Magnetic Field in a Current-Carrying Coil

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Abstract

Abstract in progress!

Introduction

We use a magnetic field sensor to measure magnetic fields. Since magnetic fields are vector quantities, they have orthogonal components. We can attempt to measure these components separately by moving a magnetic field sensor in a single dimension.

When referring to the magnetic field created by a solenoid, we call the component that runs parallel to the vertical axis of the solenoid the **axial component** of the field; likewise, we call the component that runs perpendicular to the vertical axis of the solenoid the **radial component** of the field. The direction of each field component, as measured by the sensor, is relative to the orientation of the sensor. This direction is shown with positive and negative values.

The general equation for finding the magnetic field along the perpendicular axis through the center of a coil of wire with negligible length, radius R, and N turns of wire (**Equation 3**) is

$$B = \frac{\mu_0 N I R^2}{2(x^2 + R^2)^{3/2}} \tag{1}$$

where $\mu_0 = 4\pi \times 10^{-7}\ T \cdot \frac{m}{A}$ is the permittivity of free space, I is the current through the coil, and x is the distance from the center of the coil.

The equation for finding the magnetic field of a long solenoid with n turns per unit length, we use **Equation 4**:

$$B = \mu_0 n I \tag{2}$$

where μ_0 is again the permittivity of free space, shown above. To be considered a *long* solenoid, the length of the coil inside the solenoid must be significantly longer than the diameter of the coil. Solenoids that do not fit this description are referred to as *short* solenoids. Also, Equation 4 fails when approaching the ends of the solenoid, where the magnetic field strength begins to decrease.

For short solenoids, we are not able to use either Equation 3 because the length of the coil is too long, and we are not able to use Equation 4 because the length of the coil is too short. Instead, the two equations provide bounds on the value of the magnetic field.

Apparatus

Experimental Procedure

Data

Calculations and Graphs

Discussion of Results and Error Analysis

Conclusion