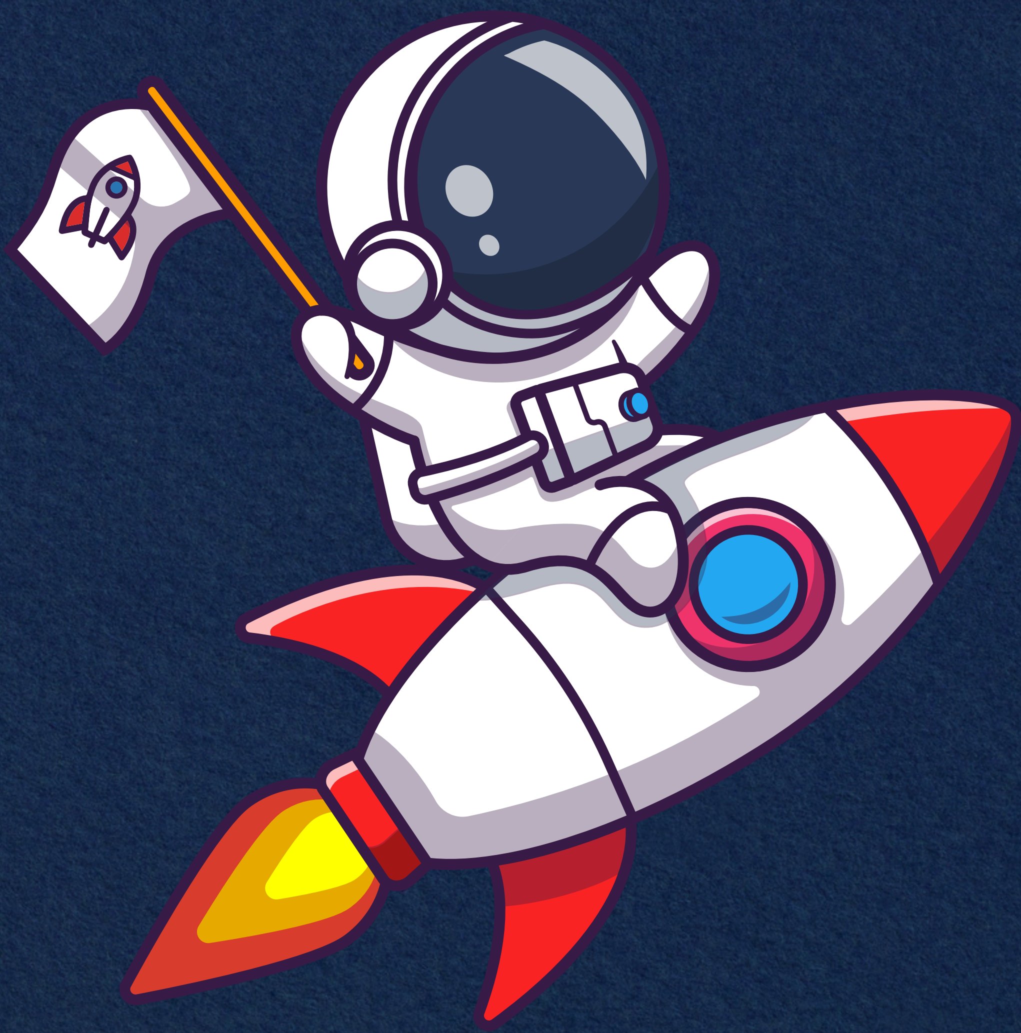
Class 12

PHYSICS

SHORT NOTES



Chapter - 3

Current Electricity

☆ Electric current :- Net electric charge flowing per unit time through an area of cross section.

$$\boxed{I = \frac{\text{No. of charges}}{\text{time}} = \frac{Q}{t}}$$

→ Unit :- Ampere or $\frac{\text{Coulomb}}{\text{Sec}}$

→ Dimensional :- $[M^0 L^0 T^0 A^1]$

☆ Average current :- $\frac{\Delta q}{\Delta t} = \frac{q_2 - q_1}{t_2 - t_1}$

☆ Instantaneous Current :- total current at any instant

$$\boxed{I_{int} = \frac{dq}{dt}}$$

→ Scalar or tensor quantity.

E.g → $I = I_1 + I_2$

☆ Electric Current in Conductor :-

Case - I :- When external electric field is not applied then,

$$\vec{u}_{avg} = \frac{\vec{u}_1 + \vec{u}_2 + \ldots\ldots + \vec{u}_n}{n} = 0$$

→ Average velocity of e^- is zero but avg. speed of e^- is not zero.

