UNIVERSITY OF WOLLONGONG IN DUBAI

LAB REPORT 5

# MAGNETIC FIELD

**Subject:** PHYS143 (DB123) Physics for Engineers.

**Group Members:**

**Subject Coordinator:** Dr. Mohammad Nassereddine

**Lab Instructor:** Mr. Nejad AlAgha

**Date of the experiment:** 9-2-2023

# Experiment 1

## Purpose

The objective of this experiment was to measure the magnetic fields for different values of length between the wire shaped as a coil with a number of turns and compare the measured value with the theoretical value.

## Hypothesis

After conducting the experiment, it is expected that the measured value of the magnetic field will not be far from the theoretical value which is calculated by using the correct formula.

## Materials used

- Power supply
- Computer
- Scale
- Coil wire
- Coil bobbin made from acrylic glass
- Magnetic field sensing equipments
- 2 safety sockets

## Procedures

1) Clamp the wire on the coil at its ends and lock it. Loosen the lock to adjust the length as required. Initial length of the coil is 0.4 m in this case.
2) Connect the power supply to the 2 safety sockets.
3) Connect the magnetic field sensor to the magnetic field sensor box. Then connect the magnetic field sensor box to the computer to allow readings to be shown on the computer using the PASCO application in this case.
4) Place the magnetic field sensor between the wires. It should be perpendicular to the wires and equal in distance from the left safety socket and the right safety socket.
5) Turn on the power supply and set the current to a value of 10 A.
6) Read the values shown on the computer through the PASCO application.
7) Repeat this procedure for different values of length of the coil. The length would be decreasing by 0.02 m for each reading until 0.3 m.

## Data

| Length (m) | $B_{measured}$ (mT) | $B_{theoretical}$ (mT) | Percentage error (%) | 1/L (m) |
|---|---|---|---|---|
| 0.4 | 0.95 | 0.942 | 0.85 | 2.5 |
| 0.38 | 0.998 | 0.992 | 0.60 | 2.63 |
| 0.36 | 1.08 | 1.047 | 3.15 | 2.78 |
| 0.34 | 1.12 | 1.11 | 0.9 | 2.94 |
| 0.32 | 1.15 | 1.17 | 1.71 | 3.125 |
| 0.3 | 1.24 | 1.256 | 1.27 | 3.33 |

## Calculations

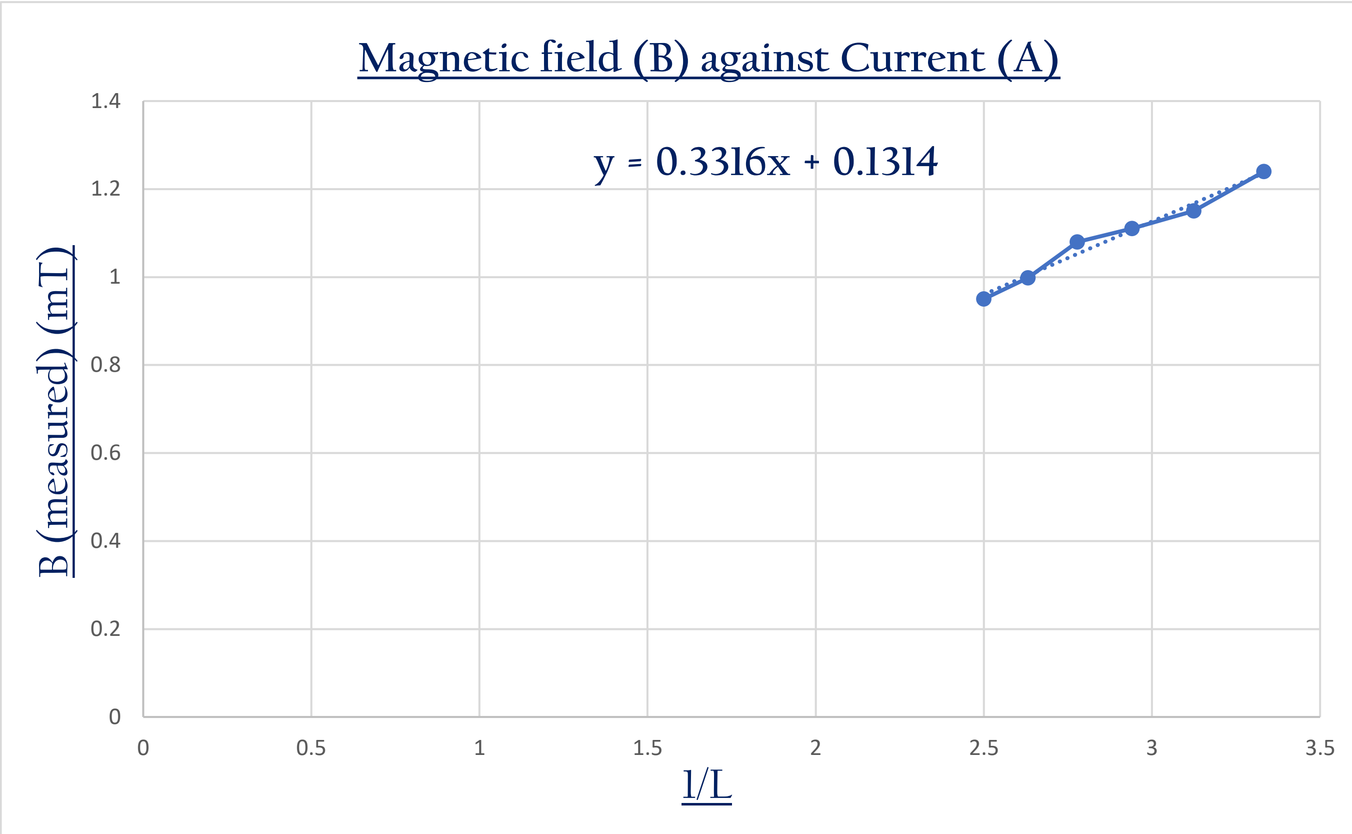
To calculate $B_{theoretical}$, we used $B = \mu_0 * n * \frac{I}{L}$

