Lakshya Batch 2020-21

Ch-03
Current Electricity
Formula Sheet

Sheet Credit: Anup Mohapatra

FORMULA SHEET CLASS-12 "CURRENT ELECTRICITY"

CHARGE :- (SCALAR)
- → constant velocity → Current Electricity
- → variable velocity → Electromagnetism

(Scalar) (UNIT = Ampere)

CURRENT :- Rate of flow of charge = $\boxed{I = \frac{q}{t}}$ = $\frac{\text{Charge}}{\text{Time}}$ $\boxed{SI = Cs^{-1}}$ (Coulombs s^{-1})

$\boxed{I_{av} = \frac{\Delta Q}{\Delta t}}$ (Average)

$\boxed{I_{inst.} = \frac{dQ}{dt}}$ (Instantaneous)

CIRCULAR PATH ⇒ $\boxed{I = \nu q = \frac{ev}{2\pi r}}$ (ν = frequency) radius

DRIFT VELOCITY :- $\boxed{V_d = \frac{-eE}{m}\tau_{avg}}$ $\boxed{V_d = \frac{eV}{ml}\tau_{avg}}$ τ_{avg} = Relaxation Time, l = length.

→ Thermal velocity = $\boxed{V_T = \sqrt{\frac{3K_BT}{m}}}$ (K_b = Boltzmann constant)

when V is applied in a conductor e- move in $(-\vec{E})$ direction. Imp

→ $\boxed{I = V_d e n A}$ नोट!! (n = no. of free e- / V)

Asmp → If no. of free e- not given assume 1 atom give one free electron

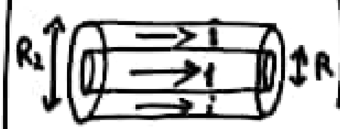
→ $\vec{j}$ = current density = $\boxed{\frac{I}{A} = enV_d}$

$\boxed{I = JA\cos\theta}$ $\boxed{I = J \cdot A}$ Area vector

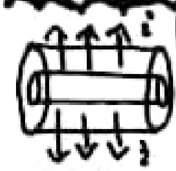
RESISTANCE :- $R = V/I$ (unit = $VA^{-1} = \Omega$) (ohm) $R = \frac{ml}{ne^2\tau A}$ $R_{net} = \rho\frac{l}{A}$ Resistivity

Resistivity :- $\boxed{\rho = \frac{m}{ne^2\tau}}$ = depend on Temp and material not l and A

RESISTANCES OF DIFFERENT STRUCTURE :-



$\boxed{R = \frac{\rho l}{\pi(R_2^2 - R_1^2)}}$



$\boxed{R = \frac{\rho[\log\frac{R_2}{R_1}]}{2\pi l}}$

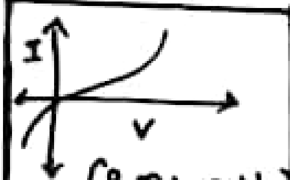
$\boxed{R = \frac{\rho l}{\pi ab}}$ R_{net} I (First)

OHMS LAW :- $\boxed{V_{12} = IR}$ (at const temp)

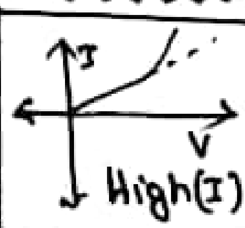
→ $\boxed{V = \left(\frac{ml}{ne^2\tau A}\right)i}$ (In terms of drift velocity)

→ $\boxed{\vec{j} = \sigma\vec{E}}$ ($\sigma = 1/\rho$ = conductivity)

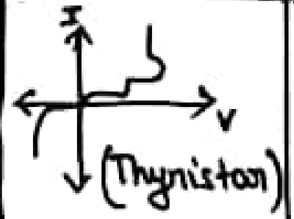
NON OHMIC CONDUCTOR



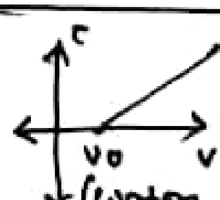
(P-n junction)



High(I)



(Thyristor)



(water voltmeter)

CURRENT DENSITY :- I per Area. ($\vec{j}$)

$\boxed{I = \int_s \vec{j} \cdot d\vec{s}}$ $\boxed{I = jA\cos\theta}$

EFFECT OF TEMPERATURE
$n \uparrow\uparrow$ (no. of free electron) $\tau \downarrow$ on $T\uparrow\uparrow$

