For quick revision of Electrostatic

1. ELECTROSTAITCS (8 marks)

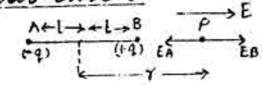
XII

Electric Field Intensity $E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$ Vector N/C $E = -\frac{dV}{dr}$ | Electric Potential $V = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$ Scalar J/C $V = E/d$, $E = -\frac{dV}{dr}$

ELECTRIC DIPOLE : Equal & opposite charge seprated by small distance. dipole Moment $\vec{P} = 2ql$ Vector $\ominus \rightarrow \oplus$ unit cm,

E and V on Axial Line :-

let $\vec{E}$ at pt P on axial line is



$\vec{E} = \vec{E}_B + (-\vec{E}_A)$

$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r-l)^2} - \frac{1}{4\pi\epsilon_0}\frac{q}{(r+l)^2}$

$\vec{E} = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right)$

$\vec{E} = \frac{2\times 2qrl}{4\pi\epsilon_0(r^2-l^2)^2} = \frac{2pr}{4\pi\epsilon_0(r^2-l^2)^2}$

$\boxed{\vec{E} = \frac{2\vec{p}}{4\pi\epsilon_0 r^3}}$ For short dipole $r \gg l$ (direction (-) to (+))

$V = V_A + V_B = \frac{1}{4\pi\epsilon_0}\frac{-q}{(r+l)} + \frac{1}{4\pi\epsilon_0}\frac{q}{(r-l)}$

$= \frac{1}{4\pi\epsilon_0}\frac{p}{(r^2-l^2)}$

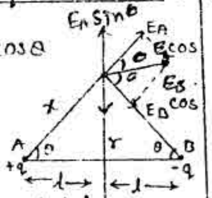
$\boxed{V = \frac{p}{4\pi\epsilon_0 r^2}}$

2. E and V on Equitorial line :

$\vec{E} = E_A\cos\theta + E_B\cos\theta$

since

$E_A = E_B$



$\therefore \vec{E} = 2E_A\cos\theta$

$\vec{E} = 2\times\frac{1}{4\pi\epsilon_0}\frac{q}{x^2}\times\left(\frac{l}{x}\right)$ $[\cos\theta = l/x]$

$\vec{E} = \frac{2ql}{4\pi\epsilon_0 x^3} = \frac{p}{4\pi\epsilon_0(\sqrt{r^2+l^2})^3}$

$\vec{E} = \frac{p}{4\pi\epsilon_0(x^2+l^2)^{3/2}}$

$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}}$ For short Dipole Direction (+) → (-)

$V = V_A + V_B = \frac{1}{4\pi\epsilon_0}\frac{+q}{x} + \frac{1}{4\pi\epsilon_0}\frac{-q}{x}$

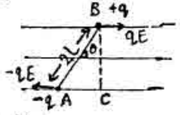
$= 0$

$\boxed{V = 0}$

3. Torque on Dipole :

Net Force

$+qE - qE = 0$



Torque = Force × ⊥ distance

$= qE \times BC$ $[BC = l2\sin$

$= qE\,2l\sin\theta$

$= E(2ql)\sin\theta$

$\boxed{\tau = PE\sin\theta = \vec{P}\times\vec{E}}$

$\tau_{max} = PE$ For $\theta = 90°$

Work Done in Rotating Dipol

$W = \int \tau\,d\theta = (1-\cos\theta)PE$

Energy of Dipole : $U = -PE\cos\theta$

stable equilibrium $\theta = 0$, $U = -PE$

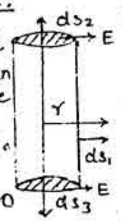
unstable equilibrium $\theta = 180° \Rightarrow U = PE$.

GAUSS THEOREM :

Total electric flux (total no. of lines of forces) emerges from closed surface is $1/\epsilon_0$ times the charge enclosed. $\oint E.ds = \phi = q/\epsilon_0$

$\vec{E}$ Due to Long Charged Wire:

Linear charge density $\lambda = q/l$



$\oint E.ds = q/\epsilon_0$

$\int E ds_1 + \int E ds_2 + \int E ds_3 = q/\epsilon_0$

For ds_2 & ds_3 $\theta = 90°$ $\therefore \cos 90° = 0$

For curved surface ds_1, $\theta = 0$

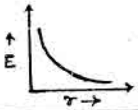
$\int E ds = \int E ds\cos\theta$

$\therefore E\int ds = q/\epsilon_0$

$E(2\pi rl) = q/\epsilon_0$

$E = \frac{q}{2\pi rl\epsilon_0} = \frac{2q/l}{\pi 4\epsilon_0 r}$

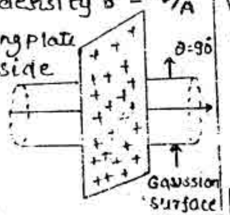
$\boxed{\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{2\lambda}{r}}$



2. $\vec{E}$ Due to charged Plane sheet:

Surface charge density $\sigma = q/A$

For non conducting plate charge is on both side



$2\int E ds = q/\epsilon_0$

$E\int ds = q/\epsilon_0$

$2EA = q/\epsilon_0$

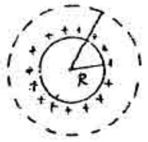
$E = \frac{q}{2\epsilon_0 A}$ or $\boxed{E = \frac{\sigma}{2\epsilon_0}}$

For conducting sheet $\boxed{E = \frac{\sigma}{\epsilon_0}}$

* $\vec{E}$ is independent of distance From the sheet.

3. $\vec{E}$ Due charged Hallow sphere :

Volume charge density $\rho = q/V$



$\int E ds = q/\epsilon_0$

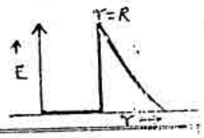
$E\int ds = q/\epsilon_0$

$E\,4\pi R^2 = q/\epsilon_0$

$\boxed{E = \frac{1}{4\pi\epsilon_0}\frac{q}{R^2}}$ on surface

$\boxed{E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}}$ outside

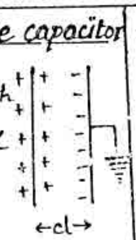
$\boxed{\vec{E} = 0 \text{ as } q = 0 \text{ inside}}$



CAPACITOR : $Q = CV$ or $C = Q/V$ Farad , C depends on dimensions.

Capacitonce for parallel plate capacitor

Consider ll plate capacitor with area of plate A. capacitance C and dist bet plates d



$C = \frac{Q}{V} = \frac{Q}{E\times d}$

$E = \frac{\sigma}{\epsilon_0}$ for charged sheet

$\sigma = \frac{Q}{A}$ for surface charge density

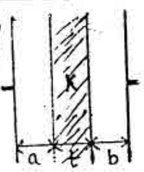
$C = \frac{\sigma A}{\sigma/\epsilon_0 \times d} = \frac{\epsilon_0 A}{d}$

if dielectric with dielectric constant K is filled between the plates.

$C = K\epsilon_0 A$

2. With Dielectric slab

Surface charge Density $\sigma = Q/A$ $\therefore Q = \sigma A$



Electric Feild

$\vec{E} = E_{air} + E_{dielectric}$

$= \frac{\sigma}{\epsilon_0} + \frac{\sigma}{K\epsilon_0}$

Potential $V = E\times d$

$\therefore V = \underbrace{\frac{\sigma}{\epsilon_0}(a+b)}_{air} + \underbrace{\frac{\sigma}{K\epsilon_0}t}_{dielectric\,slab.}$

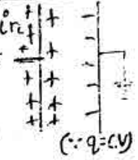
$V = \frac{\sigma}{\epsilon_0}(a+b+t/K)$

$V = \frac{\sigma}{\epsilon_0}(d-t+t/K)$

Now $C = \frac{Q}{V} = \frac{\sigma A}{\sigma/\epsilon_0(d-t+t/K)}$

3. Energy of Capacitor

Energy = work done in bringing charge at potential V



$dW = V\times dq = \frac{q}{C}.dq$ $(\because q = CV)$

$U = \int_0^Q dW = \frac{1}{C}\int_0^Q q\,dq$

$= \frac{1}{C}\left(\frac{q^2}{2}\right)_0^Q = \frac{1}{2}\frac{Q^2}{C}$

$\boxed{U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV}$

Energy Density (Energy per unit volume)

$= \frac{\frac{1}{2}CV^2}{} = \frac{\frac{1}{2}\frac{\epsilon_0 A}{d}(E\times d)^2}{A\times D}$

Volume = A×D Joule/m^3

$\boxed{U = \frac{1}{2}\epsilon_0 E^2}$

Master Card for quick revision of 2.Current Electricity (7marks)

Electric current - $i = \frac{q}{t}$, unit - Ampere, scalar

$i = \frac{q}{t} = \frac{nAle}{t}$

Drift velocity - $v = u + a\tau$

if $u = 0$ τ - relaxation time (10^{-14} s)

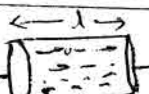
$V_d = a\tau$

also $ma = eE = F$ $\therefore a = \frac{eE}{m}$

$V_d = \frac{eE\tau}{m}$ (10^{-5} m/s)

as $V = E \times l$

$\therefore \boxed{V_d = \frac{eV\tau}{ml}}$



A - area
n - no. of free electr. in unit vol

Current $I = neAV_d$ $\frac{l}{t} = V_d$

$I = neA\frac{eV\tau}{ml}$

$\frac{I}{V} = \frac{ne^2\tau A}{ml}$

$V = IR$

$R = \frac{V}{I} = \frac{ml}{ne^2\tau A}$

Mobility $\mu = \frac{V_d}{E}$ ($m^2/s/V$)

Resistivity

$\rho = \frac{RA}{l}$

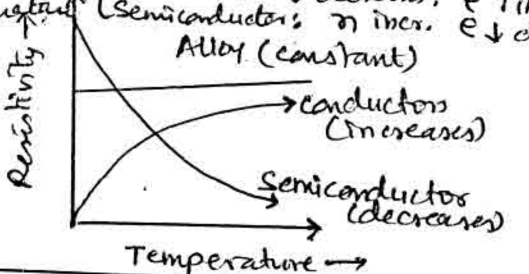
$\boxed{\rho = \frac{m}{ne^2\tau}}$

Also $\bar{J} = \sigma\bar{E}$

$J = \frac{I}{A}$ - current density (vector)

Temperature dependence of Resistivity

with increase in temperature { conductors: τ decreases, ρ ↑ inc.
Semiconductor: n incr. ρ ↓ dec



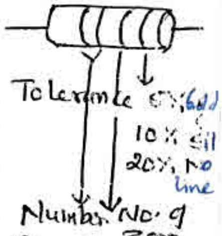
Electric Energy & Power

$E = V.I.t = I^2Rt = \frac{V^2}{R}t$

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

1 unit = 1 kWh =

Colour Code



0 Black, 1 Brown, 2 R, 3 O, 4 Y, 5 G, 6 B, 7 V, 8 Grey, 9 White

Series combination of Resistance $R = R_1 + R_2$. current same

parallel combination of Resistance $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ Voltage same

$E = V + ir$ charging

$E = V - ir$ discharging

cell in series - $i = \frac{nE}{nr + R}$ ext. Resistance high $R >> r$

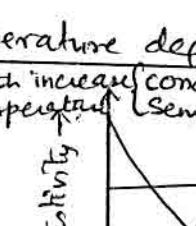
cell in parallel - $i = \frac{nE}{r + nR}$ internal Resistance high $r >> R$

KIRCHOFF'S LAW

i) $\Sigma i = 0$ - junction

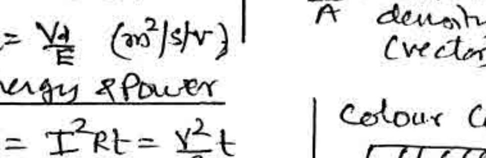
ii) $\Sigma iR = \Sigma E$ - loop rule

WHEATSTONE BRIDGE:



- balance condn $P/Q = R/S$
- Pot. at A & B same at null pt.
- Position of Galvanometer & battery can be interchanged at null pt.

METRE BRIDGE:



Unknown Resistance

$\frac{R}{X} = \frac{l}{100 - l}$

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

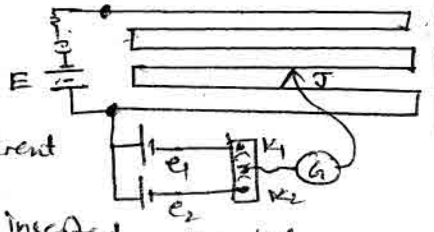
Resistivity $\rho = \frac{RA}{L}$

$= \frac{R\pi r^2}{L}$ Ω.m.

mt bridge is most sensitive when null pt. is in middle.