For example, $B = (4\pi*10^{-7}) *30*(10/0.4) = 0.942$ mT

Percentage error (%) = $(B_{theoretical} - B_{measured})/ B_{theoretical}$

For example, Percentage error (%) = (0.942-0.95)/0.942 = 0.85%

## Graph




## Calculations for $\mu_0$

The gradient of this graph is 0.3316. Gradient is equal to Y/X.

Y = B, X = 1/L. So, the gradient = BL

From the equation BL = $\mu_0$ *n*I

Theoretical value of $\mu_0 = 4\pi * 10^{-7} = 1.256 * 10^{-6}$ N/A$^2$

Experimental value of $\mu_0$ = BL/(n*I)

= 0.0003316/ (30*10)

= $1.1053*10^{-6}$ N/A$^2$

## Observations

As shown in the table, when the length decreases, the magnitude of the magnetic field increases, and as shown from the calculation above, the theoretical value of $\mu_0$ and the experimental value of $\mu_0$ are similar to each other. Thus, the experiment and the procedure can be deemed a success.

## Conclusion

The goal of this experiment was to measure the magnetic fields for different values of length between the wire shaped as a coil with a number of turns and compare the measured value with the theoretical value.

Fix the wire at the ends of the coil bobbin. Connect the power supply and turn it on. Set the current at 10A. Put the magnetic field sensor in the middle of the coil bobbin and perpendicular to the wires. Read the values of the magnetic field (B) shown on the computer. We had some problems during the lab such as the power supply was not functioning properly but they were solved by using a different power supply. The wires were not exactly circular, so when inserting the magnetic field sensor, we would have to adjust its angle, thus not resulting in a perpendicular experiment.

Some sources of error may include:

- Switching the power supply on and off may fluctuate the current value.
- Misalignment of the magnetic field sensor.
- Human error may ruin the accuracy of the results.
- Ensure that the slider is on the exact marking of the length when moving it.

The learning outcome from this experiment is that when the length decreases, the magnitude of the magnetic field increases and that the gradient of a B against 1/L graph can be used to find the experimental value of $\mu_0$.

When attempting this experiment for a second time, take precautions such as not exceeding the current, not touching the wire when the power supply is on, modifying the procedure must be done when power supply is switched off.

# Experiment 2

## Purpose

The goal of this experiment was to examine the magnetic field generated by current using a pair of Helmholtz coils. Then compare the values of the magnetic field with the theoretical values.

## Hypothesis

After conducting the experiment, it is expected that the measured value of the magnetic field will be similar to the theoretical value which is calculated by using the correct formula.

