PHYS143

Physics for Engineers

Lab Report - 5

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Instructor

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Experiment 1

Purpose:

To determine magnetic constant using a coil of variable number of turns.

Hypothesis:

Current flowing through the coil induces a magnetic field. The intensity of this magnetic field depends on the number of turns in the coil and the distance between each turning.

Materials:

- Power supply
- Half-probe
- 2 banana cables
- Coil with variable number of turns

Procedure:

1. Connect the circuit as given below with a power supply connected directly to the coil and a half-probe situated in the middle of the coil.

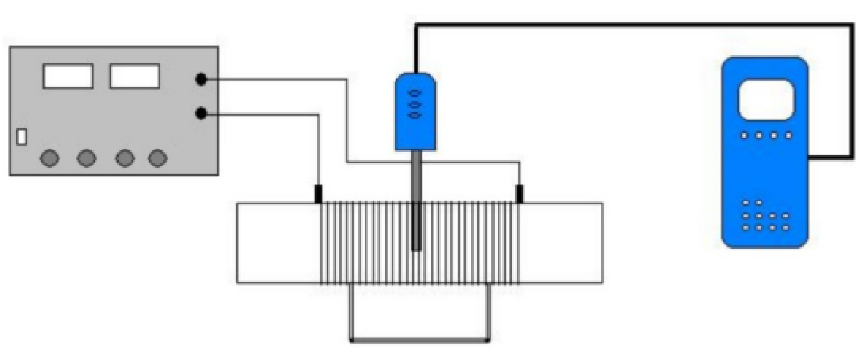

Fig. 1: Apparatus for experiment 1

2. Measure and vary the length of the coil using the given readings on the apparatus
3. Switch on the power supply and set the current to 10A and measure the magnetic flux density B with the half-probe.

Data and Observations:

Using the equation given below, we calculated theoretical values of B for different coil lengths to compare them to the measured values of B.

$$B = \frac{\mu_0 n I}{L}$$

Where:

$\mu_0 = 4\pi \times 10^{-7}$ H/m

n = 30 turns

I = 10 A

Length (m)	B [Calculated] (mT)	B [Measured] (mT)	Percentage Error (%)
0.30	1.25	1.21	3.2
0.32	1.18	1.14	3.4
0.34	1.11	1.10	0.9
0.36	1.05	0.99	5.7
0.38	0.99	0.95	4.0
0.40	0.94	0.91	3.2

Table 1: Calculated and Measured values of B for variable lengths

The previous formula can be written in the form of y= mx + c where y = B, x = 1/L and m = $\mu_0 nI$. Therefore, by plotting a graph of B against 1/L, the slope of the line can be used to calculate the value of μ_0 as follows:

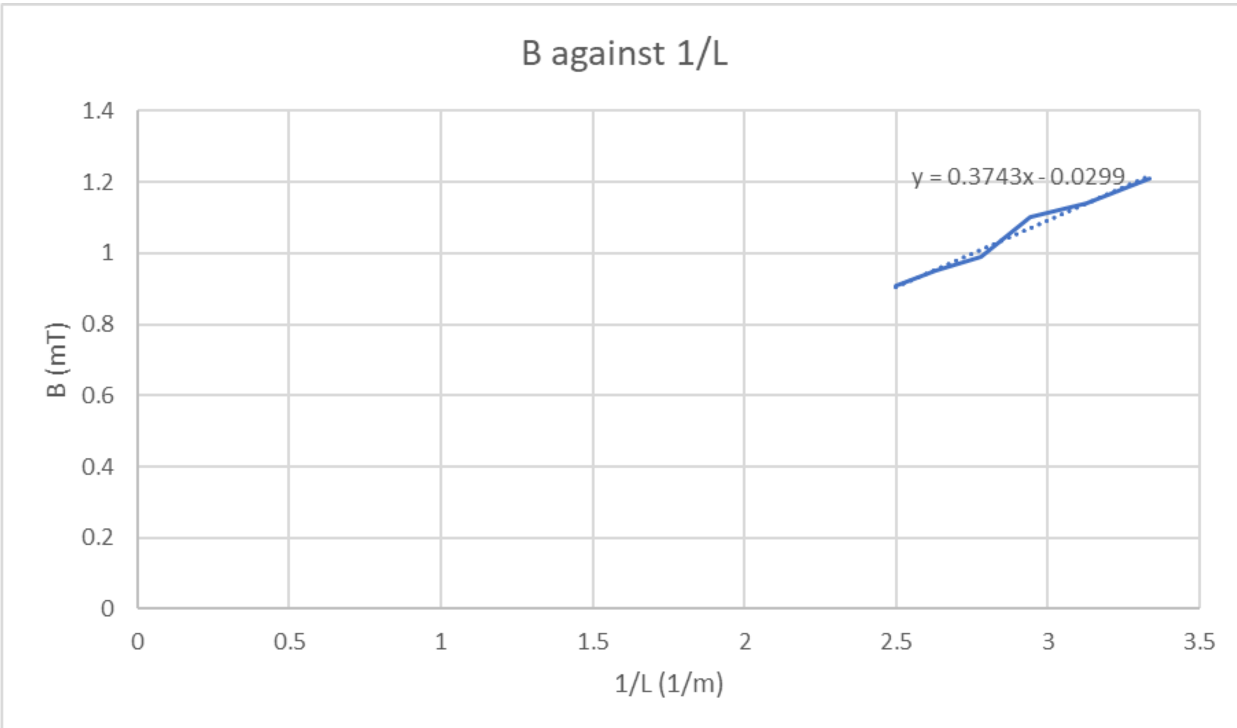

Fig. 2: Graph of B over 1/L

$$\mu_0 = \frac{m}{nI}$$

$$\mu_0 = \frac{3.743\times10^{-4}}{30\times10} = 1.248 \times 10^{-6} \text{ H/m}$$

Compared to the theoretical value of μ_0 = 4π x 10^{-7} = 1.257 x 10^{-6} H/m, it is very close to the value we got from our measured values. Hence, the experimental data is accurate.

Conclusion

In conclusion , experimenting with coils with a variable number of turns per unit length can help determine the relationship between the number of turns and the magnetic field strength generated by the coil. Relating to what we have studied in class: The number of turns in a coil is directly proportional to its inductance. The inductance of a coil is proportional to the square of the number of turns in the coil, so increasing the number of turns will increase the inductance.

The procedure is simple: we stretch the coil so it's almost equal then switch the power supply and adjust it to 10A then measure the B with the magnetic field sensor and we repeat for variable lengths. Problems we faced were some issues connecting the power supply to the outlets since some outlets were not working and some results that we got using the software on the computer weren't close to the ones we calculated. Our results made sense after more than one tries.

We learnt from this experiment that experimenting with coils with a variable number of turns per unit length helps to understand the relationship between the number of turns and the inductance of the coil. By changing the number of turns and measuring the inductance, you can observe how the inductance changes with the number of turns. If we were to repeat this lab we would be more careful where to place magnetic field sensor and not to touch the coils because they become too hot.

Experiment 2

Purpose:

To create a strong and uniform magnetic field by aligning two identical current loops using a configuration known as Helmholtz coil, and measure the magnetic constant.

Hypothesis:

A uniform magnetic field can be produced in this setup when they are separated by a distance equal to the coils' radius and having equal currents flowing through them in the same direction.

Materials:

- Helmholtz Coil
- 6 banana cables
- Half-probe.

Procedure:

1. Measure the radius of the Helmholtz coil and record the number of turns.
2. Connect the Helmholtz coil to the DC power supply. Connect an ammeter to the circuit to accurately determine the current.
3. Using the half probe, measure the field at the center of the coil for current values ranging from 0A to 1A, in 0.1A increments.
4. Note down the values of the different values of I and B(0).

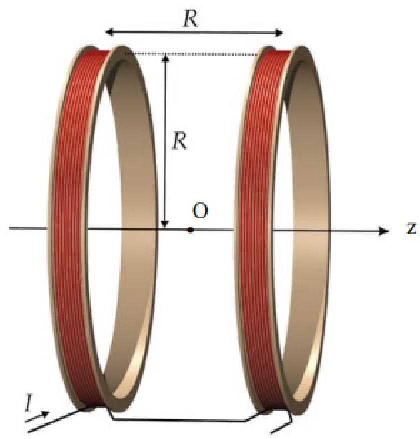

Fig. 3: Helmholtz Coil

Data and Observations:

$$B = \frac{8}{5\sqrt{5}} \frac{\mu_0 N I}{R}$$

Where,

μ_0 = 4π x 10^{-7} H/m

N = 100 turns

R = 0.0625 m

Current (A)	B [Calculated] (mT)	B [Measured] (mT)
0	0	0
0.1	0.14	0.13
0.2	0.29	0.28
0.3	0.43	0.44
0.4	0.58	0.55
0.5	0.72	0.70
0.6	0.86	0.84
0.7	1.00	0.97
0.8	1.15	1.13
0.9	1.29	1.22
1.0	1.44	1.40

Table 2: Calculated and Measured values of B for variable current

Given that, theoretically:

$$\frac{8}{5\sqrt{5}} \frac{\mu_0 N}{R} = \frac{8}{5\sqrt{5}} \frac{4\pi\times10^{-7}\times100}{0.0625} = 0.001438$$

We can expect to get a similar value using the measured values from the experiment, by plotting a graph of B against Current.

