EXPERIMENT 2
OHM'S LAW

Print 1 copy of the report page to start your lab report
Print 2 copies of the data page file

OBJECT:

To study Ohm's law for DC circuits, to learn basic construction and measurement of electric circuits, to learn curve fitting and basic error analysis.

APPARATUS:

Variable DC voltage supply, resistor, connecting wires, analog ampermeter, digital multimeter, and computer with current/voltage probes.

THEORY:

Electrical current is the amount of charge passing by a given point in a conducting path (circuit) per unit time: $I = dQ/dt$

The unit of current is the Ampere, which is equal to a (Coulomb/second) and, although it is defined by other relations, a current of one ampere exists in a wire if approximately 6.21×10^{18} electrons (charge of one Coulomb) flow through a given cross-section of wire in one second. It is agreed for convenience that the direction of the current is the same as the direction of movement of positive charges in electric field. In a metallic conductor, such as a wire, the only mobile particles are negatively charged electrons, which move in a direction opposite to that chosen for the conventional current.

The relationship between the voltage, current, and resistance in a metallic conductor is given by Ohm's law. It states as follows: If the temperature and other physical conditions of a metallic conductor are unchanged, the ratio of the potential difference across the conductor (V) to the current (I) is a constant. This constant ratio (R) is the resistance of the conductor.

$$R = V/I \qquad (1)$$

If potential difference is measured in Volts and current is in Amperes, resistance will be in Ohms (unit of resistance, equal to one Volt per Ampere).

The resistance of a metallic conductor depends only on its length, the area of cross-section, the material of the conductor and its temperature. It does not depend on either V or I. At a given temperature

$$R = \rho\, L/A,$$

where ρ, L and A are, respectively, resistivity, the length, and cross sectional area of the resistor. A resistor is called a "linear device", as opposed to a "non-linear device" such as diode, that does not obey the linear Ohm's law even without significant change in temperature. In this experiment we will study a regular resistor with constant resistance only.

PROCEDURE:

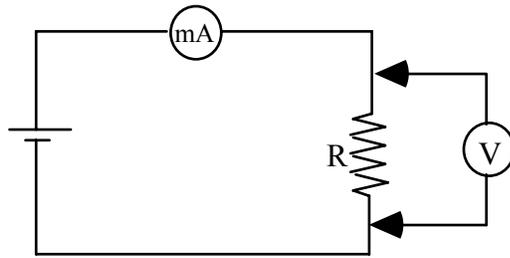1. Connect a circuit as shown in Fig.1

Figure 1.

Note: The voltmeter does not have to be connected to the circuit. You can measure the voltage across any two points by touching the points with the two leads of the voltmeter.

2. **Manual experiment**: Measure the current for 10 different voltages, with the increment of 1V. Record the current and voltage in your data table. Record the instrumental error in your measurements. The instrumental error is taken as 1/2 of the smallest division on the scale of the analog device, and 1 in the lowest digit for the digital device.

3. **Computerized experiment**: Use a computer with a voltage sensor and a current sensor in place of the voltmeter and the current meter to perform the same experiment outlined above. The data will be automatically taken and plotted. Use linear fit to obtain the resistance. Your instructor will tell you about the most recent version of the software in operation, and where to find the program for this experiment. The software is frequently updated, but should be pretty much self explaining. You need to collect data and use the computer program to plot your data and do a curve fitting. Print the graph and record the fitting parameters on your data page.

DATA ANALYSIS:

1. Plot the voltage versus current data in your data table. Use linear graph paper. Find the slope, which is experimental value for the resistance.

2. Fill out your data table: calculate the resistance for each trial, the average resistance R_{av} and the deviation for each trial $\Delta_i = R_i - R_{av}$.

3. Calculate standard deviation $\sigma = [\Sigma (\Delta_i)^2 /(n-1)]^{1/2}$ where n is the number of data points, and σ is the random error. As you can see, the random error can be reduced to as small as your time allows you to increase the number of measurements.

4. The instrumental errors in measurements of voltage and current propagates to the error in resistance. Calculate the instrumental error in resistance as follows:
   relative error in voltage, $\delta V = \Delta V/V$; relative error in current, $\delta I = \Delta I/I$. Use medium values for voltage and current in the denominators.
   relative error in $\delta R = \delta I + \delta V$, instrumental error in resistance $\Delta R = R_{av} * \delta R$

5. Combine the random error and the experimental error to obtain the total error ΔR_{tot} in your measurement of the resistance.

$$\Delta R_{tot} = (\sigma^2 + \Delta R^2)^{1/2}$$

6.Compare you results with the results of computerized experiment. Are they reasonably close?

Reminder: Check you math, check the units, check your graph, do not forget to follow the format for your lab report (see syllabus).