## Materials used

- Power supply
- Ammeter
- Scale
- Pair of Helmholtz coils
- Magnetic field sensing equipments
- Computer
- Probe wires and crocodile wires

## Procedures

1) Set the distance between the Helmholtz coils as 6.25 cm.
2) Connect the coils to a power supply source with probe wires.
3) Connect an ammeter to both the coils and measure the current in the coils.
4) Turn on the power supply and set the current reading on the ammeter to 0.1 A for the first experiment.
5) Keep increasing the current by 0.1 A until 1.0 A.
6) Place the magnetic field sensor in the middle of the coil and measure the magnetic field for the current values from 0.1 A to 1.0 A.
7) Tabulate the readings on a table and plot a graph of magnetic field vs current (B against I).
8) Calculate the gradient from the graph and use the equation to find the experimental value of the magnetic field constant ($\mu_0$).
9) Compare this value with the theoretical value of ($\mu_0$).
10) If they are similar, then the equation and experiment is a success.

## Data

| Current I (A) | $B_{measured}$ (mT) | $B_{theoretical}$ (mT) |
|---|---|---|
| 0.1 | 0.146 | 0.14 |
| 0.2 | 0.282 | 0.28 |
| 0.3 | 0.44 | 0.43 |
| 0.4 | 0.58 | 0.57 |
| 0.5 | 0.73 | 0.71 |
| 0.6 | 0.87 | 0.86 |
| 0.7 | 1.04 | 1.01 |
| 0.8 | 1.19 | 1.15 |
| 0.9 | 1.3 | 1.29 |
| 1.0 | 1.47 | 1.44 |

## Calculations

R = 0.0625 m

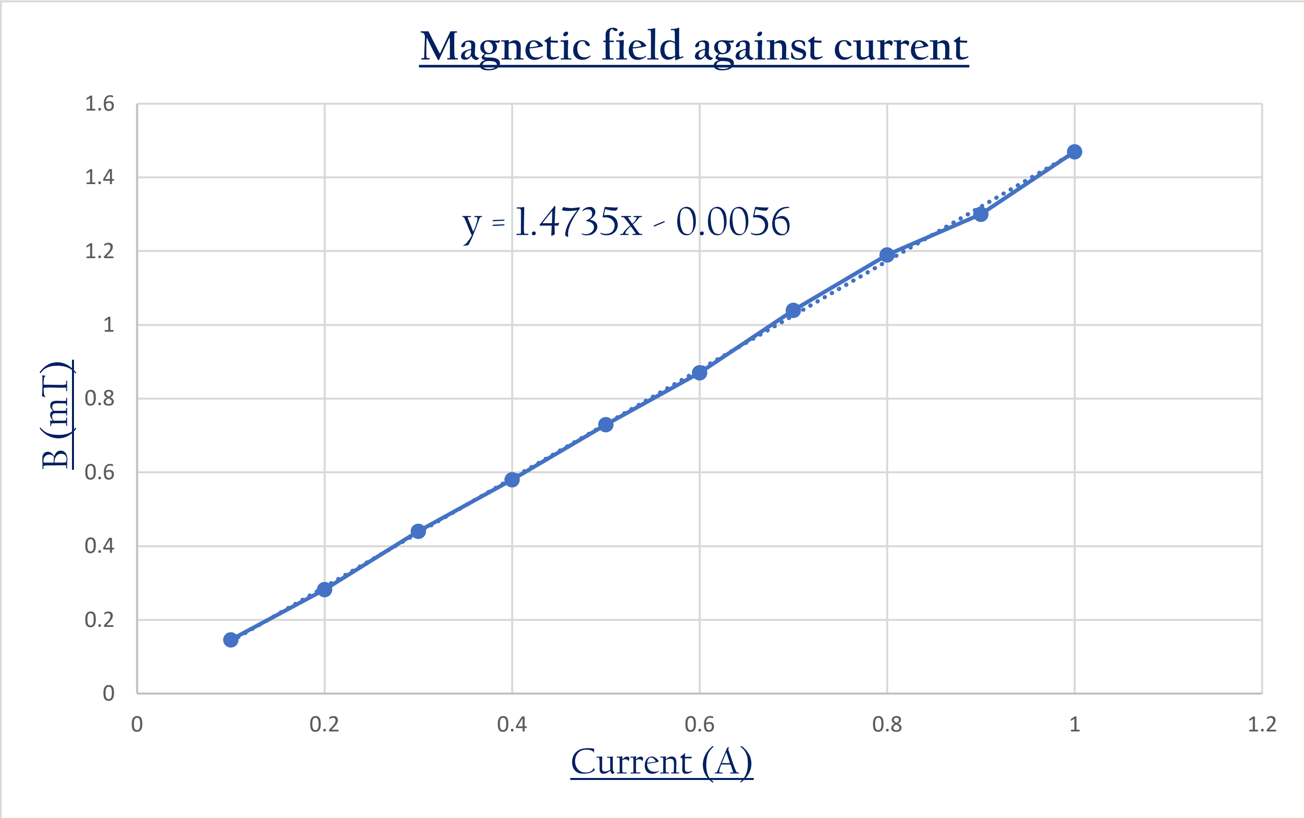
N (number of turns) = 100

I = 0.1 A

$B_{theoretical} = \frac{8}{5\sqrt{5}} * \frac{(\mu 0 * n * I)}{R}$

For example, $B_{theoretical} = \frac{8}{5\sqrt{5}} * \frac{(4\pi * 10^{-7} * 100 * 0.1)}{0.0625}$ = 0.14 mT