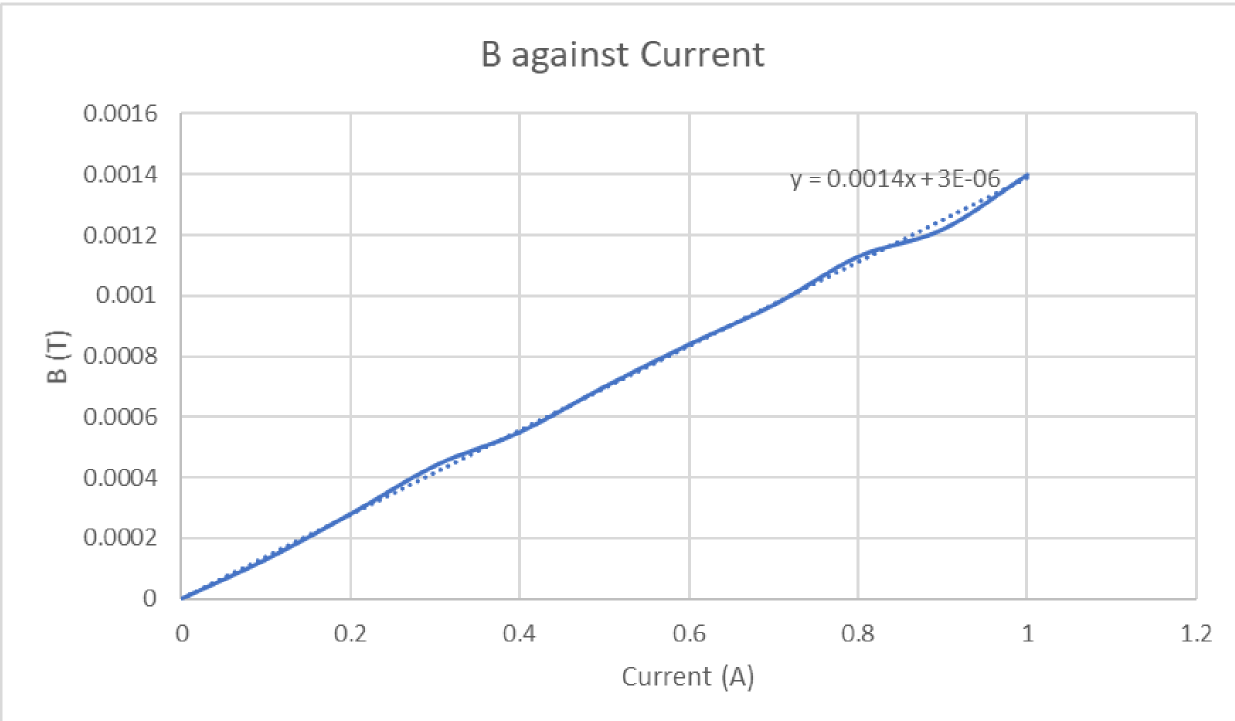

Fig. 4: Graph of B over current

The slope of the graph is be equal to:

$$m = \frac{8}{5\sqrt{5}} \frac{\mu_0 N}{R} = 0.0014$$

Which is almost the same as the theoretical value calculated before. Therefore, we have successfully conducted the experiment without any errors.

Conclusion

In conclusion, experimenting with the magnetic field at the center of a Helmholtz coil is used to study the properties of uniform magnetic fields. A Helmholtz coil is a pair of coaxial circular coils that produce a nearly uniform magnetic field in the region between the coils when they are carrying current in the same direction. The magnetic field at the center of a Helmholtz coil is related to Faraday's law of electromagnetic induction. Faraday's law states that a changing magnetic field generates an electromotive force in a conductor, which is proportional to the rate of change of the magnetic field.

The procedure was easier than the first experiment. We measured the radius of the Helmholtz coil and recorded the number of turns then connected the Helmholtz coil to the DC power supply. Finally, using the Half probe measured the field at the center of the Helmholtz coils for current values from 0 A to 1A, in 0.1A increments. We had problems finding the center of the coil but then we placed a ruler and tried to be accurate as much as possible.

Our results were not bad since it made sense to the measured ones. We learned to measure the uniformity of a magnetic field produced by the coil. By placing a small magnetic field probe or a compass at the center of the coil and measuring the field. If we were to repeat this lab we would have spent more effort finding the center of the coil to measure it perfectly.