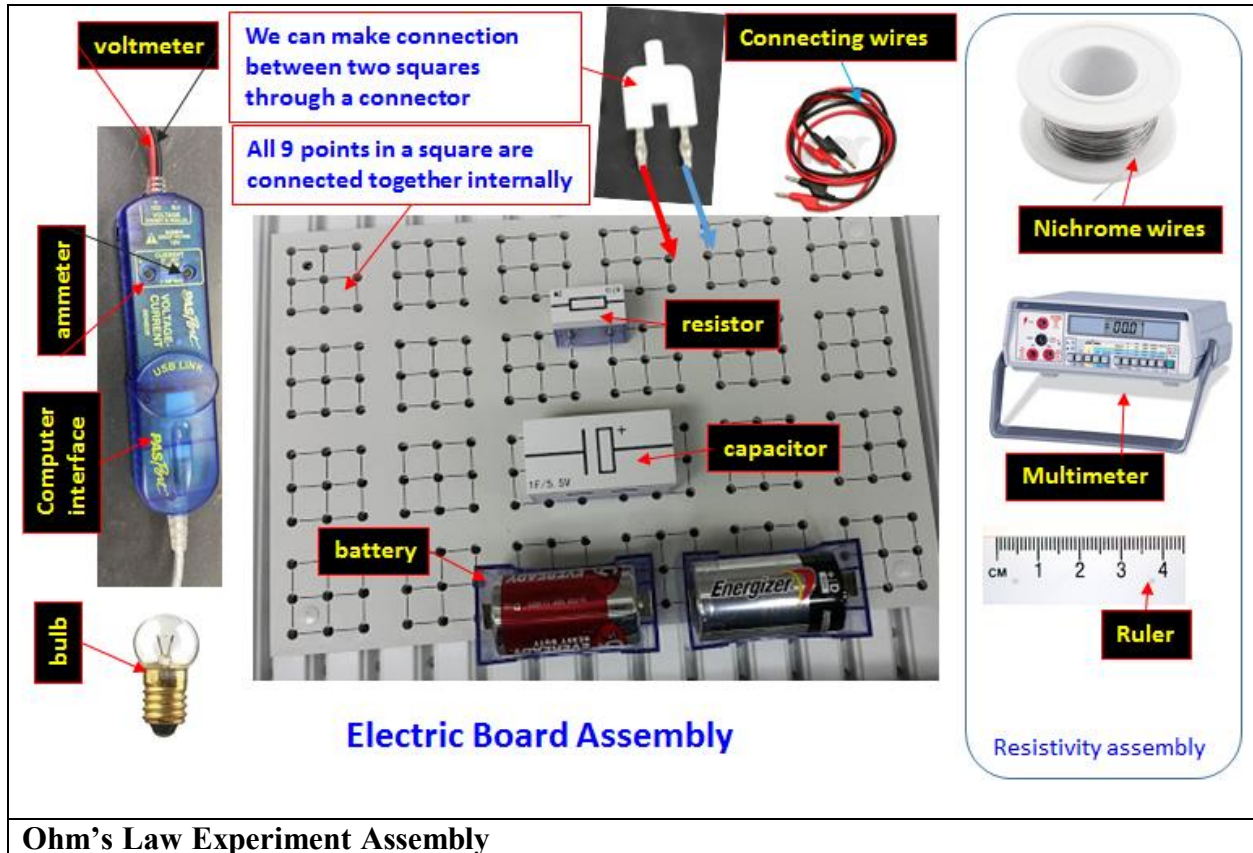


OHM'S LAW

Objectives:

- To find the unknown resistance of an ohmic resistor
- To investigate the series and parallel combination of resistors
- To investigate the non-ohmic resistors

Apparatus Required:



Theory:

Ohm's Law

The relationship between potential difference (V) across a resistor of resistance (R) and the current (I) passing through it is

$$V = RI. \quad (1)$$

Ohmic Resistors

The resistor which follows the Ohm's law is Ohmic resistor.

