Electric current

Electric current: The amount of charge crossing any cross section of the conductor in one second.

Electric current = electric charge/time interval

Formula: $I = Q/t$

Unit: The SI unit of electric current is ampere(A)

1 Ampere = 1 Coloumb/1 Second

1 A = 1 C/s

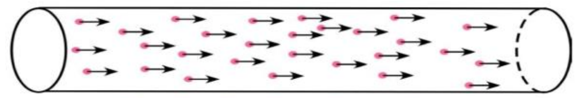


fig-2: Ordered motion of electrons

An ammeter is used to measure electric current. It is always connected in series to the circuit

Potential Difference

Work done by the electric force on unit positive charge to move it through a distance is called potential difference between those points. Potential difference is denoted by a symbol V

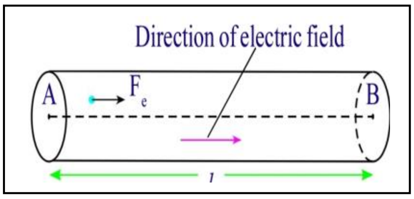
Formula: $V = W/q$

This potential difference is also called voltage.

Unit:The SI unit of potential difference is volt (V)

1 Volt = 1 Joule/1 Coulomb

1V = 1J/C



Electromotive force (emf):

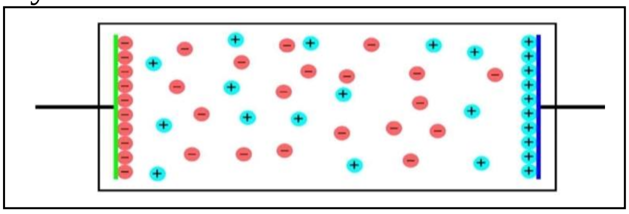
emf is defined as the work done by the chemical force to move unit positive charge from negative terminal to positive terminal of the battery.It is denoted by ε

Unit: The SI unit of emf is Volt (V)

Formula: $\varepsilon = W/q$

Usually a volt meter is used to measure potential difference or emf.

It is always connected in parallel to the electric device



Ohm's law: The potential difference between the ends of a conductor is directly proportional to the electric current passing through it at constant temperature

Formula: $V \propto I$

$V/I = \text{Constant}$

$V = IR$

Unit: S.I unit of Resistance (R) is ohm(Ω)

$1V/1A = 1\,\Omega$

Ohm's law Verification for a conductor

Aim: To show that the ratio V/I is a constant for a conductor.

Materials required: 6V battery eliminator, 0 to 1A ammeter, 0-6V volt meter, copper wires, 50cm manganin coil, Rheostat, switch

Procedure:

1.Complete the circuit as shown in the figure.

2.By using Rheostat adjust the potential difference1V between two ends of manganin wire.

3. Now observe the electric current through ammeter in the circuit.

4. Using Rheostat change the potential difference with different values upto 4.5V and note down atleast five values of V and I in the table.

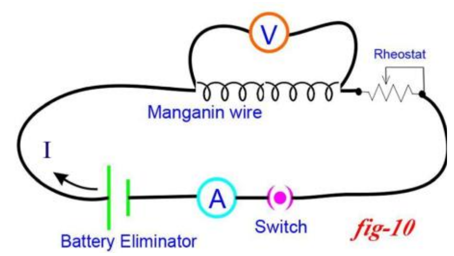


fig-10

5.

SI.No	Potential	Current	V/I

We can conclude that the ratio of V/I is constant for a conductor

Ohm's law verification for LED Type conductor

Aim: To show V/I is not constant in LED type conductor

Materials required: 6V battery eliminator, 0 to 1A ammeter, 0-6V volt meter, copper wires, 3V LED, Rheostat, switch

Procedure:

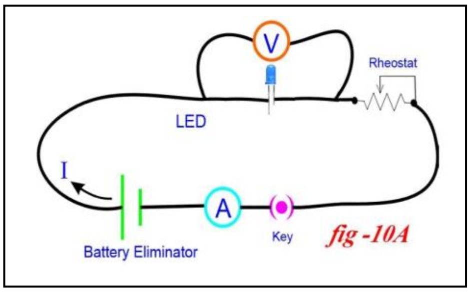


fig -10A

1.Complete the circuit as shown in the figure.
2.By using Rheostat adjust the potential difference1V between two ends of LED.
3. Now observe the electric current through ammeter in the circuit.
4. Using Rheostat change the potential difference with different values upto 3V and note down atleast five values of V and I in the table.
5.

