Student's Name: ______________________________ Student's Name: ______________________________

Lab day & time: __________________ Date: __________________

Magnetic Field (E5) - Data Sheets

Write all results on the data sheets in ink.

Activity 1: Measuring Horizontal and Vertical Components of the Earth's Magnetic Field *(3 p.)*

1.4. The magnetic field produced by the Helmholtz coils is proportional to the current. The number of turns in each coil is equal to $N = 200$ and radius of coils is equal to $a = 0.1025$ m. Using Eq. (1) from file "E5 – Theory and Procedure", calculate the calibration coefficient k of the Helmholtz coils and write it in your lab report. ($\mu_0 = 4\pi * 10^{-7}$ T·m/A).

k = ______________ (T/A) = _______________ (Gs/A)

1.5. Calculate the average current and the average **horizontal componen**t of the Earth's magnetic field $B_{X\ EARTH}$ for two opposite directions of the current in the Helmholtz coils (i.e., two values of the magnetic needle angle α).

α	|I| (A)	Average Current |I| (A)	$\|B_{X\ EARTH}\|$ (T)	$\|B_{X\ EARTH}\|$ (Gs)
$\alpha = 45°$				
$\alpha = -45°$				

1.8. Calculate the average current and the average **vertical componen**t of the Earth's magnetic field $B_{Z\ EARTH}$ for two opposite directions of the current in the Helmholtz coils (i.e., two values of the magnetic needle angle α).

α	|I| (A)	Average Current |I| (A)	$\|B_{Z\ EARTH}\|$ (T)	$\|B_{Z\ EARTH}\|$ (Gs)
$\alpha = 45°$				
$\alpha = -45°$				

1.11. Which component B_X or B_Z of the Earth's magnetic field is larger?

____

1.12. The value of the third magnetic field component $B_Y = 0$ (Gs) because during the initial setup, the Helmholtz coils were oriented to make sure that the Earth magnetic field is in X-Z plane. Therefore, both X (horizontal) and Z (vertical) components of the magnetic field are non-zero, but $B_Y = 0$ (Gs).

1.13. Calculate the absolute value of the Earth's magnetic field $|B_{EARTH}|$:

$|B_{EARTH}|$ = ____________ (Gs)

1.14. Calculate the angle between the Earth's magnetic field vector and the horizontal (the dip angle). Hint: use vertical and horizontal components of the Earth's magnetic field to find the dip angle.

Dip angle = ____________ (°)

Activity 2: Magnetic Fields Produced by Coils *(2.5 p.)*

First, disconnect the Helmholtz coils from the data interface. Locate the 800-turn coil and connect it to the "OUTPUT" terminals of the ScienceWorkshop (PASCO) 750 data interface box. Set the **"RANGE SELECT"** slide on the magnetic field sensor to "**1**" and set the "**axial"** mode.

2.1. **800-turn** coil. $N = 800$

2.2. Length of the 800-turn coil $L = 0.040$ (m)

Number of turns per unit length $n = N/L = 800/L =$ ______________ (1/m)

2.3. Slope for the **axial** ↓ mode: $m_1 =$ _________________ (T/A)

2.4. **Print** a copy of the magnetic field versus current graph for the 800-turn coil.

2.5. Slope for reversed direction of the current and the **axial** mode: $m_2 =$ ____________ (T/A)

What is the sign of the slope for the reversed direction of the current?

____

2.6. Calculate the average absolute value of the slope for the 800-turn coil.

$$|m| = \frac{|m_1| + |m_2|}{2} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\ (\text{T/A}) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\ (\text{Gs/A})$$

2.7. Using the two formulas for the magnetic field inside a solenoid **calculate the theoretical values of the B vs. I slope** for the 800-turn coil. The first formula is for the infinitely long solenoid (Eq. (2)), whereas the more accurate formula valid for a finite length solenoid is given by Eq. (3). Both formulas predict that the magnetic field inside the coil (B) is proportional to the current in the coil, but they predict different coefficient of proportionality, which is the slope of the B vs. I graph. The average radius of this coil is equal to $R = 0.018$ m and the length is $L = 0.040$ m.

Calculate the percent differences between the theoretical results given by Eq. (2)- (*infinite solenoid*) and by Eq. (3)- (*finite length solenoid*) for the slope and the actual (experimental) value using the following formula.

$$\text{Percent difference} = \frac{|Exper. - Theor.|}{|Theor.|} \times 100\% \qquad R = 0.018 \text{ m.}$$

Magnetic field vs. Current	**800-turn solenoid**
Measured value of the absolute value of the slope of the B vs. I graph	$\|m\| =$ (T/A)
Theoretical value of the slope of the B vs. I graph using Eq. (2) – (*infinite solenoid*)	$\|m_{Eq2}\| =$ (T/A)
Percent difference between theory (Eq. (2)) and the measured value	(%)
Theoretical value of the slope of the B vs. I graph using Eq. (3) – (*finite length solenoid*)	$\|m_{Eq3}\| =$ (T/A)
Percent difference between theory (Eq. (3)) and the measured value	(%)

Which of the two theoretical models (infinite solenoids versus finite length solenoid) better describes your experimental data?

____

How big is the finite length solenoid correction factor for the 800-turn coil?

Correction factor for the 800-turn coil = $\dfrac{1}{\sqrt{1+\left(2R/L\right)^2}}$ = ___________

2.8. Find the number of turns for the "unknown", red solenoid.

Replace the 800-turn coil with the "unknown", red solenoid. This coil has the length L = 0.110 m and the average radius of the coil is equal to R = 0.0175 m, but we do not know the number of turns for this coil. Measure the magnetic field vs. current *B(I)* to find the number of turns N for the unknown coil using the equation for finite solenoid Eq. (3).

Number of turns per unit length n = _____________ (1/m)

Total number of turns for the red coil N = ______________

How big is the finite length solenoid correction factor for the "unknown", red solenoid?

Correction factor for the "unknown", red coil= $\dfrac{1}{\sqrt{1+\left(2R/L\right)^2}}$ = ___________

Why the correction factor for the red coil closer to 1.000 than that for 800-turn coil?

____

____

____

____

2.9. Disconnect the "unknown", red coil and re-connect the Helmholtz coils to the "OUTPUT" terminals of the ScienceWorkshop (PASCO) 750 data interface box.

Complete the lab report and return it to the lab TA.