CLASS XII (2023-24) PHYSICS (THEORY)

Time: 3 hrs. **Max Marks: 70**

		No. of Periods	Marks
Unit–I	**Electrostatics**	**26**	**16**
	Chapter–1: Electric Charges and Fields		
	Chapter–2: Electrostatic Potential and Capacitance		
Unit-II	**Current Electricity**	**16**	
	Chapter–3: Current Electricity		
Unit-III	**Magnetic Effects of Current and Magnetism**	**25**	**17**
	Chapter–4: Moving Charges and Magnetism		
	Chapter–5: Magnetism and Matter		
Unit-IV	**Electromagnetic Induction and Alternating Currents**	**24**	
	Chapter–6: Electromagnetic Induction		
	Chapter–7: Alternating Current		
Unit–V	**Electromagnetic Waves**	**04**	**18**
	Chapter–8: Electromagnetic Waves		
Unit–VI	**Optics**	**30**	
	Chapter–9: Ray Optics and Optical Instruments		
	Chapter–10: Wave Optics		
Unit–VII	**Dual Nature of Radiation and Matter**	**8**	**12**
	Chapter–11: Dual Nature of Radiation and Matter		
Unit–VIII	**Atoms and Nuclei**	**15**	
	Chapter–12: Atoms		
	Chapter–13: Nuclei		
Unit–IX	**Electronic Devices**	**10**	**7**
	Chapter–14: Semiconductor Electronics: Materials, Devices and Simple Circuits		
	Total	**160**	**70**

COURSE STRUCTURE 2023-2024

Unit I: Electrostatics **26 Periods**

Chapter–1: Electric Charges and Fields

Electric charges, Conservation of charge, Coulomb's law-force between two- point charges, forces between multiple charges; superposition principle and continuous charge distribution. Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field. Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside).

Chapter–2: Electrostatic Potential and Capacitance

Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole in an electrostatic field. Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarization, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor (no derivation, formulae only).

Unit II: Current Electricity **18 Periods**

Chapter–3: Current Electricity

Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, V-I characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity, temperature dependence of resistance, Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel, Kirchhoff's rules, Wheatstone bridge.

Unit III: Magnetic Effects of Current and Magnetism **25 Periods**

Chapter–4: Moving Charges and Magnetism

Concept of magnetic field, Oersted's experiment. Biot - Savart law and its application to current carrying circular loop. Ampere's law and its applications to infinitely long straight wire. Straight solenoid (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields. Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; Current loop as a magnetic dipole and its magnetic dipole moment, moving coil galvanometer- its current sensitivity and conversion to ammeter and voltmeter.

Chapter–5: Magnetism and Matter

Bar magnet, bar magnet as an equivalent solenoid (qualitative treatment only), magnetic field intensity due to a magnetic dipole (bar magnet) along its axis and perpendicular to its axis (qualitative treatment only), torque on a magnetic dipole (bar magnet) in a uniform magnetic field (qualitative treatment only), magnetic field lines. Magnetic properties of materials- Para-, dia- and ferro - magnetic substances with examples, Magnetization of materials, effect of temperature on magnetic properties.

Unit IV: Electromagnetic Induction and Alternating Currents **24 Periods**

Chapter–6: Electromagnetic Induction

Electromagnetic induction; Faraday's laws, induced EMF and current; Lenz's Law, Self and mutual induction.

Chapter–7: Alternating Current
Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LCR series circuit (phasors only), resonance, power in AC circuits, power factor, wattless current. AC generator, Transformer.

Unit V: Electromagnetic waves **04 Periods**
Chapter–8: Electromagnetic Waves
Basic idea of displacement current, Electromagnetic waves, their characteristics, their transverse nature (qualitative idea only). Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

Unit VI: Optics **30 Periods**
Chapter–9: Ray Optics and Optical Instruments
Ray Optics: Reflection of light, spherical mirrors, mirror formula, refraction of light, total internal reflection and optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lens maker's formula, magnification, power of a lens, combination of thin lenses in contact, refraction of light through a prism. Optical instruments: Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Chapter–10: Wave Optics
Wave optics: Wave front and Huygen's principle, reflection and refraction of plane wave at a plane surface using wave fronts. Proof of laws of reflection and refraction using Huygen's principle. Interference, Young's double slit experiment and expression for fringe width (No derivation final expression only), coherent sources and sustained interference of light, diffraction due to a single slit, width of central maxima (qualitative treatment only).

Unit VII: Dual Nature of Radiation and Matter **08 Periods**
Chapter–11: Dual Nature of Radiation and Matter
Dual nature of radiation, Photoelectric effect, Hertz and Lenard's observations; Einstein's photoelectric equation-particle nature of light. Experimental study of photoelectric effect Matter waves-wave nature of particles, de-Broglie relation.

Unit VIII: Atoms and Nuclei **15 Periods**
Chapter–12: Atoms
Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model of hydrogen atom, Expression for radius of nth possible orbit, velocity and energy of electron in nth orbit, hydrogen line spectra (qualitative treatment only).
Chapter–13: Nuclei
Composition and size of nucleus, nuclear force Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear fusion.

Unit IX: Electronic Devices 10 Periods Chapter–
14: Semiconductor Electronics:
Materials, Devices and Simple Circuits Energy bands in conductors, semiconductors and insulators (qualitative ideas only) Intrinsic and extrinsic semiconductors- p and n type, p-n junction Semiconductor diode - I-V characteristics in forward and reverse bias, application of junction diode -diode as a rectifier

MIND MAP- Chapter -1 ELECTRIC CHARGES AND FIELDS

Electric Field ($\overrightarrow{E}$)

ELECTRIC DIPOLE:

Two equal and opposite charges separated by small distance.

