Resistivity

Lab

09/11/2017

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Abstract

In the following lab report, the students were tasked with finding the resistivity in a material and how it is affected by the length of the material. The group created a hypothesis which stated that resistivity was directly related to the length of the material. To test their hypothesis, the students placed the material and a multimeter in series with a circuit created using a DC power supply in order to measure the current as they shortened the material. The results proved their hypothesis to be incorrect and presented resistance as the value that was directly related to the length while resistivity was shown to be constant. The students learned that they had mistaken which value was affected directly by the length, and that resistivity is always constant in a material.

Objectives

The objective of the lab was to have the students implement their newfound understanding on resistivity and circuits in an experiment. By performing the experiment, the students have an opportunity to display the extent of their understanding on resistivity and circuits. The instructor tasked the individual lab groups with finding the resistivity of a material through the use of multimeters and what had been recently taught. After being provided with multiple materials, each group was left alone to craft their own experiment.

Introduction / Background

In class, the instructor reviewed basic circuit information, like Ohm's Law

$$(V = I * R). \tag{1}$$

The students were taught new circuit concepts. For example, the effects the dimensions of a wire has on resistance, the formula for resistivity

$$(\rho = 1/\sigma), \tag{2}$$

and the relationship between resistivity and resistance

$$(R = \rho \times l/A). \tag{3}$$

The formula for resistivity showed that conductivity and resistivity are inversely related. Conductivity deals with how effective a material is in allowing electricity to flow through it. Meanwhile, resistivity tells how much a material resists electricity when applied in a circuit. In order to connect the basic circuit concepts with the newly learned concepts, the students were shown how to find resistance (1) with resistivity. Using the measured length, diameter, voltage, and amperes of a material, the equation (3) can be utilized to solve for resistivity.

After learning the new circuit concepts, the lab group used this information to create a hypothesis on what they believed would affect the resistivity of a material. The equation $\rho = (V/I) \div (l/A)$ displays that the length and cross-section area of the material directly affect resistivity. It was concluded that if the material's length increased, then the resistivity increased, and if the material's cross-section area increased, then the resistivity decreased. The students devised this hypothesis believing that a longer distance the electricity had to travel would result in more energy being lost. A smaller cross-section area would allow less room for the flow of electricity, and thus the amount of energy moving across the material would be less.

Materials

Each lab group was provided with multiple materials to utilize in their experiment. For tools, the students used multimeters, DC power suppliers, and meter sticks. The materials used consisted of wires, playdough, and nails. A brief description and image of each item is provided below.

