Lab Three Report:

ENGR217-203

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Abstract:

In this lab the resistivity values for three different lengths of wires was determined. These values were determined to be similar for each of the three wires. Additionally, the properties of resistors in series and parallel were determined. In the cases of a series circuit, it was found that the voltage was divided between two resistors, while the current was constant. In the case of a parallel circuit, it was found that the current was divided between the two paths, while the voltage was constant.

Introduction:

The purpose of this lab was multifaceted. First the resistivity of each wire was to be determined. Next the amount of voltage provided to each wire resistor was to be determined based on how the circuit was set up. To complete this lab, understanding of basic circuit principles was necessary. Information about circuit theory and resistivities is found in the Theory section of the report. Next the experimental procedure and setup are displayed in the Procedure section. Finally the results are presented, analyzed, and summarized in the Results and Conclusion sections.

Theory:

It is often thought that resistance and resistivity are the same thing, but this is a false assumption. Resistance opposes the flow of free electrons, which makes it harder for the voltage to pass through the wire/resistor. Therefore, when the resistance of a wire increases, the voltage would also have to increase to keep the same current. Resistivity is the property of the material which defines the resistance. It is calculated by multiplying the resistance and cross-sectional area and then dividing that answer by the length of the wire.

There are two important laws regarding the behavior of circuits. The first, is the law of conservation of energy. In a circuit electrical potential, or voltage, is conserved as current moves through the circuit. Since the voltage at the start of the cycle, must equal the voltage at the end of the cycle, the net voltage across each path in the circuit must equal 0. In other words, no matter what path the current takes, the energy produced must equal the energy consumed. This is known as Kircoff's loop rule. The other law of conservation is the law of conservation of charge. Similar to the law of conservation of mass, the conservation of charge states that the net charge of a system must always remain the same, or charge into a system equals charge out of the system. In a circuit, this means that the current into a loop, must equal the current leaving a loop. This is known as Kircoff's Current Law. These two laws can be combined to determine the behavior of current in a circuit.

Equations:

$$\mathbf{R = (l * \rho)/a} \qquad \textbf{(1)}$$

where R is resistance, l is the length of the wire, ρ is the resistivity, and a is the cross sectional area of the wire.

$$\mathbf{V = IR} \quad \textbf{(2)}$$

where V is the voltage, I is the current, and R is the resistance of the wire.

$$\mathbf{R_{series} = R_1 + R_2 \ldots + R_N} \quad \textbf{(3)}$$

where R_{series} is the total resistance of the circuit in series, R_1 is the first resistance value, R_2 is the second resistance value, and R_N is the nth value of resistance.

$$\mathbf{1/R_{parallel} = 1/R_1 + 1/R_2 \ldots + 1/R_N} \quad \textbf{(4)}$$

where $R_{parallel}$ is the total resistance of the circuit in parallel, R_1 is the first resistance value, R_2 is the second resistance value, and R_N is the nth value of resistance.

Experimental Procedure:

First, the resistivities of each wire had to be discovered. To do so, the board was set up in the configuration seen in *figure 1*. A constant current was supplied by the power source, and the voltage across the wire was measured for varying lengths of the wire using the DAQ. 7 trials spaced out by 100mm were sufficient for the experiment. These 7 trials were conducted for each of the wires, recording voltages and lengths of wire along the way. Another parameter needed was the cross-sectional area of the wire. To obtain this, the wire diameter was measured using calipers for each wire. At the end of this step, each wire had a diameter and voltages associated with lengths recorded.

Next *figure 2* was created. Now a constant voltage source was used. The circuit was a series set up, and the probes attached to the DAQ were attached to various points on the circuit to measure the voltage across each wire. To measure the voltage across the medium wire, the probe was set up to be in parallel with it. For the thick wire the same procedure was followed. This process was repeated for 3 different voltages, and the data was recorded.

Finally the parallel circuit seen in *figure 3* was constructed. A constant voltage was applied from the power source, and the voltages were read across each resistor using the DAQ.This process was repeated for 4 different voltages, recording all data.

