Experiment No. 4:

(a) Study of Ohm's law using unknown resistances.

(b) Determination of the equivalent resistances for series and parallel combinations of resistors.

4.1 Objectives

The main objective of this lab is to design circuits with different combinations of unknown resistances to verify the Ohm's law and determine the equivalent resistances for series and parallel combinations of resistors.

4.2 Prelab

Student should read the lab manual and have clear idea about the objective, time frame and outcomes of the lab.

4.3 Outcomes

After completing this lab work student will be able to answer the following questions:

- What is the Ohm's law? How Ohm's law looks in a graph? How unknown resistance can be determined from the graph?
- How to construct series and parallel combinations of resistors and how the equivalent resistances can be calculated?
- For all possible combinations of resistors, how to plot voltage versus current graph and find the slop of best fitted lines to determine the unknown resistances?

4.4 Timing and Length of Investigation (Total 3 Hours)

- **Lab Preparation (15 minutes):**
  - To connect with the students and take class attendance.
- **Lecture on Theory (30 minutes):**
  - Teacher will clarify the objective and theory of the experiment.
- **Lecture on Procedure (15 minutes):**
  - Students will try to understand the procedure of the experiment through a video lecture.
- **Experimental Work (90 to 100 minutes):**
  - A sample data will be provided to students and teacher will clarify every part of it.
  - Students will do all the calculations, draw graphs in excel and complete the result part.
- **Post Lab Discussion (15 to 20 minutes):**
  - Teacher will summarize the total lab work and have a discussion with the students related with the questions given in the outcomes part.
- **Report Submission:**
  - After completing the lab reports students will upload their lab reports as groups in teams.

4.5 Theory

Ohm's law states that at a constant temperature the current through a conductor between two points is directly proportional to the voltage across those two points. Introducing the constant of proportionality, the resistance, one arrives at the usual mathematical equation that describes this relationship:

$$\boldsymbol{V = IR}$$

where *I* is the current and V is the potential difference across the resistance R.

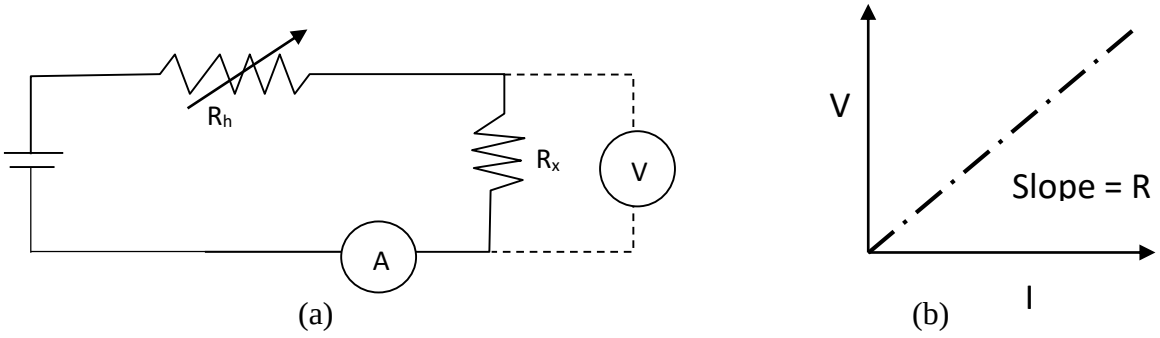

Figure 4.1: (a) Simple circuit to determine unknown resistance, R_x by using Ohm's law, ammeter (A) and voltmeter (V) are used to measure the current and potential drop in the circuit, variable resistor, R_h is used to change the current flow in the circuit (b) Slope of the V vs I graph gives the value of R.

When *N* number of resistors are connected in series and parallel connections their equivalent resistances R_s and R_p are calculated by the following two equations:

$$\boldsymbol{R_s = R_1 + R_2 + \cdots + R_N}$$

$$\boldsymbol{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}}$$

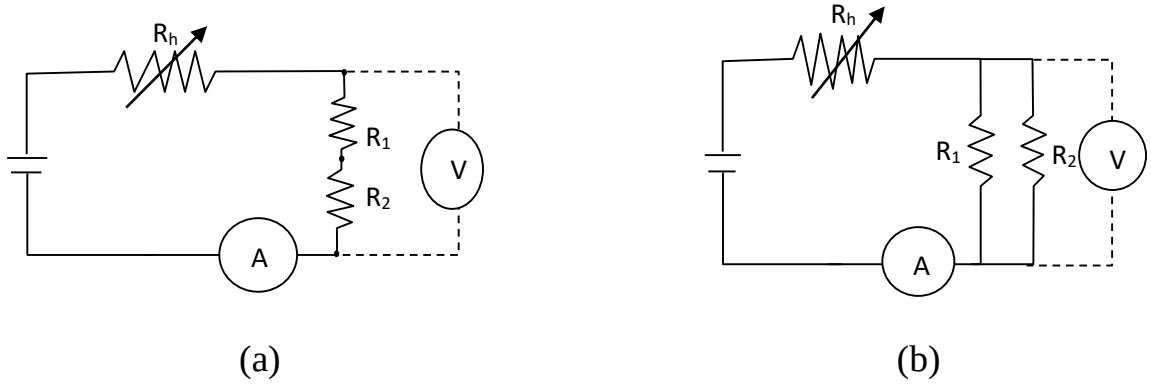

Figure 4.2: Series and parallel connections are shown for two resistors R_1 and R_2 in (a) and (b), respectively.

4.6 Apparatus

Power supply, variable resistor, ammeter, voltmeter, unknown resistors and connecting wires.

4.7 Procedure

- Construct above circuits with 2 unknown resistances (R_1 & R_2).
- Using rheostat R_h choose current not more than 1 A. Vary R_h to select 10 different currents through the circuit as measured by the ammeter A.
- Measure the corresponding potential differences (V) in the voltmeter.

4.8 Experimental Data

Table 1: Voltage current records for R_1 and R_2

Resistors	**Current I (A)**	**Voltage V (V)**
R_1		
R_2		

Table 2: Voltage current records for series and parallel connections.

Combinations of R_1 & R_2	**Current I (A)**	**Voltage V (V)**
Series Combination		
Parallel Combination		

4.9Analysis and Calculation

- Use EXCEL to plot V versus I graphs. You have to plot 4 graphs for R_1, R_2, R_1 and R_2 in series and parallel connections.
- Find the best fitted lines. Determine the slope of the best fitted lines to get the values of R_1, R_2, R_s and R_p.
- Also calculate the values of R_s and R_p by using the values of R_1 and R_2 according to the laws of series and parallel combinations of resistors.

4.10 Result

Table 3: Values of R_1, R_2, R_s and R_p.

Resistances from the graphs		Calculated Values of R_s and R_p in Ohms	Comments
Resistors	Values in Ohms		
R_1			
R_2			
R_s			
R_p			

4.11 Resources

For further understanding students may go through the following resources:

- **Fundamental of Physics (10th Edition):** Ohm's Law (Chapter 26, page 756-759)
- **Video Links:**
  - https://www.youtube.com/watch?v=Vh3XGz7hgU4
  - https://www.youtube.com/watch?v=hxYn74Yhkpk
  - **https://www.youtube.com/watch?v=2c1z4pLsI_w**