Electric Field Intensity (Axial point):

$$E_{Axial} = \frac{1}{4\pi\varepsilon_0}\left[\frac{2p}{r^3}\right]$$

Electric Field Intensity (equatorial line):

$$E_{equat} = -\frac{1}{4\pi\varepsilon_0}\left[\frac{p}{r^3}\right]$$

* $\vec{E} = \vec{F}/q$, F= Force q=charge
* Field at distance r from q

E=$1/4\pi\varepsilon_0\ q/r^2$

* Field due to system of charge

$\vec{E} = E_1 + E_2 + \ldots E_n = \sum_{i=0}^{n}(q_i / r_i^2)\hat{r}_i$

* Vector
* SI unit N/C or V/m

Force acting per unit charge

Gauss Theorem of Electrostatics

Field lines

Another way to represent electric field

Lines originates from +ve charge & terminate at –ve charge

* **Are imaginary lines**
* **Do not form close loop**
* **Always normal to the equipotential surface**
* **Never intersect**

Chapter -1 ELECTRIC CHARGES AND FIELDS

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ELECTRIC CHARGES AND FIELDS

Basic properties of charges

Additivity of charges : Total charge is the algebraic sum of individual charges.

Conservation of charges : The total charge of an isolated system is always conserved.

Quantisation of charges : Charge of an object is always in the form of integral multiple of electronic charge and never its fraction.

Coulomb's Law :

$$F = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right)$$

$$\vec{F} = \frac{1}{4\pi\varepsilon}\left(\frac{q_1 q_2}{r^2}\right)\hat{r}$$

Electric field due to point charge

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{r^2}\right)\hat{r}$$

Electric field lines

Closer field lines indicate the stronger region and rarer field lines shows weaker region

They never interest each other.

They emerge from positive charge and terminate at negative charge.

ELECTRIC DIPOLE

Two equal and opposite charges separated by small distance

Dipole Moment:

$|\vec{p}| = (q \times 2a)$

Electric field lines

Electric Field Intensity (equatorial line):

$$E_{equat} = -\frac{1}{4\pi\varepsilon_0}\left[\frac{p}{r^3}\right]$$

Electric Field Intensity (Axial point):

$$E_{Axial} = \frac{1}{4\pi\varepsilon_0}\left[\frac{2p}{r^3}\right]$$

Electric Flux: -The total number of electric field lines crossing the area.

Electric Flux: -

$$\Phi_{E\ Total} = \oint_s \vec{E}.\vec{dS}$$

$$\Phi_{E\ Total} = \oint_s E\, dS \cos\theta$$

Gauss Theorem The total electric flux over closed surfaces enclosing volume V in vacuum is $1/\epsilon_0$ times the total charge enclosed inside closed surface S.

$$\Phi_{E\ Total} = \frac{q_{enclosed}}{\epsilon_0}$$

Electric field at a point due to uniformly charged spherical shell.

Electric field intensity at point 'P' outside shell distant r (r >R).

$\therefore E = q/4\pi\ \epsilon_o\ r^2$

Electric field at a point P on the surface of sphere r= R

$E = \sigma / \epsilon_o$

Electric field at a point P inside shell (r < R)=> E= 0

Electric field intensity due to uniformly charged thin infinite plane sheet. $E = \sigma/2\epsilon_o$

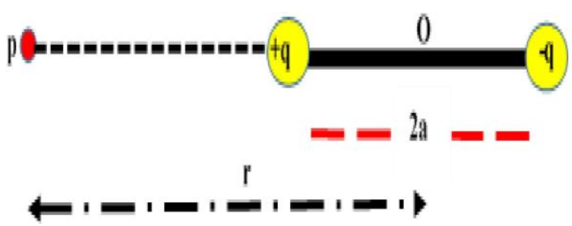
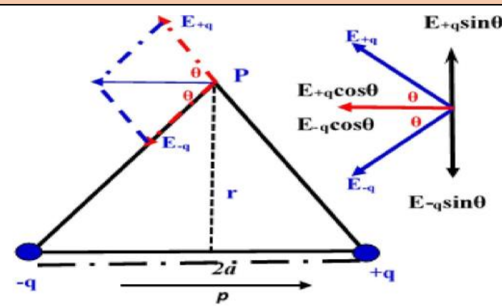
Electric field due to infinitely long uniformly charged straight wire

$E = \lambda/2\pi\epsilon_o r = 2\lambda/4\pi\epsilon_o r$

ELECTRIC DIPOLE

- *Electric dipole is a pair of equal and opposite charges separated by a very small distance.*
- **Electric dipole moment is a vector quantity used to measure the strength of an electric dipole.** $\vec{p} = (q \times 2a)$

ELECTRIC FIELD INTENSITY DUE TO AN ELECTRIC DIPOLE

<table>
<tr><th>Axial line</th><th>Equatorial line</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>$E_{Axial} = \frac{1}{4\pi\varepsilon_0}\left[\frac{2p}{r^3}\right]$</td><td>$E_{equat} = -\frac{1}{4\pi\varepsilon_0}\left[\frac{p}{r^3}\right]$</td></tr>
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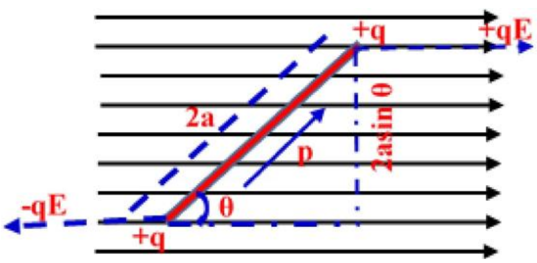
ELECTRIC DIPOLE IN A UNIFORM ELECTRIC FIELD

TORQUE



$\tau = \vec{p} \times \vec{E}$
Case i: If θ = 0°, then τ = 0.
Case ii: If θ = 90°, then τ = pE (maximum value).
Case iii: If θ = 180°, then τ = 0.

