E5a: Resistivity

Introduction:

Electrical resistivity is an intrinsic property of a material and measure how strong it opposes the flow of electrical current. A lower value of resistivity indicates that the material allows the current to move easily through the wire. When coming to electrical or electronic devices, manufacturers choose materials according to the purpose of the device. Then, if the devices is meant to be an insulator, the material must be chosen with a high resistivity value and the opposite if it is meant to be a good conductor.

This experiment is divided into three parts. In the first part, a single wire and Ohm's Law will be used to find the resistivity of brass. In the second part of the experiment, the dependence of the resistivity with the diameter of the wires will be studied and in the last part of the experiment, it will be possible to find resistivity of different materials.

Apparatus:

- Resistivity apparatus
- Different materials wires
- 850 Pasco Interface
- Computer

Figure 1

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Discussion:

Ohm's Law describes the relationship between the resistance (R) of a wire, the voltage drop across it (V), and current through it (I):

$$V = RI \qquad (1)$$

Applying a known current to a wire and measuring the voltage across it will let you determine the resistance of the wire by solving equation 1:

$$R = \frac{V}{I} \qquad (2)$$

The resistance of a particular element depends on its geometry, the resistivity and the temperature. Resistivity is the tendency of the material to behave as a resistor and is an inherent property of a material, in the same sense that density or thermal expansion are inherent properties. Materials with lower resistivity, like copper, are good conductors of electricity and widely used in circuit components while those with larger resistivity, like rubber, are used as insulators.

For a wire with length (L), cross-sectional area (A), and made from a material with resistivity (ρ) the resistance (R) will be given by the following equation:

$$R = \frac{\rho}{A}L \qquad (3)$$

In case that the geometry (length and cross sectional area) and the resistance of the wire is known, then is possible to calculate the resistivity solving equation 3:

$$\rho = \frac{RA}{L} \qquad (4)$$

A wire can be consider as a long cylinder; then the cross sectional area would have a circular shape as shown in Figure 2.

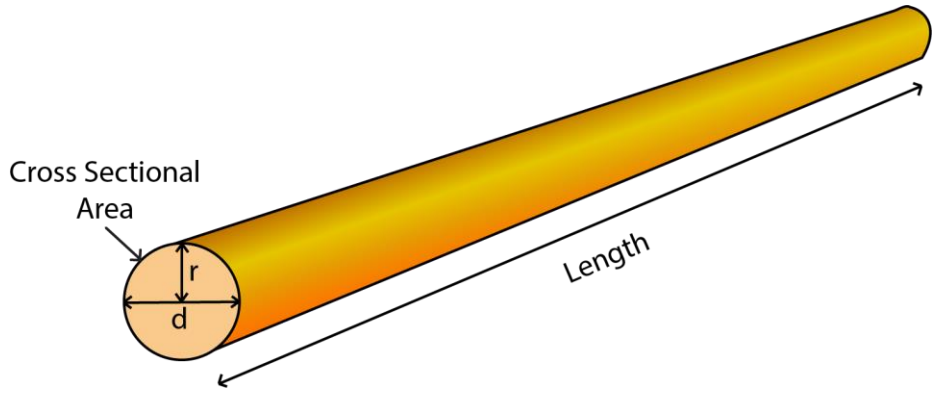

Figure 2

Then the cross sectional area of the wire can be calculated using the equation of the area of a circle:

$$A = \pi r^2 \qquad (5)$$

In this experiment, you will measure V and I to determine R for various lengths of wire. You will then make a graph of Resistance (Y-axis) versus length (X-axis). The plot will result in a straight line that has a slope equal to

$$slope = \frac{\rho}{A} \qquad (6)$$

From equation 6, it is possible to solve the resistivity in terms of the slope and the cross sectional area:

$$\rho = slope * A \qquad (7)$$

The manufacture values of the resistivity corresponding to the wires used in the experiment are reported in Table 1. These values will be used as the theoretical when calculating percent error.

Table 1. Theoretical resistivity of different materials according to manufacturer.

