

Meters - Ohm's Law

APPARATUS

1. Board on which two wires are mounted, each 1 m long, equipped with a sliding contact
2. Rheostat (variable resistance), $0 \dots 7 \Omega$
3. DC ammeter (full scale: 2 A)
4. Voltmeter (full scale: 3 V)
5. Switch
6. Wire and plug to DC supply
7. Board on which two wire wound resistors are mounted

INTRODUCTION

The ammeter is an instrument which measures the magnitude of an electrical current. A direct current (DC) is a uniform flow of electrical charges through a conductor. If an amount of charge ΔQ passes through a cross-section of a conductor in time Δt , then the current I in the conductor is given by:

$$I = \frac{\Delta Q}{\Delta t}$$

The International System of Units (SI) unit of charge is the Coulomb. The SI unit of current is the Ampere; it is equal to a rate of flow of one Coulomb per second. The ammeter is always connected in series with the conductor in which the current is to be measured (see Fig. 1).

A number of pieces of apparatus are said to be connected in series if they are so arranged that there is only one path for the current to take; the same current must flow successively through each piece. This type of connection and the parallel connection are both shown below.

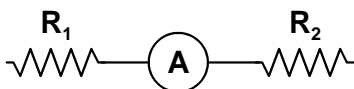


Figure 1: Series connection.

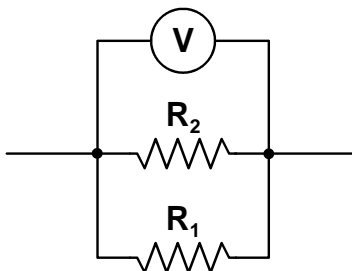


Figure 2: Parallel connection

The voltmeter measures the potential difference (voltage) between its terminals. The voltage between two points A and B is defined as the work done in moving a positive charge from A to B divided by the magnitude of the charge. The SI unit of the voltage is called the volt; it exists between two points when one Joule of work is required to transfer one Coulomb of charge. The voltmeter is always connected in parallel with the circuit element across which the potential difference is to be measured (see Fig. 2).

The positive electrode of the DC supply is connected to the blue lead of the DC power cord, and the negative electrode to a brown lead. By convention, the direction of current from a DC supply is from the positive to the negative electrode, through the external circuit. The meters should be

connected so that the current will enter the binding post on the meter marked plus (see figure 3). The symbol used to designate a DC supply has two parallel lines where the longer line represents the positive electrode.

Suppose the potential difference V between the two ends of a conductor is varied and the current I is measured. Experiment shows that for many materials

$$\frac{V}{I} = \text{const.} = R$$

where R is called the resistance of the conductor. When V is expressed in Volts, and I is expressed in Amperes, R is expressed in Ohms(Ω). The above equation is known as Ohm's Law.

A conductor whose electrical resistance is large enough to be taken into account is called a resistor and denoted by a sawtooth symbol as in figure 3. A connecting wire has such a small resistance that it maybe neglected in most laboratory work. The symbol for a connecting wire is a straight line. The two 100 cm long straight wires, mounted on a board have a resistance that cannot be neglected, unlike the copper connecting wires.

PROCEDURE

Part I: Current in a Series Circuit

- A. Connect the apparatus as shown in Fig. 3. Close the switch and note the value of the current on the ammeter. Open the switch, remove the ammeter from the position shown in the figure and place it in turn in positions B and C. For each position, note the current when the switch is closed.

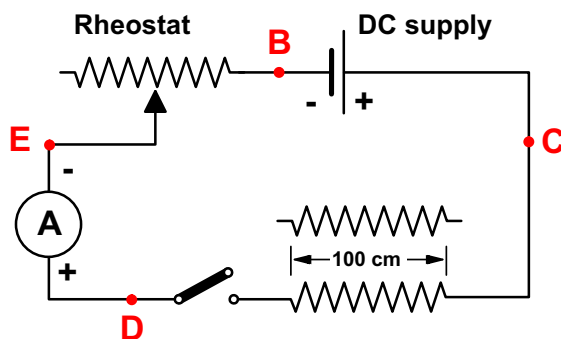


Figure 3

Question 1: When the currents at the original position of the ammeter and positions B and C in this circuit are compared, what conclusion may be drawn? [Note: A variation of a few percent may be experienced.]