POTENTIAL ENERGY

If θ = 180°, then U = pE (Unstable Equilibrium

Potential Energy U = - p E cos θ

If θ = 90°, then U = 0

If θ = 0°, then U = - pE (Stable Equilibrium)

Electric Flux and Gauss Theorem

Electric Flux

SI Unit:- Nm^2C^{-1} or V-m

Dimensiona Formula $=[M^1L^3T^{-3}A^{-1}]$.

Outward flux- $\Phi_E>0$
Inward flux- $\Phi_E<0$
Outward flux= Inward flux, $\Phi_E=0$

Formulae

i) $d\Phi_E=\vec{E}.\vec{dS}$

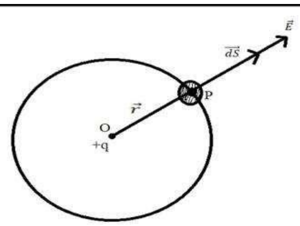
ii) $\Phi_E=\oint_S \vec{E}.\vec{dS}$

Definition-Electric flux over an area represents/measures total number of electric field lines crossing the area when it is held normal to the field direction.

Gauss' Theorem

Statement-It states that total electric flux over closed surfaces enclosing volume V in vacuum is $1/\epsilon_0$ times the total charge enclosed inside closed surface S.

$\oint_S \vec{E}.\vec{dS}=q_{Total}/\epsilon_0$



Proof-

Let +q - the point charg at O. Consider spherically symmetric Gaussian surface around it as shown. Elemental area = dS and $\vec{r}$ = the position vector.

Electric field $\vec{E}$ due to point charge +q at point P and $\vec{dS}$ are in the same direction as shown. Then the total electric flux through closed surface S is

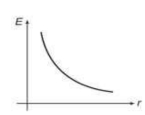
$$\Phi_{E\ Total}=\oint_S \vec{E}.\vec{dS} =\oint_S E\ dS\cos\theta= \oint_S E\ dS\cos 0^o$$

$$\Phi_{E\ Total}=E\oint_S dS= q/4\pi\epsilon_0 r^2 \oint dS =q/4\pi\epsilon_0 r^2 \times (4\pi r^2)$$

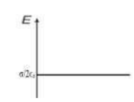
$$\Phi_{E\ Total}= q/\epsilon_0$$

Applications

Electric field due to infinitely long uniformly charged straight wire $E= \lambda/2\pi\epsilon_0 r$



Electric field intensity due thin infinite plane sheet of charge $E= \sigma/2\epsilon_0$

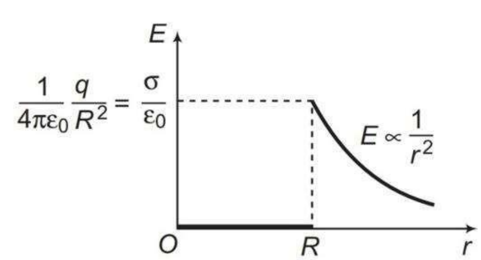


Electric field intensity due to uniformly charged thin spherical shell

At point 'P' outside shell distant r (r >R)
$E=q/4\pi\epsilon_0 r^2$

At a point on the surface of sphere r=R
$E= \sigma/\epsilon_0$

At point inside shell (r < R)
E=0



MIND MAP- ELECTRIC POTENTIAL

ELECTRIC POTENTIAL

$$V_A - V_B = \frac{W_{AB}}{q}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

SI unit volt (V)

Potential gradient. The rate of change of potential with distance

E = - dv/dr

Electric potential at a point due to a dipole:

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\cdot\hat{r}}{r^2}$$

Electric Potential Energy

U (**r**) = q V (**r**

For Potential energy of a system of two-point charges

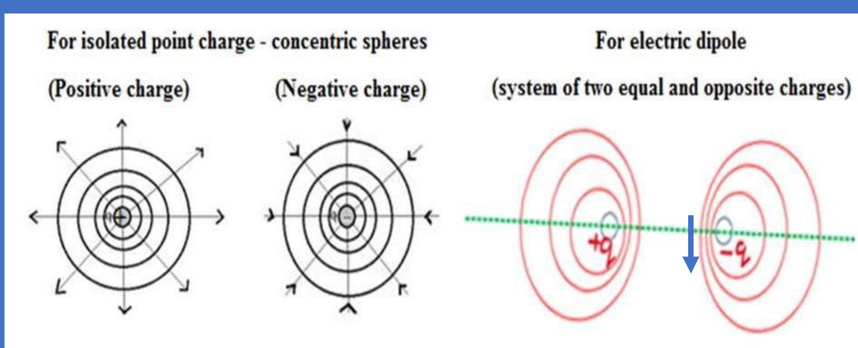
$$U(\mathbf{r}) = q_1 V(\mathbf{r}_1) + q_2 V(\mathbf{r}_2) + \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r_{12}}$$