Case - II :- When battery is applied :-

$$\boxed{a_e = \frac{eE}{M_e}}$$

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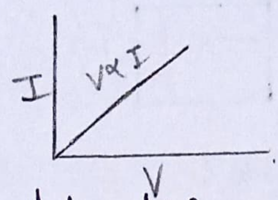
☆ Ohm's Law :-

$$\boxed{V = RI}$$

→ Resistance depend on nature and dimension of conductor not on V & I.



→ Unit of R :- Ω (ohm)

• factors on which Resistance depends :-

① Length $(R \propto l)$

② Cross sectional area of wire $\left(R \propto \frac{1}{A}\right)$

③ Temperature (T)
- Conductor → T↑ R↑
- Semiconductor → T↑ R↓
- Alloy → T↑, R → No change

④ Nature of Material (Resistivity)
(Ag < Cu < Al < Fe)

☆ Note :-

$$\boxed{R = \rho \frac{l}{A}} \qquad \boxed{V = I \rho \frac{l}{A}}$$ where ρ = Resistivity

☆ Current Density :- current flowing through conductor in per unit area.

$$\boxed{J = \frac{I}{A}}$$

→ Unit → Ampere/m²

→ It is vector quantity

→ Dimensional :- $[M^0 L^{-2} T^0 A^1]$

→ Direction of current ~~ds in~~ density is in direction of current.

$$\boxed{I = \vec{J} \cdot \vec{A}}$$

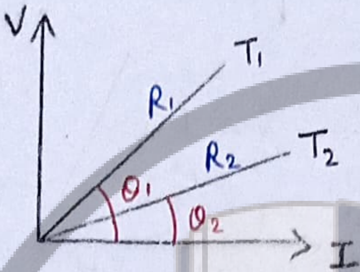
Note :-

$$\boxed{J = \sigma E}$$

$$\boxed{\vec{J} = \vec{E} \cdot \sigma}$$

$$\boxed{\sigma = \frac{1}{\rho}}$$

→ for conductors :-



If $T_1 > T_2$ then $\theta_1 > \theta_2$ & $R_1 > R_2$

Drift Velocity :-
average velocity of free electrons inside a conductor when external electric field is applied across the conductor.

Vector form :- $\boxed{\vec{V_d} = \left(\frac{e\vec{E}}{M}\right)\tau}$

where τ = Relaxation time.

$\tau = 10^{-14}$ sec.

Scalar form :- $\boxed{V_d = \frac{eE\tau}{M}}$

→ Drift velocity of e^- is always opposite to direction of $\vec{E}$.

Mobility :-

$$\boxed{\mu = \frac{V_d}{E} = \frac{q\tau}{M}}$$

→ Unit :- $\frac{C\,sec}{kg}$ or $\frac{M^2}{VS}$

Relation b/w drift velocity and Current :-

$$\boxed{I = V_d e n A} \text{ or } \boxed{I = neAV}$$

★. Note:-

Resistivity:- $\boxed{\rho = \frac{M}{e^2 \tau M}}$

① Drift velocity depend on e^- per unit volume.

② $\vec{E} = 0$, then path of electrons is straight.

★. Limitations of Ohm's Law :-

→ not apply to non-ohmic devices like diodes & transistors.

→ It fails for material where resistance varies with temperature.

→ Ohm's law is invalid for electrolytic solutions.

★. Electrical Resistivity:-

→ It is equal to resistance of material when length is 1 meter and cross sectional area is $1 m^2$.

So, $\boxed{\rho = R}$ at length = 1 m, area = $1 m^2$

→ Unit :- ohm-meter (Ωm)

$$\boxed{\rho = \frac{M}{ne^2 \tau}}$$

→ Resistivity depends on:-

① $\rho \propto \frac{1}{n}$ ② $\rho \propto \frac{1}{\tau}$

★. Concept :- (Effect of temperature)

① for Conductors:-

Temperature ↑ ⟶ no. of vibration ↑ ⟶ τ ↓ (More effective)

On T ↑, ρ ↑

② for Semiconductors:-

Temperature (↑) ⟶ no. of free e^- (↑) (n) (More effective)

