Experiment 13. Ohm's Law

Relationship between voltage and current

Objective:

(a) To verify Ohm's law.

(b) To verify the rules of combination of resistances in series and parallel.

Apparatus:

A power supply, resistors, an ammeter, a voltmeter and a personal computer.

Theory:

Ohm's law:

According to Ohm's law, the electrical current in a metallic conductor is directly proportional to the potential difference between the ends of the conductor. Thus, if V (in volts) is the potential difference between the ends of the conductor PQ and the current in the conductor is I amperes, then

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

where R (in ohms) is the constant of proportionality, known as the resistance of the conductor. Note that the resistance of a conductor depends on its temperature. As a conductor offers some resistance to the current, it is known as a resistor.

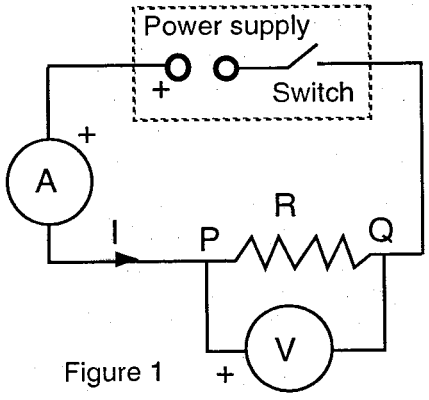


Figure 1

Equation (1) indicates that the resistance of a resistor can be determined by measuring the potential difference V and the current I. An ammeter is used to measure the current in a resistor and it is connected in series with the resistor PQ. The current must enter through the terminal marked + of the ammeter. A voltmeter is used for measuring the

potential difference V applied to the resistor and thus the terminals of the voltmeter are connected to the two ends of the resistor. The end P of the resistor through which the current enters is at a higher potential than the end Q. The terminal of the voltmeter marked + must be connected to the end of the resistor which is at a higher potential.

Laws of resistors in series and parallel:

When two (or more) resistors are connected in series as shown in Fig. 2, their equivalent resistance is given by

$$R_s = R_1 + R_2 \qquad (2)$$

When two (or more) resistors are connected in parallel as shown in Fig. 3, their equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \qquad (3)$$

Equations (2) and (3) can be extended to the cases of more than two resistors as well. Equations (2) and (3) represent the rules of combinations of resistors in series and parallel, respectively.

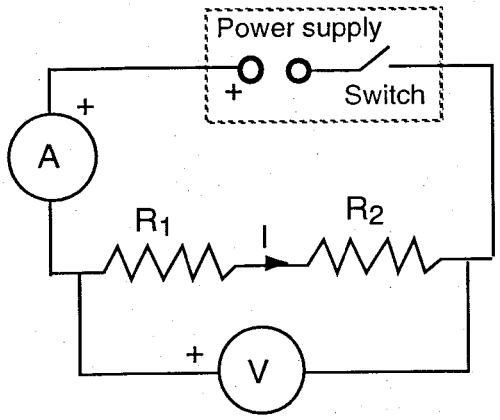


Figure 2

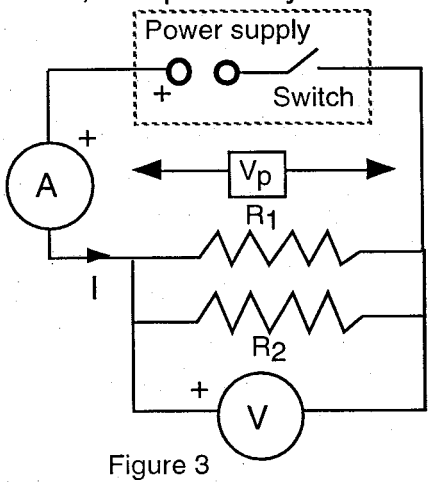


Figure 3

Note that the current in the resistors in series is the same and the potential differences across them are not equal unless the resistors have the same resistance.

In the case of a parallel combination, the potential difference across the resistors is the same, while the currents in the resistors are not equal unless the resistors have the same resistance. In any case, the sum of currents in the resistors R_1 and R_2 is equal to the total current I which is measured by the ammeter (Fig. 3).

Procedure:

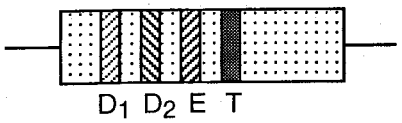
1. Find the resistance of 4 resistors by using the color code.

