ILLINOIS INSTITUTE OF TECHNOLOGY - PHYS 221 L03

Lab Report - Lab 08: Magnetic Fields and Forces

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Lab 08
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Lab 08: Magnetic Fields and Forces

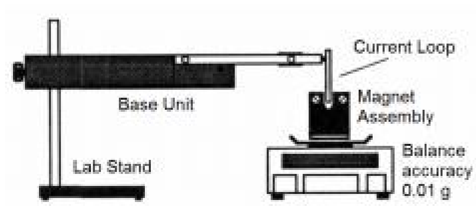
Introduction
In this lab, we experimented with magnetic forces and fields created by wires and analyzed how to calculate the force based off of different variables, such as charge, velocity, current, and length. By varying the wire length and current while also observing magnetic fields produced by current carrying wires, we were able to analyze the relationship between the magnetic fields and forces.

Equations:

1. $F_B = IL \times B$
2. $F = mg$
3. $F = ILB\sin(\theta)$

Experimental Methods
For Part 1, a long wire is suspended vertically and passes through a circular platform. A current of 5A runs through the wire from the power supply, and using the magnet, Draw arrows to represent the magnetic field based on moving a compass around the platform, graphing it based on where the compass points to when it is affected by the magnetic field. Repeat this process but switch the leads so that the current flows the opposite way.

For Part 2A, we set up the experiment to observe the changes in a magnet's weight. First, we used the PASCO software to measure the magnetic field. Then, we set up the experiment as shown below.



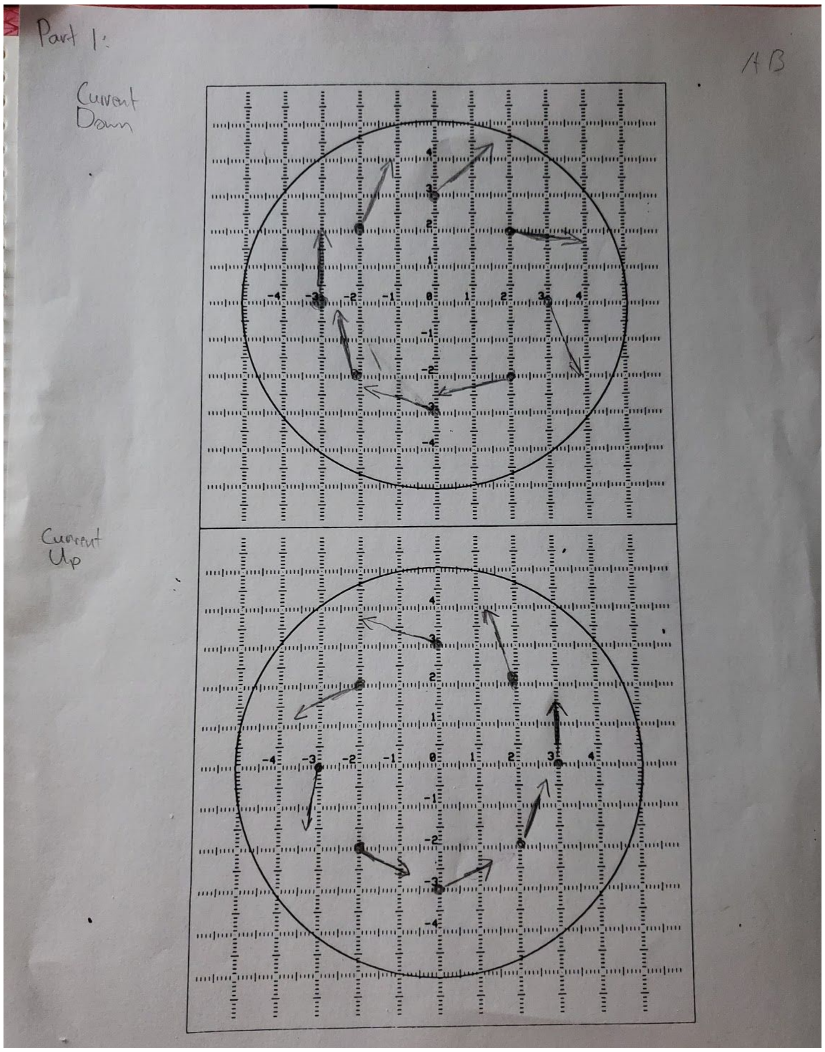
Then, after connecting the power supply and ammeter and measuring the magnet assembly's mass, we increased the current flowing through the loop by 0.5A increments up to 5A, recording the new mass of the magnet assembly.