POTENTIOMETER: principle - If constant current flows through wire of uniform cross section then potential drop is directly proportional to length of that portion

$\boxed{e_1/e_2}$

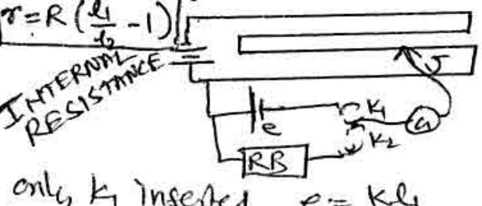


$K = \frac{E}{L}$ pot. gradient

when K_1 inserted $e_1 = Kl_1$

when k. insert

$\boxed{r = R\left(\frac{l_1}{l_2} - 1\right)}$



only K_1 inserted $e = Kl_1$

both K_1, K_2 inserted and resistance R taken from RB.

$V = Kl$

- prefered over voltmet as give exact reading and draw no curre
- Senstivity increased by increasing length, decr. main circuit cu
- Single sided deflection when i) $E < e$ ii) wrong connection

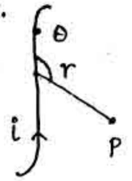
Master Card for quick revision of 3. Magnetic effect of current (8marks)

Magnetic Field : Produced by magnet, moving charge, Vector quantity.
Unit - Tesla (weber/m^2), Gauss (maxwell/cm^2) $1T = 10^4 G$

Oested Experiment : Current carrying conductor produces magnetic field.

Bio Savart Law:

It gives m.f. at a point around current carrying conductor.



$$\boxed{dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}}$$

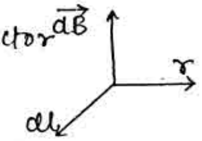
$\frac{\mu_0}{4\pi} = 10^{-7}$ T m A^{-1}

μ_0 - Permeability of free space

Direction of B : Perpendicular to dl and r.

B = 0 if $\sin\theta = 0$ ie on conductor

B = max $\sin\theta = 1$ $\theta = 90°$ ⊥r to wire.



VECTOR FORM $$\boxed{\vec{dB} = \frac{\mu_0}{4\pi}\frac{i\vec{dl}\times\vec{r}}{|\vec{r}|^3}}$$

Mag. Field At Centre of Coil :-

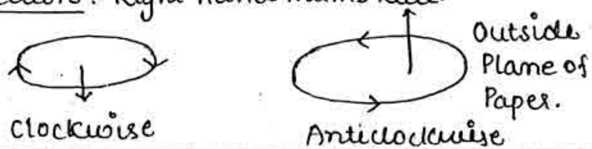
$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin 90°}{r^2}$$

$$\therefore B = \Sigma dB = \frac{\mu_0}{4\pi}\frac{i}{r^2}\Sigma dl$$

$$= \frac{\mu_0}{4\pi}\frac{i}{r^2}(2\pi r)$$

$$\boxed{B = \frac{\mu_0 i}{2r}} \quad \text{OR} \quad \boxed{B = \frac{\mu_0 n i}{2r}}$$

Direction : Right Hand Thumb Rule.



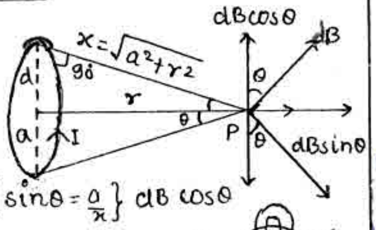
On Axis of Coil :-

$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin 90°}{x^2}$$

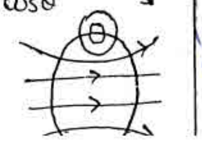
$$\therefore B = \Sigma dB\sin\theta$$

$$= \frac{\mu_0 i(2\pi a)}{4\pi x^2}\cdot\frac{a}{x}$$

$$\boxed{B = \frac{\mu_0 n i a^2}{2(a^2+r^2)^{3/2}}}$$



$\{\sin\theta = \frac{a}{x}\}$ dB cos θ



Magnetic Field lines

Ampere's Circuital Law: $\oint B.dl = \mu_0 i$

The line integral of magnetic field B aroun any closed circuit is equal to μ_0 times the current i threading through this closed circui closed ~~current~~ loop is called Amperian loop.

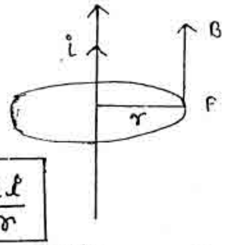
B. Due to Infinitely Long Wire :

Magnetic field at P due to wire

$$\int B.dl = \mu_0 i$$

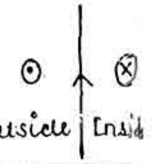
$$B\int dl = \mu_0 i$$

$$B(2\pi r) = \mu_0 i$$

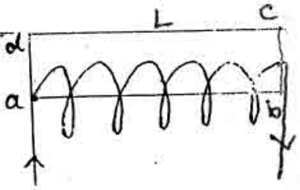


$$\therefore \boxed{B = \frac{\mu_0}{4\pi}\frac{2I}{r}}$$

Direction: Right Hand Thumb Rule
Curly finger gives field direction if thumb of right hand points current



B. due To Solenoid :-



$\int B dl = B.dl\cos\theta$

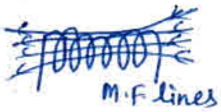
N - Total Turns

$$\int_a^d B.dl = \mu_0 i$$

$$\int_a^b B.dl + \int_b^c B dl + \int_c^d B.dl + \int_d^a B.dl = \mu_0(Ni)$$

$$\int_a^b B.dl + 0 + 0 + 0 = \mu_0(Ni)$$

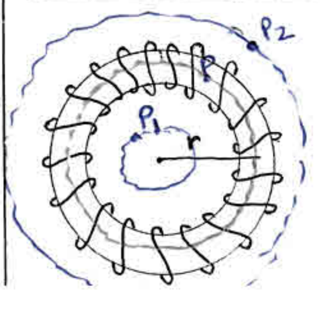
(θ = 0°) (θ:90°)+(outside)+(θ: 90°)


M.F lines

$$B.\int_a^b dl = \mu_0 Ni \qquad B.L = \mu_0 n i$$

$$\therefore \boxed{B = \mu_0 n i} \qquad n = \frac{N}{L} \text{ Turn per unit Length}$$

B. Due to Toroid : (closed Solenoid)



$$\oint B.dl = \mu_0 Ni$$

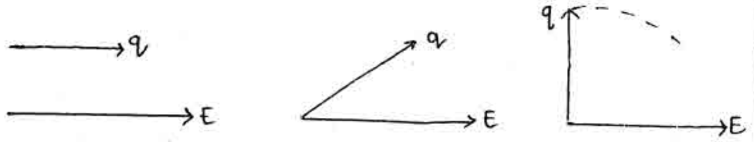
$$B(2\pi r) = \mu_0 Ni$$

$$B = \frac{\mu_0}{2\pi}\frac{Ni}{r} \quad \left\{ n = \frac{N}{2\pi r} \right\}$$

$\boxed{B = \mu_0 n i}$ - at P

Force on Charge in Electric field

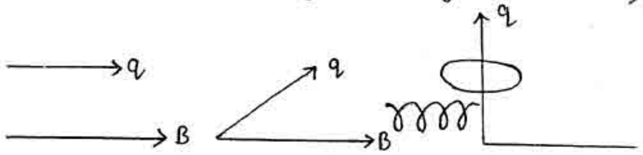
$F = qE$ (both for rest & motion)



Straight Line. Parabolic Parabolic

Magnetic Field

$F = qvB\sin\theta$ (Only for charge in Motion)



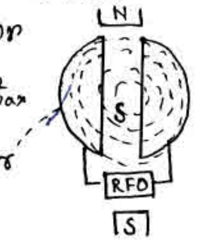
Straight Line Helical Circle

direction- FLHR / RH Palm rule

Lorentz Force : $F = qE + qvB\sin\theta = q(E + vB\sin\theta)$ $\left[V = E/B\right]$ un deflect

CYCLOTRON : Used to accelerate charge Particles.

- **principle:** The repeated motion of charged particles under mag. & elec. field accelerates it. E.F. provides energy while M.F. changes direction.
- **Construction :** Dees, Source, M.F. R.F. Oscillator



- **Working:** Max $KE = \frac{1}{2}mv_{max}^2$

$= \frac{1}{2}m\left(\frac{qBr}{m}\right)^2$

$$\boxed{K.E. = \frac{1}{2}\frac{q^2B^2r^2}{m}}$$

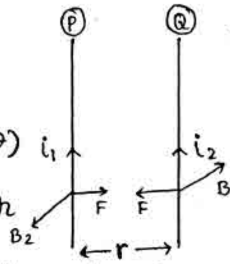
Force B/W 2 Parallel Current Carrying Wire:

Force acting on Q due to P.

$F = \left(\frac{\mu_0}{4\pi}\frac{2i_1}{r}\right) i_2 l \sin 90^\circ$

$$\boxed{F = \left(\frac{\mu_0}{4\pi}\right)\frac{2i_1i_2}{r}}$$ ($F = Bil\sin\theta$)

for unit Length



By Flemings LHR force is of attraction for same direction of current and force of repulsion for opposite direction of current.

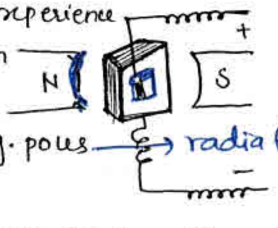
if $i_1 = i_2 = 1A$, $r = 1m$.

then $\boxed{F = 2\times10^{-7} N.}$

Moving Coil Galvanometer :-

Device to detect & measure electric current.

- **principle:** Current loop experience torque in uniform M.F.



- **Construction:** Concave mag. poles → radia field
  light coil.
- **Theory:** Deflecting Torque = Restoring force (torque)

$BinA\sin\theta = C\phi$

$(\theta = 90^\circ)$ as field is radial $\therefore BinA = C\phi$

$i = C\phi$

Current Senstivity: Deflection per unit current

$\left(I_s = \frac{\phi}{i} = \frac{1}{G} = \frac{BAN}{C}\right)$ $\frac{\text{Radian}}{\text{Ampere}}$.

Voltage Senstivity: Deflection per unit voltage.

$\boxed{V_s = \frac{I_s}{R}}$ $\left(V_s = \frac{\phi}{V} = \frac{\phi}{ir} = \frac{BAN}{CR}\right)$ $\frac{\text{Radian}}{\text{Ampere}\times\Omega}$

Limitation : → Only charged particles can be accelerated
→ light particles like e^- can't be accelerated

$\left(\frac{mv^2}{r} = qvB \quad \therefore r = \frac{mv}{qB}, \boxed{r \propto v}\right)$ $\boxed{K.E. = \frac{1}{2}\frac{q^2B^2r^2}{m}}$

$\therefore$ Time Period = Dis/velocity $= 2\pi r/v = \frac{2\pi \cancel{r} \cdot m}{\cancel{r} qB}$

$$\boxed{T = \frac{2\pi m}{qB}}$$

$\therefore$ Frequency of Revolution : $f = \frac{1}{T} = \frac{qB}{2\pi m}$.

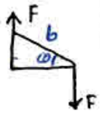
* **Application :** For nuclear reaction & other research purpose.

Torque Experienced By a Current Loop in Uniform

$\tau = F \times \perp$. distance

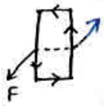
$Bil \times b\sin\theta$

$\boxed{\tau = BiA\sin\theta}$

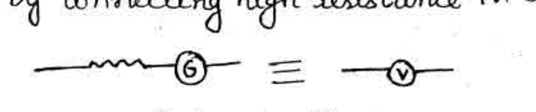


For N Turns

$\boxed{\tau = BiNA\sin\theta}$



Conversion of Galvanometer into Ammeter :

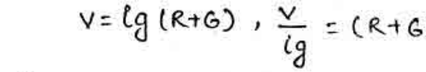


$(i - i_g)S = i_g.G$ $\therefore$ $\boxed{S = \frac{i_g.G}{i - i_g}}$

Resistance of mA > A (as $S \propto \frac{1}{i}$)

Conversion Into Voltmeter :-

By connecting high resistance in series :



$V = i_g(R+G)$, $\frac{V}{i_g} = (R+G)$, $\therefore$ $\boxed{R = \frac{V}{i_g} - G}$

{For Ideal Voltmeter, $R = \infty$}

{For Ideal Ammeter $R = 0$}.

Force on current carrying conductor in MF :

MAGNETISM

Properties of Magnet :

1). Magnets have north pole and south pole.
2). Likes poles repel & unlike attract each other.
3). Freely suspended magnet rests in N-S direction.
4). Monopole do not exists.
5). Mag. length is eq. to 0.84 times of their geometric length.

Magnetic Dipole Moment : N $\boxed{\leftarrow (2l) \rightarrow}$ S

$$\boxed{\vec{M} = M2l} \quad \text{Unit : A.m}^2$$

M → Pole Strength.

M. Due To Current Loop :

When current is passed through a loop it, behaves like a magnet.