- B. Vary the position of the knob of the rheostat and note the effect on the current. Make a sketch of the rheostat showing the position of the knob for minimum resistance (largest current), and for maximum resistance.

Part II: Potential Difference in a Series Circuit

- A.** Using the circuit shown in Fig. 3, set the contact of the rheostat at some intermediate position and close the switch. Connect the voltmeter across each part of the circuit (BC - the DC supply, CD - the resistance wire, DE - the ammeter, and finally EB - the rheostat).

Question 2: How does the sum of the voltmeter readings of the external circuit compare with that across the DC supply ? Express the difference in %. Is it reasonable?

- B.** Using the same circuit, connect the voltmeter between the 0 cm end of the wire and the sliding contact. Be sure that there is no contact with the wire until one of the knobs is pressed.

Adjust the rheostat until the current is 0.5 A. Measure the potential difference between the 0 cm end of the wire and each of the 10 cm marks, that is, at 10 cm, 20 cm, 30 cm, etc. Plot your readings with voltmeter readings on the Y-axis and lengths on the X-axis.

Question 3: What does the graph show about the wire?

Part III: Ammeter-Voltmeter Method of Measuring Resistance

- A.** Connect the DC supply, the switch, rheostat, ammeter and the two mounted wire-wound resistors in series as shown in Fig. 4. Measure the potential difference across each resistor separately, and across the two in series. Note the ammeter reading.

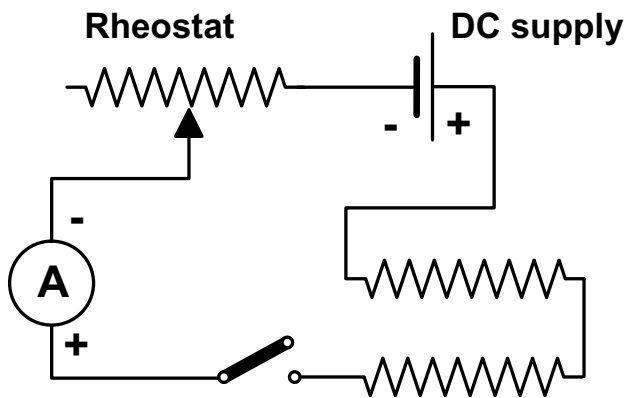


Figure 4

- B.** Repeat **A.** using two different values for the current. Compute the resistance of each resistor for each current and the resistance of the series combination from the data taken in (A) and (B).

Question 4: How does the sum of the individual resistances compare with the resistance of the combination?

Part IV: Resistors in Parallel

- A. Connect in series the DC supply, the rheostat, the ammeter, the switch, and the two wire wound resistors in parallel as shown in Fig. 5. Measure the current when the ammeter is placed, successively, at the shown position and at the positions marked B and C.

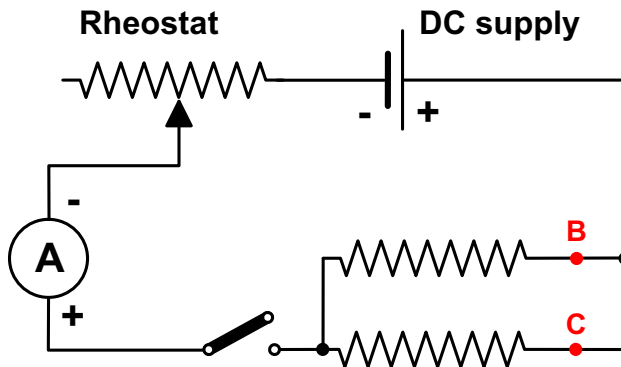


Figure 5

- B. Repeat for one other rheostat setting.

Question 5: How do the meter readings at B and C compare with that at the original position shown in Fig. 5? What conclusion can you draw?

- C. Measure the voltage across the parallel combination. This voltage divided by the total current through the combination is called the equivalent resistance of the combination. Letting R_1 and R_2 represent the individual resistances and R_{eq} the equivalent resistance of the combination, verify from your results the relationship:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$