Potential Energy of dipole in an External Field

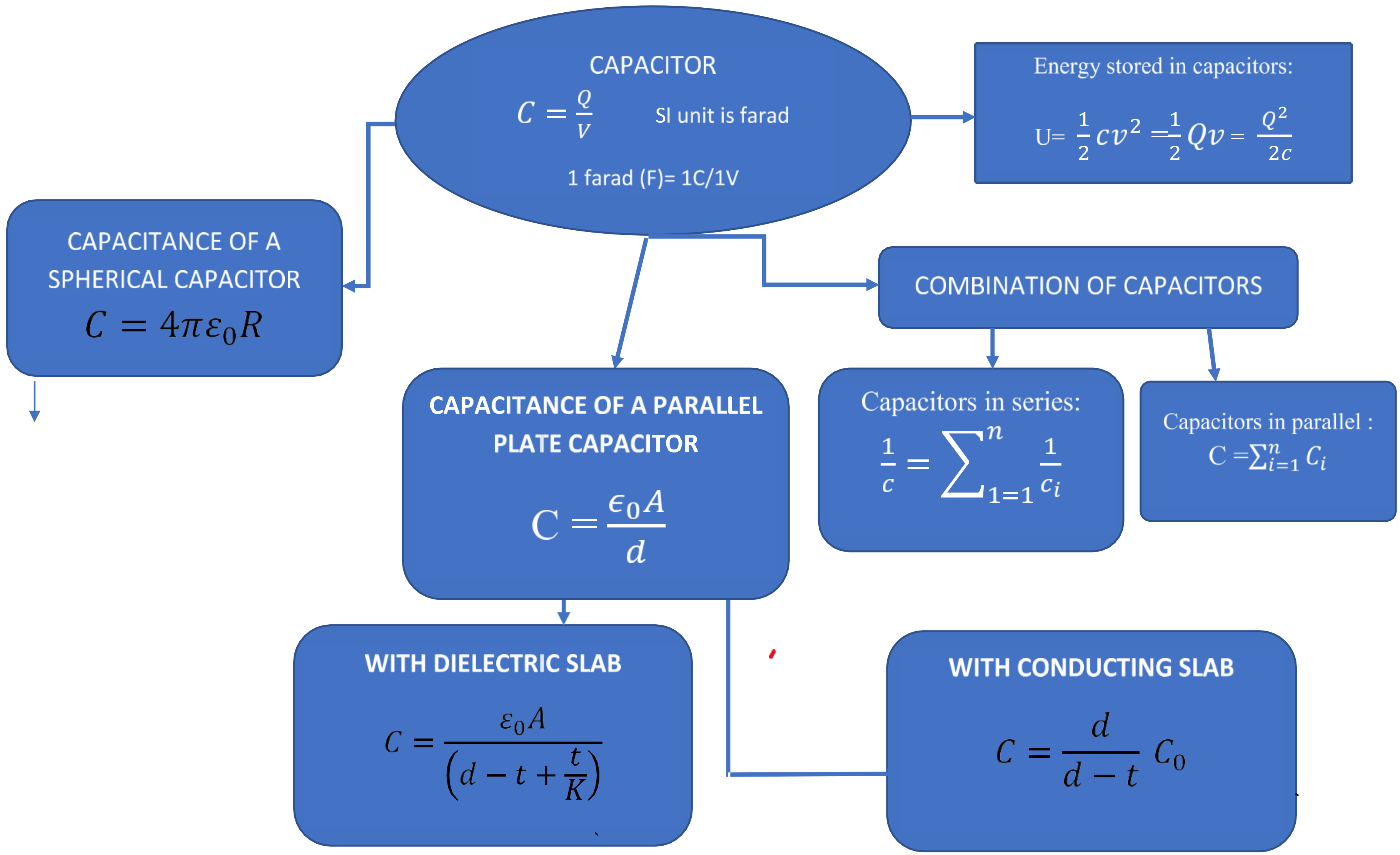
$$U = -pE\cos\theta = -\vec{p}\cdot\vec{E}$$

Equipotential Surfaces:

A surface with a constant value of potential at all points on the surface.



MIND MAP- CAPACITORS



CHAPTER-2 ELECTROSTATIC POTENTIAL AND CAPACITANCES

MASTER CARD- ELECTROSTATIC POTENTIAL

Electric potential:- The amount of work done per unit positive test charge in moving the test charge from infinity to that point.

It is scalar quantity.

SI Unit :- volt (V)

Electric potential difference:- If W is work done in moving a small positive test charge q, from point A to B in the electrostatic field of charge Q, then potential difference between points B and A,

$$V_A - V_B = \frac{W_{AB}}{q} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

Electric potential due to group of charges.

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + - - - - - - - - + \frac{q_n}{r_n}\right)$$

Potential gradient

$$E = \frac{-dV}{dr}$$

Electric potential at a point due to a dipole:

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\,.\,\hat{r}}{r^2}$$

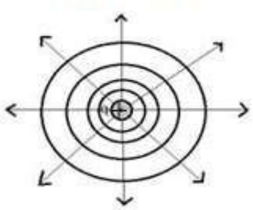
<u>Equipotential Surfaces:</u> A surface with a constant value of potential at all points on the surface.