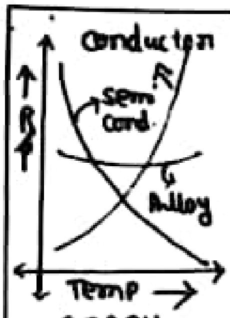
a) Conductors → $n \uparrow$ ×, $\tau \uparrow\uparrow$, $R\uparrow$ $\rho\uparrow$ Temp ↑↑

b) Semi-conductors → $n\uparrow$ $R\downarrow$ $\rho\downarrow$ as Temp ↑↑

c) Alloys (Nicrome, Manganin, constantin) → $n\uparrow$ and $\tau\downarrow$ (no change in R)

$$\boxed{\int_{R_0}^{R_F} dR = \int_{T_i}^{T_F} \alpha R_0\, dT}$$

$$\boxed{R_F = R_0 \left(1 - \alpha (T_F - T_i)\right)}$$

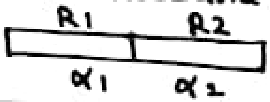


GRAPH

→ α has nothing to do with coefficient of Thermal expansion

α = Temp. coefficient of Resisance or ρ = $\boxed{\alpha = \dfrac{R_F - R_0}{R_0 \Delta T}}$

α_{copper} → $+4 \times 10^{-3}\ °C^{-1}$
$\alpha_{silicon}$ → $-7 \times 10^{-2}\ °C^{-1}$
$\alpha_{manganin}$ → $2 \times 10^{-6}\ °C^{-1}$



R_{comb} = not change Temp ↑↑ = $\boxed{\alpha_1 R_1 + \alpha_2 R_2 = 0}$

SERIES COMBINATION

$\boxed{R_e = R_1 + R_2 + R_3}$ current is constant

PARALLAL COMBINATION

$\boxed{\dfrac{1}{R_e} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}}$ Voltage const.

ELECTROMOTIVE FORCE (EMF)

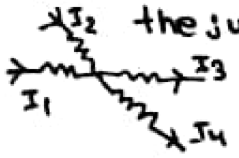
$\boxed{\mathcal{E} = F_n d/q}$ $\boxed{\mathcal{E} = \dfrac{W}{q}}$

$\boxed{V = \mathcal{E} - IR}$ (V = Terminal voltage)

▶ Imp relation.

KIRCHOFF'S LAW :-

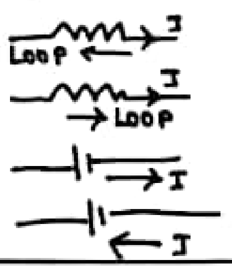
① CURRENT LAW :- Sum of current entering the junction = Current leaving the junction.



$\boxed{I_1 + I_2 = I_3 + I_4}$ (Based on principle of conservation of charge.

② LOOP LAW / VOLTAGE LAW :- Algebraic sum of potential around a closed loop is "zero".

$\boxed{\begin{matrix} W_{ext} = 0 \\ \Delta U = 0 \end{matrix}}$ $\boxed{\Sigma \Delta V = 0}$ across closed Loop (conservation of energy)

Direction	ΔV
	(+ve)
	(−ve)
	(−ve)
	(+ve)

COLOUR CODING RESISTORS

$\boxed{n\,n \times 10^{n}\ \times\times\%}$ → Gold → 5%, Silver → 10%, No → 20%

BBROY of Great Britain Very Good Wife

0 1 2 3 4 5 6 7 8 9 = n

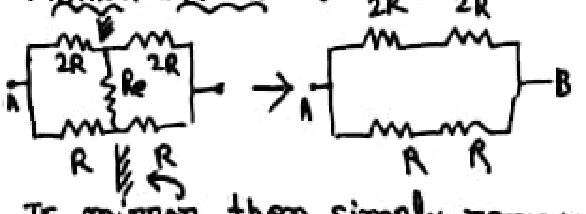
▶ MOBILITY :-

unit = $m^2 s^{-1} V^{-1}$

$\mu = \dfrac{V_d}{E}$

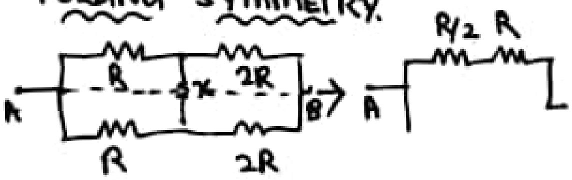
$\mu = \dfrac{q\tau}{m}$

MIRROR SYMMETRY



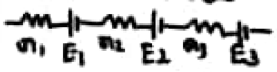
If mirror then simply remove Re across the lines of mirror. (Short circuit Re) network

FOLDING SYMMETRY



If folding symmetry across A and B then simply fold it across A and B.