Material	**Color**	**Attracted to Magnet**	**Diameter (m)**	**Approximate Resistivity (Ωm)**
Brass	Yellow	No	0.000508 0.000813 0.001016 0.001270	7.0×10^{-8}
Copper	Red	No	0.001016	1.8×10^{-8}
Nichrome	Dark Gray	No	0.001016	105×10^{-8}
Stainless Steel	Dark Gray	Yes	0.001016	79×10^{-8}

Procedures:

Part 1 - Resistance vs Length

1. Find the four yellow brass wires. Select the wire with the largest diameter and set the other three wires to the side.
2. Find the diameter of the brass wire you just selected in Table 1 and record this value in Data Table 1.
3. Ask a Lab Instructor to demonstrate how to properly place the wire in the resistance apparatus.
4. Open the appropriate computer software for your experiment.
5. Click on the upper tab corresponding to Part 1 and Part 2.
6. Set the distance between the reference probe and the slider probe to 24 cm. Then monitor the voltage and current for five seconds. Record the mean values for the voltage and current on Data Table 1.
7. Reduce the distance between the reference probe and the slider probe by 2 cm and monitor again for five seconds recording the mean values for the voltage and current on Data Table 1.
8. Repeat step seven until you reach a length of 2cm.

Part 2- Diameter vs Resistivity

1. Find the other three yellow brass wires that you set aside for Part 1. On this part of the experiment, you will use the four brass wires.
2. Record the diameter for each wire in the Data Table 2. Make sure also to include the wire used on Part 1.You will find these values in Table 1.
3. Place the thinnest wire in the resistance apparatus and set the distance between the reference probe and the slider probe to 24 cm.
4. Monitor the voltage and current for five seconds. Record the mean voltage and current on Data Table 2.
5. Repeat steps 3-4 for the remaining brass wires. For the wire with the largest

Part 3- Resistivity of Different Materials

1. Click on the upper tab corresponding to Part 3.
2. Find the remaining three wires (two grey and one red).
3. Record the diameter of the wires in Data Table 3. You will find these values in Table 1.
4. Place one of the wires in the resistance apparatus and set the distance between the reference probe and the slider probe to 24 cm.
5. Monitor the voltage and current for five seconds. Record the mean voltage and current on Data Table 3.
6. Repeat steps 3-5 for the remaining two wires.

Analysis:

Part 1 - Resistance vs Length

1. Calculate the cross sectional area of the wire using equation 5.
2. Using Ohm's law, equation 2, calculate the resistance of the wire for each length.
3. Construct a graph using excel with the resistance as a function of length.
4. Using the slope and the calculated cross sectional area, calculate the resistivity of the wire. Use equation 7.
5. Compare the calculated resistivity with the theoretical value reported in Table 1 to find the percent error.

Part 2- Diameter vs Resistivity

1. Calculate the cross sectional area of each wire using equation 5.
2. Using Ohm's law, equation 2, calculate the resistance for each wire.
3. Using the equation for resistivity, equation 4, calculate the resistivity for each wire.
4. Calculate the mean and standard deviation for resistivity.
5. Compare the mean of the resistivity with the theoretical value for brass reported in Table 1 and calculate the percent error.

Part 3- Resistivity of Different Materials

1. Calculate the cross sectional area of each wire using equation 5.
2. Using Ohm's law, equation 2, calculate the resistance for each wire.
3. Using the equation for resistivity, equation 4, calculate the resistivity for each wire.
4. Use the theoretical values for resistivity from Table 1 to figure out the material of each wire. You will do this by comparing the calculated and the theoretical resistivity. Once you recognize the material of each wire, calculate the corresponding percent errors.

E5a: Resistivity

Student Name_____

*Lab Partner Name*_____

*Lab Partner Name*_____

Physics Course_____

Physics Professor_____

Experiment Start Date_____

Lab Assistant Name	*Date*	*Time In*	*Time Out*

Experiment Stamped Completed

Data Sheet: E5a: Resistivity of Different Materials

NAME: _____ DATE: _____

Table 1 - Resistance vs Length

Diameter of wire: _____ Cross Sectional Area of wire: _____

Length ( )	Voltage ( )	Current ( )	Resistance ( )

Slope of graph Resistance vs Length:_____

Calculated Resistivity from slope:_____ Theoretical Resistivity:_____

Percent Error:_____

Data Sheet: E5a: Resistivity of Different Materials

NAME: _____ DATE: _____

Table 2 - Resistivity vs Diameter

Length of wire: _____

Diameter ( )	Cross Sectional Area ( )	Voltage ( )	Current ( )	Resistance ( )	Resistivity ( )

Mean of Resistivity: _____ Standard Deviation of Resistivity: _____

Theoretical Resistivity: _____

Percent Error: _____

Data Sheet: E5a: Resistivity of Different Materials

NAME: _____ DATE: _____

Table 3 - Resistivity of Different Materials

Length of the wires: _____

Diameter ( )	Cross Sectional Area ( )	Voltage ( )	Current ( )	Resistance ( )	Calculate Resistivity ( )	Theoretical Resistivity ( )	Percent Error