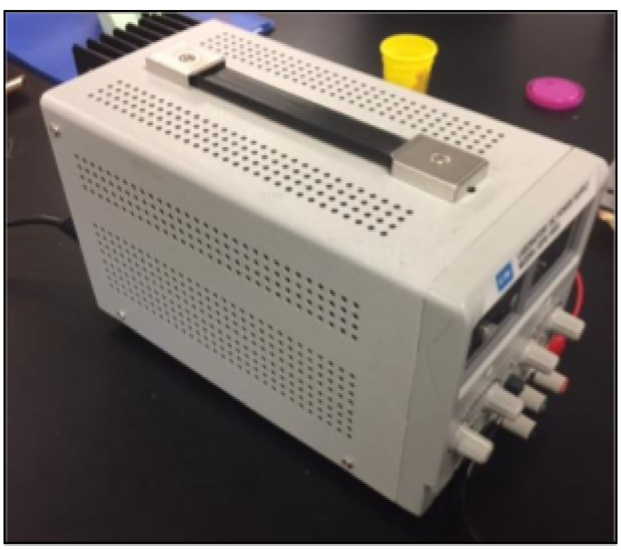

Figure 1 - DC Power Supply

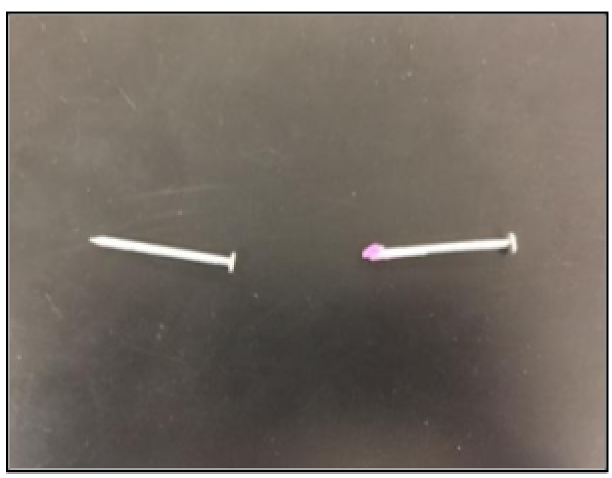

Figure 2 - Two nails

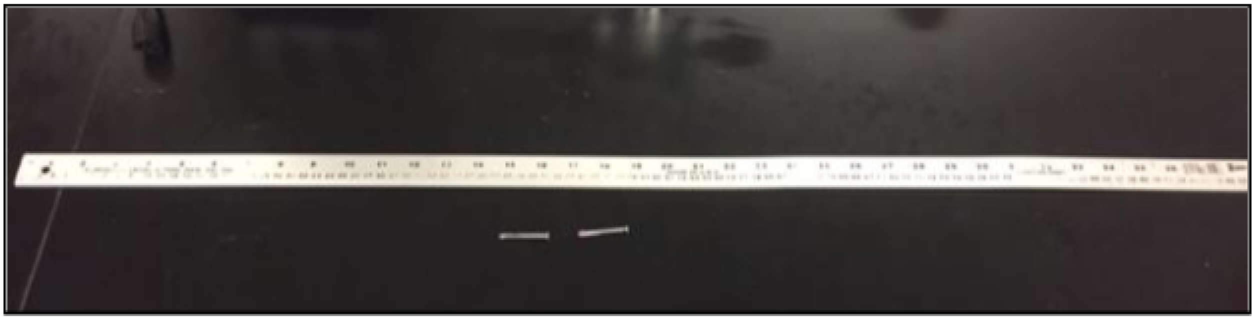

Figure 3 - Meter Stick

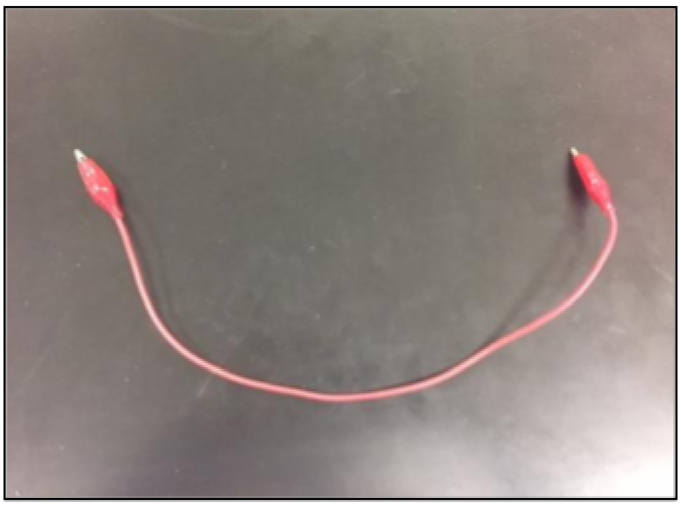

Figure 4 - Wires

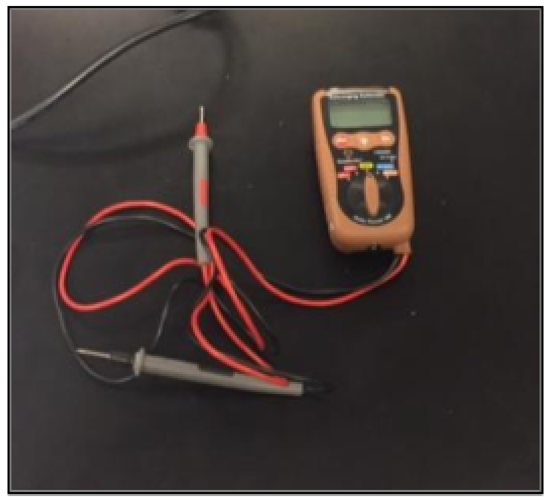

Figure 5 - Multimeter

Figure 6 - Playdough

Procedure

Using the items depicted above, the group formulated a lab setup that would allow them to find the resistivity when the diameter or length of the wire (playdough) was changed. The