Example: Surface of a charged conductor

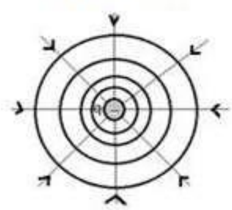
<u>Equipotential Surfaces for various charge systems</u>

For isolated point charge - concentric spheres

(Positive charge)

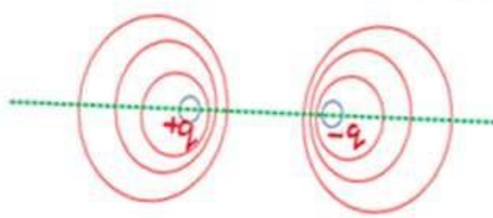


(Negative charge)



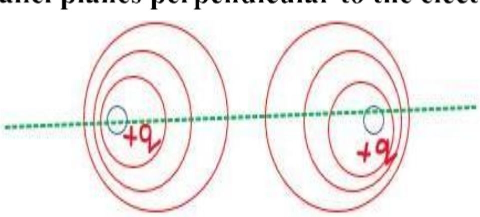
For electric dipole

(system of two equal and opposite charges)

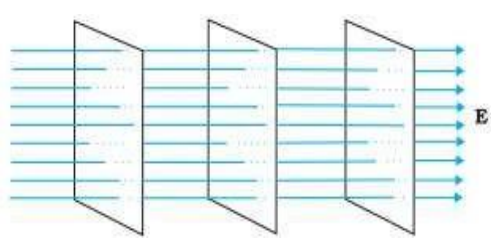


For like charges:

Parallel planes perpendicular to the electric field



For uniform electric field:



Electric Potential Energy

The amount of work done in assembling the charges at their locations by bringing them in, from infinity.

Note that **U is +ve** for like charges and **-ve** for unlike charges.

For Potential energy of a system of two-point charges:

$$U(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r_{12}}$$

For Potential energy of a single point charge in external field:

$U(\mathbf{r}) = q\,V(\mathbf{r})$

For Potential energy of a system of two-point charges in external field:

$$U(\mathbf{r}) = q_1 V(\mathbf{r}_1) + q_2 V(\mathbf{r}_2) + \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r_{12}}$$

For Potential energy of a system of three-point charges:

$$U = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right]$$

Potential Energy of dipole in an External Field-

$$U = -pE\cos\theta = -\vec{p}.\vec{E}$$

TYPE OF MATERIAL

CONDUCTOR

(Electrical Current Flows)

INSULATOR

(Electrical Current Doesn't Flow)

DIELECTRIC
(Material That Can Be Polarised By An Applied Field)

Conductors placed in electric field

(E_{net} =0)

Dielectric placed in Electric field

($E_{net} \neq 0$)

POLAR DIELECTRIC
(Dipole moment is not zero)

NON POLAR DIELECTRIC
(Dipole moment is zero)

DIELECTRIC CONSTANT:(K or ε_r).

$$K = \varepsilon_r = \frac{\varepsilon_0}{\varepsilon}$$

POLARIZATION DENSITY:.

$$P = \frac{Dipole\ moment\ of\ dielectric}{volume\ of\ dielcetric}$$

$$P = \frac{Qd}{Ad} = \frac{Q}{A} = \sigma_p$$

ELECTRIC SUSCEPTIBILITY: The ratio of the polarization to ε_0 times the electric field is called the electric susceptibility of the dielectric.

The unit of electric susceptibility is C^2/Nm^2

DIELECTRIC STRENGTH: The maximum electric field that can exist in a dielectric without causing the breakdown of its insulating property is called dielectric strength of the material.

The Unit of dielectric strength is **V/m**.

CAPACITOR:-

A device to store charges & electrostatic potential energy.

Capacitance: $C = \frac{Q}{V}$

SI. unit : **farad (F)**

Capacitance of a parallel plate capacitor with no medium between plates :

$C_0 = C = \frac{\epsilon_0 A}{d}$

Capacitance of a parallel plate capacitor with a dielectric medium thickness t

$C_m = \frac{\epsilon_0 A}{\left(d - t + \frac{t}{K}\right)}$

Capacitance of a parallel plate capacitor with a dielectric medium thickness t

$C_m = \frac{\epsilon_0 A}{\left(d - t + \frac{t}{K}\right)}$

If t = d then $C_m = K\frac{\epsilon_0 A}{d}$

$\Rightarrow \quad C_m = KC_0$

Combination of capacitors:

(i) Capacitors in series: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

(ii) Capacitors in parallel : $C = \sum_{i=1}^{n} C_i$

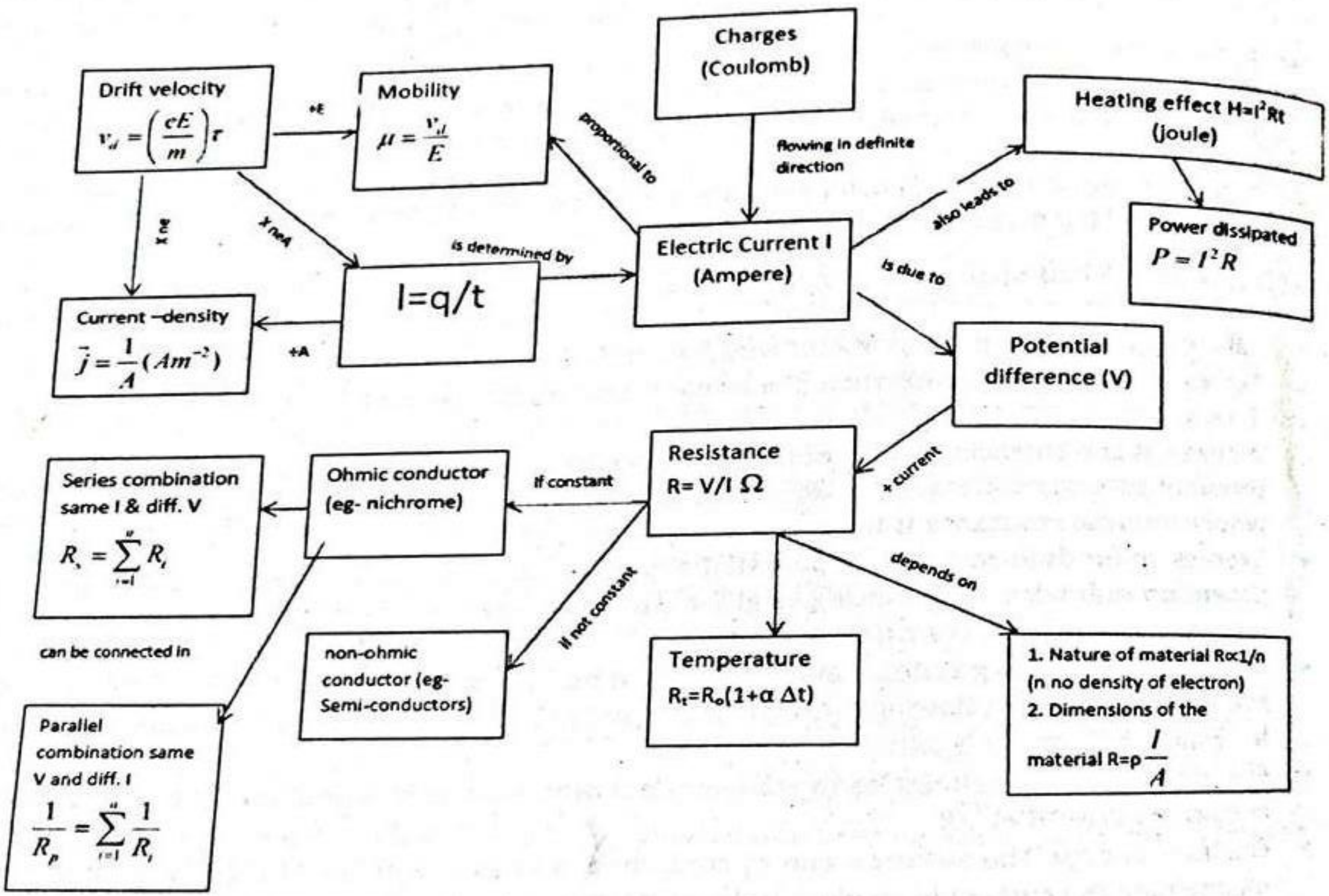
Energy stored in capacitors:

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

***Introducing dielectric slab between the plates of the charged conductor with:**

PROPERTY	BATTERY CONNECTED	BATTERY DISCONNECTED
Charge	KQ_0	Q_0
Potential difference	V_0	V_0/K
Electric Field	E_0	E_0/K
Capacitance	KC_0	KC_0
Energy	$K\frac{1}{2}\epsilon_0 E^2$ (Energy is supplied by battery)	$\frac{1}{K}\frac{1}{2}\epsilon_0 E^2$ (Energy used for polarization)

MIND MAP CHAPTER-3 - CURRENT ELECTRICITY



Master Card -UNIT-2 - CURRENT ELECTRICITY

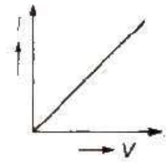
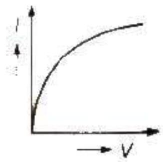
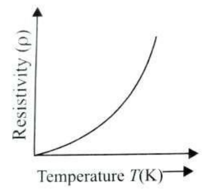
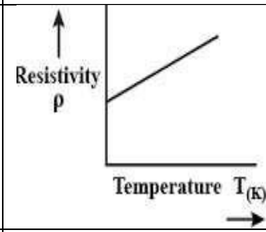
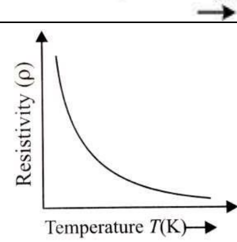
Physical Quantity	FORMULA	MEANING	UNIT
Resistivity of metallic conductor	$\rho_T = \rho_0 \left[1 + \alpha (T - T_0)\right]$	ρ_T=Resistivity at T temperature ρ_0= Resistivity at reference temperature α = temperature co-efficient of resistivity	ρ : Ω m α : ${}^0C^{-1}$ T : ${}^0C$
temperature co-efficient of resistivity	$\alpha = \frac{R_2 - R_1}{R_1 (T_1 - T_2)}$	α = temperature co-efficient of resistivity R_2= Resistance at final temperature R_1= Resistance at initial temperature T_1 and T_2= Initial and final temperature	α : ${}^0C^{-1}$ R_1, R_2: Ω T_1, T_2 : ${}^0C$
Electrical Energy	$E = VIt = I^2 Rt$	E= Energy, V= Voltage, I= Current, R= Resistance, t= Time	E: joule V: volt I: ampere
Power	$P = VI = I^2 R = \frac{V^2}{R}$	P= Power, V= Voltage, I= Current, R= Resistance	P: watt
Combination of Resistors	1] In Series: $R_{eq} = R_1 + R_2 + ... + R_n$ 2] In Parallel: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$	R_{eq}= Equivalent resistance	R_{eq}: Ω
EMF of Cell	$\varepsilon = \frac{W}{q}$	ε= emf of cell W= work done q= charge	ε: volt W: joule q: coulomb
Potential Difference of Cell	$V = IR = \varepsilon - Ir$	V= Potential difference, I= Current, R= Resistance, ε= emf, r = Internal resistance	V: volt ε: volt r: Ω
Internal resistance of cell	$r = \frac{\varepsilon}{I} - R$	r= Internal resistance, ε= emf, I= Current, R= External resistance	r, R: Ω
	$I = \frac{\varepsilon}{R + r}$		I: ampere (A)
Combination of Cell	1] In Series: $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ $r_{eq} = r_1 + r_2$	ε_{eq}= Equivalent emf r_{eq} = Equivalent resistance	ε_{eq}: volt r_{eq} = Ω
	$I = \frac{nE}{(R + nr)}$	I= Current, n= no. cells in series, E= emf, R= external resistance, r= internal resistance	I: A E: volt R,r: Ω
	2] In Parallel: $V = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} - I \frac{r_1 r_2}{r_1 + r_2}$	V= Potential Difference, I= Current, ε_1, ε_2= emf's of cell 1 and 2 r_1, r_2= internal resistances of cell 1 and 2	V: volt ε_1, ε_2: volt r_1, r_2: Ω
	$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$	ε_{eq}= equivalent emf, ε_1, ε_2= emf's of cell 1 and 2 r_1, r_2= internal resistances of cell 1 and 2	ε_{eq} : volt ε_1, ε_2: volt r_1, r_2: Ω
	$r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$	r_{eq}= equivalent resistance r_1, r_2= internal resistances of cell 1 and 2	r_{eq}: Ω r_1, r_2: Ω