$(M = iA)$ = Current × Area ; $\boxed{M = NiA}$

$$\therefore M = \frac{q}{t}(\pi r)^2 = \frac{evr}{2} \quad \left\{ \text{for } e^-, v = 2\pi r/t \right\}$$

Magnetic Dipole Movement of a Revolving e^- :

$$M = iA = \frac{q}{t}(\pi r)^2 = \frac{evr}{2} \quad (\text{for } e^-, v = 2\pi r/t)$$

Bohr magneton $(\mu_e)_{min} = \frac{eh}{4\pi m} = 9.2 \times 10^{-24}\ Am^2$

Magnetic Field Intensity due to Magnetic Dipole :

1). On Axial Line : $\boxed{B = \frac{\mu_0}{4\pi}\frac{2m}{r^3}}$

2). On Equatorial Line : $\boxed{B = \frac{\mu_0}{4\pi}\frac{H}{r^3}}$

Torque Acting on Dipole in Mag. Field :-

$$\tau = F \times dis. = MB\,2l\sin\theta = M2lB\sin\theta = MB\sin\theta$$

$$\therefore \boxed{\tau = MB\sin\theta}$$

→ Torque is ⊥ to mag. field and mag. dipole moment (M)

→ $\tau_{max} = MB = (\sin\theta = 1)$, $\theta = 90°$

→ $\tau_{min} = 0 = (\sin\theta = 0)$, $\theta = 0$

{ Due to Torque rotatory motion or linear }

Workdone in Rotating the Dipole :-

$$W = MB[\cos\theta_1 - \cos\theta_2]$$

Permanent Magnets are Made up of Steel :

Hysteresis Loop / Curve : The graph plotted b/w external field (H) & mag. induction (B) is called "BH curve" or Hysteresis Loop.

Energy Loss : Workdone (energy loss) in magnetisation and demagnetisation is eq. to area of BH curve.

Elements of Earth's Magnetic Field :

1). **Angle of Dip** : Angle b/w horizontal line & mag. meridian as a freely suspended magnet.

2). **Angle of Declination** : Angle b/w geographical meridian & mag. meridian at a point is called Angle of Declination.

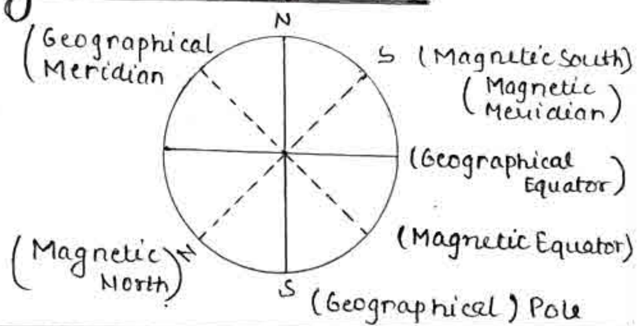
3). **Horizontal Intensity of Earth Mag. field**

The horizontal component of to. Earth's mag field at any point is called horizontal intensity.

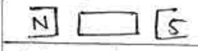
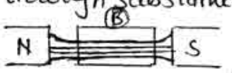
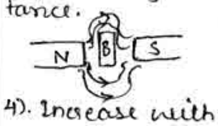
$$\frac{BV}{BH} = \frac{B\sin\delta}{B\cos\delta} = \tan\delta, \quad B^2 = (BH)^2 + (BV)^2$$

$$B = \sqrt{BH^2 + BV^2}$$

Magnetic Field of Earth:



Magnetic Material :-

Paramegnatic	Dimagnetic	Ferromegnatic
1) Odd no. of e^- in outer most orbit & possess net dipol moment.	1) Even no. of e^- and possess net dipole moment is 0.	1) It consists of domain seprated by domain wall.
2) Alligns ∥ to field & get weakly magnetised along ext. field. 	2) Allign ⊥ to ext. field. 	2). Strong form of Paramagnetism
3). Mag. field pass through substance 	3) Mag. field repealled by substance. 	3) Temp. at which Ferromagnetic sub. becomes paramagnetic called curie Temperature.
4). Increase with Decrease in temp.	4). Increase with increase in temp.	

Electromagnets: Are prepared by passing electric current in a solenoid. The magnetism lasts till the current is passed.

It can be increased by :-

1). Increasing no. of turns.
2). Increasing current.
3). Using soft iron core.

→ Electromagnets are prepared from soft

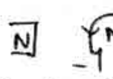
4. ELECTRO MAGNETIC INDUCTION

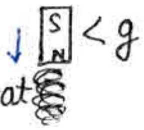
The phenomina of producing induced current due to change in magnetic flux is called electromagnetic induction.

Faraday Law:- (i) change in magnetic flux induces current which last till there is change.

(ii) $e = -\frac{d\phi}{dt}$

Lenz's Law:- Inducee current opposses the factor due to which it is produced.





acc. to law of conservat-ion of energy.

Method of producing emf:-

$\phi = BA\cos\theta$

$e = -\frac{d\phi}{dt} = -\frac{d\,BA\cos\theta}{dt}$

$\rightarrow B$
$\rightarrow A$
$\rightarrow \theta$

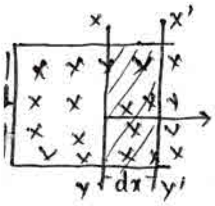
Induced current / charge:-

$e = -\frac{d\phi}{dt}$, $i = \frac{e}{R} = \frac{-d\phi}{R\,dt}$, $\frac{dq}{dt} = \frac{-d\phi}{R\,dt}$

$$\boxed{dq = -\frac{d\phi}{R}}$$

Motional Emf:- The emf induced due to motion of a conductor in M.field.

Motional Emf:- $e = -\frac{d\phi}{dt}$



$= -\frac{dB.A}{dt}$

$= -\frac{B\,dA}{dt} = -\frac{Bl\,dx}{dt}$

$$\boxed{e = -Bvl}$$

Direction = Anticlockwise

Force:- $i = \frac{Bvl}{R}$

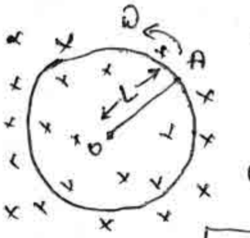
$F = Bil = -B\left(\frac{Bvl}{R}\right)l$

$F = -\frac{B^2 v l^2}{R}$

Power:- $P = FV$

$P = -\frac{B^2 v^2 l^2}{R}$

Rotating rod:- $e = -\frac{d\phi}{dt}$



$e = -\frac{dBA}{dt}$

$e = \frac{B\,dA}{dt}$

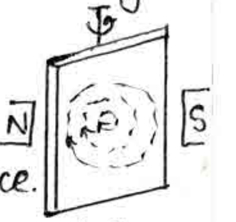
$e = \frac{B\pi L^2}{2\pi/\omega}$

$$\boxed{e = \frac{1}{2}B\omega L^2}$$

or $\boxed{e = \frac{1}{2}B\omega R^2}$

- no. of spokes is increased emf remain same.

Eddy Current:- The circulating induced current in a oscillating metallic block kept in magnetic field. It can be reduced by using laminated core, or cutting slots in block.



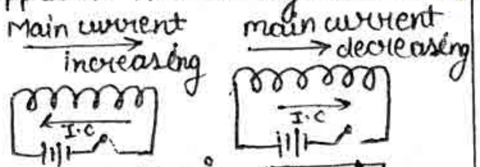
Application -

(i) magnetic brakes

(ii) Induction furnance.

(iii) Dead beat galvanometer.

Self-Induction:- change in current in a coil, induced current is produced which opposes the change in same coil.



$\phi \propto i$, $\boxed{\phi = Li}$

Unit → L = 1 Henry (H)

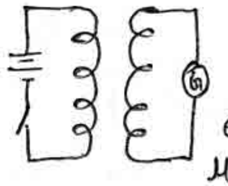
D.formula → $L = [ML^2T^{-2}A^{-2}]$

Solenoid: $\phi = Li$ $[n = N/L]$

$\phi = BAN = (\mu_0 niA)N$

$Li = \mu_0 niAN$

Mutual-Induction: when the change in current in primary coil induces current in secondary coil.



$\phi \propto i$

$\phi = mi$

Unit - Henry

ϵ_0 = Farad/m

μ_0 = Henry/m

Solenoil: $B_2 = \mu_0 n_2 i_2$

$\phi = B_2 AN_1$

$\phi = (\mu_0 n_2 i_2)AN_1$

$\phi = mi_2$

$m\cancel{i_2} = \mu_0 n_1 n_2 Al\cancel{i_2}$

$m = \mu_0 n_1 n_2 Al$

★ No. of turns is double than inductance become four times ($L \propto n^2$).

Electrical Resonance:

$F = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$

Power in A.C. circuit:

$P = \frac{1}{2}V_0 i_0 \cos\phi$

$P = \frac{V_0}{\sqrt{2}}\frac{i_0}{\sqrt{2}}\cos\phi$

$[P = V_{RMS}\,i_{RMS}\cos\phi]$

$[\cos\phi = \frac{R}{Z}]$

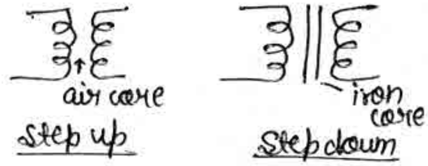
ALTERNATING CURRENT

* **TRANSFORMER** :- It is a device use to change AC voltage.

Principle: It is based on principle of mutual Induction.

Construction:- two coil Primary & secondary

- **Step up**: Increase voltage (K>1) and decrease current.
- **Step down**: decrease voltage (K<1) and increases current.



Theory: $\left[\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} = K\right]$

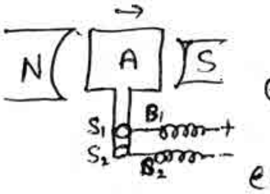
$$\left[\eta = \frac{\text{output}}{\text{input}} \times 100\%\right]$$

* **A.C. Generator** :- It is a device which convert mechanical energy into electrical energy.

Principle: It is based on principle of electro-magnetic induction.

Construction:-

(i) Armature coil.
(ii) Field magnet
(iii) Slip ring (iv) Brushes.



$e = \frac{-d\phi}{dt}$

$e = \frac{-d\,BA\cos\omega t}{dt}$

$e = -BA(-\omega\sin\omega t)$

$e = BA\omega\sin\omega t$

$e = BAN\omega\sin\omega t$

$e_{max} = e_0 = BAN\omega$

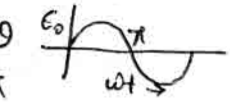
$$\boxed{e = e_0\sin\omega t}$$

* **Alternating current** :-

D.C - Direction & magnitude are fixed.

A.C - Change in both magnitude and direction.

- **HALF-CYCLE** :- $V_{avg.} = \int_0^{\pi}\frac{V}{\pi}$



$V_{avg} = \frac{1}{\pi}\int_0^{\pi} V_0\sin\theta\, d\theta$

$V_{av} = \frac{1}{\pi}\left[-V_0\cos\theta\right]_0^{\pi}$

$V_{av} = \frac{-V_0}{\pi}\left[\cos\pi - \cos 0\right]$

$V_{av} = \frac{2V_0}{\pi}$ or $I_{av} = \frac{2I_0}{\pi}$

- **Full Cycle** :- $V_{av} = \frac{1}{2\pi}\int_0^{2\pi} V\, d\theta$

$V_{avg} = \frac{1}{2\pi}\int_0^{2\pi} V_0\sin\theta\, d\theta$

$V_{avg} = \frac{V_0}{2\pi}\left(-\cos\theta\right)_0^{2\pi}$

$V_{avg} = \frac{V_0}{2\pi}\left(-\cos 2\pi + \cos 0\right) = \frac{V_0}{2\pi}(-1+1)$

$\Rightarrow \boxed{V_{avg} = 0}$ or $\boxed{I_{avg} = 0}$

- **Root mean Square** :

$V_{Rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} V^2}$

$V^2_{Rms} = \frac{1}{2\pi}\int_0^{2\pi} V^2 = \frac{1}{2\pi}\int_0^{2\pi} V_0^2\sin^2\theta\, d\theta$

$V^2_{Rms} = \frac{V_0^2}{2\pi}(\pi) = \frac{V_0^2}{2}$ $\left[\int\sin^2\theta = \pi\right]$

$\boxed{V_{Rms} = \frac{V_0}{\sqrt{2}}}$ or $\boxed{I_{Rms} = \frac{I_0}{\sqrt{2}}}$

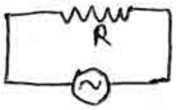
A.C. Circuit :-

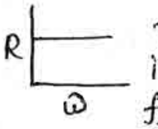
- **Pure Resistive Circuit : (circuit containing resistance)**

V&I same phase

$\frac{V}{R} = \frac{V_0}{R}\sin\omega t$

$\left[i = i_0\sin\omega t\right]$ $\left[V = V_0\sin\omega t\right]$





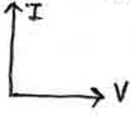
Resistance is independent frequency of A.C

