INDIAN SCHOOL AL WADI AL KABIR		
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HANDOUT	CHAPTER ELECTRICITY	A4 FILE FORMAT (PORTFOLIO)
CLASS & SEC:	NAME OF THE STUDENT:	ROLL NO.

Electricity has an important place in modern society. It is a controllable and convenient form of energy for a variety of uses in homes, schools, hospitals, industries and so on.

Electricity is the flow of electric charges.

Properties of Electric charges

- Like charges repel and opposite charges attracts
- Electric charge is always conserved (not created, only exchanged) in an isolated system.
- Electric charge is quantized. That is, when an object is charged, its charge is always a multiple of a fundamental unit of charge.

$$Q = ne$$

Q = total charge
n = number of electrons or protons
e = charge of 1 electron or protons
fundamental units of charge,e= $1.602 \times 10^{-19}\ C$

SI unit of Charge is **coulombs (C)**

Electric switch

A switch makes a conducting link between the cell and the appliance.

Electric circuit

A continuous and closed path of an electric current is called an electric circuit.

If the circuit is broken anywhere (or the switch is turned off , the current stops flowing and the bulb does not glow

Electric current

Electric current is expressed by the amount of charge flowing through a particular area in unit time

OR

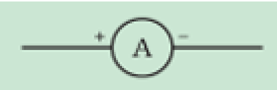
It is the rate of flow of electric charges.

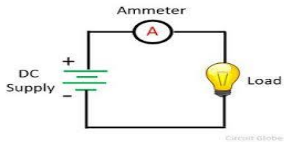
Equation for electric current

If a net charge Q, flows across any cross-section of a conductor in time t, then the current I, through the cross-section is

$$I = Q/t$$

The electric current is expressed by a unit called ampere (A). One ampere is constituted by the flow of one coulomb of charge per second, that is, 1 A = 1 C/1 s.
Small quantities of current are expressed in milliampere (1 mA = 10^{-3} A) or in microampere (1 µA = 10^{-6} A).
An instrument called **ammeter** measures electric current in a circuit. It is always **<u>connected in series</u>** in a circuit through which the current is to be measured.





<u>Conventionally, in an electric circuit the direction of electric current is taken as opposite to the direction of the flow of electrons.</u>

<u>A simple electric circuit diagram</u>

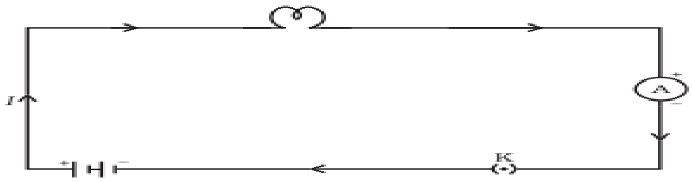


Figure 12.1
A schematic diagram of an electric circuit comprising – cell, electric bulb, ammeter and plug key

(Note that the electric current flows in the circuit from the positive terminal of the cell to the negative terminal of the cell through the bulb and ammeter.)

<u>ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE</u>

- Name a device that helps to maintain a potential difference across a conductor.

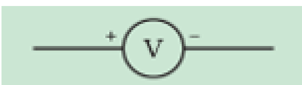
  Cell or Battery

Potential differential difference (Voltage):
Work done to move a unit charge from one point to another

$$\textbf{Potential}\ differnece\ between\ two\ points\ = \frac{work(W)}{charge(Q)}$$

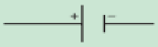
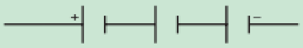
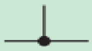
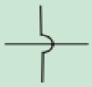
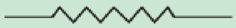
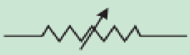
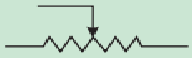
$$1\ volt\ = \frac{1\ joules}{1\ coulombs}$$

<u>One volt</u> is the potential difference between two points in a current carrying conductor when *1 joule of work is done* to move a charge of *1 coulomb* from one point to the other.
The potential difference is measured by means of an instrument called the **<u>voltmeter</u>**. The **<u>voltmeter is always connected in parallel</u>** across the points between which the potential difference is to be measured.



