LAB 9: THE MAGNETIC FORCE ON A CURRENT CARRYING WIRE

Equipment List:
Pan Balance
Power supply
Pasco Magnetic force apparatus
aluminum support rods
red and black banana leads
One Gauss meter for the entire class

Introduction: A wire carrying a current will experience a force when subjected to an external magnetic field. In this lab, the external field is supplied by the red and white horseshoe shaped set of magnets provided in your kit. Your goal is to calculate the magnetic field within your permanent horseshoe magnet. To understand this lab, think of the forces acting on the magnet not the current element. By Newton's third law, the force on the current element is equal in magnitude to the force back on the magnet. The pan balance reads the normal force acting on the magnet. So there are three forces acting on the magnet: gravity, normal, and the magnetic force from the current carrying wire. With this knowledge the magnetic field within your magnet can be calculated.

Procedure: Set up your apartus as instructed. The readings taken from the pan balance must be done with great sensitvity and care. **Do not exceed the maximum current value through your circuit elements or else they will burn and be ruined. The maximum current through any of the conductors is 5 amps.** Take the data for at least five different lengths of the conductor.

1. For each length, use the balance to determine the force on the magnet from the current in the length of wire conductor.
2. For each length, once you have the force, calculate the strength of the magnetic field.
3. Use as many different lengths for your current element as as time permits.

Analysis: First, write down in your lab book the maximum current that can be put through any of the conductors. (Hint: it is written on this page.) When taking data, keep checking that your current is less than this value.

Directly compute the value of the magnetic field for all of your five or six measurements (five field values for five conductor lengths). Your answer should be in units of kilogauss (because that is the unit the meter will read). Find the average field magnitude and its uncertainty (the standard deviation of the mean). There is one Gauss meter for the entire

The lengths of your conductors are given by the following code:

SF 40	1.2 cm
SF 37	2.2 cm
SF 39	3.2 cm
SF 38	4.2 cm
SF 41	6.4 cm
SF 42	8.4 cm

class, which should be used to verify your calculated value for the magnetic field within your permanent magnet.

Standard deviation of a set of values $\{x_i\}$

$$s(x) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

NOTE: The Gauss meter is expensive and the probe is very delicate. It can be easily broken. Take great care in using it. Your instructor should directly help in taking all measurements with the Gauss meter.

Compare your average field value to the Gauss meter reading. Does the meter value fall within the most probable range from your average and uncertainty (average plus or minus the standard deviation)? If so, you have "agreement". If not, consider in your conclusion what could have happened. Also, calculate the percent discrepancy between the meter value and your average value. You could get as much as twenty or thirty percent discrepancy (remember, the field in the magnet is not really uniform and will fluctuate in value as the meter probe is moved about so stable spacial values are unlikely). Using the right hand rule, predict the direction of the magnetic field within the magnet (white to red or red to white).

Graph the magnetic force versus the length of the conductor and from the slope determine the value the magnetic field. Compare the value for the field that you get from the graph to the previous method of taking the average. Which gives a more accurate result?

Conclusion: Comment on the agreement or lack thereof between your average field value and the Gauss meter reading. If there is discrepancy, try to explain why. Compare also to the value from your graph. How uniform do you think the magnet's field is? Why? Can you think of any factors that might give rise to errors in your data?