On T ↑, ρ ↓

☆ Variation of Resistance / Resistivity with Temperature :-

① for Conductors :-

$$\boxed{R_T = R_0(1+\alpha\Delta T)}$$

$$\boxed{\rho_T = \rho_0(1+\alpha\Delta T)}$$

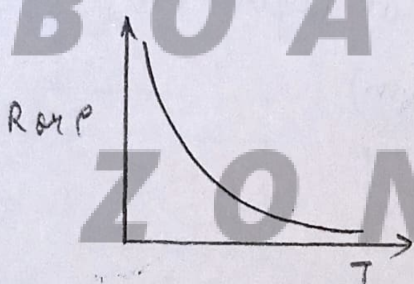
where α is thermal cofficient

(For copper)

② for Semiconductors :-

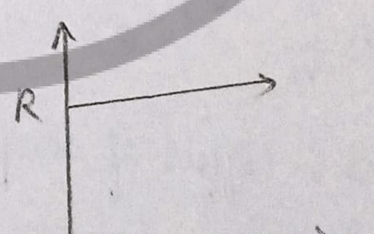
$$\boxed{R_T = R_0(1-\alpha\Delta T)}$$

$$\boxed{\rho_T = \rho_0(1-\alpha\Delta T)}$$



③ for Alloys :-

$$\boxed{R_T = R_0}$$



☆ Note :-

For conductor , $\alpha = +ve$

for semiconductor, $\alpha = -ve$

for alloy , $\alpha = 0$

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★. Electric Power & Energy:- Dissipated energy per unit time is called electrical Power.

$$\boxed{\Delta W = E = VI\Delta t}$$

$$\boxed{P = \frac{\Delta W}{\Delta t} = VI}$$

$$\boxed{P = I^2R = \frac{V^2}{R}}$$

→ Unit of Power → Watt (W)
→ Unit of Energy → Joule
→ Commercial unit of electrical energy → kWh (Kilo watt hour)

★. Combination of Resistors:-

1. Series Combination:-

$$\boxed{R_{eq} = R_1 + R_2 + R_3}$$

$R_{eq} = nR$ (For same resistors)

② Parallel Combination:-

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

$$R_{eq} = \frac{R_1R_2}{R_1+R_2}$$

$R_{eq} = \frac{R}{n}$ (For same resistors)

★. Cell:- convert chemical energy into electrical energy
→ Cell produce potential difference across terminals which forces the electrons to move.
→ Combination of more than one cell called battery.

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★. Electromotive force (E.M.F):- maximum potential difference across the e^- of cell when no current drawn from it.

$$\boxed{\varepsilon = I(R+r)}$$

→ unit → Volt (V), JC^{-}

→ It is applicable for open circuit only.

★. Internal Resistance :- (r) Resistance offered by electrolyte and electrode of cell when electric current flows through it.

→ Internal resistance depends on:-

- Distance by electrodes
- Nature, Concentration & temp. of electrolyte
- Nature of electrodes.

→ Due to internal resistance, potential across terminals decreases.

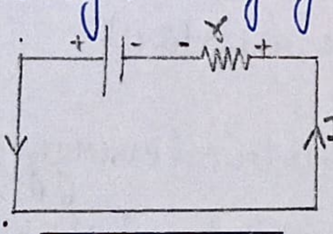
★. Terminal Potential Difference :- (V) When current flows through the circuit then potential difference is called terminal voltage.

$$\boxed{V < \varepsilon}$$

$$\boxed{V = \varepsilon - Ir}$$

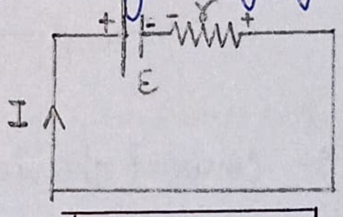
★. Note :-

① During Discharging ($V < \varepsilon$)



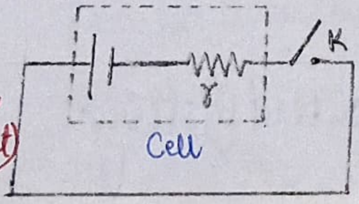
$$\boxed{V = \varepsilon - Ir}$$

② During Charging ($V > \varepsilon$)



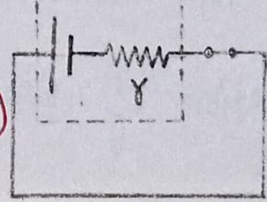
$$\boxed{V = \varepsilon + Ir}$$

(Open Circuit)



Emf is measured

(Closed Circuit)



Potential difference is Measured

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Internal Resistance of a Cell in terms of E, V & R :-

$$\boxed{r = \frac{\varepsilon - V}{I}}$$

$$\boxed{r = \left(\frac{\varepsilon}{V} - 1\right) R}$$

Combination of Cell :-

1. Series Combination :-

$$\boxed{V = \varepsilon_{eq} - I r_{eq}}$$

$$\boxed{\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2} \qquad \boxed{r_{eq} = r_1 + r_2}$$

