ELECTRICITY

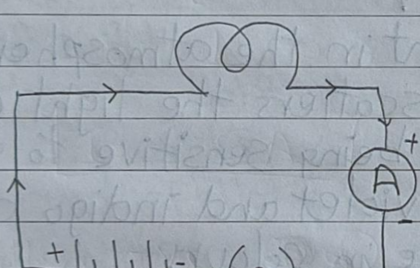
Properties of charge (Q) → SI unit - Coulomb (C)

1. Unlike charges attract, like charges repel
2. Charge is additive (Total charge = sum of all charges)
3. $F \propto \frac{q_1 q_2}{r^2}$ Coulomb's law ✗ (not in syllabus)
4. Charge is conserved (neither created, nor destroyed)
5. Charge is quantised

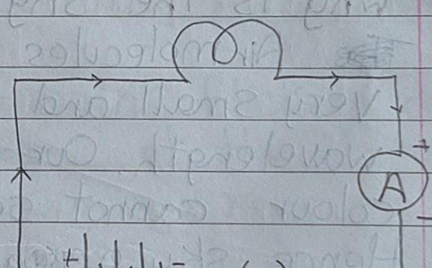
$$Q = ne$$ where e = charge on electron (1.6×10^{-19} C)
n = no. of electrons

Electric Circuit (ckt)

» Closed and continuous path of the electric current is called electric circuit.



(A) closed circuit



(B) open circuit

Electric Current (I)

» Rate of flow of electric charges

$$I = \frac{Q}{t}, \quad Q = It$$

SI unit - Ampere (A)

1 Ampere = $\frac{1 \text{ Colomb}}{1 \text{ second}}$ $1A = \frac{1C}{1s}$ A = C/s

1 Coulomb = 1 Ampere × 1 second $1C = 1A \times 1s$

$1mA = 10^{-3} A$, $1\mu A = 10^{-6} A$
milli Ampere micro Ampere

Q Calculate the no. of electrons in 1 Coulomb of charge.

$Q = ne$ $Q = 1C$

$n = \frac{Q}{e} = \frac{1C}{1.6 \times 10^{-19} C} = \frac{10 C}{16 \times 10^{-19} C} = \frac{0.625 C}{10^{-19} C}$

$= 0.625 \times 10^{19}$

$= 6.25 \times 10^{18}$ electrons

Electric Potential and Potential difference

Electric Potential - The electric potential energy per unit charge
SI Unit - Volt

Electric Potential difference - The electric potential difference

Potential difference is the amount of work done per unit charge. Work = Force × Displacement
(acts on electrons) → (electrons displace)

$V = \frac{W}{Q}$ Potential difference = $\frac{\text{Work}}{\text{Charge}}$

Date:

Ohm's Law

SI unit – Ω

$V \propto I$

I↑ – V↑ (directly proportional)
I↓ – V↓

$V \propto I$

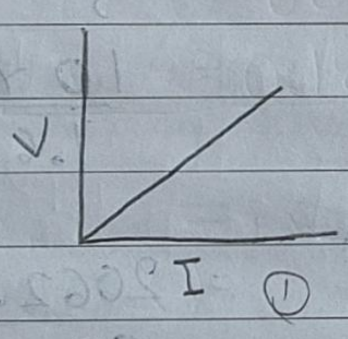
$V = IR$ where V is potential difference
I is current
R is Resistance (constant)
oppose electron flow

↓

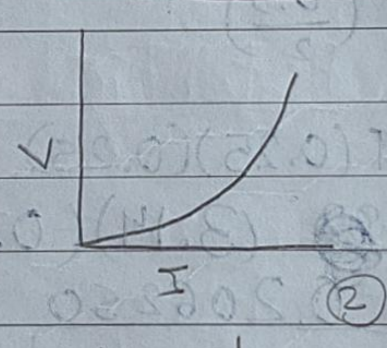
$R = \frac{V}{I}$, $I = \frac{V}{R}$

R↑ – I↓ (inversely proportional)
R↓ – I↑

At constant temperatures, the strength of the current flow is directly proportional to the potential difference across its ends.



Ohmic



Non-ohmic

Resistence depends on :

FACTORS

1. Length of the conductor

① ← $R \propto L$ (directly proportional)

L↓ , R↓
L↑ , R↑

2. Area of cross section

② ← $R \propto \frac{1}{A}$ (inversely proportional)

A↑ , R↓
A↓ , R↑

3. Nature of material

Metals - R↓ (less)

(Alloys) Insulators - R↑ (more)

4. Temperature $\propto$ R (Directly Proportional)

Temp. ↑ , R ↑
Temp. ↓ , R ↓

From ① and ②,

$R \propto \frac{L}{A}$ or $R = \rho \frac{L}{A}$ (ρ – rho – "Resistivity") $\rho = \frac{RA}{L}$

ρ (rho) is a constant of proportionality and is called resistivity.