Series arrangement of Ohmic resistors

If two resistors R_1 and R_2 are connected in series, the equivalent resistor R_s is

$$R_s = R_1 + R_2. \quad (2)$$

Parallel arrangement of Ohmic resistors

If two resistors R_1 and R_2 are connected in parallel, the equivalent resistor R_p is

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2},$$
$$R_p = \frac{R_1 R_2}{R_1 + R_2}. \quad (3)$$

Non-Ohmic Resistors

Those resistors which don't follow Ohm's law are called non-ohmic resistors. Unlike Ohmic resistor the resistance of non-ohmic resistors is not constant. One of the many examples of non-ohmic resistors is filament lamp. The resistance of filament lamp increases as the temperature increase.

The resistance R of non-ohmic resistor at temperature T is

$$R = R_0 + \alpha R_0 (T - T_0). \quad (4)$$

Where, R_0 is the resistance at room temperature T_0 and α is the temperature coefficient of resistors.

Experiments:

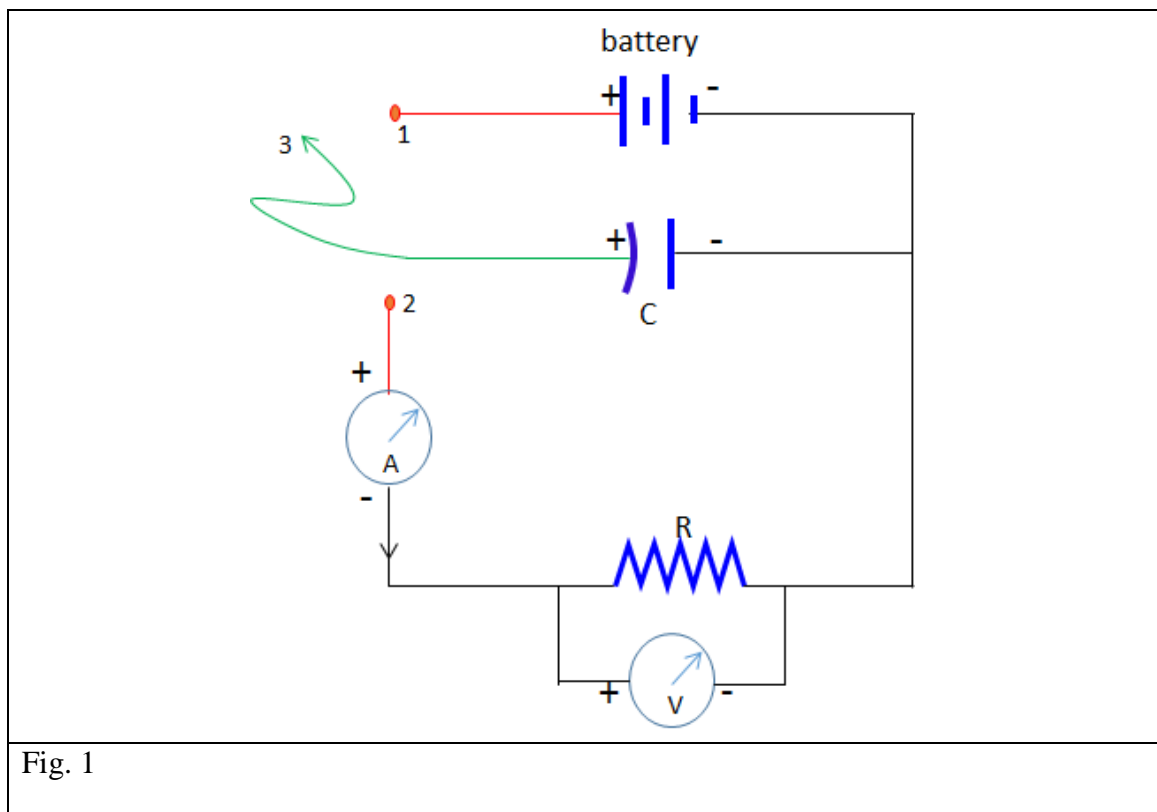
Part 1: Finding the value of R_1

In this exercise you will apply different potential differences across an ohmic resistor and measure the corresponding currents. The different potential difference are created through the discharging capacitor. Using equation (1) you will be calculating the resistance of the resistor and compare it with the directly measured value.

