CURRENT ELECTRICITY

Electric Current: It is defined as the rate of flow of electric charge through a cross-section of the conductor.

$\boxed{i = \frac{dq}{dt}}$ if the current is steady $\boxed{i = \frac{q}{t}}$

- Current is a scalar quantity
- SI unit is ampere (A). $1A = \frac{1C}{1s} = 6.25 \times 10^{18}$ electron/s

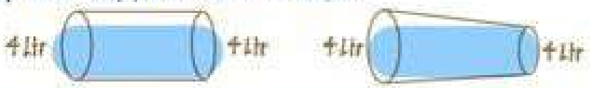
▶ **direction of current**

+ve charge →

← −ve charge

→ direction of current.

Note: The current is same for all cross section of a conductor of non uniform cross section.

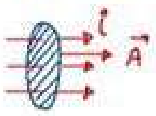


▶ Current in different situation is due to motion of different charge carriers.

Conductors / vacuum	Electrolyte	Semiconductor	discharge tube
due to motion of $e^{\ominus}$	due to +ve & −ve ions	due to motion of $e^{\ominus}$ & Holes	due to +ve ions & negative $e^{\ominus}$.

Note: Discharge tube → containing atomic gases.

▷ **Current density:** at a point inside the conductor is defined as the amount of current flowing per unit area around that point of the conductor,



$\vec{J} = \frac{i}{\vec{A}}$

if area A is not normal to the current but makes an angle θ with the direction of current, then

$J = \frac{i}{A\cos\theta}$ or $i = JA\cos\theta = \vec{J} \cdot \vec{A}$

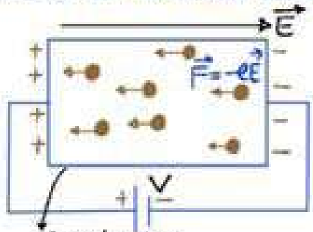
↳ Current density is a vector quantity

↳ SI unit $= Am^{-2}$.

or $i = \int \vec{J} \cdot d\vec{s}$ {ds is small area of given surface area}.

▶ **Drift velocity:** The average velocity with which free electron get drifted towards the positive end of the conductor under the influence of an external electric field.

Given by $\vec{V}_d = -\frac{e\vec{E}}{m}\tau$



τ = time of relaxation

e = Charge of electron

m = mass of electron

E = applied Electric field.

↳ Without electric field

- e^- moving randomly
- $\vec{u} = 0$; $i = 0$

● **Relation between i & V_d**

$\boxed{i = AneV_d}$

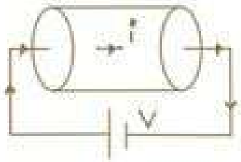
Mobility: It is defined as the magnitude of drift velocity per unit electric field. It is denoted by μ.

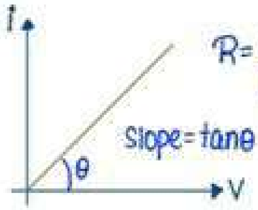
$\mu = \frac{|V_d|}{E}$ SI unit $= m^2 V^{-1} s^{-1}$

Ohm's Law: It states that the current (I) flowing through a conductor is directly proportional to the potential difference (V) across the ends of the conductor, provided physical conditions of the conductor such as temperature, mechanical strain etc are kept constant.

$V \propto i \Rightarrow \boxed{V = RI}$

R = constant of proportionality R is called resistance of the conductor.





$R = \frac{V}{I} = \frac{1}{\tan\theta\text{(Slope of I-V)}}$

SI unit is ohm (Ω)

● The resistance of a conductor is

$\boxed{R = \frac{m}{ne^2\tau}\frac{l}{A} = \rho\frac{l}{A}}$ where $\boxed{\rho = \frac{m}{ne^2\tau}}$ SI unit → Ωm

ρ = Specific resistance or resistivity of the conductor.

↳ depends upon material of the conductor.

↳ If length of a given metallic wire of resistance R is stretched to n times, its resistance becomes n^2R but its resistivity remains unchanged.

ie $R = \frac{\rho l}{A} = \rho\frac{nl}{A/n} = n^2\frac{\rho l}{A} = n^2R$

Note: Mass of the material remain constant.

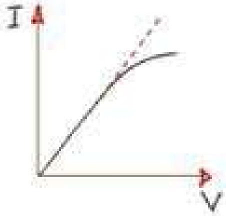
Conductivity: The reciprocal of resistivity is known as conductivity or specific conductance. It is denoted by σ.

$\sigma = \frac{1}{\rho} = \frac{ne^2\tau}{m}$ SI unit → $\Omega^{-1}m^{-1}$

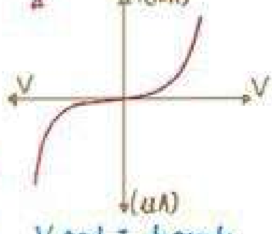
● Relationship between $\vec{J}$, σ & $\vec{E}$ → $\vec{J} = \sigma\vec{E}$

↳ **Ohmic Conductors:** Those conductors which obey Ohm's law are known as ohmic conductors. e.g metals. For ohmic conductors the graph between current and potential difference is a straight line passing through the origin.

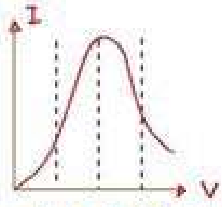
↳ **Non-ohmic Conductors:** Those conductors which do not obey Ohm's law are known as non-ohmic conductors. e.g diode valve, junction diode.



The relation between V & I is non-linear.



V and I depends on the sign of V.



⇒ there is more than one value of V for the same current i.