   In general, there are four bands of different colors painted on the

resistors. The color of the first band D_1 (which is nearest to an end of the resistor), gives the first digit of the resistance of the resistor. The color of the second band D_2 gives the second digit of the resistance of the resistor. The color of the third band E gives the exponent of 10 by which the number obtained by by using the colors of D_1 and D_2 should to be multiplied to obtain the resistance of the resistor. The color of the fourth band T gives the tolerance of the resistor which is a measure of the accuracy of the resistance of the resistor.

The color code is:

0 - -Black	5 - -Green	Tolerance:
1 - -Brown	6 - -Blue	Gold - - 5%
2 - -Red	7 - -Violet	Silver - -10%
3 - -Orange	8 - -Gray	No color - -20%
4 - -Yellow	9 - -White	



D_1 -- red (2) E -- orange (3)
D_2 -- green (5) T -- silver (10%)

The resistance of the resistor shown in the above diagram is 25×10^3 ohm (25000 ohm) and the tolerance is 10%.

2. Find the least counts for the different ranges of the voltmeter and ammeter.
3. Make the connections as shown in Fig. 1 including one of the resistors in the circuit. Use the highest ranges of the ammeter and voltmeter. Keep the voltage less than 6 volts. Switch on the circuit and take the readings of the voltmeter (V) and ammeter (I). While taking readings, use the ranges of the ammeter and voltmeter that give the values of V and I to the same degree of accuracy. Change the value of V and take the readings of V and i again. Thus take about six pairs of values of V and i and enter the data into Table III.
4. Choose 2 resistors and determine their individual resistances. Connect them in series (Fig. 2) and determine the series resistance. Then connect them in parallel (Fig. 3) and determine the parallel resistance.

The units of voltage, current and resistance are volt, ampere and ohm, respectively.

Use the computer program EXCEL and file ohmform to prepare the lab report.

York College of The City University of New York

Physics I Name:

Experiment No. 13: Pre-Lab Questionnaire

1. How is an ammeter connected in the circuit?

2. How is a voltmeter connected in the circuit?

3. The following four bands are painted on a resistor:
   D_1 - orange; D_2 - yellow; D_3 - red; D_4 - silver.
   What is the resistance of the resistor? What is the tolerance?

4. Consider the following data and fill out the blanks:

Resistor(s)	V in volts	I in mA	R in ohms
R_1	3.4	7.1	R_1 =
R_2	3.5	6.7	R_2 =
R_1 and R_2 in series	3.8	3.7	R_{se} =
R_1 and R_2 in parallel	3.2	12.7	R_{pe} =

Using the values of R_1 and R_2 from the above table, calculate R_s.

Using the values of R_1 and R_2 from the above table, calculate R_p.

Percent difference between R_{se} and R_s =

Percent difference between R_{pe} and R_p =

15

Experiment No. 13

Name: Marks:

Partner: Remarks:

Section:

Date Submitted:

Title:

Objective:

Theory/Formulas:

Data Sheet

Table I

Determination of resistance by color code:

Resistor No.	Color of band number				Resistance	Tolerance
	1	2	3	4		

Table II

Least counts:

No.	Voltmeter		Ammeter	
	Range	Least count	Range	Least count
1				
2				
3				

Table III

Verification of Ohm's law:

Resistor No.:

(Choose a resistor whose resistance is less than 1000 ohm.)

No.	V in volts	I in milliamps	R in ohms
1			
2			
3			
4			
5			
6			

Table IV

Verification of laws of resistances in series and parallel:
(Choose R_1 and R_2 such that their resistances are a few hundred ohms.)

Resistance(s)	Reading No.	V in volts	I in milliamps	R in ohms
R_1				
	Average R_1 =			
R_2				
	Average R_2 =			
R_{se} (R_1 and R_2 in series)				
	Average R_{se} =			
R_{pe} (R_1 and R_2 in parallel)				
	Average R_{pe} =			

By using the computer program EXCEL and the file ohmform, plot a graph between I and V (Table III). Determine R from the slope of the graph.

Calculate R_s by using Eq. (2) and the values of R_1 and R_2 from Table IV. Find the percent difference between the theoretical and experimental values of R_s.

Calculate R_p by using Eq. (3) and the values of R_1 and R_2 from Table IV. Find the percent difference between the theoretical and experimental values of R_p.

Experiment No. 13: Questions

1. State Ohm's law.

2. What will be the equivalent resistance of two 10-ohm resistors if they are connected in (a) series, (b) parallel? Show your calculations.