Figure 1

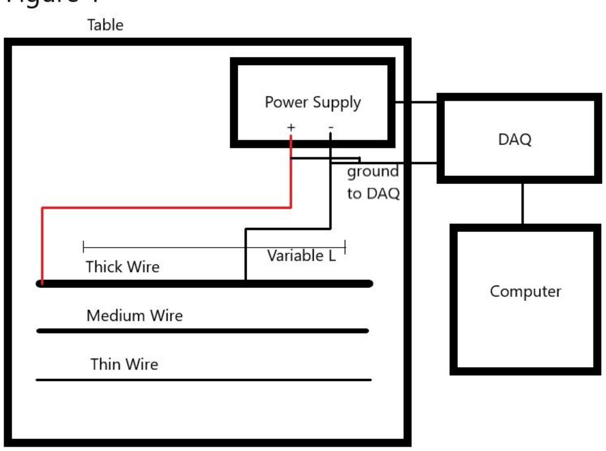


Figure 2

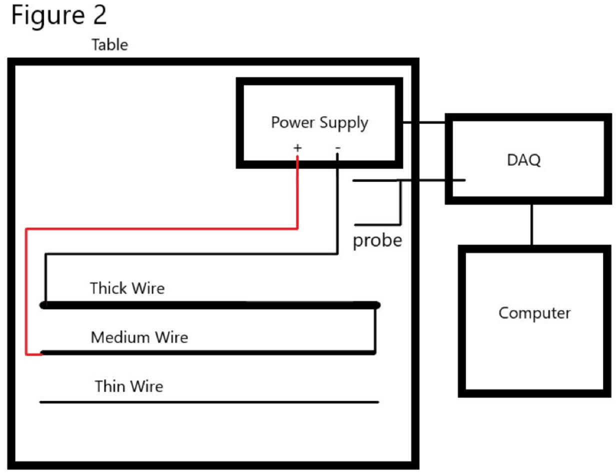
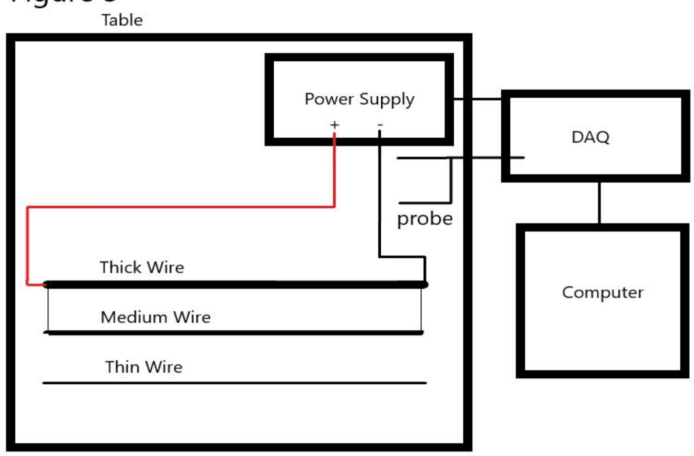


Figure 3



Results and Discussion:

The calculated resistivities are depicted in Table 1. As the thickness increases, the resistivity decreases. This follows suit with the equation $R = \frac{l*\rho}{a}$. Area is dependent on thickness, which is inversely related to resistivity.

Table 1. Wire Thickness vs Resistivity constant

Wire Thickness (mm)	Resistivity
0.4	0.01192275018
0.32	0.01423132069
0.24	0.01734956725

Figure 3 shows the experimentally determined relationship between the measured voltage across a varying length of wire at constant current. The relationship is linear, and this is expected. Given the formulas for voltage, $V = IR$ and resistance, $R = \frac{l*\rho}{a}$, we see that $V = I\ \frac{l*\rho}{a}$. Given that ϱ, **I**, and **a** are constant, *V* is directly related to *l*, resulting in a linear relationship. It can also be noted that as the resistivity of the wire increases, the rate at which *V* increases also increases by a factor of $\boldsymbol{\varrho}$**.**