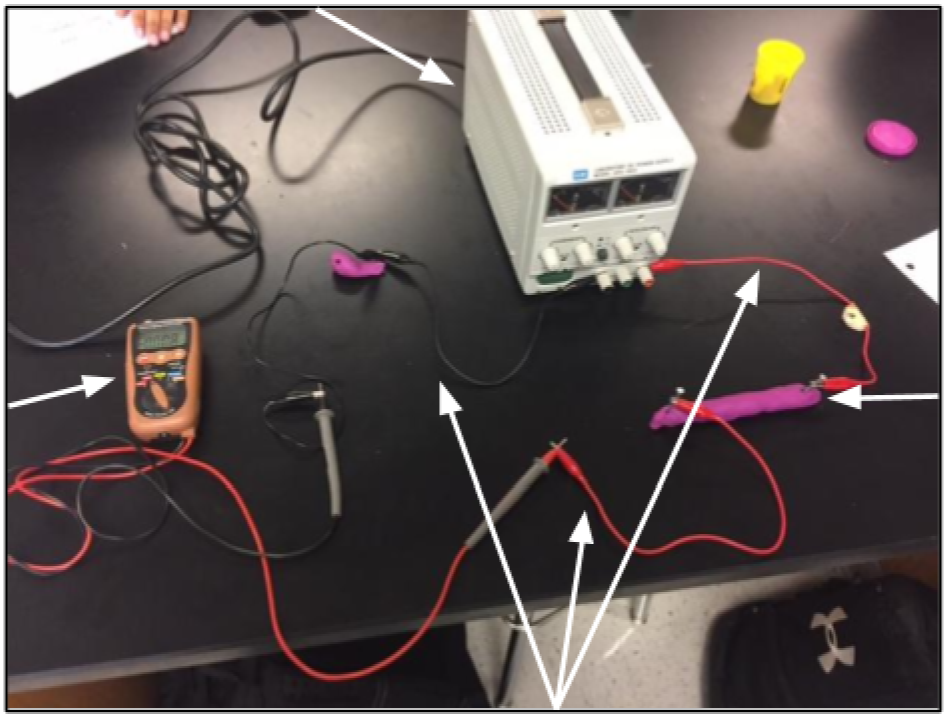

Figure 7 - Lab Setup

power supply would be used to provide a voltage to the circuit, and to allow a student to control the amount of voltage going into the circuit. Four wires (three wires would have been suffice) were attached to one another to form a series circuit. Between the wires in series, the playdough (with nails) and the multimeter were implemented in series with the circuit. In order to measure the effect the length and cross-sectional area of a material can have on resistivity, the playdough was rolled into a cylinder-like shape to allow the group members to measure the diameter and length with ease. Implementing the multimeter in series with the circuit was necessary for measuring the current. Once the experiment was set up, the group began collecting data by measuring the current at 5V every time the length of the playdough was changed. The different lengths for the playdough that were tested in the experiment were 15cm, 12cm, and 9cm. During each trial, the diameter remained constant (1.5cm). For a better representation of the data collected, refer to Figure 8.

Lab Steps

1. Plug power supply into outlet
2. Attach a wire on the positive output and one on the negative output of the power supply
3. Roll the playdough into a cylinder-like shape and attach two nails at each end vertically
4. Attach either the positive or negative wire to one of the nails
5. Attach a new wire to the other nail
6. Use the new wire to connect one multimeter probe to a nail
7. Use the remaining negative / positive wire to connect with the remaining multimeter probe
8. Turn the multimeter dial to mA and power on the power supply
9. Record the current every time the length is changed

