Exp. 6: Magnetic Field of Coil

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Physics 2410 Lab

13 October 2023

Abstract

A study was done to determine the variation of the magnetic field at various locations on a solenoid coil with a current running through it. This was achieved by using a magnetic sensor and taking measurements of the magnetic field at the sensor at different points near the coil. Additionally, the inductance of the coil was determined by taking three measurements of the magnetic field at several points near the coil. The inductance (in Henries) of the coil was determined to be 0.499 mH by equation and 0.482 mH by experiment.

Introduction

The purpose of this experiment was to determine the magnetic field at various points along a solenoid. The magnetic field along a solenoid can be calculated both experimentally and with an equation. The equation used for the magnetic field was , where is the permeability of free space, *I* is the amount of current flowing through the solenoid, *N* is the number of coils of wire in the solenoid, is the length of the solenoid, is the distance between the far end of the solenoid and the field probe, and is the distance between the near end of the solenoid and the field probe. By taking measurements along a solenoid also, experimental values for the solenoid’s magnetic field can also be determined. These values can then be graphed alongside each other to compare their values.

Additionally, the inductance of the solenoid coil can be calculated both experimentally and with the formula , where *A* is the cross-sectional area of the coil. To calculate the inductance experimentally, the magnetic field of the coil can be measured when various amounts of current are running through it. The slope of the magnetic field values over the current values can then be taken and plugged into the formula to determine the inductance by equation.

Procedure

A solenoid was set up with a magnetic field probe set at the relative center of the solenoid’s cross-section. Measurements were taken of the coil’s length, outer diameter, inner diameter, average radius, and number of turns, and a current of 2.22 amps was supplied to the solenoid by a DC power supply. By then setting the distance to be 42.5 cm and to be 7 cm, the first measurement of the magnetic field of the solenoid could be taken. After this measurement was taken, the probe was moved 1 cm down the track, and another measurement was taken. This process was repeated for 52 tests. Additionally, a formula was used to find the same values for the magnetic field by equation.

The inductance of the coil was then determined by equation and experimentally. Using the formula , the inductance was calculated by equation. To determine the inductance of the coil experimentally, the power supply was set to supply 0.3 A of current to the solenoid. The value of the magnetic field was measured. The current was then increased by 0.1 A, and another measurement was taken. This process was repeated for 8 tests. Using these values for the current and magnetic field, a trendline could be created for the data. The slope of this trendline could then be used to determine the experimental inductance of the coil.

Results

The magnetic field at various points along the solenoid can be represented with the following graph.

Here, the blue marks represent the experimental values, and the orange marks represent the values determined by equation. As can be seen, the values are extremely like each other, with the experimental values being marginally smaller than the values by equation. Additionally, the inductance by equation was 0.499 mH by equation and 0.482 mH by experiment. These values are also nearly identical.

Question A: The magnetic field stays relatively constant.

Question B: The magnetic field begins to decrease significantly. The magnetic field begins to decrease at a slower rate, but still nearing zero.

Question C: About four data points.

Question D: All three values were essentially zero.

Questions to be Answered

1. The graphs are nearly identical. Yes. Yes.
2. The percentage difference is about 3.4%.
3. As the distance from the coil decreases, the magnetic field of the coil is becoming weaker at an increasingly fast rate. This is because magnets weaken with distance.
4. 21.7, 38.6, 60.3, 86.8, 118, 154, 195, 241 nJ