SERIES GROUPING OF CELLS :-



$E_{eq} = E_1 + E_2 + E_3$

$I r_{eq} = i(r_1 + r_2 + r_3)$

$$\boxed{E_{eq} - I R_{eq} = E_1 + E_2 + E_3 - i(r_1 + r_2 + r_3)}$$

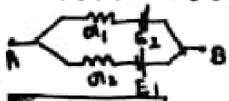
If a external Resistance is added :-

$$I = \frac{V}{R_e} = \frac{nE}{nr + R_{ext}} \quad (n \text{ in series})$$

$n \rightarrow$ E and a are connected and Polarity of m are reversed then,

$$\boxed{E_{eq} = (n - 2m)E} \quad \boxed{r_{eq} = nr}$$

PARALLEL GROUPING OF CELLS :-



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

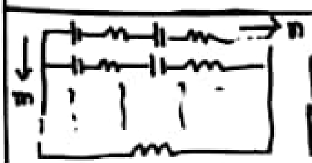
$$\boxed{\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}}$$

For n-cells in Parallel $\rightarrow$

$$\boxed{E_{eq} = E} \quad \boxed{r_{eq} = \frac{r}{n}}$$

$$\boxed{I = \frac{nE}{nR_{ext} + r}}$$ (If external resistance of R is connected.

MIXED GROUPING :- (n - Cells. in row m cell column)



$$\boxed{E_{eq} = nE} \quad \boxed{R_{eq} = R + \frac{nr}{m}}$$

$$\boxed{I = \frac{mnE}{mR + nr}} \quad \boxed{I_{max} = \frac{nE}{2R}}$$

R - external Resistance

POWER :-

$\rightarrow$ Energy - absorbed

$\rightarrow dE = Vdq$

Power absorbed - (P)

1) $P = I^2 R$

2) $P = V^2/R$

3) $P = VI$

$$\boxed{P = \frac{dE}{dt} = \frac{Vdq}{dt}}$$

$$\boxed{P = VI}$$

ENERGY DISSIPATED RESISTOR (HEAT)

$$\boxed{E = \int P\,dt}$$

For Pure only Resistance Formula.

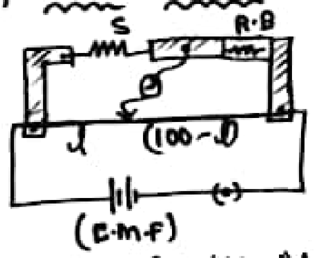
1) $E = I^2 R t$

2) $E = V^2/R\,t$

3) $E = Vit$

$\boxed{\text{Brightness } \propto \text{ Power consumed}}$

1) METRE BRIDGE (Jo by Jo)

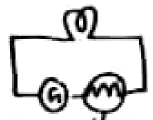


$$\boxed{\frac{S}{l} = \frac{R}{(100 - l)}}$$

$$\boxed{\rho = \frac{SA}{l'} = \frac{S\pi r^2}{l'}}$$

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} + \frac{100 - \Delta l}{(100 - l)}$$

CONVERSION G TO V



$$\boxed{V = I_g (G + R)}$$

$V_{amm} \; d$

Heavy resistance in series

R_{volt}.. ideal is always ∞

$\rightarrow$ Measured V is small than original

CONVERSION GALVANOMETER TO AMMETER

$$\boxed{I_g G = (I - I_g) S}$$

$\rightarrow$ S - $\boxed{\text{Shunt}}$ (small resistance)

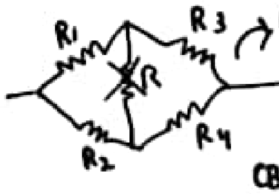
$$\boxed{R_{amm} = \frac{GS}{G + S}}$$

R_{amm} ideal is always equal to ZERO

Imp

$\rightarrow$ Measured current is always small than original

WHEATSTONE BRIDGE :-



when no I through R

$$\boxed{\frac{R_1}{R_2} = \frac{R_3}{R_4}}$$

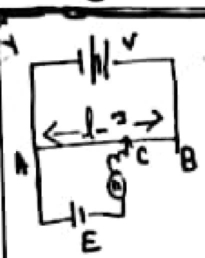
(Balanced W.S Bridge)

POTENTIOMETER :-

$$\boxed{V_{AC} = \frac{V}{l} x}$$

x : length of which V

l : original length



comparison of EMF :-

$$\boxed{\frac{E_1}{E_2} = \frac{l_1}{l_2}} \quad \boxed{K = \frac{V}{l}} \text{ Potential Gradient}$$

Internal resistance :-

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

Battery EMF > cell's EMF

Efficiency source EMF

$$\boxed{\eta = \frac{R}{R + r}} = \frac{P_{output}}{P_{input}}$$

$\eta_{max} = 50\%$

$max\ P = E^2/4R$

FUSE :-

Heat produced Per unit t = Heat radiated per unit t

$$\boxed{I^2 = Kr^3}$$

$\hookrightarrow$ Some constant.