For Part 2B, we measured the difference in mass, but this time with current loops of varying lengths. After setting the current at 5A, record the new mass and then repeat for all the other current loops.

Results and Discussion

Part 1:

For Part 1, we analyzed the magnetic fields by mapping the direction of the field on a graph for when the current is pointing down and when the current is pointing up. Below are the graphs of the magnetic fields.



These graphs can both be verified by the right hand rule (RHR), for when current is directed down, the thumb points down as well, and the fingers curl clockwise in the direction of the magnetic field, and when current is pointed up, the thumb points up and the fingers curl counterclockwise in the direction of the magnetic field, which is shown in the graphs.

Part 2A:

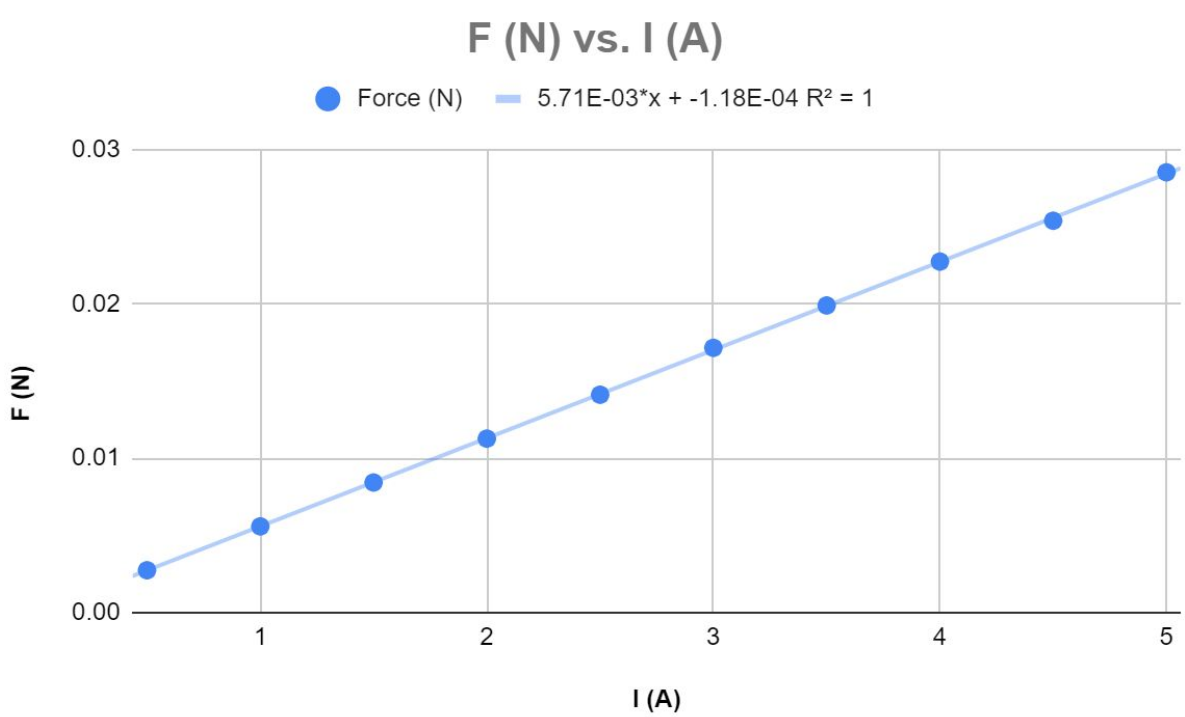
1. Subtract the mass of the magnet assembly from the mass value in your data table. This is the net mass. Record these values as a column in your data table. Multiply the net mass by $g = 9.8\ m/s^2$. Why does this value equal the magnetic force F_B?

