Current Electricity

Current Electricity → Scaler Quantity.

Current Electricity → S.I unit $\boxed{\text{Ampere}}$ or C/s (coloumb per sec)

Avg Current → $\dfrac{\text{Total Charge}}{\text{Total time}}$ i.e $\dfrac{\Delta q}{\Delta t}$ or $\dfrac{dq}{dt}$ → instaneous current at any instant

Speed of e^- on a conductor → 10^6 m/s, Avg displacement of e^- is zero (0).

Relaxation Time has no contribution in current.
→ is the avg time between the 2 successive collisions.

Drift velocity (V_d) → τ is the avg rate at which free e^- are displaced against the E.f
→ in the order of 1 Mm/s.

depends upon:-
- → temperature
- → Material
- → Temp ↑, KE ↑, τ ↓, V_d ↓, μ ↓

$V_d = \left(\dfrac{e\tau}{m}\right)E$, where μ (mobility) $= \dfrac{e\tau}{m}$.

$\boxed{(*)\ I = neAV_d}$

- e → 1.6×10^{-19} C
- A → Area
- V_d → drift velocity
- n → no. of free e^- carriers per volume

Resistance, Resistivity and Conductivity

$R = \dfrac{\rho l}{A}$, $\rho = \dfrac{m}{ne^2\tau}$

- l → in the direc^n of current
- A → ⊥ to the direction of current.

R depends upon → material, Temp, Geometry, Dimension

ρ → depends upon :- material, temperature
doesn't depend upon geometry

(*) Temp ↑, K.E ↑, τ ↓, ρ ↑, R ↑

(*) $\rho = \dfrac{1}{\sigma}$ → Conductivity

Ohm's Law

$V = IR$

$\boxed{\text{Temp} \uparrow, \text{K.E} \uparrow, \tau \downarrow, \rho \uparrow, R \uparrow}$

* Empirical Relation b/w ρ and Temp

$$\rho_f = \rho_0 (1 + \alpha \Delta T) \quad , \text{ when } \Delta T < 100\,^\circ C.$$

$$\rho_f = \rho_0 e^{\alpha \Delta T} \quad , \text{ when } \Delta T > 100\,^\circ C.$$

Current Density

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

Cell

$$* \quad \boxed{V_A - V_B = iR}$$

$$* \quad P = \frac{V^2}{R}$$

KCL (Kirchoff's current Law)

Conservation of charge,

$$\sum \text{incoming} + \text{outgoing} = 0$$

KVL (Kirchoff's voltage law)

Conservation of Energy.

Go through anti or clockwise direcⁿ to conserve voltage.

short circuit :-

means $\boxed{i = 0, \; V = 0, R = 0.}$

$$\boxed{V_1 = \frac{R_1}{R_1 + R_2} V, \; V_2 = \frac{R_2}{R_1 + R_2} V}$$

Series Connection :-

$$R_{eq} = R_1 + R_2 \; ---$$

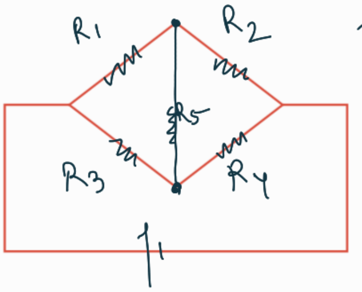
Parallel Connection

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \; \cdots$$

$$* \quad I_1 = \frac{R_2}{R_1 + R_2} I$$

$$I_2 = \frac{R_1}{R_1 + R_2} I.$$

Wheatstone Bridge :-



Wheatstone Bridge

if and only, $\dfrac{R_1}{R_3} = \dfrac{R_2}{R_4}$,

then it is called a balanced wheatstone bridge.

