Magnetic Field Gradient Generation for Localization of Miniature Medical Devices

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USC Viterbi School of Engineering

SHINE Summer High School Intensive in Next-Generation Engineering

Introduction

Professor Monge's research concerns the location of miniature wireless medical devices within the body. After the creation of localizable microchips which mimic nuclear spin, Professor Monge's team was able to begin utilizing magnetic field gradients to interact with these chips.

Magnetic Field Gradient
- A magnetic field (B field) whose size, shape, and strength is varied at various points.

Objective & Impact of Professor's Research

The objective of Professor Monge's research is to utilize magnetic field gradients in order to localize miniature wireless medical devices in the body. The function of these devices is entirely contingent upon their location within the body, thus the ability to precisely locate and move them is paramount to ensuring proper functionality.

Skills Learned

- Python Coding and Graphing
- Magnetic field and gaussmeter details
- Deeper understanding of electromagnetism
- Testing with a physical coil

Design Fundamentals

Based on the diagram and equation illustrated in Figure 1 below, we found the relationship between radius and number of turns needed.

This was used to design the physical model, as shown in Figure 2.

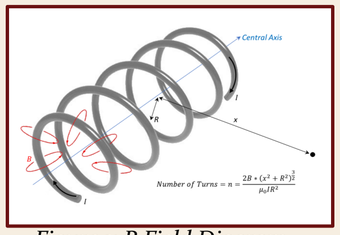
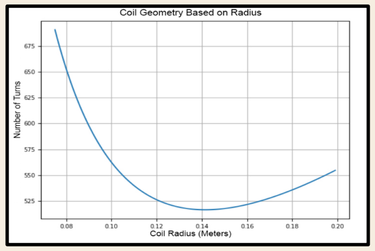


Figure 1: B Field Diagram

From this equation, creating a coil of radius 4.27 cm would need roughly 500 turns. Calculations showed that about 15 cm of depth to coil was needed.

Figure 2: Turns vs Coil Radius



The final test setup is shown in Figure 3 below.

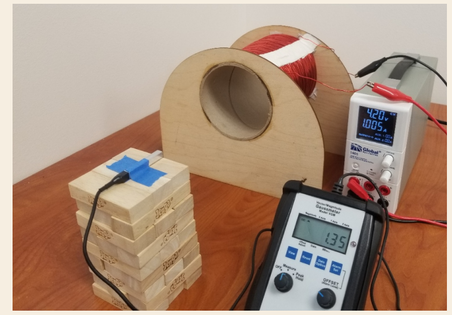
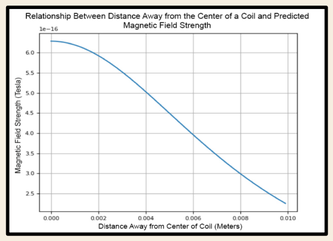


Figure 3: Test Setup

Results

The data confirmed that distance varied inversely with magnetic field strength. This is shown clearly in a comparison between the predicted (Figure 4) and the observed (Figure 5) field strength curves below.

Figure 4 Predicted Magnetic Field Strength



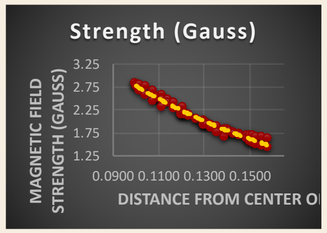


Figure 5 Observed Magnetic Field Strength

How This Relates to STEM Coursework

I began to learn about the electromagnetic spectrum in freshman year, in which we learned about many types of light, from ultraviolet to infrared.

This knowledge was furthered in chemistry, in which we explored nuclear spin and the basics of the property of magnetism.

As I continue to learn about physics, the knowledge of how magnetic fields are created, shaped, and how they function will be incredibly useful.

The ability to delve deeper into not only what a magnetic field is, but its inception, its function, and its fundamental properties is an opportunity I have yet to experience until SHINE.

Next Steps

- Measure and analyze magnetic field strength in three dimensions, rather than simply away from the coil in a flat plane
- Measure field strength in the opposite direction
  - Strength should theoretically be the same magnitude, but negative
- Create Magnetic Field Gradient and analyze impact of movement on signal strength
  - Test gradient impact on miniature medical devices

Acknowledgements

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