**Physics 121 Spring 2019**

**Lab 7: Measuring the Magnetic Field of the Earth.**

In this lab, we will create a magnetic field with currents and use that to measure the Earth’s magnetic field in our lab room. Our method will provide a measure of only the horizontal component at the Earth’s magnetic field, *B*H, while the Earth’s total magnetic field vector is directed downward at an angle  (called the "dip angle") below the horizontal.

The experimental set-up involves a small magnetic compass placed at the center of a pair of Helmholtz coils (the same coils used in Lab 6). This arrangement makes a device known as *tangent galvanometer*. As part of your homework due by class today, you were to derive the equation for the magnetic field at the center of these coils in terms of *N*, the number of turns of wire, *I*, the conventional current, and *R,* the radius of the coils. Write this equation in the space below.

$B\_{coil}=$ (1)

With the plane of the coil aligned parallel to the Earth’s magnetic field, the field of the coil, *B*coil, will be perpendicular to *B*H. The compass needle will point in the direction of the net *B* field, which will be the vector sum of the two perpendicular components. The orientation of the needle, then, will be along the hypotenuse of a right triangle, with sides equal to *B*coil and *B*H.



**Figure 1**: The deflection of the compass needle due to the magnetic field of the coil, perpendicular to the horizontal component of the Earth’s magnetic field.

The angle  (see Figure 1) through which the needle is deflected away from the direction of *B*H gives a measure of the strength of Bcoil relative to BH. Specifically,

tan  = Bcoil / BH. (2)

By calculating *B*coil from the data and reading the deflection angle, , of the compass, we can use Equation (2) to obtain a value for *B*H.

**Procedure:**

1. Measure the radius, *R*, of the coils, and the number of turns, *N*, of coil to be used.

2. Place the compass at the very center of the coil, let the needle settle, and turn the coil so that the north-south direction is *in* the plane of the coils.

3. Carefully rotate the compass until the ends of the compass needle are aligned with 00 and 1800 on the compass scale.

4. Connect the circuit diagrammed in Figure 2. IMPORTANT: do NOT turn on the power until your instructor has checked your circuit.

Coils

DMM

Compass

mA

Com

Power Supply



 +V

**Figure 2**: Schematic of circuit for measuring Earth’s magnetic field.

5. Turn on the power supply and adjust the current so that the compass deflects through 400. (You may need to tap on the compass lightly to make sure that the compass needle is not binding and moves freely.) Read the angle at both ends of the compass needle to ensure that your reading is not affected by a poor viewing angle. Estimate the uncertainty in the angle measurement.

6. Turn off the power, reverse the leads and repeat the last step. Adjust the current to get to the same angle. Do you get the same current? If not, calculate the average of your two currents and set half the difference as the uncertainty.

7. Record your angle and average current, with uncertainties, in your data table.

8. Repeat for four other angles. For each angle, remember to get a measurement of the current in each direction; after measuring the current for a given angle, turn off the power supply, switch the leads into the power supply, turn it back on, and turn up the power slowly to get back to the same angle.

**Analysis:**

1. Calculate and record *B*H for each trial. Calculate the average *B*H from the five trials and its uncertainty (/sqrt(N)).

2. Compare your value for *B*H with values from National observatory and comment on the agreement. (<https://www.ngdc.noaa.gov/geomag-web/#igrfwmm>).