Resistivity

Name: ______________________

Introduction and Objectives:

The resistance of an electrical conductor depends on several factors. Its physical shape is one factor. The type of conductor material is another, as might be expected. That is, two conductors with the same physical shape, but of different materials, have different resistances. This important material characteristic of resistance is expressed in terms of a quantity called resistivity.

Temperature is another factor affecting resistance. In the present experiment, the factors of shape or dimensions and resistivity will be considered.

After performing this experiment and analyzing the data, you should be able to:

1. Explain on what factors the resistance of a wire depends and why.
2. Distinguish between resistance and resistivity.
3. Describe how the resistivity of a material may be measured.

Equipment Needed:

- Ammeter (0 to 0.5 A)
- Voltmeter (0 to 3 V)
- Rheostat (20 Ω)
- Battery or power supply (3 V)
- Meterstick
- Micrometer caliper

Conductor board with wires of various types, lengths, and diameters. For example, two wires of the same material (No. 24 and 30) and two wires of different material.

Theory:

The resistance of an electrical conductor depends on several factors. Consider a wire conductor. The resistance, of course, depends on the *type* of conductor material, and also on (a) the length, (b) the cross-sectional area, and (c) the temperature of the wire. As might be expected the resistance of a wire conductor is directly proportional to its length *l* and inversely proportional to its cross-sectional area *A:*

$$R \propto \frac{l}{A}$$

For example, a 4-m length of wire has twice as much resistance as a 2-m length of the same wire. Also, the larger the cross-sectional area, the greater the current flow (less resistance) for a given voltage. These geometrical conditions are analogous to those for liquid flow in a pipe. The longer the pipe, the more resistance to flow. But, the larger the cross-sectional area of the pipe, the greater the flow rate or the smaller the resistance to flow.

The material property of resistance is characterized by the resistivity ρ, and for a given temperature,

$$R = \frac{\rho l}{A} \qquad (1)$$

The resistivity is independent of the shape of the conductor, and rearranging Eq. 1,

$$\rho = \frac{RA}{l} \qquad (2)$$

From this equation, resistivity can be seen to have the units Ω-m or Ω-cm. Common metal conductors have resistivity's on the order of 10^{-6} Ω-cm. Another name sometimes used for resistivity is *specific resistance,* indicating that it is specific for a given material.

To determine the resistivity of some materials, a circuit arrangement as illustrated in Fig. 1 will be used. The ammeter measures the current ***I*** in a wire conductor on the conductor board and the voltmeter registers the voltage drop *V* across the conductor. Then, the resistance of the wire, by Ohm's law, is ***R = V / I.***

Measuring the length ***l*** of the wire and its cross-sectional area ***A*** (from diameter ***d*** measurement, ***d/2 = r*** and **A = πr^2),** the resistivity of the conductor can be calculated from Eq. 2. The rheostat R_h is used to limit the current in the circuit initially so as to protect the meters.

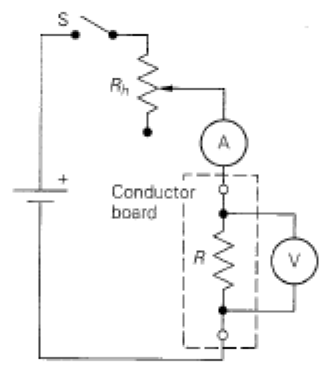

Figure 28.1 Resistivity measurement. The circuit diagram for experimental procedure to measure resistivity. See text for description.

Experimental Procedure:

1. Set up the circuit shown in Fig.1 with one of the wires on the conductor board in the circuit. Leave the switch S open and set the rheostat at maximum resistance. *Have the instructor check the circuit before activating.* *
2. After the circuit has been checked, close the switch and adjust the rheostat until the current in the circuit as indicated on the ammeter is 0.5 A. Read and record the meter values and open the switch as soon as possible to prevent heating temperature change.
3. Measure (a) the length of the wire between the voltmeter connections and (b) the diameter of the wire. Record these in the data table.
4. Test the effect of length. Change the length of the wire being tested by moving one of the voltmeter contact points and repeat the measurements.
5. Return the rheostat to its maximum resistance and repeat the procedure for the other wires on the board.
6. (a) Compute the resistances and cross-sectional areas of the wires, and use these values to determine the resistivity's of the materials.
   (b) Find the average resistivity for each material with more than one experimental value.
7. Compare the experimental values of the resistivity's with the accepted values by computing the percent error.

Data Table

Wire	Type of Material	Voltage, V (V)	Current, I (A)	Resistance $R = V/I$ (Ω)	Length (m)	Gauge	Cross-Sectional Area (m^2)	Resistivity (Ω-m)
1								
2								
3								
4								

Type of Material	**Accepted Value**	**Experimental Value**	**Percent Error**
______________	______________	________________	___________
______________	______________	________________	___________
______________	______________	________________	___________

Questions:

1. Do the experimental data confirm that the resistance of a conductor is (a) directly proportional to its length and (b) inversely proportional to its cross-sectional area? Support your answers!

2. How does the resistance of a wire vary with resistivity?

3. An annealed copper wire (No. 15 AWG gauge) is to be replaced with an aluminum wire with approximately the same length and resistance. What gauge of aluminum wire would be required?