PHYS 2426
Engineering Physics II

MAGNETIC FIELD OF THE EARTH

I. OBJECTIVE:

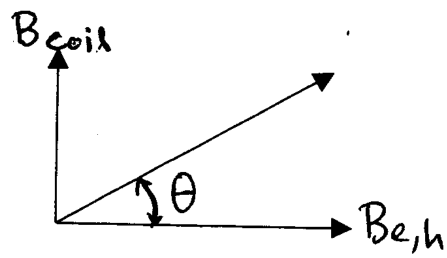
The objective of this experiment is to measure the magnetic field of the earth using the Tangent Galvanometer. The one used in this experiment is a coil of wire set in a vertical plane parallel to the horizontal component of the earth's magnetic field. The student will measure the coil current and the deflection angle of a compass placed at the center of the coil. The student then will calculate the magnetic field of the coil (at its center) and the magnetic field of the earth.

II. APPARATUS:

Tangent galvanometer, compass, dip needle, power supply, ammeter and connecting wires.

III. EXPERIMENTAL PROCEDURE:

1. Place the compass on the platform in the center of the coil and align the coil in a north-south direction until its plane is parallel to the compass needle. In this position the compass needle should be reading zero degrees (0°).



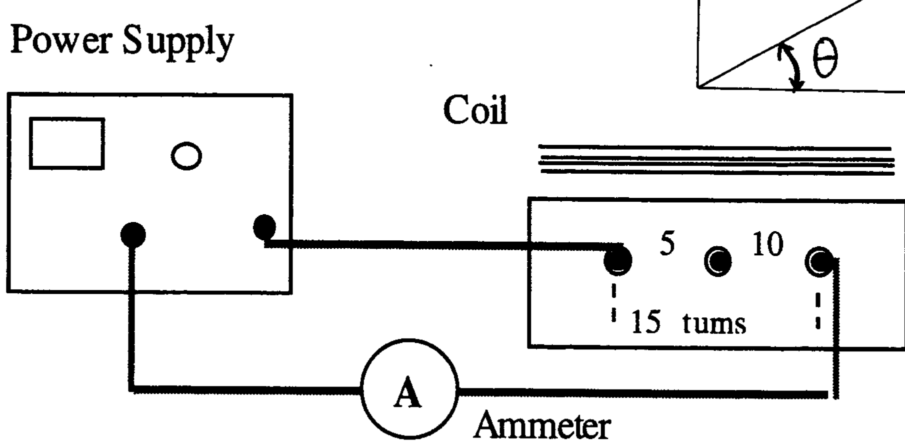


Figure (1)

2. Wire the circuit as shown in Figure (1). Keep the power supply and the multimeter as far away from the coil as possible since they distort the compass reading. Turn the power supply on and increase the coil current until the compass deflection angle is 20°. Record the current and the angle in the data table. Note that Figure (1) also shows the relative directions of the coil magnetic field B_{coil}, the horizontal component of the earth's magnetic field $B_{\text{e,h}}$ and the compass deflection angle θ.
3. Increase the coil current until the compass deflection angle is 30°, 40°, 50° and 60° and each time record the current and the deflection angle in the data table. Turn the power supply and the ammeter off.
4. Place the dip needle away from the apparatus and rotate the protractor into a horizontal position. Align the compass until the needle reads 270°. Rotate the protractor to the vertical position and allow the needle to come to rest. The needle will point in the direction of the earth's magnetic field. Read the angle which the needle makes with the horizontal direction. This angle is called the dip angle. Figure (2) shows the dip angle, α, the magnetic field of the earth B_{e}, its horizontal component $B_{\text{e,h}}$ and its vertical component $B_{\text{e,v}}$.
5. Measure the coil radius and record it in the data table. Also count the number of turns in the coil.
6. Ask the instructor to use a Gaussmeter to measure the earth's magnetic field. Call this the accepted value of the earth's magnetic field in this room, $B_{\text{e,accepted}}$ and record it in the data table.

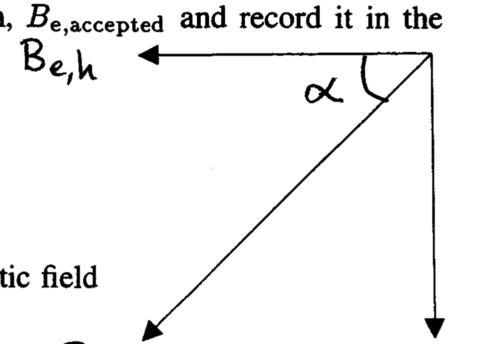


Figure (2)

IV. ANALYSIS

1. For each case, calculate the magnitude of the coil magnetic field

$$B_{\text{coil}} = \frac{N\mu_0 I}{2R_{\text{coil}}}$$

where N is the number of turns and $\mu_0 = 4\pi \times 10^{-7}\ \text{Tm/A}$ is the permeability of free space. The direction of the magnetic field at the center of the coil is perpendicular to the plane of the coil and is related to the direction of the current by the Right Hand Rule. See Figure (1) where the direction of the current is taken to be clockwise (looking from the back of the coil) or as indicated by the arrow (looking from the top).

2. For each case, calculate the horizontal component of the earth's magnetic field, $B_{\text{e,h}}$, from the relation

$$B_{\text{e,h}} = \frac{B_{\text{coil}}}{\tan\theta}.$$

This relation is easily seen from Figure (1). You should get values which are very close to each other since they all represent the same physical quantity, $B_{\text{e,h}}$.

3. Calculate the average value of the horizontal component of the earth's magnetic field $\overline{B}_{\text{e,h}}$.

4. Calculate the magnetic field of the earth B_{e} from the relation

$$B_{\text{e}} = \frac{\overline{B}_{\text{e,h}}}{\cos\alpha}.$$

This relation is easily seen from Figure (2).

5. Find the percent difference between the largest and smallest values of $B_{\text{e,h}}$.

6. Calculate the percent difference between your result for B_{e} and the accepted value (ask your instructor). The instructor should use the Gaussmeter and measure the earth's magnetic field outside the lab in the hallway.

$$\%\text{difference} = \frac{|B_{\text{e}} - B_{\text{accepted}}|}{\left(\dfrac{B_{\text{e}} + B_{\text{accepted}}}{2}\right)}$$

7. Using the values you obtained for B_{e}, $B_{\text{e,h}}$ and the dip angle α, draw a vector diagram to scale of the earth's magnetic field showing its horizontal and vertical components and the angle it makes with the horizontal (north). Use the following scale $1\ \text{Gauss} = 1 \times 10^{-4}\ \text{T} = 10\ \text{cm}$.

8. In your conclusion, comment on the accuracy of this experiment. What is the largest percent difference? What are the two most important sources of error?

Coil Current I(A)	Compass Deflection Angle θ (degrees)	$B_c = \frac{N\mu_0 I}{2R_c}$ (Tesla)	$B_{e,h} = \frac{B_c}{\tan\theta}$ (Tesla)
	20		
	30		
	40		
	50		
	60		
			$\overline{B}_{e,h} =$

Coil Radius, $R_c =$
Number of Turns, $N =$
Dip Angle, $\alpha =$
$B_{e,accepted} =$