SI unit − Ωm [$\rho = \frac{RA}{l} = \frac{\Omega m^2}{m} = \Omega m$]

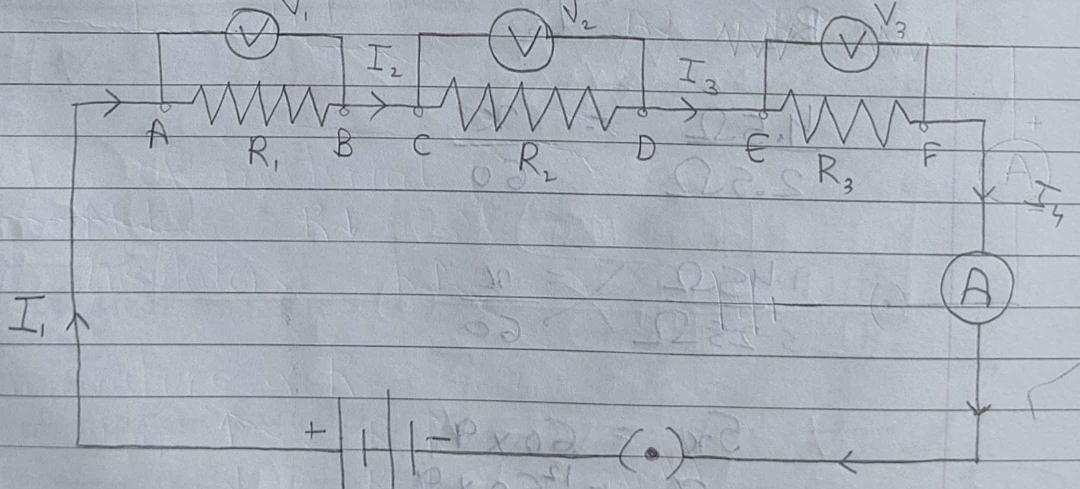
Resistivity ≠ Resistence

>>> Property of the material which is defined as resistence of the material in particular dimensions of length 1m and area of cross section $1 m^2$.

Note: As long as nature of the material changes, resistivity will not change.
[Material change = Resistivity change
Material → no change = Resistivity → no change]

Combination of Resistors

Series combination of Resistors



Current is constant, Voltage is distributed

>>>

$I_1 = I_2 = I_3 = I_4$ (constant)
$V = V_1 + V_2 + V_3 \rightarrow (1)$

According to ohm's law
$V = IR$

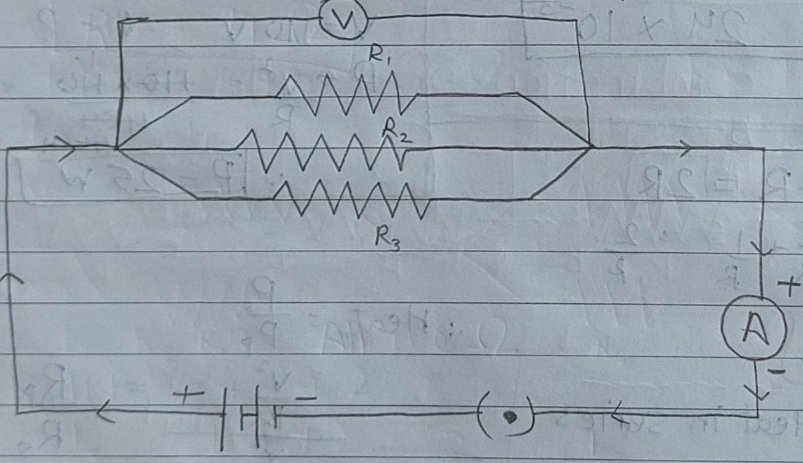
$\therefore V_1 = IR_1 \rightarrow (2)$
$V_2 = IR_2 \rightarrow (3)$
$V_3 = IR_3 \rightarrow (4)$

Substitute eq^n (2), (3), (4) in (1)

$IR = IR_1 + IR_2 + IR_3$
$(I) R = I (R_1 + R_2 + R_3)$

$$\boxed{R_s = R_1 + R_2 + R_3}$$ R↑ I↓

Parallel Combination of Resistors



Voltage is constant

Current is distributed

$V = V_1 = V_2 = V_3$
$I = I_1 + I_2 + I_3 \rightarrow (1)$

According to Ohm's law
$V = IR$, $\left| I = \frac{V}{R} \right|$ >>>

Date:

$$I_1 = \frac{V}{R_1} \rightarrow (2)$$

$$I_2 = \frac{V}{R_2} \rightarrow (3)$$

$$I_3 = \frac{V}{R_3} \rightarrow (4)$$

Substitute eq^n (2), (3), (4) in (1)

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\cancel{V}\left(\frac{1}{R}\right) = \cancel{V}\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$\boxed{R_p = \frac{R}{n}}$$

where n is the number of resistors

HEATING EFFECT OF ELECTRIC CURRENT

1. Whenever a current is passed through a conductor; it becomes hot after some time, which means that the electric energy is converted into heat energy.

2. When we apply potential difference across the ends of the conductor, electrons begin to drift from lower potential to higher potential.

3. The motion of these electrons is not smooth because they experience resistence on account of their collision

$$\boxed{H = I^2Rt}$$ → Joule's law of heating

(work) $W = H$

$\boxed{H = VQ}$ $\left[V = \frac{W}{Q} \Rightarrow W = VQ\right]$

$\boxed{H = VIt}$ $[Q = It]$

$H = IR \times It$ $[V = IR]$

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

$H = \left(\frac{V}{R}\right)^2 Rt$ $\left[V = IR \Rightarrow I = \frac{V}{R}\right]$

$H = \frac{V^2}{R^2} \times Rt$

$\boxed{H = \frac{V^2}{R} \cdot t}$

Applications

1. Iron box
2. Electric heater
3. Toaster
4. Hair dryer
5. Oven
6. Electric bulb
7. Electric fuse