Investigation of electromagnetic field produced by a copper wire coil under varying conditions

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This study aims to investigate the relationship between various factors and the strength of the resulting magnetic field generated by a copper wire coil. The factors explicitly examined include the distance from the center of the coil in the axial direction, the number of wire turns, and the diameter and length of the coil. By systematically varying these factors, we measured the resulting magnetic field strengths. The experimental results provide insights into how these factors affect the magnetic field strength.

1 Introduction

Electromagnetism is a fundamental force that governs the interactions between electric charges and magnetic fields. It describes the relationship between electric currents and the magnetic fields they produce. Understanding this relationship is crucial in various fields of science and technology, as well as for the engeneering of numerous devices, including motors, generators, and transformers.

The purpose of this experiment is to investigate the electromagnetic field produced by a copper wire coil. By passing an electric current through the coil, we can observe the formation of a magnetic field. By utilizing a wireless magnetic field sensor, the strength of the magnetic field inside the coil was measured. Our objective is to examine the relationship between various factors and the strength of the resulting magnetic field. Factors that were explicitly investigated were the distance from the center of the coil in axial direction, the number of wire turns and the diameter as well as the length of the coil.

1.1 Background Knowledge

To understand the relationship between electric currents and magnetic fields, we turn to Maxwell's equations, which describe the behavior of electromagnetic fields. One of Maxwell's equations, known as Ampere's law, reveals the connection between the current flowing through a wire and the magnetic field it generates.

According to Ampere's law, when an electric current passes through a conductor, a magnetic field is created around it. The strength and direction of the magnetic field depend on the magnitude and direction of the current. The magnetic field forms a closed loop around the conductor, with the field lines curving around it.

The relationship between current and magnetic field can be further understood through the right-hand rule. If the thumb of the right hand points in the direction of the current, the curled fingers represent the direction of the magnetic field lines around the conductor. The magnetic field strength decreases as the distance from the conductor increases, proportional to the inverse of the square of the distance ($H = \frac{I}{2\pi r}$, where H is the strength of the magnetic field, I the current applied and r the distance from the wire).

In this experiment, we will investigate the electromagnetic field produced by a copper wire coil. Copper is an excellent conductor due to its high electrical conductivity. When an electric current is passed through the coil, a magnetic field is generated in its surroundings. Understanding the characteristics of the electromagnetic field generated by copper wire coils is essential for designing efficient electromagnetic devices and advancing technologies such as energy transmission, wireless communication, and magnetic sensing.

2 Methods

2.1 Tools and material

Tools and material that were used include: - Different premanufactured copper coils - The coils were specifically designed to have most traits in common with one varying - Wireless magnetic field sensor by [Pasco](https://www.pasco.com](https://www.pasco.com) - We used the IPad application SPARKvue to retrieve the results sent by the sensor

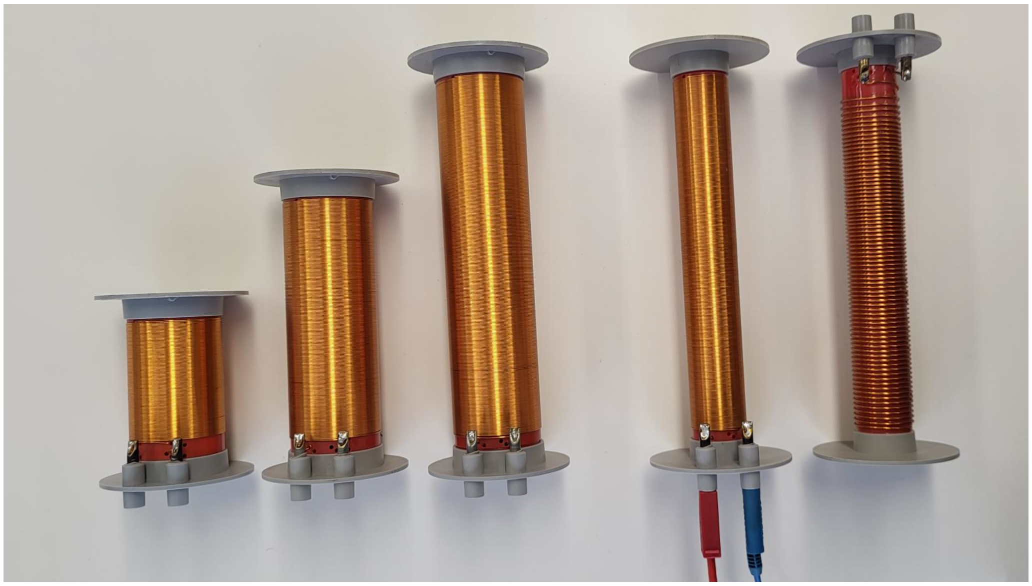

Fig. 1: Copper wire coils that were used

2.2 Procedure

First an open circuit was created with two ends, that could be plugged into a copper wire coil to close the circuit and apply voltage to the coil. With the power supply, the voltage as well as the maximum current could be regulated. An arbitrary voltage was chosen that allowed for good measurements, the effective voltage and current were then measured for each measurement directly in the circuit.

The

3 Results

The results were collected in a spreadsheet and exported into a CSV format, both of which are found in the same directory as this file or under those links: - Spreadsheet (ODS format) - CSV

The most important data that was recorded is presented in the following sections.

3.1 Experiment one

In this experiment three coils were measured with the same density of copper wire but different lengths and consequently a lower number of wire turns.

Here is the recorded data:

Windings	Length (cm)	Invisible shaft (cm)	Current (A)	Voltage (V)	Field Strength (mT)	Resistance (Ω)	Diameter (mm)
300	16	7.6	0.45	1.525	1.02	3.5	41
200	10.6	5.035	0.4	1.14	1.11	2.2	41
100	5.3	2.5	0.3	0.585	0.944	1.1	41

$e = mc^2$

$\oint \mathbf{B} \cdot \mathbf{dl} = \mu_0 \cdot I_{\text{enc}}$

4 Sources

4.1 Tools and material

1. magnetic field sensor
    2. Produced by pasco (https://www.pasco.com(https://www.pasco.com](https://www.pasco.com))

4.2 Information, Knowledge

1. https://www.maxwells-equations.com/