Sl.No	Potential	Current	V/I

We can conclude that the ratio of V/I is not constant for LED type conductors.

Ohmic materials:

Definition: Which materials obey Ohm's law are called Ohmic materials

Ex: Metals.

The shape of the V-I graph of Ohmic Conductor is Straight line passing through the origin

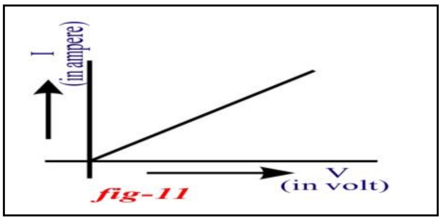


fig-11

Non ohmic materials:

Definition: Which materials do not obey Ohm's law are called Non ohmic materials

Ex: Semi conductor, LED, gaseous conductors etc.

The shape of V-I graph of Non ohmic conductor is a curved line

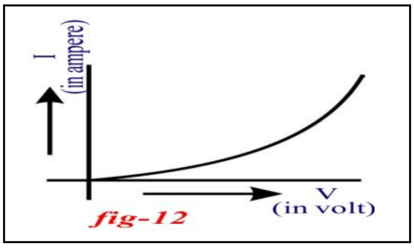


fig-12

Limitations of Ohm's Law

1.Ohm's law is valid for metal conductors.
2.Ohm's law is not applicable to gaseous conductors.
3.Ohm's law is not applicable to semi conductors.

Resistance: The obstruction to the motion of the motion of the electros in a conductor

Resistor: The material which offers resistance to the motion of electrons is called resistor.

<u>Factors affecting the resistance of a material</u>

1.Temperature:

If the temperature of the conductor is increases than resistance also increases[at V= Constant]

Activity:

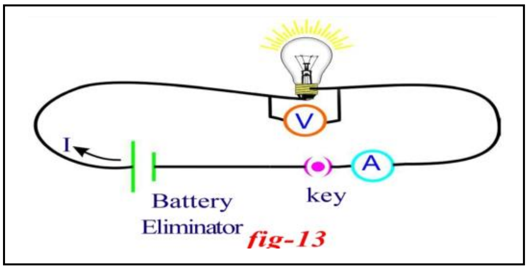


fig-13

1. Complete the circuit as shown in the figure.
2. Adjust the knob to keep the potential difference at 1.5V in the battery eliminator.

3. Now run the circuit and note down the Ammeter reading in the table. Now touch the bulb and sense the heat.
4. Similarly repeat the experiment with 3V, 4.5V, 6V and note down V and I values in the table.
5.

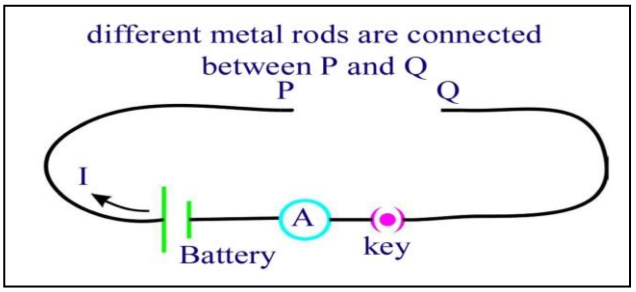
SI.No	Potential	Current	V/I

We conclude that the temperature of the conductor is increases than resistance also increases

2. Nature of material:

If the nature of material is changes than the resistance of material is changes.

Activity: 1. Collect different copper, nichrome, manganin wires of the same length and same cross sectional area.



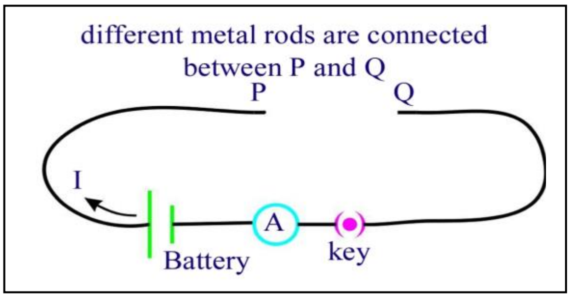
2. Make a circuit as shown in figure
3. P and Q are the free ends of the conducting wires.
4. Connect one of the wires between the ends P and Q.
5. Switch on the circuit.
6. Measure the electric current for a fixed voltage using the ammeter connected to the circuit.
7. Repeat this with other wires and measure electric currents in each case
8. we conclude that the resistance of a conductor depends on the material of the conductor.