- **Pure ~~resistive~~capacitor circuit (circuit containing capacitor only)**

current leads

$Q = CV$

$\frac{dQ}{dt} = C\frac{dV}{dt}$, $i = C\frac{d}{dt}(V_0\sin\omega t)$



$i = CV_0\frac{d}{dt}\sin\omega t$, $CV_0\omega\cos\omega t$

$i = \frac{V_0}{1/C\omega}\sin(\omega t + \pi/2)$

$$\boxed{i = i_0\sin(\omega t + \pi/2)}$$

$i_0 = V_0/\frac{1}{C\omega}$ $\boxed{X_C = \frac{1}{C\omega}}$

- **Pure inductive circuit** : $V = V_0\sin\omega t$

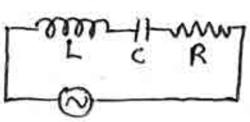
leads

$V = L\frac{di}{dt}$ $di = +\frac{V\,dt}{L}$

$di = \frac{V_0\sin\omega t\, dt}{L}$

* $\int di = \underline{V_0}\int\sin\omega t\, dt = V_0(-\cos\omega t)$

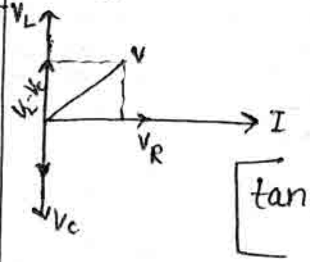
- **Series LCR Circuit** :-



$V^2 = V_R^2 + (V_L - V_C)^2$

$(IZ)^2 = (IR)^2 + (IX_L - IX_C)^2$

$$\boxed{Z = \sqrt{R^2 + (X_L - X_C)^2}}$$



$$\boxed{Z = \sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}}$$

$$\left[\tan\phi = \frac{L\omega - \frac{1}{C\omega}}{R}\right]$$

$$\boxed{\tan\phi = \frac{X_L - X_C}{R}}$$

$V_L > V_C$ $\tan\phi$ - +ve

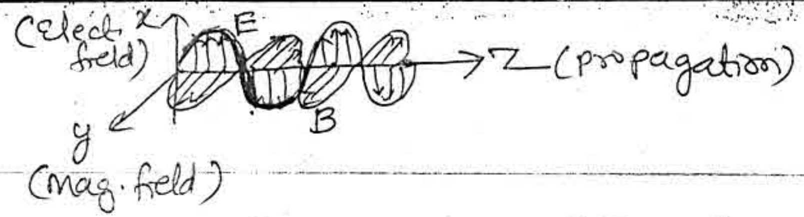
$\cos\phi = \underline{R}$

Master Card for quick revision of Electromagnetic Waves (3marks)

Different types of electromagnetic waves, their productions and detections are summarised in a table given below.

Different parts of the Electromagnetic spectrum

Name	Frequency range (Hz)	Wavelength range	Production	Detection	Main properties and uses
Radiowaves (Marconi) 1895	10^4 to 10^8	> 0.1 m	Rapid acceleration and deaccelerations of electrons in aerials.	Receivers aerials.	Different wavelengths find specialised uses in radio communication.
Microwaves	10^9 to 10^{12}	0.1 m to 1 mm	Klystron valve or magnetron valve.	Point contact diodes.	(*a*) Radar communication. (*b*) Analysis of fine details of molecular and atomic structure. (*c*) Since $\lambda = 3 \times 10^{-2}$ m, useful for demonstration of all wave properties on macroscopic scale. , microwave ovens
Infrared (Herschel) 1800	10^{11} to 5×10^{14}	1 mm to 700 nm	Vibration of atoms and molecules.	Thermopiles, Bolometer, Infrared photographic film.	Green house effect (*a*) Useful for elucidating molecular structure. (*b*) Less scattered than visible light by atmospheric particles–useful for haze photography. (c) heating effect, drying, physiotherapy
Visible light (Newton)	4×10^{14} to 7×10^{14}	700 nm to 400 nm	Electrons in atoms emit light when they move from one energy level to a lower energy level.	Human eye, Photocells, Photographic film.	(*a*) Detected by stimulating nerve endings of human retina. (*b*) Can cause chemical reaction.
Ultraviolet (Ritter) 1800	10^{16} to 10^{17}	400 nm to 1 nm	Inner shell electrons in atoms moving from one energy level to a lower level.	Photocells, Photographic film.	harmful for welders / absorbed by ozone layer (*a*) Absorbed by glass (*b*) Can cause many chemical reactions (c) food preservation,
X-rays (Rontgen) 1895	10^{16} to 10^{19}	1 nm to 10^{-3} nm	X-ray tubes or inner shell electrons.	Photographic film, Geiger tubes, Ionization chamber.	(*a*) Penetrate matter (*e.g.*, radiography) (*b*) Ionize gases (*c*) Cause fluorescence (*d*) Cause photoelectric emission from metals. (*e*) Reflected and diffracted by crystals enabling ionic lattice spacing and N_A (or wavelength) to be measured.
Gamma rays (Becqurel) 1896	10^{18} to 10^{22}	$< 10^{-3}$ nm	Radioactive decay of the nucleus.	Photographic film, Geiger tubes, Ionization chamber.	Similar to X-rays.



$E_x = E_0 \sin(kz - \omega t)$

$B_y = B_0 \sin(kz - \omega t)$

$k = 2\pi/\lambda$

→ Em waves carry energy & momentum. → Exert radiation pressure, → $p = \frac{U}{c}$ (energy)

momentum → complete absorp

- Speed of light $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = \frac{E_0}{B_0}$ • Energy $u = \frac{1}{2} \epsilon_0 E_{rms}^2 + \frac{1}{2\mu_0} B_{rms}^2$ $= \frac{1}{4} \epsilon_0 E_0^2 + \frac{1}{4\mu_0} B_0^2$
- E.F ⊥ M.F and both are perpendicular to wave.
- displacement current $I_d = \epsilon_0 \frac{d\phi_E}{dt}$ due to change in electric field.
- E and B are in same phase
- Can be polarised, reflected, refracted, diffracted.

6. RAY OPTICS

Reflection of Light: $i = r$, Magnitization $m = \frac{I}{O} = -\frac{v}{u}$
− real inverted.
+ virtual errect.

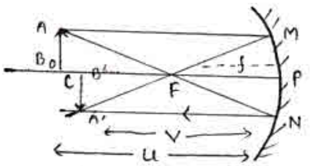
→ Convex Mirror $+f$, $m < 1$ and negative
→ Concave Mirror $-f$ $m > 1$, < 1, $= 1$ both + & −

$m > 1$ (enlarged) $m < 1$ (small)

Refraction of Light: $\mu = \frac{\sin i}{\sin r}$, ${}_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{1}{{}_1\mu_2} = {}_2\mu_1$

Total Internal Reflection (i) Denser → Rarer ii) $i > i_c$ $\sin i_c = \left(\frac{1}{\mu_d}\right)$

Mirror Formula :-



Object AB image A'B'

$\Delta AFB \approx \Delta PFN$

$$\frac{AB}{PN} = \frac{AB}{A'B'} = \frac{FB}{PF} = \frac{u-f}{f} \quad \text{①}$$

$\Delta A'B'F \approx \Delta MFP$

$$\frac{MP}{A'B'} = \frac{AB}{A'B'} = \frac{PF}{FB'} = \frac{f}{v-f} \quad \text{—(II)}$$

from eq-(I) and (II).

$$\frac{u-f}{f} = \frac{f}{v-f}$$

By sign convention u, v, f are −ve.

$$f^2 = (u-f)(v-f)$$

$$f^2 = uv - uf - fv + f^2$$

$$uv = uf + vf.$$

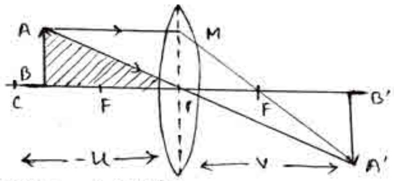
Dividing by uvf

$$\frac{uv}{uvf} = \frac{uf}{uvf} + \frac{vf}{uvf}$$

$$\boxed{\frac{1}{f} = \frac{1}{v} + \frac{1}{u}}$$

$m = I/O = -v/u$

Thin lens Formula :



$\Delta ABP \approx \Delta A'B'P$

$$\frac{AB}{A'B'} = \frac{PB}{PB'} = \frac{u}{v} \quad \text{— (1)}$$

$\Delta MPF \approx \Delta A'B'F$

$$\frac{PM}{A'B'} = \frac{PF}{FB'} = \frac{f}{v-f} \quad \text{—}$$

$$\frac{AB}{A'B'} = \frac{v}{v-f} \quad \text{— (II)}$$

From eq (1) and (2)

$$\frac{f}{v-f} = \frac{u}{v}$$

Since u = −ve sign convention

$$vf = (-u)v - (-u)f$$

$$vf = -uv + uf$$

$$uv = uf - vf$$

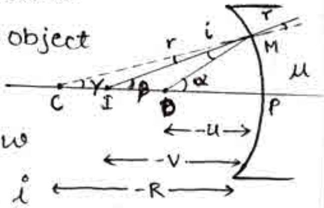
Dividing by uvf

$$\boxed{\frac{1}{f} = \frac{1}{v} - \frac{1}{u}}$$

Refraction Through Spherical Surface

ASSUMPTION:

1). Small Aperture
2). Point size object



By Snell's law

$$\mu = \frac{\sin i}{\sin r} = \frac{i}{r}$$ (since i & r are very small)

$$i = \mu r$$

ΔCOM

$$\alpha = i + \gamma \qquad \therefore i = \alpha - \gamma$$

ΔCIM

$$\beta = r + \gamma \qquad \therefore r = \beta - \gamma$$

$$\alpha - \gamma = \mu(\beta - \gamma)$$

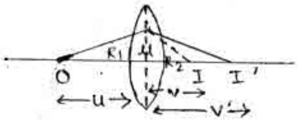
$$\frac{PM}{\cancel{-}u} - \frac{PM}{\cancel{-}R} = \mu\left(\frac{PM}{\cancel{-}v} - \frac{PM}{\cancel{-}R}\right)$$

$$\frac{1}{u} - \frac{1}{R} = \frac{\mu}{v} - \frac{\mu}{R}$$

$$\frac{\mu}{v} - \frac{1}{u} = \frac{\mu}{R} - \frac{1}{R}$$

$$\boxed{\frac{\mu}{v} - \frac{1}{u} = \frac{(\mu-1)}{R}.}$$

Lens Maker Formula :



By Refraction through first surface

$$\frac{\mu}{v'} - \frac{1}{u} = \frac{\mu-1}{R_1} \quad \text{- - - - (1)}$$

I' acts as an object for second surface so that final image is formed at I, so for second surface.

$$\frac{1/\mu}{v} - \frac{1}{v'} = \frac{1/\mu - 1}{R_2}$$

$$\frac{1}{\mu v} - \frac{1}{v'} = \frac{1-\mu}{\mu R_2}$$

Multiplying by μ

$$\frac{1}{v} - \frac{\mu}{v'} = \frac{1-\mu}{R_2} \quad \text{—— (II)}$$

adding eq (1) & (II).

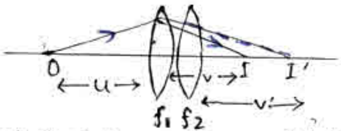
$$\frac{1}{v} - \frac{1}{u} = (\mu-1)\left(1/R_1 - 1/R_2\right)$$

$$\boxed{\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

Power of Lens :

$$P = \frac{1}{f(m)} = \frac{100}{f(cm)} \text{ Diopter.}$$

Combined Focal Length :



First lens forms image I' of O

$$\frac{1}{f_1} = \frac{1}{v'} - \frac{1}{u} \quad \text{—— (1)}$$

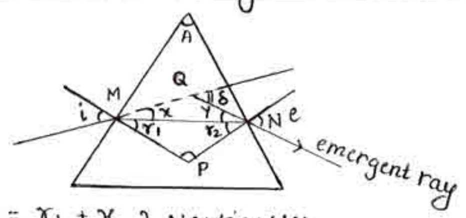
I' acts as object for second lens and final image is formed at I, so for second lens.

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v'} \quad \text{—— (2)}$$

Adding eq (1) & (II)

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$$

Refraction Through a Prism :



$i = r_1 + x$ } vertically
$e = r_2 + y$ } opposite Angles.

$i + e = (r_1 + r_2) + (x + y)$ —— (1)

$\delta = x + y$ exterior ∠ is equal to sum of interior angles.

$\angle P = 180 - (r_1 + r_2)$.

In quadrilateral AMPN.