Gravitational force is not equal to magnetic force but they correlate because they have the same units.
Below is Table 1, which shows the recorded data of the current and the change in mass, as well as the calculated data for force.
Table 1:

Current (A)	Mass Change (kg)	Force (N)
0.5	0.00028	0.002744
1	0.00057	0.005586
1.5	0.00086	0.008428
2	0.00115	0.01127
2.5	0.00144	0.014112
3	0.00175	0.01715
3.5	0.00203	0.019894
4	0.00232	0.022736
4.5	0.00259	0.025382
5	0.00291	0.028518

Using equation 2, we were able to find the force by multiplying the change in mass by the gravitational constant.

2. Plot a graph of the magnetic force F versus the current I, and find the slope of the best-fit line from your graph.



3. From Equation 2, the slope of the best-fit line should correspond to LB (product of the length of the 3-4 segment and the magnetic field strength - prove this in the theory section of your report). Using the slope of your graph, find the magnetic field strength of the magnet. Verify this by using the Hall probe and find the percentage difference.
    a. The slope represents the magnetic field, where in Graph 1 it is 0.00571T. The measured magnetic field was 0.01497T, and when compared to the value from the graph, a percent error of 61.857% is present. This high percent error may be due to the difficulty of getting an accurate reading of the magnetic field from the sensor since it was impossible to fit it between the gap in the magnet assembly.

Part 2B:

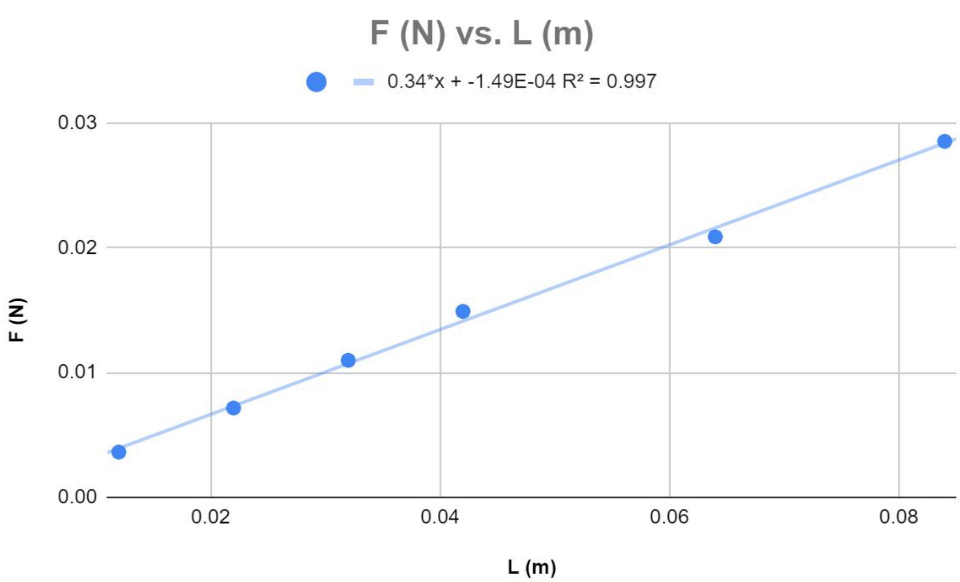
1. Repeat an analysis similar to steps 1 and 2 from Part 2A for each current loop segment. Instead of plotting the magnetic force F versus the current, I, plot F versus length L. Find the slope of the best-fit line from your graph.