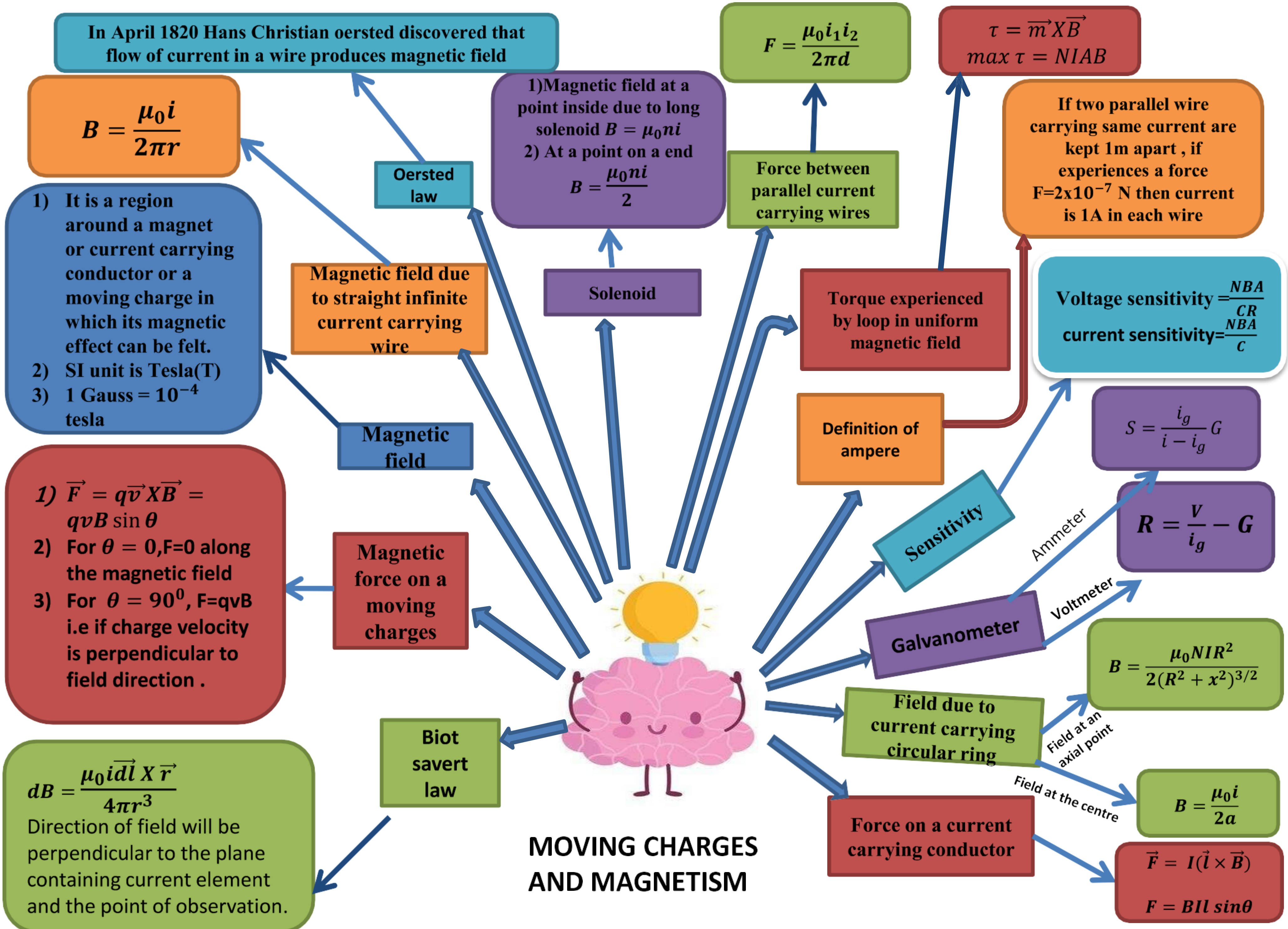
	$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + ... + \frac{\varepsilon_n}{r_n}$		
	$I = \frac{mE}{(mR + r)}$	I= Current, E= emf, R= external resistance, r= internal resistance, m= number of cells connected in parallel	I: ampere E: emf R. r: Ω
Kirchhoff's Rules:	1] Junction Rule: $\sum I = 0$ 2] Loop Rule: $\sum V = 0$ OR $\sum IR = 0$		
Wheatstone Bridge:	$\frac{R_1}{R_2} = \frac{R_3}{R_4}$	R_1, R_2, R_3, R_4= Resistances	
Meter Bridge:	$\frac{R}{S} = \frac{l}{(100 - l)}$ OR $R = S\frac{l}{(100 - l)}$	R= unknown resistance S= known resistance l= Balancing length	R, S: Ω l: cm