$\angle A + 90° + \angle P + 90° = 360°$

$A + 90° + 180 - (r_1 + r_2) + 90 = 360$

$A = r_1 + r_2$ —— (2)

$i + e = A + \delta$

At minimum deviation δm

i.e., $r_1 = r_2 = r$

$2i = A + \delta m$

$\therefore i = \left(\frac{A + \delta m}{2}\right)$ —— (3)

$A = 2r \therefore r = (A/2)$ —— (4)

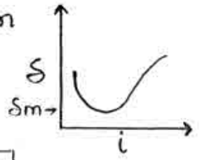
By Snells Law

$$\mu = \frac{\sin i}{\sin r}$$

$$\boxed{\mu = \frac{\sin\left(\frac{A + \delta m}{2}\right)}{\sin\left(\frac{A}{2}\right)}}$$

For thin prism

$$\mu = \frac{\frac{A + \delta m}{2}}{A/2}$$



$$\boxed{\delta m = (\mu - 1)A}$$

A - Prism Angle
μ = Refractive Index.

Angular Dispersion : $\theta = \delta v - \delta R = (\mu_v - \mu_R) A$

Dispersive Power : $\omega = \frac{\theta}{\delta y} = \frac{\delta v - \delta R}{\delta y} = \frac{(\mu v - \mu R) A}{(\mu y - 1) A} = \boxed{\omega = \frac{(\mu v - \mu R)}{(\mu y - 1)}}$

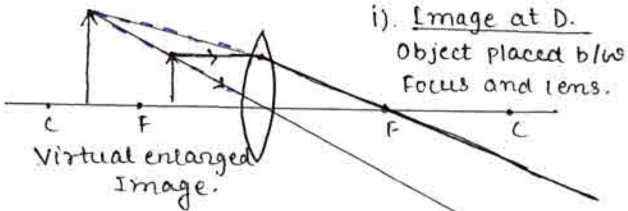
Scattering of Light : $\delta \propto \frac{1}{\lambda^4}$ (Rayleigh)
(RAYLEIGH LAW).

→ Danger signals Red.
→ Sky appears blue.
→ Reddish appearance of sun-rise, sunset.

OPTICAL INSTRUMENTS :

Simple Microscope : Convex lens of low focal length and high power.

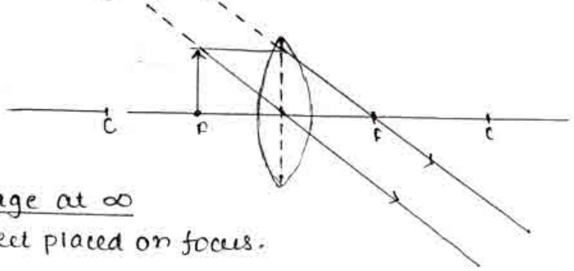
i). Image at D.
Object placed b/w Focus and lens.



Magnifying Power.

$$\boxed{m = 1 + \frac{D}{f_e}}$$

$m = \frac{\beta}{\alpha}$ Angle made by image / angle made by object when kept in position of image.



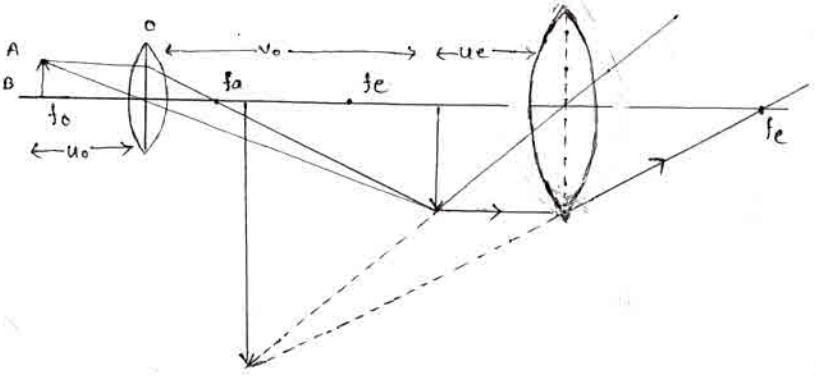
II) Image at ∞
Object placed on focus.

Magnifying Power $\boxed{m = \frac{D}{f}}$

Compound Microscope : Objective – (convex lens of low focal length and small aperture).
Eyelens – (convex lens of high focal length and large aperture).

i) Image at D.

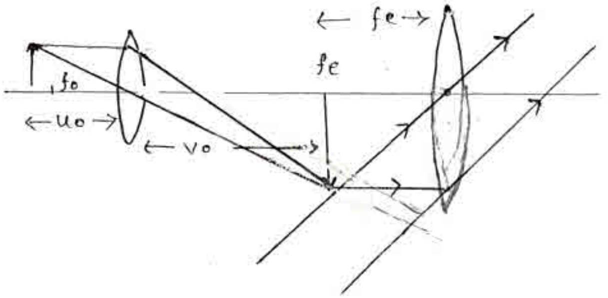
Final Virtual Inverted Image.



$$m = m_o \times m_e = \frac{v_o}{-u_o}\left(1 + \frac{D}{f_e}\right) \approx \frac{1}{f_e}\left(1 + \frac{D}{f_e}\right)$$

II) Image at Infinity ∞

Final Image at Infinity.

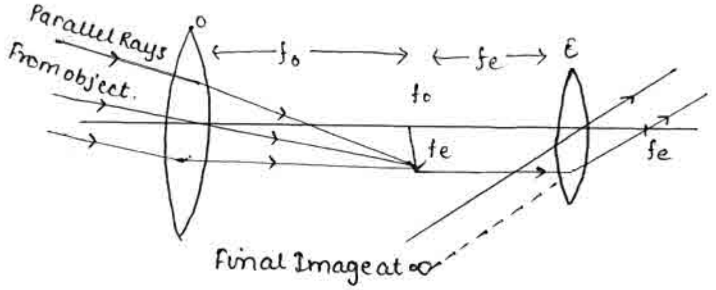


$$m = -\frac{v_o}{u_o}\left(\frac{D}{f_e}\right) \approx \frac{L}{f_o} \cdot \frac{D}{f_e}$$

Length of tube $L = v_o + f_e$

Astronaumical Telescope : Objective : (convex lens of high focal length & large apeture.)
Eyelens :(Convex lens of low focal length & small aperture.)

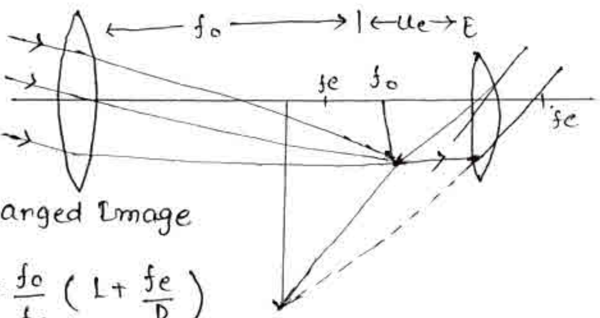
i) Image at Infinity.



$$m = \frac{f_o}{f_e}$$

$L = f_o + f_e$ (Length of tube)

ii) Image at D



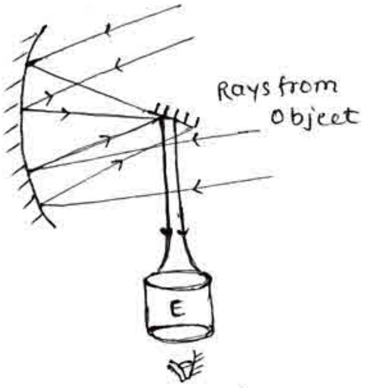
$$m = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

$$R.P = \frac{D}{1.22\lambda}$$ D - Diameter of objective

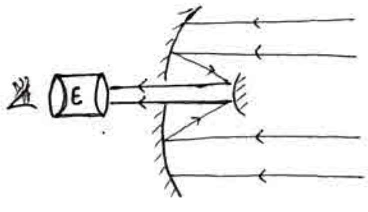
Length of the Tube $L = f_o + u_e$

Reflecting Telescope: Concave mirror acts as an objective.

Newtonian Telescope



Cassegrain Telescope



ADVANTAGES:

1) Bright Image is formed.

2). Image free from chromatiz abberation.

Resolving Power:- The ability of optical instrument to form distinct image of two object situated close to eachother.

Resolving power of microscope

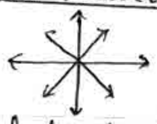
$$\left[(R.P)_m = \frac{2\mu \sin\theta}{\lambda}\right]$$

Telescope

$$\left[(R.P)_T = \frac{D}{1.22\lambda}\right]$$

$$\boxed{R.P \propto \frac{1}{\text{limit of resolution}}}$$

Polarisation :-



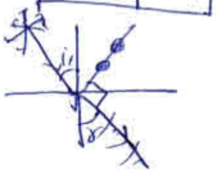
unpolarised

Partially Polarised

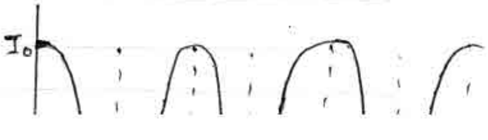
$$\boxed{C = \frac{E_o}{B_o}}$$

linear polarised

Brewsters law $\boxed{\tan i_p = \mu}$

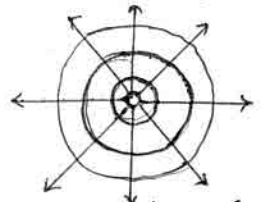


Malus law: $\boxed{I_\theta = I_o \cos^2\theta}$

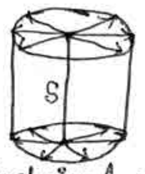


(4: Unit) **WAVE OPTICS**

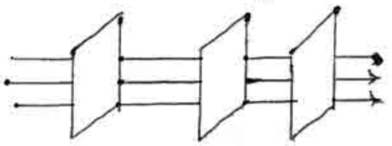
- A wavelet is the point of disturbance due to propagation of light.
- A wavefront is the locus of paints having the same phase of oscillation.
- A line perpendicular to a wavefront is called a 'ray'.



Spherical W.f.



Cylindrical w.f from a linear source

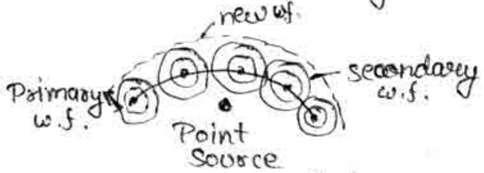


Plane w.f.

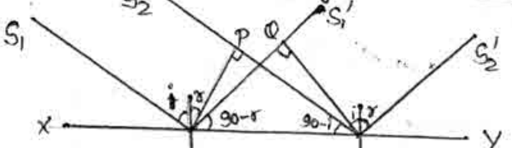
HUYGEN'S PRINCIPLE :- find the shape of wavefront at any perticular instance. The two postrulate are-

(i) Each point on primary wave.f. acts as a source of secondary w.f. which travell in all direction with speed of light.

(ii) The forward envelope or common tangent of secondary w.f. give shape of new wavefronts.



Reflection by Huygen's Principle



ΔMPN and ΔMQN, MN = MN common side

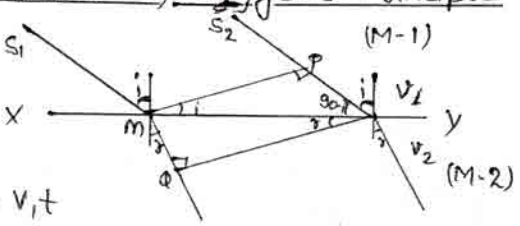
∠P = ∠Q = 90°, PN = MQ (dist. covered by light in same time)

ΔMPN ≈ ΔMQN (by SAS)

$90 - i = 90 - r$

$\boxed{i = r}$

Refraction by Huygen's Principle



PN = $V_1 t$

MQ = $V_2 t$

$\mu_0 = \frac{\sin i}{\sin r} = \frac{PN/MN}{MQ/MN} = \frac{PN}{PQ}$

$\boxed{\mu_0 = \frac{V_1 \cancel{t}}{V_2 \cancel{t}} = \frac{V_1}{V_t}}$

Interference of light → variation of intensity of light due to overlapping of two light waves.

Constructive - Resultant increase and bright light is formed.

Path diff. :- $\Delta x = 0, \lambda, 2\lambda, \cdots 3\lambda$

Phase diff. :- $\Delta\phi = 0, 2\pi, 4\pi, 6\pi \cdots 2n\pi$

Destructive - Resultant is minimum.

Destructive :- Path diff :- $\Delta x = \lambda/2, 3\lambda/2 \cdots \frac{(2n-1)\lambda}{2}$

Phase diff :- $\Delta\phi = \pi, 3\pi, 5\pi \cdots (2n-1)\pi$

$\boxed{\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x}$

Young's double slit Experiment (YDS) :- A monochromatic light beam is incident in double slit the pattern obtain on screen consist of alternate bright and dark bands called fringes.