   Table 2:

Segment	Length (m)	Mass Change (kg)	Current (A)	Force (N)
SF38	0.042	0.00152	5	0.014896
SF42	0.084	0.00291	5	0.028518
SF41	0.064	0.00213	5	0.020874
SF39	0.032	0.00112	5	0.010976
SF40	0.012	0.00037	5	0.003626
SF37	0.022	0.00073	5	0.007154

   Above is Table 2, which shows the recorded data for the segment, segment length, mass change, and current, as well as the calculated force. Using this data, we can now plot F vs. L, which is shown below in Graph 2.

   Graph 2:



2. From Equation 2, the slope of the best-fit line should correspond to IB, the product of the current and the magnetic field strength. Prove this in the theory section of your report. Using the slope of your graph, find the magnetic field strength of the magnet. Compare this with the value obtained by using the Hall probe and that obtained from Part 2A.
    a. The slope represents IB, which is projected to be 0.34. Using equation 1, we can calculate the magnetic field strength, which comes out to be 0.068T. The measured field strength was 0.01497T, which has a percent error of 354.242%. This large percent error can also be due to the error talked about in part 2A, which is the struggle to accurately measure the magnetic field of the magnet due to the size of the magnetic field sensor and the magnet assembly.
3. Segments 2-3 and 4-5 of the current loop (see Fig 3.) are also within the magnetic field of the assembly. Why are we justified in ignoring the force acting on these segments?
    a. We can ignore the force acting on these segments because the magnetic field cancels out at those areas. When magnetic fields are perpendicular to the current, they equal zero.

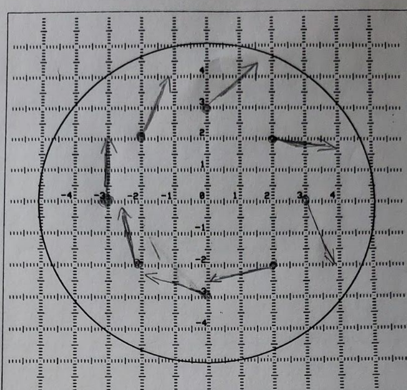
Conclusion

Through the usage of magnets, current loops, and wires, we were able to see how magnetic fields and forces interact with each other, and the trend seen was that when the magnetic field is stronger, the heavier the magnet assembly became, and when the loop was longer, the magnetic field became stronger due to more current running through the loop, which also caused the magnet assembly to become heavier.

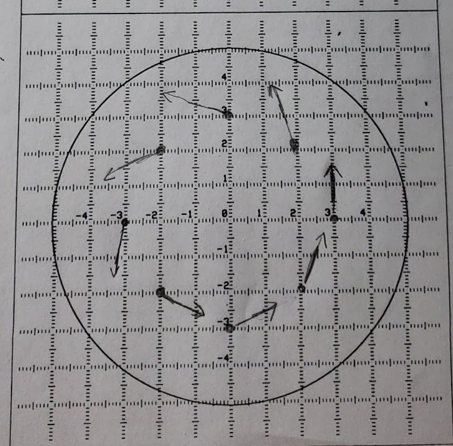
Part 1:

AB

Current Down



Current Up



Part 2A:

1. 0.01497 T
2.

Current Loop	Length
SF 42	8.4cm

3. $m_{magnet} = 161.75g$

AB

Current (A)	mass (g)
0.5	162.03g
1.0	162.32g
1.5	162.61g
2.0	162.90g
2.5	163.19g
3.0	163.50g
3.5	163.79g
4.0	164.07g
4.5	164.34g
5.0	164.66g

Part 2B

Loop Length	Mass (g)	Current (A)
SF38, 4.2cm	163.27g	5.0
SF42, 8.4cm	164.66g	
SF41, 6.4cm	163.88g	
SF39, 3.2cm	162.87g	
SF40, 1.2cm	162.12g	
SF37, 2.2cm	162.48g	