3. Length of the conductor:

The resistance of a conductor is directly proportional to its length [at A and T are constant]

Activity:

1.Collect manganin wires of different lengths with the same cross sectional areas.

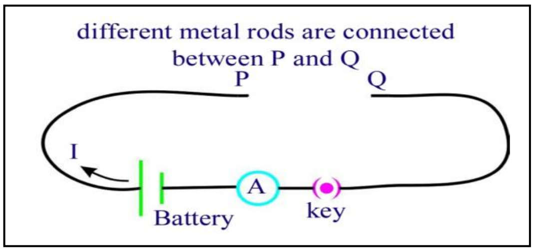


2. Make a circuit as shown in figure.
3.Connect one of the manganin wires, say 10cm length, between P and Q.
4. Measure the value of the current using the ammeter connected to the circuit.
5. Repeat this for other lengths of the wires.
6. Note corresponding values of currents.
7. we can conclude that the resistance (R) of a conductor is directly proportional to its length (l) for a constant potential difference.

4. Cross section area:

The resistance of a conductor is inversely proportional to its cross section area [at L and T are constant]

Activity:



1. Collect manganin wires of equal lengths but different cross sectional areas.
2. Make a circuit as shown in figure.
3. Connect one of the wires between points P and Q.
4. Note the value of the current using the ammeter connected to the circuit
5. Repeat this with other wires.
6. Note the corresponding values of currents in each case.
7. we conclude that the resistance of a conductor is inversely proportional to its cross section area

Derivation of $R = \rho\, l/A$

The resistance of a conductor is directly proportional to its length [at A and T are constant]

$R \propto l$ ………..(1)

The resistance of a conductor is inversely proportional to its cross section area [at L and T are constant]

$R \propto 1/A$ ………(2)

From (1) and (2) equations

$R \propto l/A$

$R = \rho\, l/A$

Where ρ is specific resistance or resistivity

Specific resistance (or) Resistivity(ρ)

Definition:The resistance per unit length of a unit cross section of the material is called resistivity.

Formula: $\rho = RA/l$

Units: The S.I unit is Ω-m

Specific resistance depends on the temperature and nature of the material

Conductivity: The reciprocal of resistivity is called conductivity (σ).

The values resistivity of material determine their conductivity.

From the table, we observe that

1. If resistivity of the material is decrease than Conductivity (Flow of current) is increase
2. The values of resistivity of conductors like metals low resistivity behaves as good conductors
3. The values of resistivity of semi conductors like Silicon and Germanium are 10^5 to 10^{10} Ω-m times more than that of metals, but 10^{15} to 10^{16} Ω-m times less than that of insulators.
4. The values of resistivity of insulators are very high of the order of 10^{14} to 10^{16} Ω-m
5. The filament of an electric bulb is usually made of tungsten because of its higher resistivity values and melting point 3422^0 C.
6. Alloys like Nichrome(Ni, Cr and Fe) and Manganin(Cu, Mn and Ni) are used as heating elements because 30-100 times larger values of resistivity than metals resistance varies very little with temperature and they do not oxidise easily.
7. Semiconductors like Silicon and Germanium are used to make Diodes, Transistors and Integrated Circuits(ICs)

Resistivity of various materials

Material	$\rho_{(\Omega\text{-m})}$ at 20 °C
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Gold	2.44×10^{-8}
Aluminium	2.82×10^{-8}
Calcium	3.36×10^{-8}
Tungsten	5.60×10^{-8}
Zinc	5.90×10^{-8}
Nickel	6.99×10^{-8}
Iron	1.00×10^{-7}
Lead	2.20×10^{-7}
Nichrome	1.10×10^{-6}
Carbon (Graphite)	2.50×10^{-6}
Germanium	4.60×10^{-1}
Drinking water	2.00×10^{-1}
Silicon	6.40×10^{2}
Wet wood	1.00×10^{3}
Glass	10.0×10^{10}
Rubber	1.00×10^{13}
Air	1.30×10^{16}