Physics 251 Laboratory

Magnetic Fields

<u>Pre-Lab: Please do the pre-lab exercise on the web.</u>

Introduction

By now, you have studied methods for calculating the magnetic field due to current traveling in a wire. In particular, the Biot-Savart law is

$$\vec{B} = \frac{m_0}{4p} \int \frac{Id\vec{l} \times \hat{r}}{r^2}$$

Using this, you can find the magnetic field at the center of a circular, current-carrying wire loop.

$$\vec{B} = \frac{m_0 I}{2R}$$

In this lab, we will observe the effects of such a field, using a compass needle as a detector. As a final result, we will calculate the magnitude of the horizontal component of the Earth's magnetic field, which we will label $B_{Earth,H}$.

Equipment/Supplies

Glass jar, wooden frame, wire, compass, power supply, ammeter, patch cords and connectors.

Section 1

Place the compass in the indentation on the wooden frame, and slip the glass jar over the end of the frame. When you wind the wire in a coil around the jar, you will want the compass to be located as nearly as possible in the center of the coil.

Your only magnetic field sensor is a compass. The compass is a useful device if you are lost in the woods, but it can only tell you the direction of a magnetic field. It cannot tell you the magnitude. We can overcome this difficulty by using the playing the Earth's magnetic field and the field of our coil against one another. The compass needle indicates **the direction of the net magnetic field**. Describe how to orient your coil on the table in order to create "contrast" between the Earth's magnetic field and the coil's magnetic field. That is, how do you place the coil such that the Earth's field and the coil's field will make the compass point in different directions. Sketch your apparatus on the results page (indicate which way is

North on your sketch). Also, give an equation which relates the magnitudes of the two fields ($B_{Earth,H}$ and B_{coil}) to the angle between the fields (think trigonometry).

Section 2

Now, wind the coil around the glass jar, and attach it to the power supply. Place your ammeter (set up to measure large currents) in series with the coil. This will give you a more accurate measure of the current than the panel meter on the power supply. Wind the coils close together and centered around the compass. Record the number of loops you made on the results sheet. How will this affect your results? Write down a formula for the magnetic field at the center of your coil that includes the number of turns.

To determine $B_{Earth,H}$ you will need to combine your two equations so that you have a single equation relating the current, diameter and number of turns to the angle θ and $B_{Earth,H}$. Then record data. You should do this twice, once varying the current with a fixed number of coils and once varying the number of coils with a fixed current. Use the tables on the results page to record your data.

Section 3

Using your data and equation 3, you can now calculate the $B_{Earth,H}$. By fitting your data to a straight line. Use excel on the lab computers to plot your data and to fit a line to your data. How is $B_{Earth,H}$ related to your fit parameters? Please attach your graph and fit data, including your two calculated values of $B_{Earth,H}$ to the results page when you hand it in.

Name ________________________________ Date ______________________

Lab Partners ____

Magnetic Fields
Results

Section 1:

Sketch your apparatus and give your equation relating B_{coil}, B_{earth} and è the angle between them. This is your "equation 1".

Section 2:

Write down an equation for magnetic field strength as a function of the current, the diameter of the coil and the number of turns. This is your "equation 2".

Combine "equation 1" and "equation 2" to give a linear relationship between è, N, R, I and B_{earth} . This is your "equation 3".

Don't' forget to attach your graphs and your two values for B_{earth}

Data:

Number of Coils ____________________ Current (I) ______________________(Amps)

È (degrees)	I (amps)
10°	
20°	
25°	
30°	
35°	
40°	
45°	
50°	
60°	
70°	
80°	

Number of turns	È (degrees)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

Explain to "the Boss" how you set up your apparatus and why you set it up that way. (Specifically the orientation of the coil to magnetic N.)

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Overall :

What was good about this lab and what could be improved? ________________________________

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