Expression for Interference Pattern:

Let,
two interference ware -

$$y_1 = a_1 \sin \omega t$$

$$y_2 = a_2 (\sin(\omega t + \phi)) \quad [\because \phi = \text{phase diff.}]$$

by P. of Susperposition -

$$y = y_1 + y_2$$

$$y = a_1 \sin\omega t + a_2 \sin(\omega t + \phi)$$

$$y = a_1 \sin\omega t + a_2 \sin\omega t \cos\phi + a_2 \cos\omega t \sin\phi$$

$$y = \sin\omega t (a_1 + a_2 \cos\phi) + a_2 \cos\omega t \sin\phi$$

$$y = R\sin\omega t \cos\theta + \cos\omega t \, R\sin\theta \quad \left\{ \begin{array}{l} a_1 + a_2\cos\phi = R\cos\theta \\ a_2 \sin\phi = R\sin\theta \end{array} \right\}$$

$$y = R\sin(\omega t + \theta)$$

- $a_1 + a_2\cos\phi + a_2\sin\phi = R\cos\theta + R\sin\theta$

Square both side

$$a_1^2 + a_2^2 \cos^2\phi + a_2^2 \sin^2\phi = R^2\cos^2\theta + R^2\sin^2\theta$$

$$a_1^2 + a_2^2(\cos^2\phi + \sin^2\phi) + 2a_1a_2\cos\phi = R^2(\sin^2\theta + \cos^2\theta)$$

$$a_1^2 + a_2^2 + 2a_1a_2\cos\phi = \cancel{R^2} = R^2$$

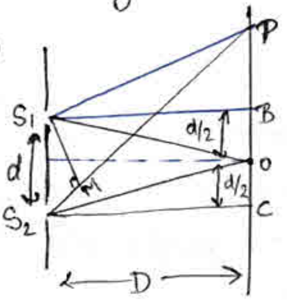
$$\boxed{R = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}}$$

$$R_{max} = (a_1 + a_2) \qquad \theta = 0^\circ$$

$$R_{min} = (a_1 - a_2) \qquad \theta = 180^\circ$$

$$\boxed{I \propto a^2 \propto \omega}$$

Expression for fringe width:



$$S_2M = S_2P - S_1P$$

from ΔS_2PC

$$S_2P^2 = D^2 + (x + d/2)^2$$

from ΔS_1BP_1

$$S_1P^2 = D^2 + (x - d/2)^2$$

$$S_2P^2 - S_1P^2 = 2xd$$

$$(S_2P - S_1P)(S_2P + S_1P) = 2xd$$

$$(S_2P - S_1P)(D + D) = 2xd$$

$$S_2P - S_1P = \frac{2xd}{2D}$$

From bright fringe for path difference,

$$S_2P - S_1P = n\lambda$$

$$\frac{xd}{D} = n\lambda$$

$$x_n = \frac{nD\lambda}{d}$$

$$\boxed{x = \frac{D\lambda}{d}}$$

$$\beta = x_{n+1} - x_n$$

$$\beta = \frac{(n+1)\lambda D}{d} - \frac{n\lambda D}{d}$$

$$\boxed{\beta = \frac{\lambda D}{d}}$$

For destructive interference:

$$\frac{xd}{D} = (2n-1)\frac{\lambda}{2}$$

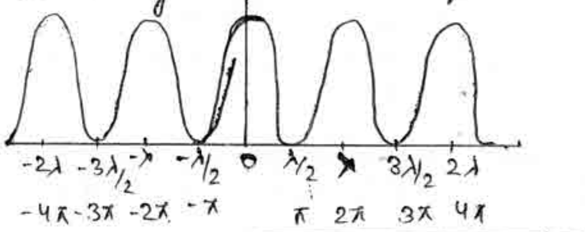
$$\boxed{x_n = (2n-1)\frac{\lambda D}{2d}}$$

$$\beta = x_{n+1} - x_n$$

$$\beta = \frac{(2(n+1)-1)\lambda D}{2d} - \frac{(2n-1)\lambda D}{2d}$$

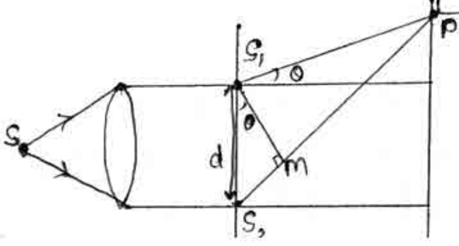
$$\boxed{\beta = \frac{\lambda D}{d}}$$

Interference pattern the intensity of all bright band is equal.

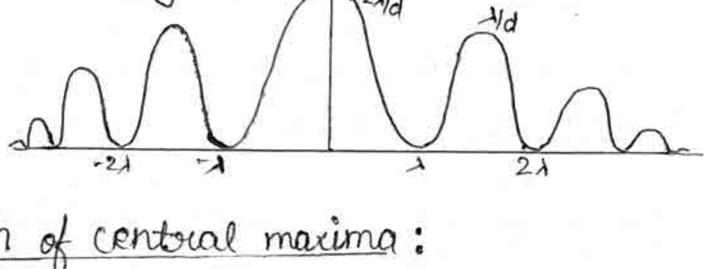


Single slit diffraction →

- dark band or minima - $\boxed{d\sin\theta = n\lambda}$
- maxima - $\boxed{d\sin\theta = \frac{(2n+1)}{2}\lambda}$



- **Coherent Source** - The two light source behave like coherent source if they belong to same parent source.
- **Diffraction** - It is bending of light at sharp corners or edges.
- **Fresnel's distance** = $\boxed{d_f = d^2/\lambda}$
- **Intensity distribution curve**:



- **Linear width of central maxima**:

$$\boxed{\text{angle} = \frac{\text{arc}}{\text{radius}}}, \qquad \beta_0 = \theta \times D$$

$$\boxed{B = \lambda D}$$

[redacted]

UNIT-VII - DUAL NATURE OF MATTER AND RADIATION

Photoelectric emission :- The emission of electron due to action of light of suitable energy is called photoelectric emission. The e^- emitted are called photoelectrons.

Properties of Photon - (a) Photon is a bundle of energy - $\boxed{E = h\nu}$ $\boxed{E = \frac{hc}{\lambda}}$

(b) Photon travell with speed of light.

(c) Rest mass of photon is zero.

(d) momentum of photon is $\boxed{p = E/c}$.

Photoelectric effect → The of e^- from a metal surface when light of suitable frequency is incident on it is called photoelectric effect.

Alkali metals like Li, Na, K show photoelectric effect with visible light metal like Zn, Mg, Ca respond to ultraviolet light.

Laws of Photoelectric emission - ~~(a)~~

(a) minimum energy required called threshold energy or work function. The freq. corresponding to threshold energy called threshold freq..

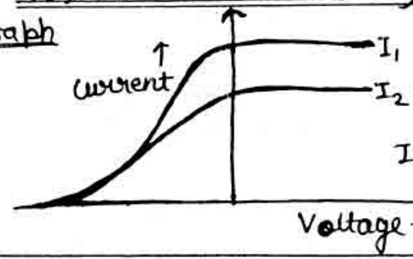
~~(b)~~ $\underbrace{E = \phi}_{\text{work function}} = h\nu_0$ ν_0 = threshold frequency

(b) Every photon interact with a single electron.

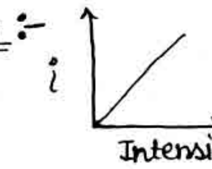
(c) increase the energy of incident photon the Kinetic energy of e^- emitted increase.

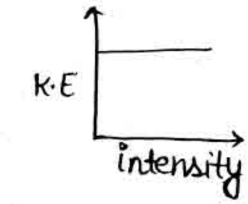
Effect of Intensity :-

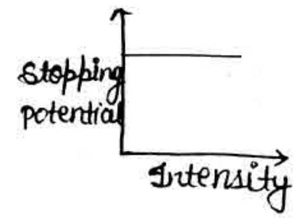
Graph



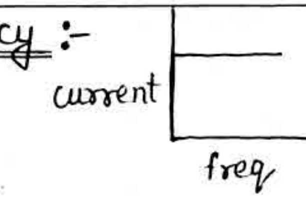
$I_1 > I_2$ (freq = constant)

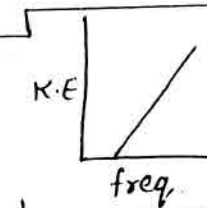


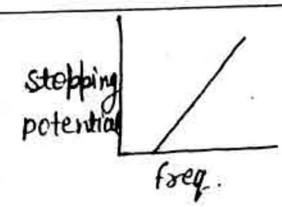


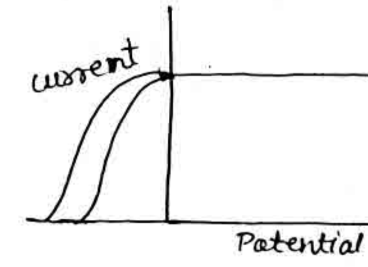


Effect of frequency :-



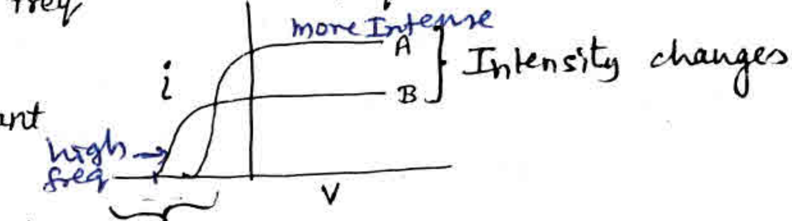






$\nu_2 > \nu_1$

intensity constant

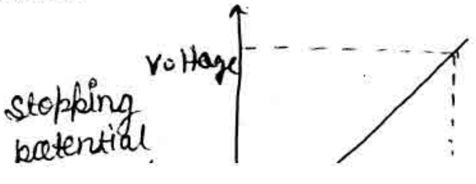


Intensity changes

Determination of Plank's Constant :- frequency

From Einstein Photoelectric equation -

$$h\nu = h\nu_0 + K.E$$
$$eV_0 = K.E$$
$$h\nu = h\nu_0 + eV_0$$



Einstein Photoelectric Equation:-

Photoelectric effect was explained using quantum theory by Einstein.

$$E = \phi + K.E$$

$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

$$h\nu - h\nu_0 = \frac{1}{2}mv^2$$

$$\boxed{h(\nu - \nu_0) = \frac{1}{2}mv^2}$$

Interms of wavelength-

$$h\left(\frac{c}{\lambda} - \frac{c}{\lambda_0}\right) = \frac{1}{2}mv^2$$

$$\boxed{hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = \frac{1}{2}mv^2}$$

Dual Nature of Matter-

De-broglie Hypothesis - Acc. to debroglie a wave is associated with ~~energy~~ every moving particle. This wave is called matter wave and its wavelength is known as debroglie wavelength.

Expression for λ:

By particle nature,

$$E = mc^2$$

By ~~nature~~ wave nature,

$$E = h\nu$$

equ. both the energy

$$mc^2 = h\nu$$

$$m = \frac{h\cancel{c}}{\lambda c^{\cancel{2}}}$$

$$m = \frac{h}{\lambda c}$$

$$\lambda = \frac{h}{m.c}$$

$$\boxed{\lambda = \frac{h}{p}}$$

In term of Energy

$$p = mv$$

$$E = \frac{1}{2}mv^2$$

$$2E = mv^2$$

$$2mE = m^2v^2$$

$$2mE = p^2$$

$$\boxed{p = \sqrt{2mE}}$$

Therefore,

$$\boxed{\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}}$$

(P = momentum)

In term of charge & potential

$$E = qV$$

$$\boxed{\lambda = \frac{h}{\sqrt{2qVm}}}$$

for electron:-

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$\boxed{\lambda = \frac{12.3}{\sqrt{V}}\,\text{Å}}$$

temp:-

$$\boxed{\lambda = \frac{h}{\sqrt{3mKT}}} \qquad E = \frac{3}{2}KT$$

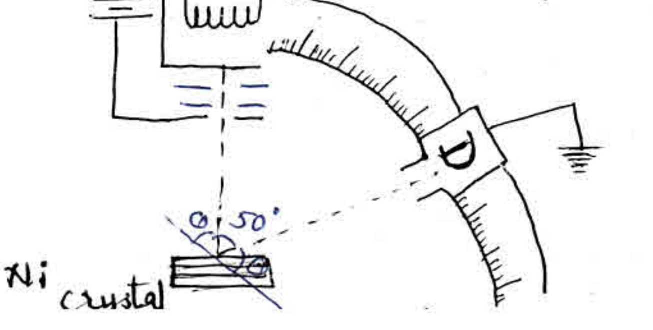
K = Boltzmann constant

Davission & Germer Experiment:-

(i) Electron gun - produces a fine beam of e^- of high speed.

(ii) Nickel crystal:- It is used to diffract the e^- beam.

(iii) Detector:- It is used to find the intensity of diffracted e^- beam.



Theory/ working:- A high energy e^- beam is incident on a nickel crystal which diffracts this e^- beam. The intensity of diffracted beam in various direction is measured with help of detector mounted on circular scale.