Parallel connection

Symbols used to represent some of the most commonly used electrical components

Sl. No.	Components	Symbols
1	An electric cell	
2	A battery or a combination of cells	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	
5	A wire joint	
6	Wires crossing without joining	
7	Electric bulb	 or 
8	A resistor of resistance *R*	
9	Variable resistance or rheostat	 or 
10	Ammeter	
11	Voltmeter	

OHM'S LAW

In 1827, a German physicist **Georg Simon Ohm** (1787–1854) found out the relationship between the current I, flowing in a metallic wire and the potential difference V, across its terminals.

Ohm's Law

Ohm's law states that the electric current, I flowing through a metallic wire is directly proportional to the potential difference V, across its ends provided its temperature remains the same.

$$V \propto I$$

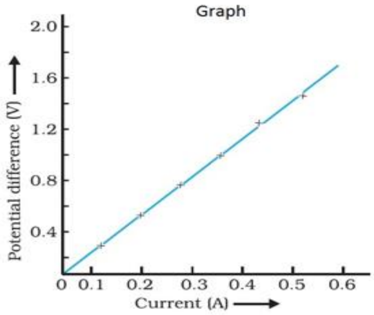
Or $$\frac{V}{I} = Constant = R$$

Or $$V = IR$$

Where R is a constant for the given metallic wire at a given temperature and is called its resistance.

<u>V–I graph</u>

A straight line plot shows that as the current through a wire increases, the potential difference across the wire increases linearly – this is Ohm's law.



Resistance of a conductor

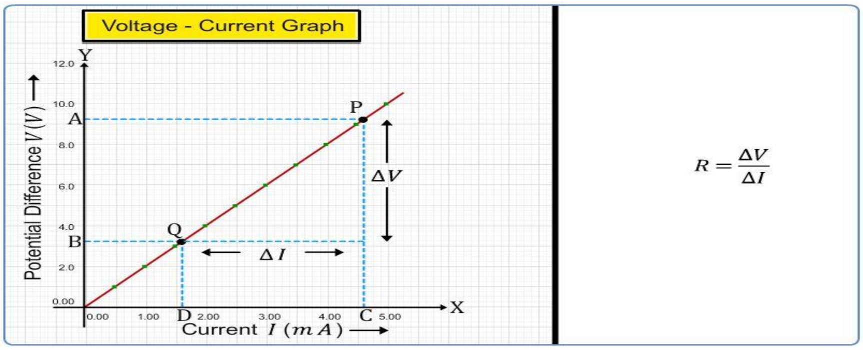
It is the property of a conductor to resist the flow of charges through it.
Its SI unit is ohm(Ω)
According to Ohm's law,
If the potential difference across the two ends of a conductor is 1 V and the current through it is 1 A, then the resistance R, of the conductor is **1 Ω**. That is,

$$1\ ohm = \frac{1\,Volt}{I\ ampere}$$

Note:-The current through a resistor is inversely proportional to its resistance. If the resistance is doubled the current gets halved.

$$I = \frac{V}{2R}$$

In many practical cases it is necessary to increase or decrease the current in an electric circuit. A component used to regulate current without changing the voltage source is called **variable resistance.**
In an electric circuit, a device called **rheostat** is often used to change the resistance in the circuit.
We can determine the resistance of a resistor with the help of V-I graph



Factors on which the resistance of a conductor depends

i. **The nature of the material.**
eg. Iron has more electrical resistance than a geometrically similar copper conductor

ii. **The length (l) of the material.**
Longer materials have greater resistance.

iii. **The cross-sectional area A of the material.**
Larger areas offer less resistance.

iv. **The temperature T of the material.**
The higher temperatures usually result in higher resistances.

