Analyzing Magnetic Fields of Different Coil Setups

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The properties of conductive coils determine the behavior of the magnetic fields they produce when a current is ran through the coil. We measured magnetic field strength of the coils under different configurations and with a solenoid in order to determine confirm relationship between distance from coils and field strength. We observed behaviors within close of approximation of the theoretical equations with error fits within.

INTRODUCTION

The magnetic field strength of coils is defined by the Biot-Savart law at a certain point. Restricting the degree of freedom to one axis access simplifies the relation in order to analyze differences in setups and how they relate to the magnetic field.

Data analysis allows for the determination of parameters within certain error. Curve fitting using analytical software allows for an analytical determination of theoretical and experimental data. The goal of this lab was to set up a variety of different coils in different configuration in order to the analyze the behavior of the magnetic field in relation to the position along the x-axis.

I. PROCEDURE AND METHODOLOGY

The lab set up included the utilization of PASCO 850 Universal Interface along with a dynamic track mount. The track mount established the axial dimension on which a magnetic field sensor was centered through the coils. The setups included single coil, Helmholtz, solenoid, and parallel track configurations as seen in Fig. 1. The coils obey the Biot-Savart Law:

$$d\mathbf{B} = \frac{\mu_0}{4\pi}\frac{Id\ell\times\hat{\mathbf{r}}}{r^2}$$

which was used to create the model for analysis. For each individual setup the coils and solenoid were re calibrated and centered along the axis of the coils. PASCO coupled with the Magnetic Field Sensor and the Rotary Motion Sensor provided Position (m), Magnetic Field (Axial), Magnetic Field (Perpendicular), and Time (s) data for each configuration. A total of 3 configurations with varying distance parameters where tested: Single Coil, Two Coils, Solenoid, and Parallel to Track. The two coil configuration included a subset of set ups where the distance between the two coils were 1.5R and .5R, where R is the Radius of the Coil.

Once experimental data was collected from the setup, iPython IDE coupled with Jupyter Notebook was utilized for data analysis.

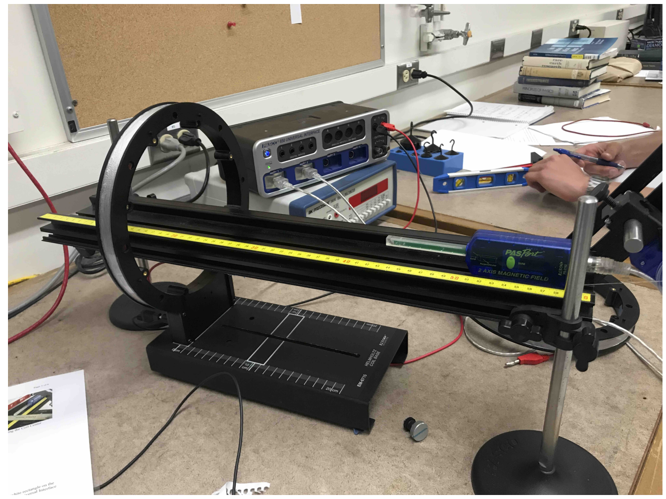

FIG. 1. Setup for Single Coil Helmholtz Configuration Including the Dynamic track Setup, The PASCO 850 Univeral Interfrace, The 500 Turn Coil, and the Magnetic Field Sensor.

II. DATA AND RESULTS

The initial recording of the data was unsuccessful as the unfamiliarity with PASCO software led us to export the data containing the Magnetic Field Strength with only 4 significant figures. This export essentially cut off after the Magnetic Field went below 1e−4. We retook the data with more significant figures. The following data is from the second experiment run. All of the fit within the models provided by the theoretical equations for their respective configurations within acceptable error margins of 5%.

III. ERROR ANALYSIS

From the Fig. 2 the Curve Fit is well within the error bars represented in the graph. The dominant experimental error was introduced by the calibration of the graph as well as the deviation from the center of the coil as was evident in our sensor data of the Perpendicular Magnetic Field Strength.

IV. CONCLUSION

The Theoretical and Experimental data coincided to withing error margins within 5%. There was not huge deviation from the modeled equation as represented by the goodness of fit of the data analysis.

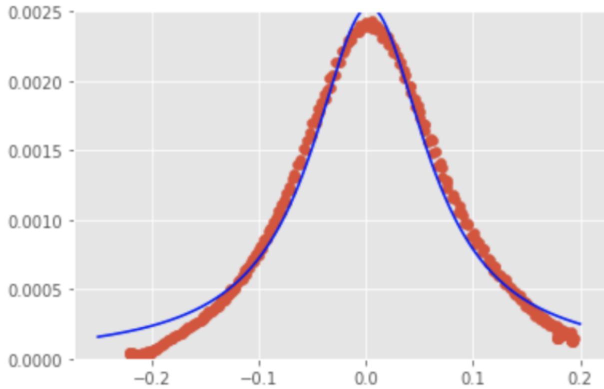

FIG. 2. Curve Fit of Single Coil Analysis Using Python, x-axix Position(m) with x=0 centered at the coil. y-axis(Magnetic Field (Axial T))