At 54 Volt a clear hump (maxima) at angle of 50°, then by Bragg's law for diffraction by crystal.

$$\boxed{2d\sin\theta = n\lambda}$$

$$0.91 \times \sin 65° = 1 \times \lambda$$

$$\therefore \lambda = 1.65\,\text{Å}$$

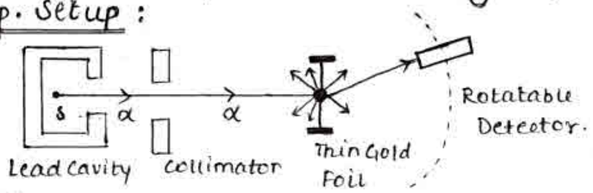
by debroglie hypothesis -

$$\lambda = \underline{h} = \underline{12.3} = \underline{12.3} = 1.66\,\text{Å}$$

8. ATOM & NUCLEI (6 marks)

Rutherford α-particle scattering Exp :-

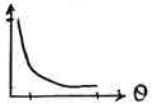
Exp. Setup :



- OBSERVATIONS :

I) Most of the α particle passed underiated.

II) Few α particle scattered at angle θ.



$$N \propto \frac{1}{\sin^4(\theta/2)}$$

III) Very few retraces their path.

- RUTHERFORD'S MODEL OF ATOM : (1909)

1) Most of the part of atom is hollow.

II) The central core is (+)vely charged called nucleus (10^{-15}m).

e^- revolves around the nucleus & radius of orbit decreases due to decrease in energy (dement).

Distance of closest approach :

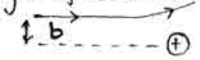
$$\frac{1}{2}mv^2 = \frac{1}{4\pi\epsilon_0}\frac{(Ze)(2e)}{r_0}$$

$$\therefore \boxed{r_0 = \frac{2Ze^2}{4\pi\epsilon_0 (1/2 mv^2)}}$$

Impact Parameter : It is perpendicular distance of the velocity vector of the α-particles from centre of nucleus when α-particle is far away from atom.

$$\boxed{b = \frac{1}{4\pi\epsilon_0}\frac{2Ze^2}{mv^2}\cot\theta/2}$$

- smaller is b, larger is angle of scattering θ.
- $\cot\frac{\theta}{2} = \frac{2b}{r_0}$



- for θ = 180° (rebounds) b = 0

- **BOHR'S MODEL : (1913)**

I). The e^- can exist in certain orbit without radiating energy. $\boxed{\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r^2}}$

II). Only those orbit are allowed for which the angular momentum (mvr) is integral multiple of $h/2\pi$. $\boxed{mvr = \frac{nh}{2\pi}}$ n = 1, 2, 3 . . . . Quantum NO.

III) Electrons Revolving in their stationary orbit do not radiate energy (non radiative orbits or Bohr's orbits)

IV) If the e^- goes from orbit of energy E_1 to other orbit of energy E_2 then a photon of energy $h\nu$ is radiated such that. $\boxed{h\nu = E_2 - E_1}$

Radius of Bohr Orbit : $r_n = \frac{\epsilon_0 n^2 h^2}{\pi m e^2 Z}$

For Hydrogen Z = 1

ENERGY OF BOHR ORBITS :-

$$E = KE + PE = \frac{1}{2}mv^2 + \frac{Ze(-e)}{4\pi\epsilon_0 r}$$

$$= \frac{1}{2}\frac{Ze^2}{4\pi\epsilon_0 r} - \frac{Ze^2}{4\pi\epsilon_0 r} \left(\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r}\right)$$

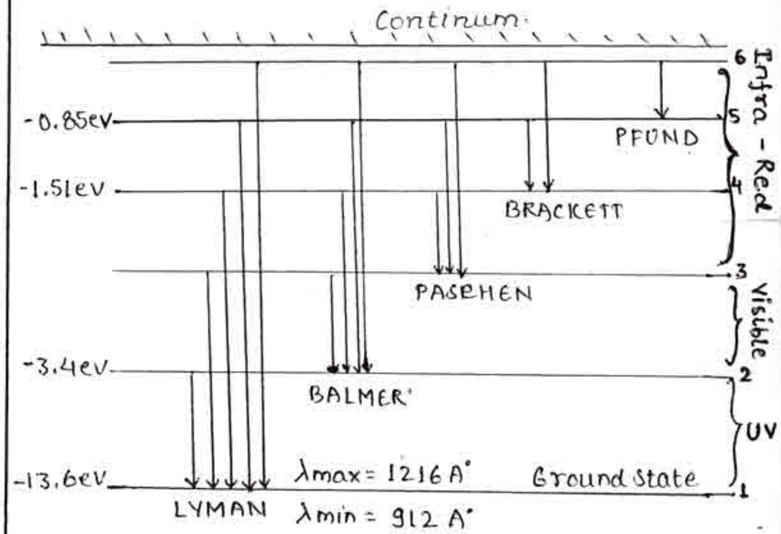
$$E_n = \frac{-Ze^2}{8\pi\epsilon_0 r_n}$$

For H Atom $\boxed{E_n = \frac{-e^2}{8\pi\epsilon_0 r_n}} = \boxed{\frac{-13.6}{n^2}eV}$

HYDROGEN SPECTRUM :-

Hydrogen spectrum consist of group of radiation emitted by a H-atom whose wavelenght is given as $\boxed{\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)}$ Rydberg constant $R = 1.09 \times 10^7 m^{-1}$

$$\boxed{R = \frac{\pi m e^4}{8\epsilon_0^2 C h^3}}$$



Lyman Series : Electron jump from higher orbit to first orbit.

$n_1 = 1$, $n_2 = 2, 3, 4 \ldots$

$$\nu_1 = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 3/4 R$$

$$\nu_2 = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 8/9 R$$

} Ultra Voilet Region.

Balmer : Visible Region

Pashon, Brackett, Pfund :- Far Infrared.

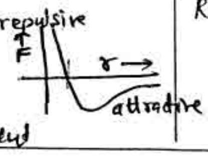
Nucleons = Protons + Neutrons

$A = Z + N$.

Mass No. = Atomic No. + No. of Neutrons.

$_Z^AX$ OR $_ZX^A$

Nuclear force
- strong
- short range
- spin dependent
- charge independent



Nuclear Volume ∝ Mass No.

$\frac{4}{3}\pi R^3 \propto A$

OR $\boxed{R = R_0 A^{1/3}}$

$R_0 = 1.4 \times 10^{-15}$ m

1 Fermi = 10^{-15} m.

1 amu = $\frac{1}{12}\left({}^{12}_{6}C\right) = 1.66 \times 10^{-22}$ kg

Electron Volt (eV) – Unit of energy

1 eV = 1.6×10^{-19} J.

1 amu = 931 MeV

NUCLEAR DENSITY : 10^{17} kg/m³

Independent of mass no. and same for all elements $\rho = \frac{m.A}{4/3\pi R_0^3 A} = \frac{3m}{4\pi R_0^3}$

IsotoPes : Same protons (Z) but different (A) No. of Neutron. Ex: $_1H^1$, $_1H^2$, $_1H^3$; $_2He^3$, $_2He^4$, $_2He^6$

IsobArs : Same (A) but different (Z) Ex: $_{11}Na^{22}$; $_{10}Ne^{22}$; $_{20}Ca^{40}$; $_{18}Ar^{40}$

IsotoNes : Same no. neutrons. Ex: $_1H^3$; $_2He^4$; $_8O^{16}$; $_6C^{14}$

Mass Energy Relation : $\boxed{E = \Delta mc^2}$

Energy & mass are interconvertible.

Mass Defect : Differences in masses of nucleons & nucleus.

$$\Delta m = [ZM_p + (A-Z)M_n] - \begin{bmatrix}\text{mass of} \\ _ZX^A \text{ nucleus}\end{bmatrix}$$

Binding Energy : Energy equivalent to mass defect. B.E. = $\Delta M.C^2$

Packing Fraction : B.E per nucleon.

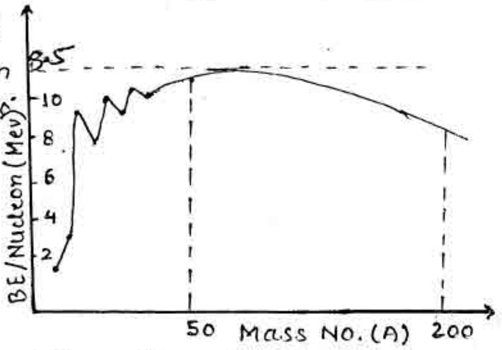
$$P.F = B.E/A$$

Variation in B.E/Nucleon with mass no.

1) BE/A is very less for A = 8 and then increases upto A = 60.

2) Decreases after A = 120.

3) Maximum 10.5 mev for Range A = 30 to A = 120.



4) Peak for $_2He^4$, $_6C^{12}$, $_8O^{16}$ etc indicate more stabilit

5). More is BE/A, more is stability of a nucleus.

NUCLEAR FISSION : Splitting of heavy nucleus. $_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + Q$ (200 Mev

NUCLEAR FUSION : Fusing two or more lighter nuclei. $_1H^1 + {}_1H^1 \rightarrow {}_1H^2 + e^+ + \nu$

RADIOACTIVITY : Spontaneous emission of radiation (α, β, γ) from radioactive nuclei.

Laws of Radioactive Decay :

1) Spontaneous.

2). Rate of disintegration is directly proportional to no. of atom at that time.

3). Independent of temperature, pressure etc.

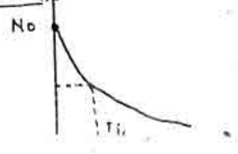
4) α-β not emitted simultaneously

$\boxed{N = N_0 e^{-\lambda t}}$

Half Life : $\boxed{T_{1/2} = \frac{0.693}{\lambda} = \frac{\log_e 2}{\lambda}}$

$\boxed{N = N_0 \left(\frac{1}{2}\right)^{t/T_{1/2}}}$ t = total time

$\boxed{\text{Average Life} = \frac{1}{\lambda} = 1.44\,T_{1/2}}$



	α ($_2He^4$)	β (electron)	γ (photon)
Charge =	$2 \times 1.6 \times 10^{-19}$ C	-1.6×10^{-19} C	0
Mass =	$4 \times 1.67 \times 10^{-27}$ kg	9.1×10^{-31} kg	Rest mass 0
In field =	Deflected by electric or Mag. field		No effect.
Speed =	Less than β	Less than γ	Speed of light

Unit of Radioactivity.

- Curie (Ci) – 3.7×10^{10} decay/sec (activity of 1g radium).
- Becquerel (Bq) – 1 decay/sec (S.I unit of radioactivity)
- Rutherford (Rd) – 10^6 Decay/sec.

α-decay $_ZX^A \xrightarrow{-\alpha} {}_{Z-2}Y^{A-4} + {}_2He^4$

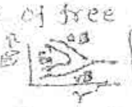
β-decay $_ZX^A \xrightarrow{-\beta} {}_{Z+1}Y^A + {}_{-1}e^0$

γ-decay $_ZX^A \xrightarrow{-\gamma} {}_ZX^A$ $\begin{cases} n \rightarrow p + e^- + \bar{\nu} & \beta^- \text{ decay} \\ p \rightarrow n + e^+ + \nu & \beta^+ \text{ decay} \end{cases}$

ELECTRONIC DEVICES (7marks)

(Band Theory)

Intrinsic Semiconductor: (Pure Semiconductor) - No. of free e^- = No. of holes.
Si (E_g - 1.1eV), Ge (0.7eV)

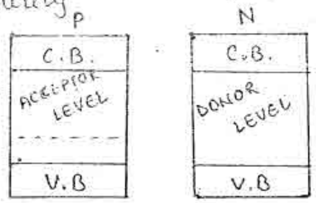


Conductors $E_g = 0$
Semiconductor $E_g \leq 3eV$
Insulator $E_g \geq 3eV$

Extrinsic Semiconductor: (Impure Semiconductor)

P-Type: (Acceptor Type) Trivalent (B, Al, In, Ga) Impurity
Majority carrier holes

N-Type: (Donor Type) Pentavalent (Bi, P, As, Sb)
Majority carrier electrons.

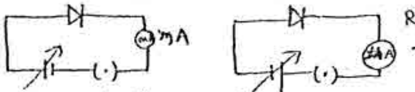


Doping: Mixing suitable impurity in Si, Ge.

NET CHARGE ON PURE OR IMPURE SEMICONDUCTOR IS 0 ZERO.

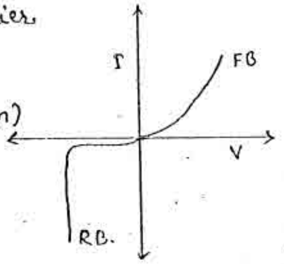
PN Junction:

Two process { drift
diffusion



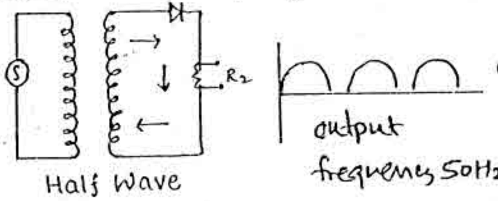
Forward Biasing Reverse Biasing

Reverse current induce to minority charge carriers.