$$R \propto l$$

$$R \propto \frac{1}{A}$$

$$R \propto \frac{l}{A}$$

$$R = \rho \frac{l}{A}$$

$$\rho = \frac{RA}{l}$$

where **ρ (rho)** is a constant of proportionality and is called the **electrical resistivity of the material of the conductor.**

In SI system of unit

$$\rho = \frac{R(\Omega)A(m^2)}{l(m)} = \frac{\Omega m^2}{m} = \Omega m$$

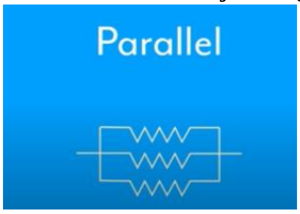
The SI unit of resistivity is Ω m.

Resistivity is a characteristic property of the material.

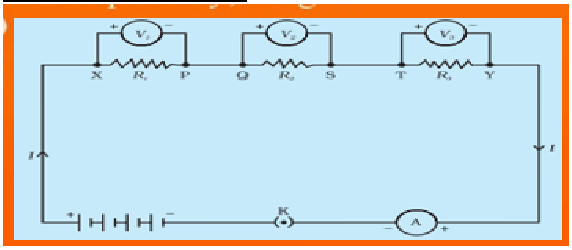
The metals and alloys have very low resistivity in the range of 10^{-8} Ω m to 10^{-6} Ω m. They are good conductors of electricity. Insulators like rubber and glass have resistivity of the order of 10^{12} to 10^{17} Ω m. Both the resistance and resistivity of a material vary with temperature.

RESISTANCE OF A SYSTEM OF RESISTORS

Two methods of joining the resistors together



Resistors in series



The figure shows three resistance R_1, R_2, R_3 connected in series. Now suppose potential difference across resistance R_1 is V_1, R_2 is V_2 and R_3 is V_3. Let the potential difference across battery be V, then:

$V = V_1 + V_2 + V_3$ ----------(1)

Applying Ohm's law to the whole circuit; $V = IR$ ----------(2)

Applying Ohm's law to the three resistor separately, we get:

$$V_1 = I \times R_1 ----(3)$$
$$V_2 = I \times R_2 ----(4)$$
$$V_3 = I \times R_3 ----(5)$$

Substituting (2), (3), (4),(5) in (1)

$$IR = IR_1 + IR_2 + IR_3$$

Or

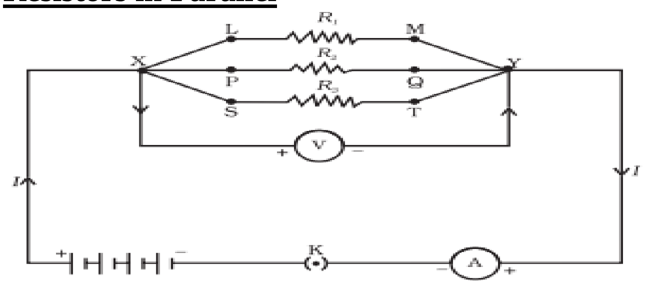
$$IR = I(R_1 + R_2 + R_3)$$

Or

$$R = (R_1 + R_2 + R_3)$$

We can conclude that when several resistors are joined in series, the resistance of the combination Rs equals the sum of their individual resistance.

Resistors in Parallel



Consider the arrangement of three resistors joined in parallel with a combination of cells (or a battery) .

It is observed that the total current I, is equal to the sum of the separate currents through each branch of the combination.

$I = I_1 + I_2 + I_3$ ……………….1

Let R_p be the equivalent resistance of the parallel combination of resistors.

By applying Ohm's law to the parallel combination of resistors,

we have $I = V/R_p$ ………………2

On applying Ohm's law to each resistor,

we have

$I_1 = V/R_1$; ………………….3

$I_2 = V/R_2$; ………………….4

and $I_3 = V/R_3$ ……....................5

On substituting 2,3,4,5 in equation 1

$$\frac{V}{Rp} = \frac{V}{R1} + \frac{V}{R2} + \frac{V}{R3}$$

$$\frac{1}{Rp} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

we can conclude that the reciprocal of the equivalent resistance of a group of resistances joined in parallel is equal to the sum of the reciprocals of the individual resistances.

