magnetic fields (Coil with current)
- Learn to map fields with a compass and describe the field of a large coil.
- Use symmetry arguments to describe the field of the coil.
- Learn to measure field strength and direction with a magnetic field probe
- Observe that a changing magnetic field can produce a voltage (Magnet in and out of coil)
- Design an experiment to measure the field of the coil while eliminating background field due to the earth.

Warm-Up: Qualitative Magnetic Field Maps

1. Here a few applets to help visualize magnetic fields

a. http://phet.colorado.edu/en/simulation/faraday
b. http://www.surendranath.org/Applets/Electricity/MovChgMag/MCM.html

2. Place a magnet under a dish. Slowly sprinkle iron filings into the dish and observe the pattern that emerges. It may help to tap on the dish a little bit. Draw the pattern you observe below.

Use the compass provided to explore the field around the magnet as well. How are the magnetic filings and the compass similar?

3. Gather around the double coil device and see the TF doing a demo of electron beam in a combined B and E field. Understand the directions of the coil current and electric field across the two plates for deflecting electrons. Compare the deflected trajectories caused by E field and B field. Watch the e-beam forming a circle. Sort out the directions to see if the electrons are behaving according to the rule you know. Now watch how an additional small magnet would make the e-beam flying out of plane. What additional B field components would make it happen like that?

Lab: Investigating Magnetic Fields

Lab Report: It is your task to produce a write-up that documents the apparatus and measurements you make. Answer all questions highlighted in red.

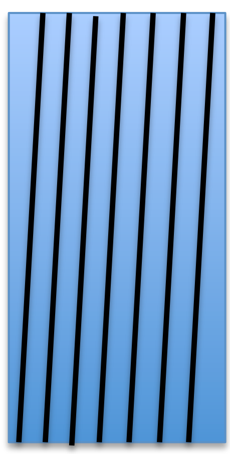
Note: You will need all of the data that you collect in this lab for a later class problem. Please be diligent and make sure you save and have access to your data for later use.

Part 1: Magnetic field and current carrying loops.

Motivating Question: What does the B-field look like around a current carrying loop?

Task: Drive the large coil with a 5 amp DC current.

Map out the magnetic field of the large coil at your table. Explore the field with a compass and draw the field lines below on the figure. Indicate where the field is stronger and weaker. Use this opportunity to try the 1 axis magnetic field probe located at your table.



Draw the set-up you are working with in a simple diagram. Explain the purpose of each component.

At about what distance is the magnetic field of the coil equal to zero? How do you know this?

Switch the direction of the current and repeat? What changed?

Part 2: Magnetic fields of a Current Carrying loop (Direct Current)

Motivating Question: A current carrying loop creates its own magnetic field. How can we differentiate between this field and the Earth's magnetic field?

Task: Use the Gaussmeter to measure the magnetic fields along the axis of the coil.

Devise an experimental strategy that measures the magnetic field of the coil that will discriminate the B-field of the coil from the B-field of the earth. We are only concerned with the filed along the central axis.

When you are ready discuss your experiment with a TF.

Make a plot of the coil magnetic field as a function of distance along the symmetry axis using MATLAB. In your report include a labeled graph. Make sure you save the data for later use (in homework). What did you have to do to discriminate the Earth's field from the large coil's field?

Part 3: Permanent Magnets and Wire Loops

Motivating Question: Can we produce a voltage with a coil and a magnet?

Task: Use the galvanometer, small coil on the wooden stand, and a permanent magnet.

Investigate how magnets and coils can interact. Use the coil provided and the galvanometer (measures current).

What do you need to do to produce a deflection of the galvanometer?

What is a galvanometer?

This applet may help your understanding of what is going on

http://phet.colorado.edu/en/simulation/faradays-law

Explain what it takes for a magnetic field to produce a potential difference across a coil.

Part 4: Alternating Currents and Magnetic Fields

Motivating Question: How can I investigate a magnetic field in a coil without the earth's field distorting our data?

Task: Drive the large coil on the table with an AC current at around 300 Hz. Measure the magnetic field along the central axis with the pick-up coil. The pick-up coil signal will need to be amplified.

Design an experiment to measure the magnetic field of the coil that is independent of the earth's magnetic field. Once you have a plan talk to your TF.

Draw the set-up you are working with in a simple diagram. Explain the purpose of each component.

Briefly describe your experimental procedure.

Make a numerical plot of the induced coil voltage as a function of distance. Make a sketch of the coil magnetic field as a function of distance. How are the two related?

Individually save all of your data for later use in homework.