Lab 3: Resistivity of Copper Wire

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EE 145L
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1 Abstract

The purpose of this lab is to explore the relationship between temperature, resistivity and resistance for copper wire and to experimentally determine the resistivity at 0C ρ_o and the temperature coefficient α_o of copper. ρ_o and α_o were found to be $\rho = 1.59 * 10^{-8}\Omega m$ and $\alpha_o = .00397C^{-1}$, and were found to be accurate compared to accepted values within 1.79 and 0.47 percent error respectively.

2 Introduction

When discussing a metal's ability to conduct electricity, one of the important values to consider is the metal's resistivity ρ. ρ is the reciprocal of conductivity σ which describes the ability of the metal to conduct electricity. A material's resistivity is influenced partially by lattice vibrations, which make it more difficult for electrons to move through a material. It is intuitive to think then, that because these vibrations increase in magnitude with temperature, that a material's resistivity is proportional to the temperature of the material.

Normally, when measuring how well a material conducts electricity, the Resistance R of a component is measured. Resistance and resistivity differ in that resistance describes how an **object** resists the flow of electricity whereas resistivity describes how a **material** resists the flow of electricity. For a length of wire, the resistivity can be found from Equation 1, where A is the cross-sectional area of the wire and L is the length of the wire.

$$\rho = R\frac{A}{L} \tag{1}$$

The resistivity of a material varies with temperature according to Equation 2 where ρ_o is the resistivity of the material at T_o and α_o is the temperature coefficient of resistivity. In this lab, T_o will be chosen as 0 Celsius. The goal of this lab is to experimentally find the value of ρ_o and α_o for copper.

$$\rho = \rho_o + \rho_o * \alpha_o * (T - T_o) \tag{2}$$

3 Materials and Methods

Materials:
- 20m long, .0245mm diameter spool of copper wire

- digital thermometer
- digital multimeter
- glass beaker, filled with water
- hotplate

Methods:
The beaker was first filled with enough water to fully submerse the spool of copper wire. The beaker was placed on the hotplate, and the leads of the multimeter were connected to either end of the copper wire. The multimeter was turned on and set to the resistance mode. The thermometer was placed in the water and turned on. The hotplate was set to maximum heat. A first data point (resistance and temperature) was collected for the starting temperature, and for every 10 degrees celsius afterwards until the water reached 100 degrees. All of the resistance values were then converted to resistivity ($\Omega * m$) using L = 20m and $A = \pi * .000245m^2$.

4 Results and Analysis

The experimental data from this lab is shown in Figure 1. A best-fit line has been applied to the data to characterize it. By matching the best fit equation with Equation 2 where $\rho_o * \alpha_o$ is the slope and ρ_o is the y-intercept, it is shown that $\rho_o = 1.48 * 10^{-8}\Omega m$ and $\rho_o * \alpha_o = 5.88 * 10^{-11}$. α_o can be calculated as $\frac{5.88*10^{-11}}{1.48*10^{-8}} = .00397C^{-1}$.

Accepted values of resistivity at 20C and the temperature coefficient were found as $\rho_o = 1.59 * 10^{-8}\Omega m$ and $\alpha_o = 0.0039C^{-1}$ from http://www.endmemo.com/physics/resistt.php. Comparing these to the experimental values, the temperature coefficient was found to be .00397 compared to .0039 giving a percent error of 1.79%. According to the best fit equation, at 20C the resistivity of the copper wire would be $\rho = 1.60 * 10^{-8}\Omega m$ compared to the accepted value of $\rho = 1.59 * 10^{-8}\Omega m$, giving a percent error of 0.47%. These errors are very small and indicate a good accuracy for the collected data. Any error is likely due to temperature fluctuation and hysteresis of the copper wire within the heated water bath, as well as equipment inaccuracies.

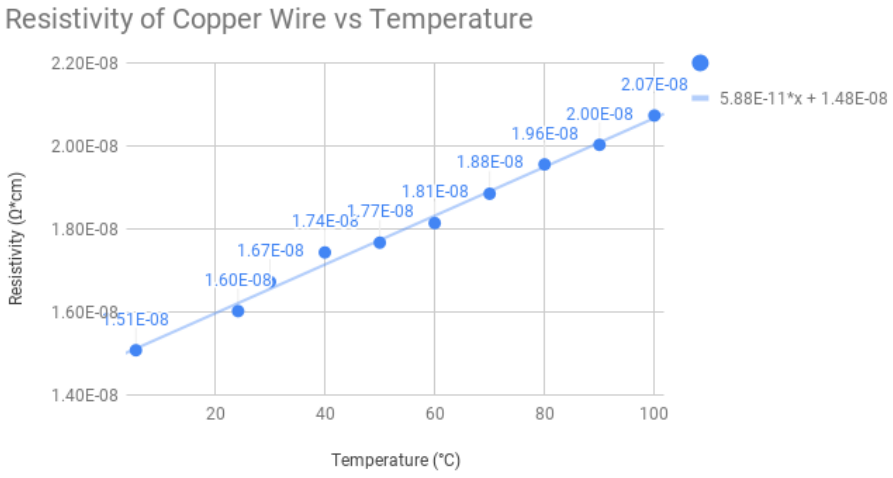

Figure 1: Resistivity of Copper Wire vs Temperature

5 Conclusions

In this experiment, the relationship between temperature, resistivity and resistance was explored. It was shown that for a length of copper wire, resistivity and resistance both increase proportionally with temperature. For copper, the temperature coefficient and resistivity at 0C and 20C were found and compared with accepted values.α_o and ρ_o were found to be accurate compared to the accepted values within 1.79 and 0.47 percent error respectively. These results show a very small error that indicates high accuracy of the data. The relatively high 1.79 percent error is due mostly to the fact that the accepted value of α_o was rounded to one fewer decimal places than the experimental value.