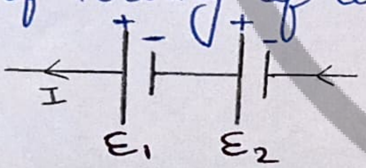
Case :- If there are n no. of same cells

$$\boxed{\varepsilon_{eq} = n\varepsilon} \qquad \boxed{r_{eq} = n r}$$

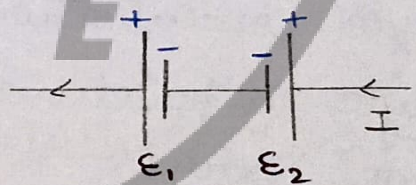
$$\therefore \boxed{I = \frac{\varepsilon_{eq}}{R + r_{eq}} = \frac{n\varepsilon}{R + nr}}$$

Note :-

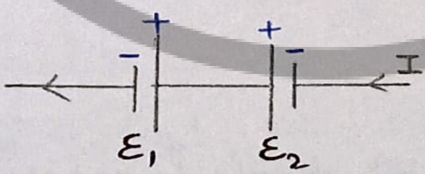
① If Polarity of cell is different.



$$\boxed{\varepsilon = \varepsilon_1 + \varepsilon_2}$$



$$\boxed{\varepsilon = \varepsilon_1 - \varepsilon_2}$$



$$\boxed{\varepsilon = \varepsilon_2 - \varepsilon_1}$$

But $r_1 + r_2 = r$ for all conditions.

② Internal Resistance of ideal cell is zero.

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2. Parallel Combination :-

$$\boxed{V = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) r_p - I r_p}$$

$$\boxed{\varepsilon_{eq} = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) r_p}$$

$$\boxed{r_{eq} = r_p = \left(r_1 + r_2\right)}$$

Case :- If there are n number of same cells.

$$\boxed{\varepsilon_{eq} = \varepsilon} \qquad \boxed{r_{eq} = \frac{r}{n}}$$

$$\boxed{I = \frac{n\varepsilon}{nR + r}}$$

★ Note :-

Factors on which internal resistance depends are :-

① Electrode surface area

② Electrode distance

③ Electrolyte concentration

④ Electrolyte Temperature

⑤ Electrolyte Nature.

V. Imp for Exam

★ Kirchoff's Law :-

1. Kirchoff's first law / Kirchoff Current Law (KCL) :-

→ Based on law of conservation of charge.

→ According to this, at any junction the sum of current entering the junction is equal to the sum of currents leaving the junction.

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$$\underbrace{I_1 + I_2}_{\text{Entering current}} = \underbrace{I_3 + I_4 + I_5}_{\text{Leaving current}}$$

$$\boxed{I_1 + I_2 - I_3 - I_4 - I_5 = 0}$$ → at any junction total current is always zero.

Note:-

→ This law is valid for both open & closed circuit.

→ If current is negative then consider direction opposite.

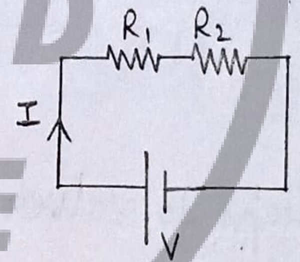
2. Kirchoff's 2nd Law / Kirchoff Voltage Law (KVL):-

→ Based on law of conservation of energy.

→ The algebric sum of changes in potential around any closed loop involving resistors and cells is zero.

$$\boxed{\Sigma \Delta V = 0}$$

$$\boxed{V - IR_1 - IR_2 = 0}$$



A. Sign Convention to apply Kirchoff Law:-

• Sign for Potential:-

higher Potential $\xrightarrow{\text{Potential drop}}$ Low Potential

$$\boxed{\Delta V = -ve}$$

Lower Potential $\xrightarrow{\text{Potential gain}}$ high Potential

$$\boxed{\Delta V = +ve}$$

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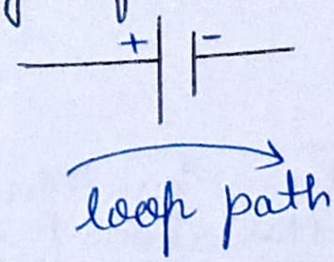
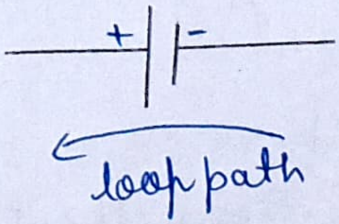
- Sign for cell :-