Procedure:

1. Connect the circuit diagram as shown in **Fig. 1**. R = Resistor, C = Capacitor, V = voltmeter and A = ammeter.
2. For power supply, apply two 1.5 volt batteries in series (Connect negative of one battery to positive of another battery). If batteries are not provided you can use power supply. **Be careful don't exceed 5.0V.**
3. Ammeter (A) and Voltmeter (V) are built in the I-V sensor. Connect I-V sensor to computer via interface.
4. Make sure all positive terminals are connected to positive and negative terminals are connected to negative.
5. Have your instruct check the circuit diagram.

6. Open the data studio software. Click on new experiment. Go to graph mode by dragging and dropping the graph from the left panel.
7. Choose Voltage in vertical axis and current in horizontal axis. Set up current and voltage ranges in the graph by using Ohm's law.
8. **Make the graph ready but don't start the program.**
9. Connect points 1 and 3 so that the capacitor will be charged by the battery. Since resistor is not included in the circuit the capacitor will be charged immediately.
10. Disconnect points 1 and 3. and
11. Connect points 2 and 3 and start data studio program immediately.
12. You will see a straight line in making in I - V graph from top to bottom.
13. Once the graph completes stop data studio. **Don't close the window as you will find similar graph for R_2 , R_s and R_p in the same window.**
14. Find the average value of resistor R_1 from graph by using equation (1). i.e. the slope of I - V curve.



Part 2: Finding value of R_2

Replace resistor R_1 in the circuit by another resistor R_2 and find the value of R_2 using same procedure as in part 1. You should start I - V curve for R_2 in the same earlier graph where you had I - V curve for R_1 .

Part 3: Investigating series combination of R_1 and R_2

In this exercise, you will connect R_1 and R_2 in series and find the equivalent resistance R_s . Then you will compare it with the expected value calculated from equation (2).

Procedure:

1. Connect R_1 and R_2 in series as shown in **Fig. 2 (a)**. Find the average value of series equivalent resistor R_s using same procedure as in part 1. You should start I-V curve in the same earlier graph where you had I-V curve for R_1 and R_2 .
2. Using equation (2) for R_1 and R_2 from part 1 and part 2 respectively, find the expected (theoretical) value of R_s .
3. Compare two values of R_s (find % error).