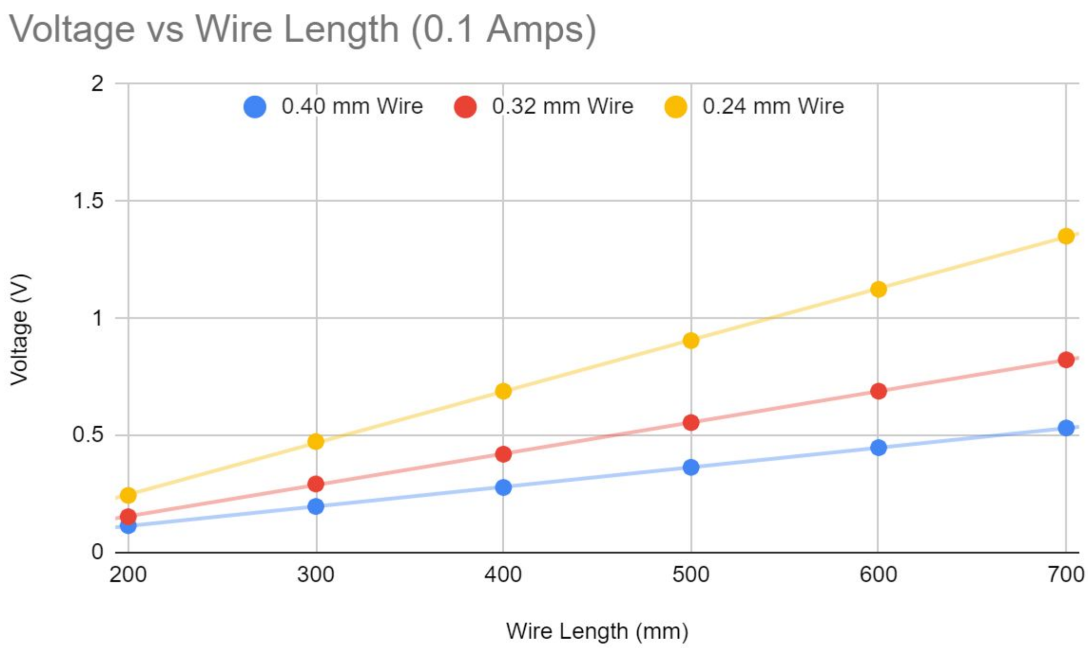


Fig 3. Voltage vs wire length. Voltage increases approximately linearly with wire length

Figure 4 and 5 show the voltage across resistors in two different configurations. Figure 3 shows the two resistors in series. For a series circuit, the voltage across each resistor is proportional to the resistance of the wire, but the current going through each resistor is equal since there is only one path for current to flow. The total sum of the voltage across the resistors should equal the voltage of the power source. Our data confirms this result as the sum of both values nearly exactly equals the total voltage.

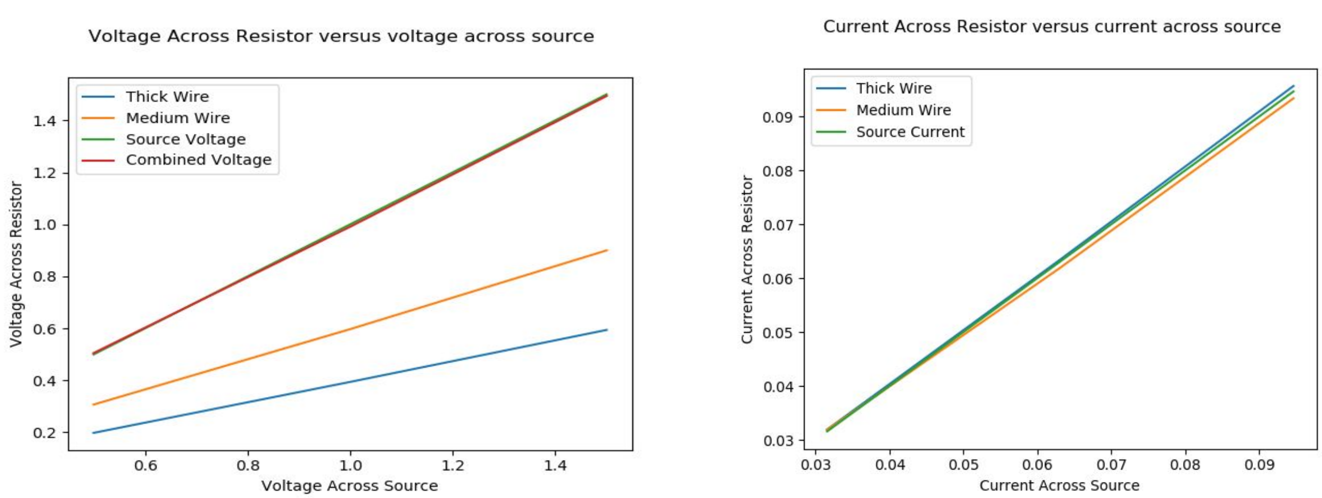
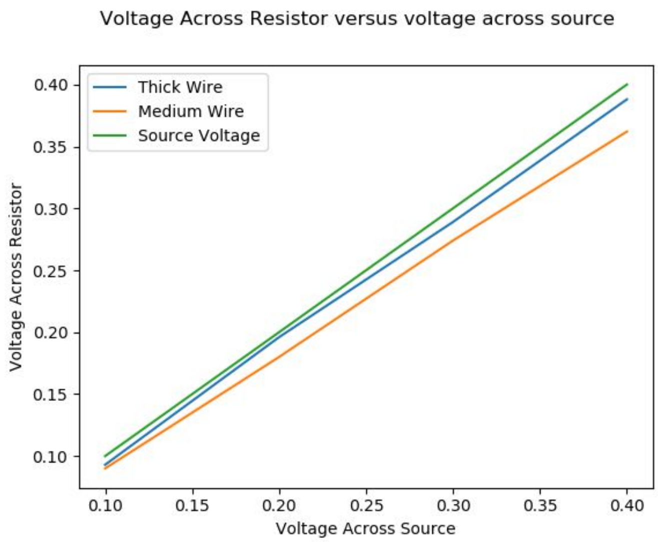


