NATIONAL UNIVERSITY OF TECHNOLOGY

COMPUTER ENGINEERING DEPARTMENT

Applied physics Lab (PHY13002)

Experiment No:5

Title: Experiment to calculate Magnetic Forces on Wires

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Objectives:

- Investigate the relationship between magnetic force and current in a conductor.
- Examine how the length of the wire affects the magnetic force when placed in a magnetic field.
- Analyze the physical meaning of the Force vs. Current and Force vs. Length graphs to understand magnetic force behavior.

Apparatus:

1. Basic Current Balance
2. Current Balance Accessory
3. Ohaus Cent-o-Gram Balance
4. Low Voltage AC/DC Power Supply
5. Large Base and Support Rod
6. Banana Plug Cord Set (Red, 5 pack)
7. Banana Plug Cord Set (Black, 5 pack)
8. Experiment Resources CD
9. Data Studio Software
10. Magnets
11. Current Loop(s)
12. Ammeter

Theoretical explanation:

In this experiment, we examine the magnetic force acting on a current-carrying wire placed in a magnetic field. According to the formula **Fm = ILBsin(θ)**, the magnetic force (Fm) is directly proportional to the current (I), the length of the wire (L), the magnetic field strength (B), and the sine of the angle (θ) between the wire and the magnetic field. This equation allows us to calculate the force acting on the wire when these variables are known. The experiment focuses on how changing the current, wire length, and magnetic field strength influences the magnetic force, providing insights into the physical behavior of the force under varying conditions.

Instead of directly measuring the magnetic force, we first measure the change in mass (ΔM) of a magnet assembly due to the applied current. This change in mass is directly proportional to the magnetic force, as indicated by the equation **Fm = ΔM × g**, where **g** is the acceleration due to gravity. By adjusting the current and recording the corresponding changes in mass, we can calculate the magnetic force indirectly. This approach simplifies the process, allowing us to quantify the magnetic force without specialized force sensors, while still demonstrating the principles of electromagnetism and the behavior of magnetic forces in different conditions.

Procedure for Experiment 1: Force vs. Current

a) Set up the equipment by mounting the Main Unit on a lab stand and attaching the Current Loop.
b) Place the Magnet Assembly on the balance and insert 4–6 magnets into the holder to create a constant magnetic field.
c) Record the initial mass of the magnet holder and magnets with no current flowing.
d) Turn on the power supply and set the current to 0.5 A.
e) Measure and record the mass of the magnet assembly under the influence of the magnetic field.
f) Gradually increase the current by 0.5 A increments, up to a maximum of 3A, recording the mass after each change.
g) After all measurements, subtract the initial mass (with no current) from each recorded mass to determine the force at each current.

Procedure for Experiment 2: Force vs Length of wire:

a) After completing Experiment 1, ensure the magnet holder and magnets remain in place.
b) Set up the shortest current loop and place it in the magnetic field.
c) Set the power supply to between 2.0 A and 3.0 A.
d) Record the mass of the magnet assembly at this current 0A.
e) Gradually replace the current loop(wires) with longer loops, positioning them in the magnetic field.
f) Measure and record the mass for each wire length at the current setting of 2.5A, using the O/T button to find change in mass.
g) After all measurements, subtract the initial mass from each recorded mass to calculate the magnetic force for each length.

Experiment 1:

Observations and Calculations:

Initial Mass at Current (I=0): 164.11g

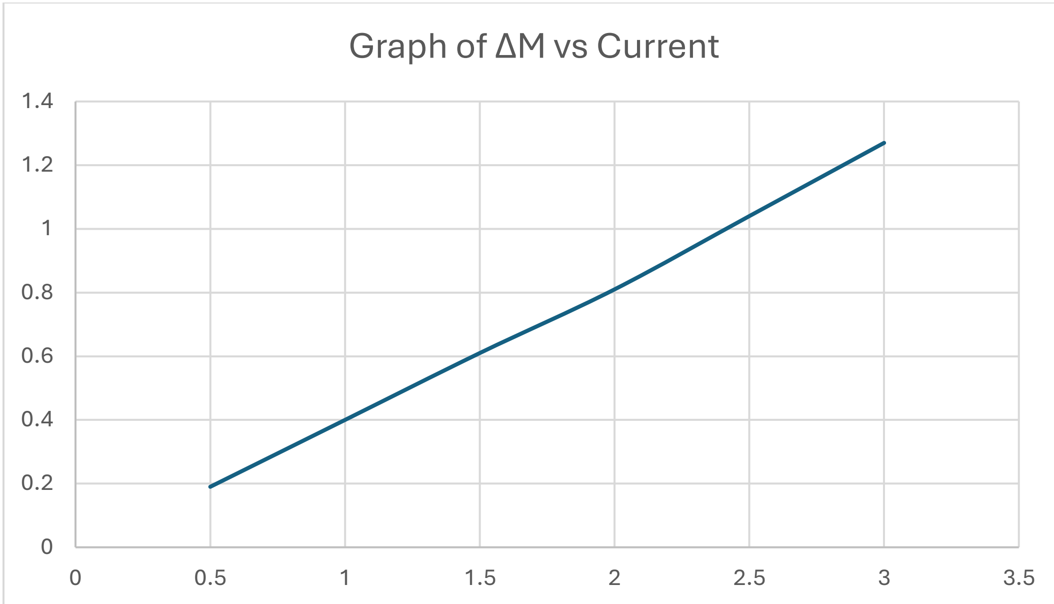
Current (A)	M_1-M_{init}(Δm)
0.5	0.19
1.0	0.40
1.5	0.61
2.0	0.81
2.5	1.04
3.0	1.27

- As the current increases, the difference in mass (Δm) also increases, indicating a stronger magnetic force.
- At a current of 0.5 A, the force is 0.19 grams, and it increases steadily with the current.
- The force reaches 1.27 grams at 3.0 A, showing a clear proportionality between current and magnetic force.

Result and Analysis:

Result:
The experiment demonstrated that the magnetic force acting on a current-carrying wire increases as the current through the wire is increased. As recorded, the force measured, represented by the change in mass (Δm), showed a steady increase from 0.19 grams at 0.5 A to 1.27 grams at 3.0 A. This confirms the direct relationship between the magnetic force and the current flowing through the wire.

Analysis:
The data supports the theoretical prediction that the magnetic force is directly proportional to the current. As we increased the current, the force on the current-carrying wire also increased, causing the magnet assembly to lift higher. This result aligns with the equation $F_m = I \times L \times B$, where the force increases with current (I), given the constant length of wire (L) and magnetic field strength (B). The experiment shows that the force increases in a predictable and linear manner with the increase in current, which is an important principle in electromagnetism. The results suggests that controlling the current can effectively control the force exerted by magnetic fields in practical applications like motors and solenoids.



➢ The graph is a straight line hence it shows Δm is directly proportional to Current showing that Force is also directly proportional to Current.

Experiment 2:

Observation and Calculations:

Wire Code	Length(cm)	Δm
40	1.2	0.27
37	2.2	0.51
39	3.2	0.82
38	4.2	1.06

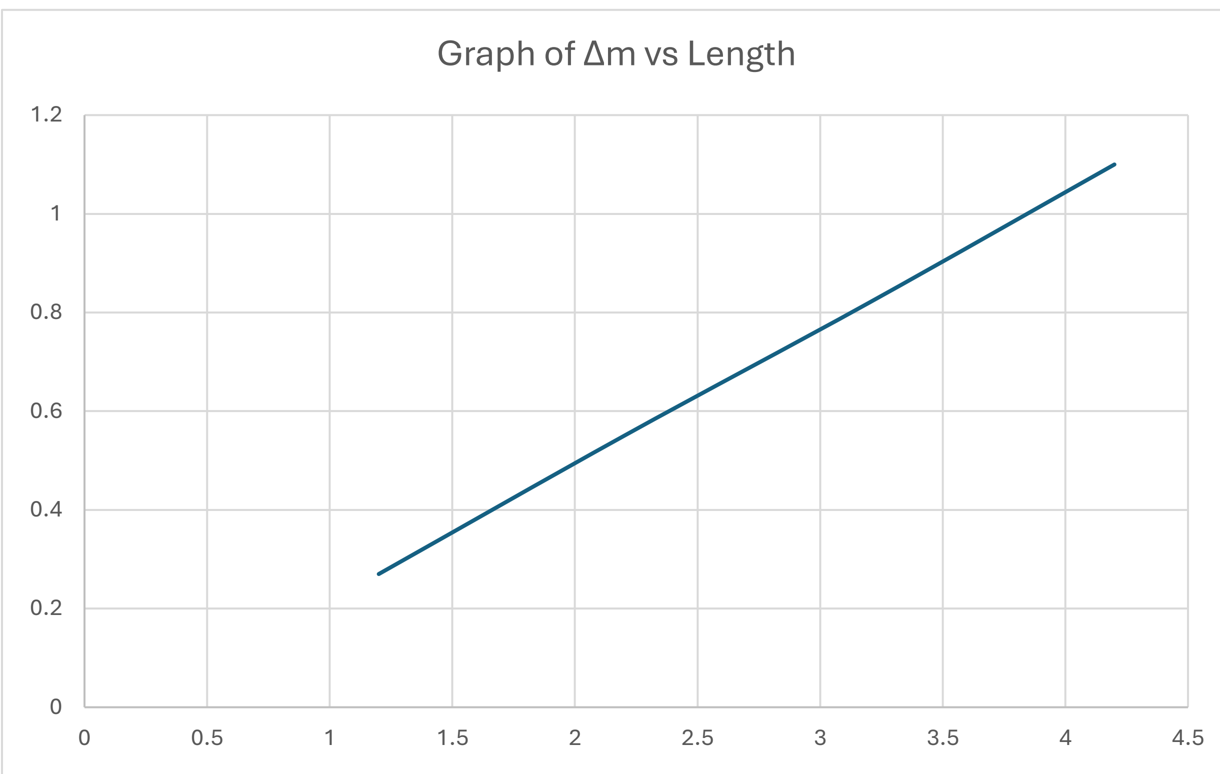
- As the length of the wire increased, the magnetic force also increased.
- At a wire length of 1.2 cm, the force was 0.27 grams, and it steadily increased up to 4.2 cm, where the force reached 1.06 grams.
- The results show a direct relationship between the length of the wire and the magnetic force acting on it.
- **Force (Fm)** is calculated by subtracting the initial mass (with no current) from the measured mass (with current).
- $F_m=(\Delta m)\times g$,where Δm is the change in mass (in grams) and g is the acceleration due to gravity (approximately 9.8 m/s²).
- For example, for a wire length of 1.2 cm:

$$F_m=0.27\ g\times 9.8\ m/s \approx 2.65\ mN$$

Result and Analysis

<u>Result:</u>
The experiment demonstrated that as the length of the wire in the magnetic field increased, the magnetic force acting on it also increased. Starting at a force of 0.27 grams for a 1.2 cm wire, the force steadily rose to 1.06 grams for a 4.2 cm wire. This clearly shows that the force is directly related to the wire's length.

<u>Analysis:</u>
The findings confirm the theoretical relationship described by $F_m = I \times L \times B$, where the force is proportional to the wire length (L) for a constant current (I) and magnetic field (B). The increase in magnetic force with wire length reflects the principle that a longer conductor in a magnetic field interacts with a greater number of magnetic lines of force. This behavior is fundamental to designing practical devices like electric motors and generators, which rely on wire length to optimize force output. The results matched theoretical expectations, illustrating the practical implications of the relationship between force and wire length.



- The graph is a straight line hence it shows Δm is directly proportional to Length showing that Force is also directly proportional to Length.

Precaution:

- Keep the setup away from other electronic devices or ferromagnetic materials to prevent interference with the magnetic field.
- Ensure all connections are secure and the power supply is properly calibrated before starting.
- Avoid touching the current-carrying wires during the experiment to prevent electric shocks or accidental circuit disturbances.
- Handle the magnet assembly, current loops, and balance with care to avoid damage or misalignment.
- Use consistent settings on the power supply and avoid sudden changes in current to maintain accuracy.
- Take multiple measurements for each current and length to minimize errors and improve reliability.
- Ensure the wire loop does not touch the magnets during the experiment to prevent inaccuracies.

Comments:

- Achieving stable readings required careful adjustments to the setup, especially in aligning the current loop and balance.
- Consistent increases in force with current and wire length validated the expected results, reinforcing the theoretical relationship.
- Minor variations in mass measurements could be attributed to small setup misalignments or external disturbances.
- Using the O/T button measurements were made easy and reliable for data analysis.
- The experiments illustrated the practical applications of magnetic forces, improving understanding of their behavior in different conditions.

Conclusion:

The experiments successfully demonstrated the relationship between magnetic force and both current (Experiment 1) and wire length (Experiment 2). In Experiment 1, the magnetic force increased linearly with current, while in Experiment 2, the force showed a direct relationship with the wire's length in the magnetic field. These results confirmed the theoretical formula $F_m = I \times L \times B$, emphasizing the proportionality of force with current and length.

Through precise setup, repeated measurements, and careful alignment, the experiments provided accurate and consistent data. They highlighted the importance of understanding magnetic forces in practical applications like electric motors. Overall, the experiments deepened insight into the fundamental principles of electromagnetism.