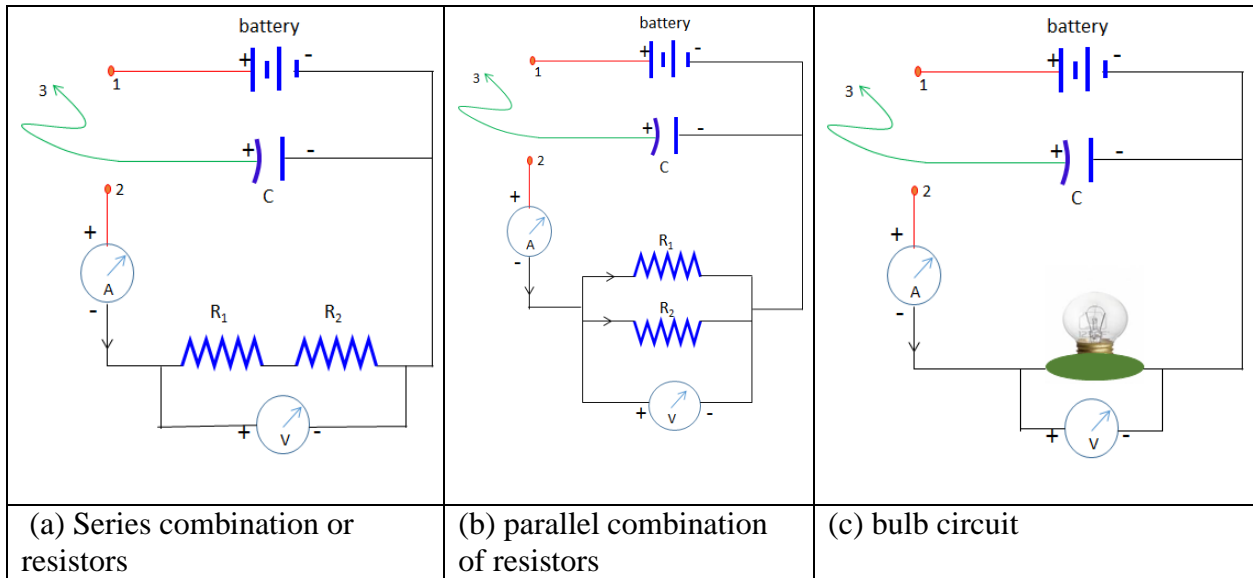


Fig. 2

Part 4: Investigating Parallel combination of R_1 and R_2

In this exercise, you will connect R_1 and R_2 in parallel as shown in **Fig. 2 (b)** and find the equivalent resistance R_p . Then you will compare it with the expected value calculated from equation (3)

Procedure:

1. Connect R_1 and R_2 in parallel as shown in **Fig. 2(b)**. Find the value of series equivalent resistor R_s using same procedure as in part 1. You should start I-V curve the in same earlier graph where you had I-V curve for R_1 , R_2 and R_s .
2. Using equation (3) for R_1 and R_2 from part 1 and part 2 respectively, find the expected (theoretical) value of R_p .
3. Compare two values of R_p (find % error).

Part 4: Investigating non-Ohmic Resistor: the filament bulb

In this exercise, you will apply different voltage across the filament bulb and find the corresponding current. You will plot the resistance versus voltage graph and see how resistance changes at different temperature.

Procedure:

1. Measure the direct value of resistance of the bulb with Ohm meter at room temperature and record it as (R_0) in the excel table. Take the room temperature resistance of the bulb R_0 as 3.0Ω if Ohm meter is not available.
1. Complete the circuit diagram as shown in **Fig. 2 (c)** by replacing the resistor with a bulb.
2. Repeat procedure of part 1 to get the I - V curve for the bulb.
3. You will notice I - V curve is not linear i.e. the bulb is a non-linear resistor.
4. Take axes (co-ordinate measurement) tool from the top of the data studio graph. Move the tool on the curve to find the values of V (y-coordinate) and their corresponding values of I (x-coordinate). Take the value for each 0.3 volt and record them in excel.
5. Record the maximum and minimum values of V and their corresponding I values.
6. Calculate the corresponding differential resistances by dividing voltages with their corresponding currents.
7. Alternatively, you can take a slope of the I - V curve at the interval of 0.3 V. The slope will be the direct measure of R . Take a slope tool and select very small portion of the curve around respective voltages mentioned.

Analysis:

2. Find the value of power for the maximum value of V that you have recorded ($P = V^2/R$).
3. Is the lowest value of your differential resistance closer to R_0 ? Verify and explain.
4. Find the temperature T at your maximum recorded voltage with the help of equation (4). Take T_0 from the wall thermometer.
5. The bulb is rated as 2.5V and 0.25 W power for the safe use. Explain with calculation what will happen if you apply 4.0 V to the bulb? (Provided the melting point of Tungsten filament as 3695K and its temperature coefficient is $4.5 \times 10^{-3} \text{ K}^{-1}$)