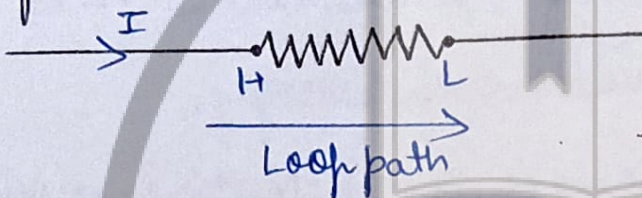


then $\boxed{\Delta V = -\mathcal{E}}$

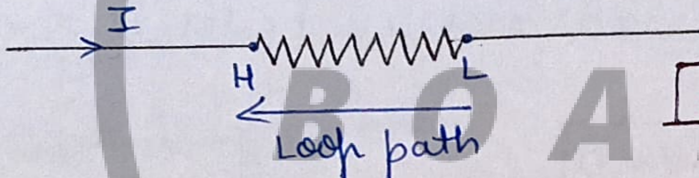


then $\boxed{\Delta V = +\mathcal{E}}$

- Sign for Resistance :-



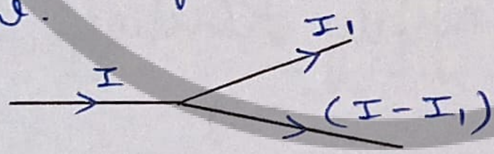
$\boxed{\Delta V = -IR}$



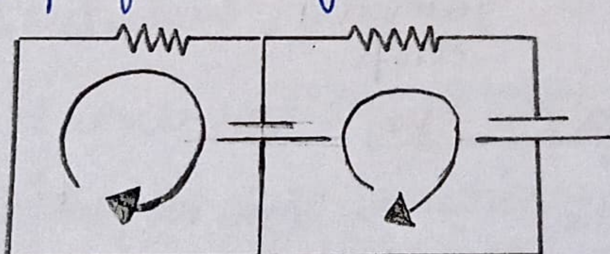
$\boxed{\Delta V = +IR}$

★. Steps to solve Circuit By KVL :-

① Draw the current from one or more cell and follow current law.



② Choose a loop for every closed circuit.



May be clockwise or anticlockwise.

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*. Wheatstone Bridge :-

→ Designed by C. F Wheatstone.

→ A special type of circuit containing four resistance, a galvanometer and a cell is called Wheatstone Bridge.

→ It is used to find unknown resistance.

→ Its principle is that if $\boxed{\frac{P}{R} = \frac{Q}{S}}$ then $\boxed{I_g = 0}$

• Application :-

Meter Bridge and carry foster bridge follow this concept to find unknown resistance.

*. Note :-

→ If $P = Q = R = S$, then wheatstone bridge is sensitive.

→ Internal resistance does not affect the value of unknown resistance.

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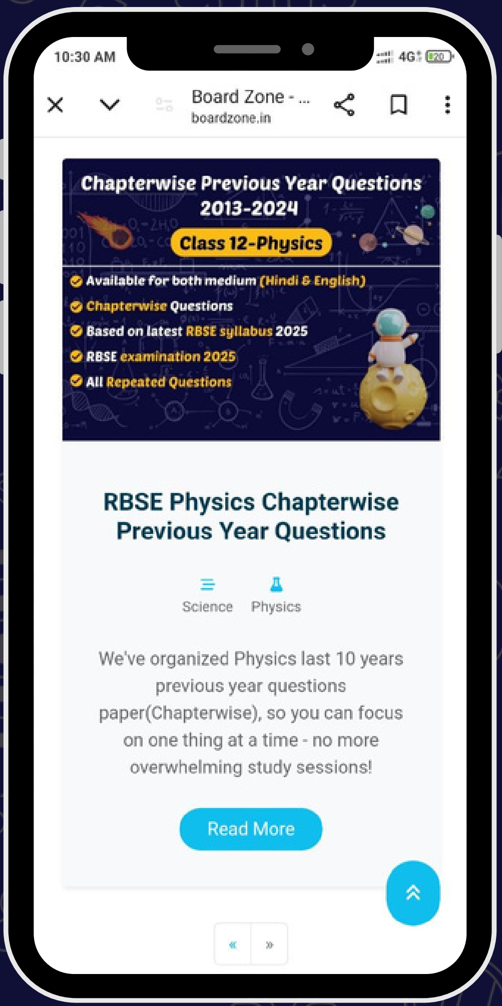

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