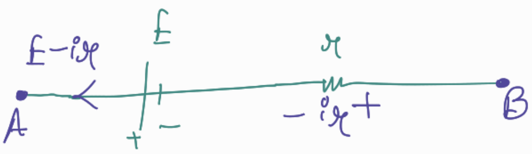
Terminal Voltages

Case-I :- (Disconnected)

$$\Rightarrow V_A - V_B = \text{Emf}$$

$$\Rightarrow \text{Terminal Voltage} = \text{Emf}$$

Case-II :- (Source)



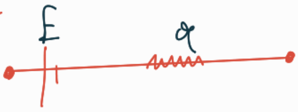
Terminal voltage,

$$V_A - V_B = E - ir$$

$$\boxed{P = \Delta V \times i} \quad = (E - ir)\, i = Ei - i^2 R$$

Cost dissipation due to internal resistance

Case-III :→ (load)

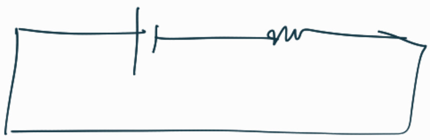


Terminal Voltage,

$$V_A - V_B = E + ir$$

$$P = (E + ir)\,i = Ei + i^2 r$$

Case-IV (Short circuit)



$$\boxed{i = \frac{E}{r}}$$

$$V_A - V_B = E - ir = \cancel{E} - \cancel{E} = 0$$

Combination of Cells :→

$\boxed{\text{Series Combination}}$ → If anyone is in opposite polarity then, it will get −ve.

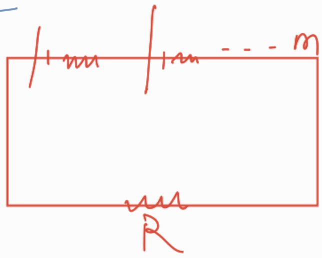
$$E_{eq} = E_1 + E_2 \ldots$$

$$R_{eq} = R_1 + R_2 \ldots$$

If 'n' identical cells.

$$E_{eq} = mE, \quad R_{eq} = mR.$$

Case → 1



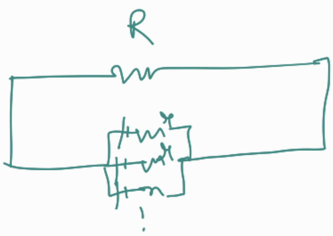
$$\boxed{i = \frac{mE}{mr + R}}$$

Parallel combination of cell . .

$$E_{eq} = \frac{\frac{1}{E_1} + \frac{1}{E_2} \ldots}{\frac{1}{r_1} + \frac{1}{r_2} \ldots}$$

(*) If 'n' identical cells.

$$i = \frac{nE}{nR + r}$$ →



Grids of Cells :→

$$E_{eq} = \frac{m}{n} E.$$

$$R_{eq} = \frac{m}{n} R.$$

$$i = \frac{mE}{R + \left(\frac{mr}{n}\right)}$$

For i_{max},

$$\Rightarrow i_{max} \longrightarrow R = \frac{mr}{n}$$

$$\boxed{nR = mr}$$

Heat and Power consumption →

Heat = Power × time , $H = I^2 R T$ (*) 1 kWh = 3.6×10^6 Joule.

Bulb $P = \frac{V^2}{R}$

(i) Series Connection

$$\boxed{P = i^2 R}$$

(ii) Parallel Connection

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

(iii) Series connection of resistors/bulbs

$$\frac{1}{P_{net}} = \frac{1}{P_1} + \frac{1}{P_2}$$

(iv) Parallel connection of resistors/bulbs.

$$P_{net} = P_1 + P_2$$

(*) **Funda** :- In series, resistance with higher value, have more Power.
In parallel, resistance with lower value has more power.

Maximum Power Transfer

$I = \frac{E}{R+r}$, Power absorbed $\Rightarrow P = I^2 R = \left(\frac{E}{r+R}\right)^2 \times R$

(*) Power is maximum when $\Rightarrow r = R$.

Galvanometer (measures small amount of current in mA or µA).
→ denoted by I_a or I_{max}.

(*) **Formula**
use same logic as in ohm's law.

Ammeter (measures large amount of current).

* $$\boxed{I_g R_g = (I_A - I_G) R_s.}$$

* To increase the range of galvanometer, a shunt resistance is connected parallel to it.

Voltmeter :→ (measures P.d)

This can be measured by connecting a resistance in series with galvanometer.

(*) $V = I_g (R_G + R)$

** **Topics** :- Potentiometer and RC Circuit
Read from Notes.