## Graph




## Calculations for $\mu_0$

$$B = \frac{8}{5\sqrt{5}} * \frac{(\mu 0 * n * I)}{R}$$

$$\frac{B}{I} = \frac{8}{5\sqrt{5}} * \frac{(\mu 0 * n)}{R}$$

Theoretical value of $\mu_0$

$\mu_0 = 4\pi * 10^{-7} = 1.256 * 10^{-6}$ N/A$^2$

Experimental value of $\mu_0$

$$\mu_0 = \frac{B}{I} * \frac{R5\sqrt{5}}{N8}$$

$$\mu_0 = 0.0014735 * \frac{0.0625*(5\sqrt{5})}{100*8}$$

$\mu_0 = 1.287 * 10^{-6}$ N/A$^2$

## Observations

As shown in the table, when current increases magnetic field also increases, and as shown in the calculations, the theoretical value of $\mu_0$ and the experimental value of $\mu_0$ are pretty similar so the experiment was a success.

## Conclusion

The experiment on the Helmholtz coil demonstrated the principles of magnetic fields generated by current and the effectiveness of using Helmholtz coils to produce uniform magnetic fields. The procedures involved setting up the Helmholtz coils, connecting them to a power source and measuring the current, increasing the current from 0.1 A to 1.0 A, each time by 0.1 A for each reading, and measuring the magnetic field using a magnetic field sensor. The observations showed that the magnetic field increased as the current increased. The results of the experiment showed a close agreement between the measured and calculated values of the magnetic field, indicating that the formula used to calculate the magnetic field was correct.

Some sources of error may include:

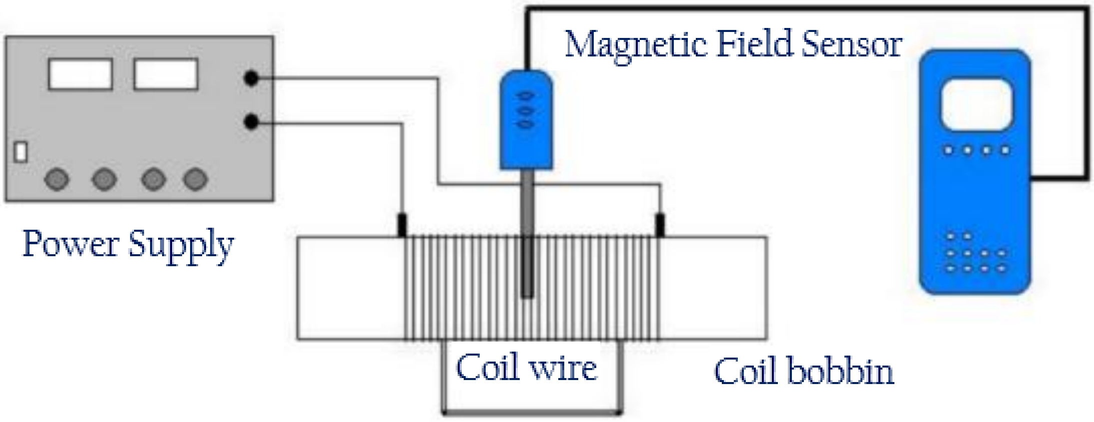
- Inaccurate measurements of the radius of the coil can cause deviations in calculated results.
- Faulty equipment may interfere with the results.
- Ensure that the magnetic field sensor is placed perpendicularly and its tip is on the same line as the centre of the coils.

The learning outcome from this experiment is that when current increases magnetic field also increases and that the gradient of a B against I graph can be used to find the experimental value of $\mu_0$. The experiment provided valuable insights into the relationship between current and magnetic field, and the results support the hypothesis that the magnetic field generated by current using Helmholtz coils can be accurately measured and compared to theoretical values.

When attempting this experiment for a second time, take precautions such as, not touching the wire when the power supply is on, modifying the procedure must be done when power supply is switched off, operating the coils must be done with low voltages.

# Experimental Set-ups

## Experiment 1




## Experiment 2