Exp. 7: Current Balance

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Abstract

A study was done to determine the value of *K*, where *K* is a constant in the formula which relates the strength of a current running through a wire to the force applied due to the wire’s magnetic field. This was determined by using a current balance to measure the distance a wire was moved when running a current through another wire underneath it. The value for *Ktheoretical­­­­­* was calculated with the formula to be 9.07E-06, and the value for *Kexperimental*­ was determined to be 7.05E-06.

Introduction

When a current passes through a wire, it generates a magnetic field of proportional strength outside of the wire. The direction of this wire can be determined using the right-hand rule. The magnetic field in a cylindrical object, such as a wire, is represented by the formula , where is the permeability of free space, *I* is the current through the wire, and *R* is the radius. Because this field forms a circular shape around the wire, another wire placed on the magnetized wire will be pushed up with a particular force. This force can be represented with the formula , where *L* is the length of the wire, and *d* is the separation distance between the two wires. By allowing *K* to represent , the formula can be simplified to . The goal of this experiment is to find this value *K*.

Procedure

In this experiment, a current balance was set up to have two thin wires with one resting on top of the other. Several measurements were taken, including the length of the wires (*L*), the lever arm (*a*), the distance from the knife-edge to the front of the scale (*b*), and the diameter of the wire. An AC power supply was used to run a current through the lower wire so that a magnetic field would be created, pushing the upper wire upwards. A telescope and mirror were then used to determine the change in height (*D*) of the upper wire when the power supply was turned on by determining the change in elevation on a ruler. This was repeated 5 times. Additionally, the separation was calculated using the formula . The overall separation was calculated with the formula *d* = *d0* + diameter. *Ktheoretical­­­­­*­­ could then be calculated with the formula .

To determine *Kexperimental*­, wires of cumulative mass 20, 30, 40, 50, and 60 mg were placed each placed on a scale on top of the upper wire. For each test, the current running through the wire was increased until the wire returned to its equilibrium position. The force on the wire was then calculated using the formula , where *m* is the mass of the wire bits. The current *I* was then measured. A scatter plot with a trendline of Force vs. I2 was generated, and the slope of this trendline was used as *Kexperimental*­.

Results

The value for *Ktheoretical­­­­­* was calculated to be 9.07E-06, and the value for *Kexperimental*­ was determined to be 7.05E-06. While not exactly equal, the *K* values are similar. This difference in values may be the cause of human error, such as when using the telescope to determine the change in elevation of the wire. This could also be due to error in measuring the current balance’s various implements.

Questions to be Answered

1. The percent difference is 22.2%, which is not reasonable.
2. Random uncertainties: the weight of the wire bits. Systematic uncertainties: the accuracy of the measuring tools, including the calipers, ammeter, and ruler.
3. The diameter of a very small wire becomes increasingly negligible as the separation distance increases. This is because a small amount of magnetic field is contained in the wire itself, and the strength of this field is proportional to the wire’s diameter.
4. A graph with arrows and symbols

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