Data & Results

Tables & Graphs

Length (cm)	15	12	9
Current (mA) at 5V	25.0	30.9	40.7

Figure 8 - Raw Data

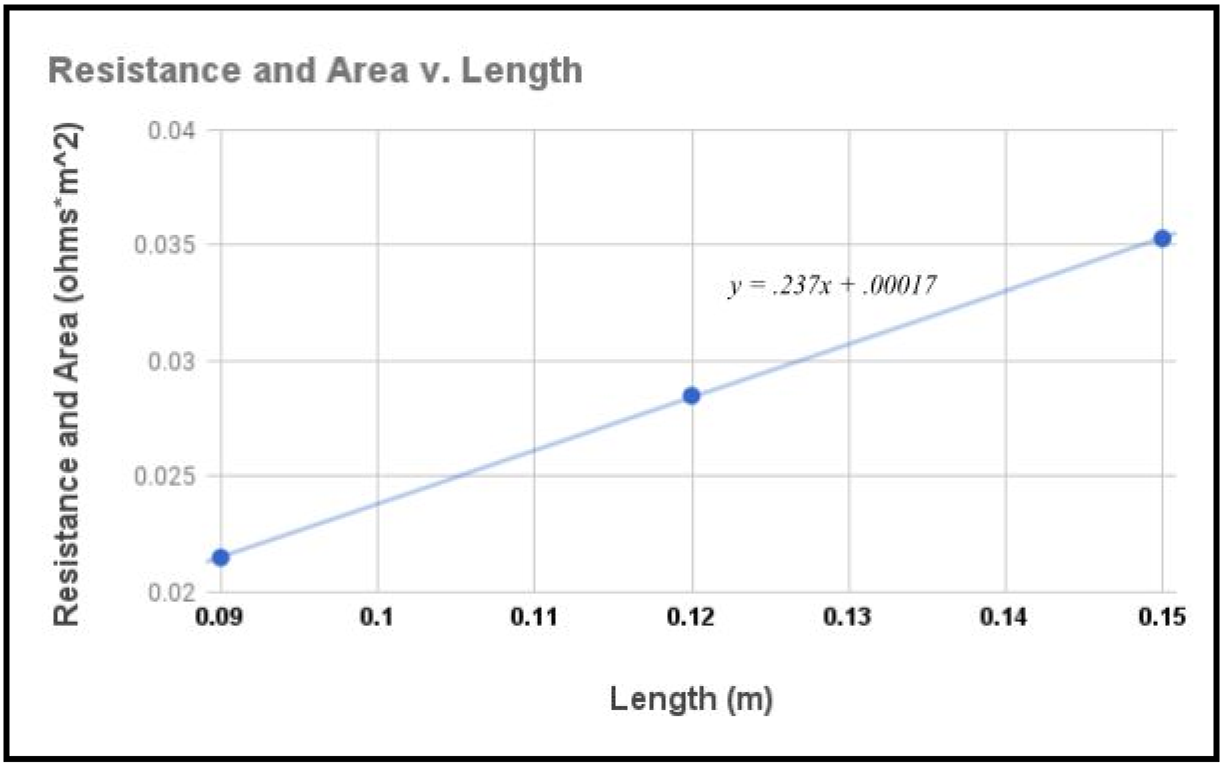

Figure 9 - Graphed Data & Resistivity

Calculations

Conversions:

$1.5cm \times (1m/100cm) = .015m$

$15cm \times (1m/100cm) = .15m$

$12cm \times (1m/100cm) = .12m$

$9cm \times (1m/100cm) = .09m$

$25mA \times (1A/1000mA) = .025A$

$30.9mA \times (1A/1000mA) = .031A$

$40.7mA \times (1A/1000mA) = .041A$

R x A:

$(5V\ /\ .025A) = 200.0\Omega \rightarrow 200.0\Omega \times (\pi \times .0075^2) = .0353\Omega \times m^2$

$(5V\ /\ .031A) = 161.3\Omega \rightarrow 161.3\Omega \times (\pi \times .0075^2) = .0285\Omega \times m^2$

$(5V\ /\ .041A) = 121.9\Omega \rightarrow 121.9\Omega \times (\pi \times .0075^2) = .0215\Omega \times m^2$

Resistivity:

$.0353\Omega \times m^2/.15m = .235\Omega \times m$

$.0285\Omega \times m^2/.12m = .238\Omega \times m$

$.0215\Omega \times m^2/.09m = .239\Omega \times m$

$(.235 + .238 + .239) / 3 = .237$

Description / Discussion

After completing the experiment, the students utilized the data to solve for resistance (1). Their calculations exhibited the resistance decreasing as the length of the playdough grew shorter. The resistance values were then multiplied with the area of the cross-section in order to find $R \times A$. These values were utilized in the graph, Figure 9, along with the length values. The slope created by the line-of-best-fit resulted in the resistivity value of the playdough. When the resistivity was found through their calculations, the students noticed that their answers were relatively the same.

Conclusion

Considering the results from the experiment and calculations, it was concluded that the original hypothesis was incorrect. The resistivity remained relatively constant as the length of the playdough changed. Instead, it was the resistance value that changed as the length of the playdough was shorten. When producing their hypothesis, the students had mistaken which values were constant and which were not. The values of resistivity that were found through calculations were exactly equal to one another. This inaccuracy is a result from possible errors that occurred during the experiment. During the experiment, the group had noticed that their playdough had begun to melt from the heat being created by the electricity. Also, the group struggled with reading the values produced by the multimeter because they would continuously fluctuate, thus making it difficult to read an exact value. These complications were the likely causes of the small errors observed in the data and calculations. Ultimately, the lab helped the students learn that resistivity was a constant in each material, while resistance was directly related to the length of the material. The lab has helped the students improve their knowledge on resistivity and circuits by correcting their misunderstandings.