Fig 4. Voltage across each resistor in series, the sum of both wires approximately equals the total source voltage. For the current, it is clear that the current through each resistor is equal to the source current.

Figure 5 shows the resistor configuration in parallel. For this set up, since there are two paths for current to flow, the current in each path is proportional to the resistance, however the voltage across each resistor is equal to the source voltage. Our data confirms this result, since the voltage across each resistor almost exactly equals the source voltage and the sum of the currents is almost equal to the source current..



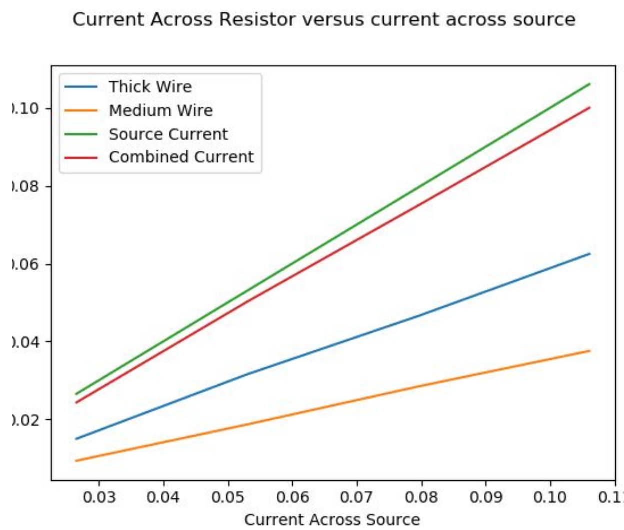


Fig. 5 Voltage across each resistor in parallel, for each resistor the voltage across it is approximately equal to the source voltage. For the current, the sum of the current through each branch is approximately equal to the total source current.

A potential source of error for this lab that was not accounted for, was the resistance of the wires used to connect the circuits. The resistance of these wires would also cause a drop in voltage that would need to be factored in as well in a circuit analysis.

Conclusion:

Using ohm's law and the definition of resistance, we were able to calculate the resistivity of a set of three wires, which were found to have relatively similar values. This is consistent with our theoretical definition of resistivity as it is an inherent property of a material, and all three wires are of the same material. In the second part of this lab, we confirm that Kircoff's loop and junction rule held true in our series and parallel set up. In series, the total current through each wire was the same but the voltage was divided based on the resistance of each resistor. However, the sum of both values equaled the source voltage. In the parallel set up, the opposite was true, where the voltage was constant, but the current was divided based on the resistance. Similarly, the sum of both currents equaled the source current.