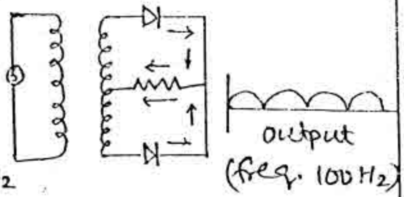


- * **Depletion Layer:** Layer near junction having no free charge (10^{-6}m)
- * Width of Depletion layer decreases with F.B. and Vice Versa
- * **Potential Barrier:** Potential Developed across junction.

Rectifiers: Conversion of a.c into d.c

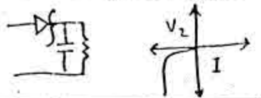


Half Wave

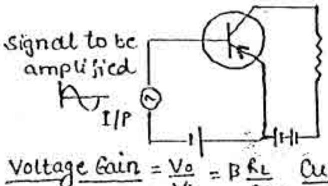


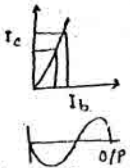
Principle: Diode conduct in FB and do not conduct in R.B.

Zener: Used in reverse biasing as voltage stabilize.



Amplifier: (CE Mode)





$V_0 = V_{cc} - I_c R_L$

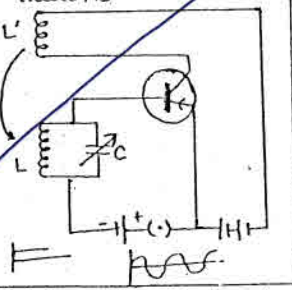
Voltage Gain $= \frac{V_0}{V_i} = \beta \frac{R_L}{R_{in}}$ **Current Gain** $\beta = I_c / I_b$

Principle: Small change in input current In result in large change in O/P I_c.

~~**Oscillator:** Produce electronic oscillations.~~

~~→ tank circuit~~

~~→ Feedback (Positive)~~



~~$f = \frac{1}{2\pi\sqrt{LC}}$~~

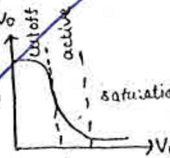
~~**Transistor as Switch:**~~

~~$V_0 = V_{cc} - i_c R_L$~~

~~V_i is low unable to FB & is V_0 is high.~~

~~V_i is high~~

~~V_0 is nearly 0~~



~~Transistor in cutoff region - ON~~ (transfer ch. curve)
~~Saturation Region - OFF~~

---

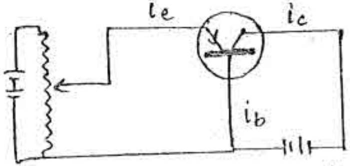
* LED Light emitting Diode : Used in FB light produced due to e-h combination.

* PHOTODIODE RB. e-h pairs generated due to incident photon $h\nu > E_g$.

* SOLAR CELL Convert solar energy into electrical energy. Properties → [$E_g \approx 1.5eV$. high optical absorption
electrical conductivity

Generation, seperation, collection

Transistor Action:

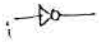
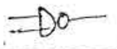


$i_e = i_b + i_c$ $i_b = 5\%$ of i_e

Base region is very thin and regulates O/P current.

Logic Gates: Electronic devices which give one O/P for one or more I/P

Basic Logic Gate AND, OR, NOT **UNIVERSAL GATE** - NAND, NOR

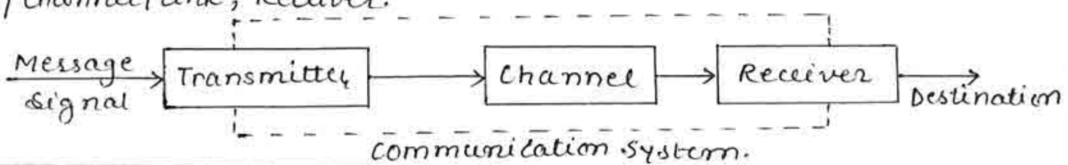
	OR	AND	NOT	NAND	NOR
Symbol					
Truth Table A B 0 0 0 1 1 0 1 1	$A+B$ 0 1 1 1	$A.B$ 0 0 0 1	$\overline{A}$ 1 0	$\overline{A.B}$ 1 1 1 0	$\overline{A+B}$ 1 0 0 0
	A	A	Y	AND+NOT	OR+NOT

10. COMMUNICATION SYSTEM (5 Marks)

ELEMENTS OF COMMUNICATION SYSTEM:

Communication is the act of transmission of information. Every communication. system has three essential elements.

Transmitter, Medium / Channel / Link, Receiver.



Basic Modes of Commonication:

- Point to Point: Link between single transmitter and a receiver.
- Broadcast: Large no. of receivers corresponding to a single transmitter.

Basic Terminology:

Transducer: Device converts one form of energy to other.

Signal: Information in electric form.
Analog - continious Digital - Disscontinious

Noise: Unwanted Signal.

Attenuation: loss of strength of signal on propogation.

Amplification: Increasing amplitude.

Repeater: Combination of receiver and a transmitter used to extend range of communication.

Bandwidth of Signals:

Bandwidth refers to the frequency range over which signal lies or an equipment operates.

- Speech Signal: 300 Hz to 3100 Hz B.W. - 3100 - 300 = 2800 Hz (Telephonic Communication)
- Music Signal: 20 Hz to 20 KHz B.W. = 20 KHz (approx)
- Video Signal: BW = 4.2 MHz T.V. Signals (Voice + Picture) - 6 MHz
- Digital Data: (Computer Data) - 300 MHz

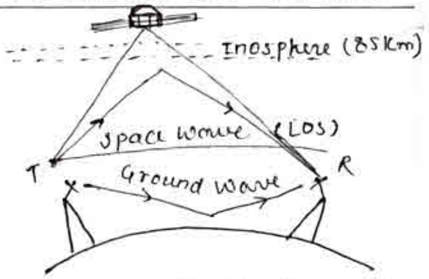
Bandwidth of Transmission Medium:

Wire / Cable.

- Coaxial Cable - 750 MHz (normally operated below 18GHz)
- Optical Fibre - 100 GHz

Wireless: AM = 540-1600 KHz
FM = 88-108 MHz
TV = 54-890 MHz
Mobile = 896-935 MHz
Satellite = 3.7-6.4 GHz.

Propogation of EM Waves :-

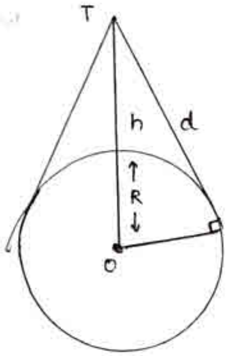


- Ground Wave - (0-2MHz) For AM broadcast.
  Ground wave moves over surface of the earth. Higher freq. waves can't be sent as ground wave due to their absorption by Earth.
- Sky Wave - (2MHz-30MHz) - By ionospheric reflection of radio waves back to earth - For SW broadcast. Frequency higher than 30MHz penetrate. through inosphere & cant be sent as sky wave. Eg. TV Signal.
- Space Wave - (Frequency greater than 30MHz)
  - LOS line of sight - Directly from transmitter to receiver.
  - Satellite Communication - Via satellite.

Terms Related to Sky Wave:

- Critical Frequency: Highest frequency of radio waves which sent normally to ionosphere. gets reflected. $f_c = 9(N_{max})^{1/2}$ N - No. Density of electron/m^3.
- Maximum Usable Frequency MUF:- Highest frequency of radiowave which when sent at same angle i towards ionosphere gets reflected. MUF = $f_c \sec i$

Range of T.V. Transmission:



$OT^2 = OP^2 + PT^2$

$(R+h)^2 = R^2 + d^2$

$\cancel{R^2} + h^2 + 2Rh = \cancel{R^2} + d^2$

$h << R$

h^2 is negligible

$d^2 = 2Rh$

$\boxed{d = \sqrt{2Rh}}$

Modulation:

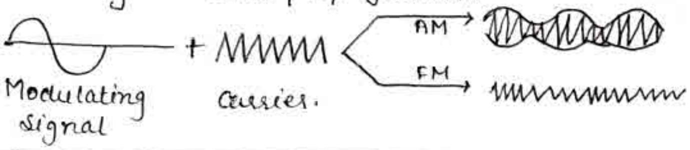
Need: 1. Height of antenna required is 151km ($\lambda/4$) which is immposible.

2. Power radiated $\propto \frac{1}{\lambda^2}$

low freq. signal suffer damping.

3. Mixing of low. freq. signal.

- Modulation is superposition of low freq. audio signal over high freq. carrier wave for long distance propogation.



Amplitude Modulation: Variation in amplitude of carrier wave according to information signal.

Message signal - $m(t) = A_m \sin \omega_m t$

Carrier Wave - $C(t) = A_c \sin \omega_c t$.

Modulated signal $C_m(t) = m(t) + C(t)$

$C_m(t) = (A_c + A_m \sin \omega_m t) \sin \omega_c t$

Modulation Index $\cdot\ \mu = \frac{A_m}{A_c}$

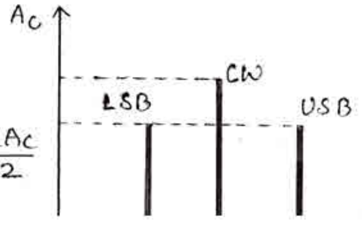
$C_m(t) = A_c \sin \omega_c t + \mu A_c \sin \omega_m t \sin \omega_c t$

$$\boxed{C_m(t) = A_c \sin \omega_c t + \frac{\mu A_c}{2} \cos(\omega_c - \omega_m)t - \frac{\mu A_c}{2} \cos(\omega_c + \omega_m)t.}$$

Frequency Spectrum:

LSB - Lower side Band

USB - Upper side Band



The maximum line of sight distance dm between two antennas having heights h_T & h_R above the earth is given by:

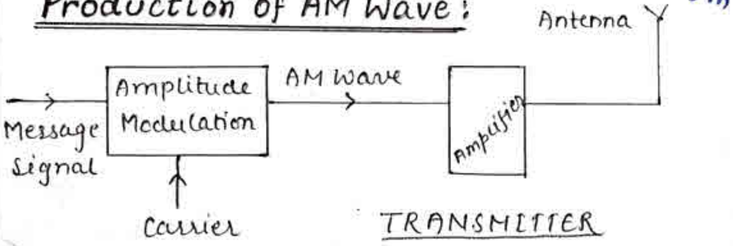
$$d_m = \sqrt{2Rh_T} + \sqrt{2RH_R}$$

Frequency Modulation: freq of carrier wave changes according to message signal.

Carrier swing - total variation in frequency $= 2\Delta f$

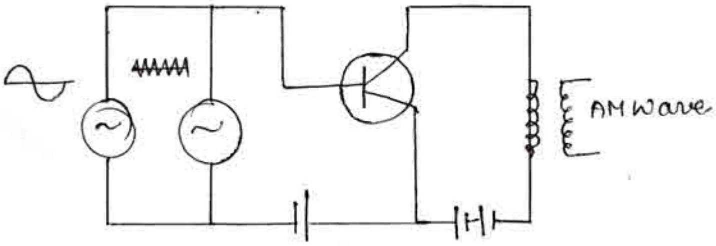
Mod. index $= \frac{\Delta f}{f_m}$

Production of AM Wave:

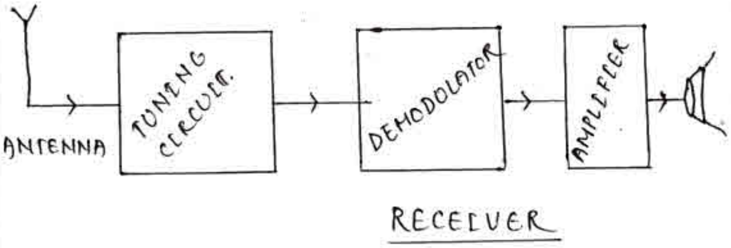


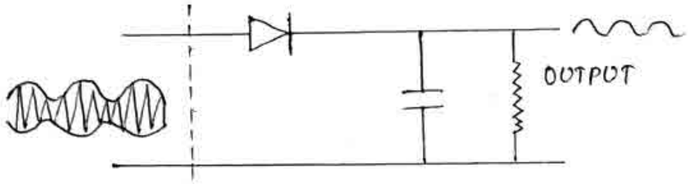
B.W. of AM Wave $= (\omega_c + \omega_m) - (\omega_c - \omega_m)$

$= 2\omega_m$



DEMODULATION: Demodulation is reverse process of modulation. It is to recover message signal at receiving end.





Advantages of FM:

1) Good quality (2) High fidelity

3) Highly efficient.

Internet: www - world wide web

LAN - Local Area N; WAN - Wide A N