Disadvantages of series circuit

or

Series arrangements are not used in domestic circuits. Why?

- In a series circuit, current is constant throughout the circuit.
- It is impossible to connect two appliances (Say electric heater and electric bulb) in series, because they need currents of different values to operate properly.
- In a series circuit, when one component fails, the circuit is broken and none of the component works.

Advantages of parallel circuits

Or

Why parallel arrangements are used in domestic circuits?

- Parallel circuits divide the current through the electrical gadgets. If one appliance is fused, the current continues to flow through the others. Hence other appliances continue to work
- Parallel circuits are helpful when each gadget has different resistance and requires different current to operate properly.

Heating Effect of Electric Current

When electric current is supplied to a purely resistive conductor, the energy of electric current is dissipated entirely in the form of heat and as a result, resistor gets heated. The heating of resistor because of dissipation of electrical energy is commonly known as **heating effect of electric current.**

Joule's law of heating

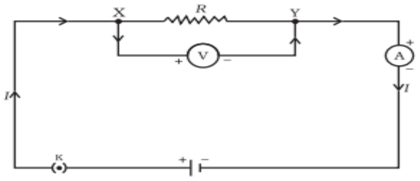


Figure 12.13
A steady current in a purely resistive electric circuit

Consider current **I** flowing through a resistor of resistance **R.** Let the potential difference across it be **V**. Let **t** be the time during which a charge **Q** flows across.
The power input to the circuit, P= W/t
where, W, Work done in moving the charge (Q),

$$W = VQ$$
$$P = VQ/t$$
$$= VI$$

Energy supplied to the circuit by the source= P×t = VIt
This energy gets dissipated in the resistor as heat
Thus for a Current I, the amount of heat produced in time t,

$$\mathbf{H = VIt}$$

Applying ohm's law, V=IR

$$\mathbf{H = I^2Rt}$$

This is known as Joule's law of heating

Joule's law of heating

$H = I^2Rt$

Heat produced in a resistor is

i. **directly proportional to the square of the current for a given resistance**
ii. **directly proportional to resistance for a given current**
iii. **directly proportional to the time for which the current flows through the resistor**

Practical Applications of Heating Effect Of Electric Current

i. **It is applied in electric laundry iron, electric toaster, electric oven, electric kettle and electric heater.**

ii. **It is used to produce light in an electric bulb.**

Here the filament must retain the heat generated so that it gets very hot and emits light. (Tungsten-metal has high melting point(3380^oC) is used for making bulb filament).

iii) **It is applied in fuse which is used in electric circuits.**

It protects the appliances by stopping the flow of high amount of current. Fuse is placed in series with the device. It consists of a piece of wire made of metal or alloy having an appropriate melting point. If a current larger than the specified value flows through the circuit, the temperature of the fuse wire increases. This melts the fuse wire and breaks the circuit.

Electric power

It is the rate at which electric energy is dissipated or consumed in an electric circuit.

Power, P= W/t

= VQ/ t

=VI

P = VI (applying Ohm's law V=IR and I=V/R)

$P= I^2R$

$P= V^2/R$

SI unit is watt(W)

Define 1 watt?

It is the power consumed by a device that carries 1A of current when operated at a potential difference of 1V.

1 watt= 1 volt×1 ampere =1VA

1 kilowatt=1000 watts

Electrical energy

It is the product of power and time

Unit is watthour(Wh)

1Wh is the energy consumed when 1 watt of power is used for 1 hour

Commercial unit of electrical energy is kilowatt hour(kWh)

1kWh=1000 watt×3600 second

=3600000 J

=3.6×10^6J

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