Tips:

1] When components are connected in series, then current flowing through them is same.	6] In numerical question diagrams are given, then see the direction of the cell placed in the circuit.
2] When components are connected in parallel, then potential difference across them is same.	7] Alloys have very high resistivity and low temperature coefficient of resistance.
3] If the cells are connected facing each other, then effective emf will be the subtraction of both cells.	8] While calculating total resistance use the internal resistance of cell also.
4] If the storage battery is being charged, so it will not contribute in the total emf of the circuit	9] In Solving Kirchhoff's rules numerical, use appropriate sign conventions of current and emf of cell or voltage drop.
5] Write the formulas clearly and correctly in numerical questions.	10] In meter bridge numerical, first draw circuit diagram according to given conditions.

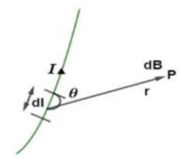
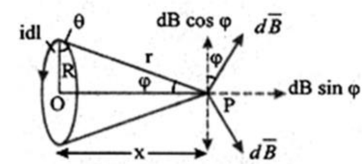
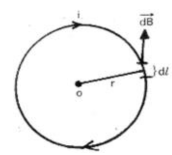
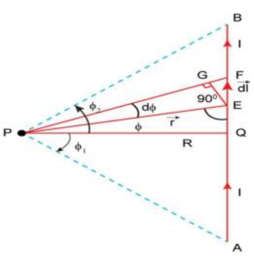
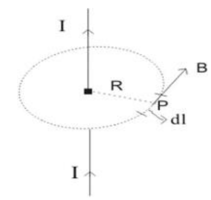
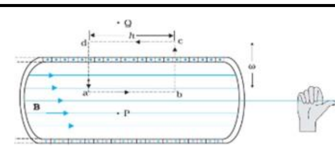
Graphs:

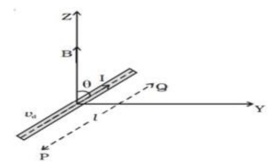
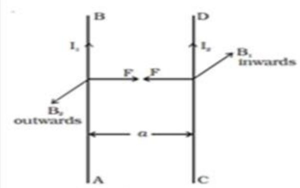
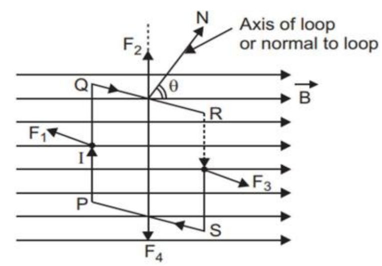
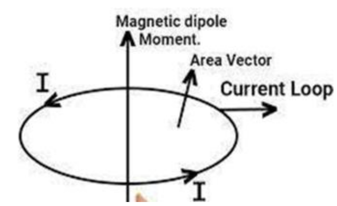
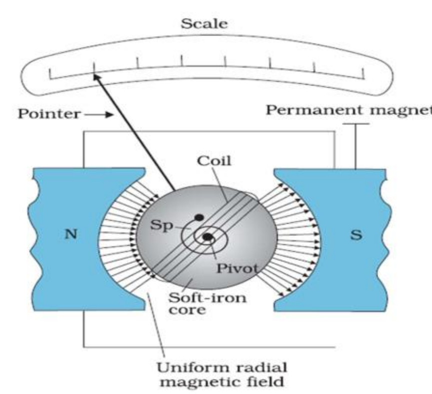
Ohmic Conductors- slope of V-I graph gives Resistance	
Non-Ohmic conductors - V-I graph is not a straight line	
Resistivity ρ_T of copper as a function of temperature T.	
Resistivity ρ_T of nichrome as a function of temperature T.	
Temperature dependence of resistivity for a typical semiconductor.	

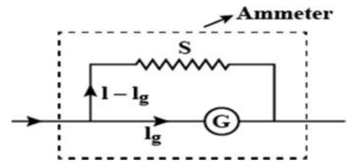
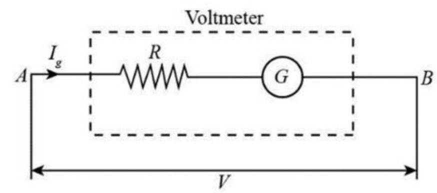


MOVING CHARGES AND MAGNETISM
In April 1820 Hans Christian oersted discovered that flow of current in a wire produces magnetic field
Oersted law
Magnetic field due to straight infinite current carrying wire
$B = \frac{\mu_0 i}{2\pi r}$
Magnetic field
1) It is a region around a magnet or current carrying conductor or a moving charge in which its magnetic effect can be felt.
2) SI unit is Tesla(T)
3) 1 Gauss = 10^{-4} tesla
Magnetic force on a moving charges
1) $\vec{F} = q\vec{v} X \vec{B} = qvB \sin\theta$
2) For $\theta = 0$, F=0 along the magnetic field
3) For $\theta = 90^0$, F=qvB i.e if charge velocity is perpendicular to field direction .
Biot savert law
$dB = \frac{\mu_0 i \vec{dl} \, X \, \vec{r}}{4\pi r^3}$
Direction of field will be perpendicular to the plane containing current element and the point of observation.
Solenoid
1)Magnetic field at a point inside due to long solenoid $B = \mu_0 ni$
2) At a point on a end $B = \frac{\mu_0 ni}{2}$
Force between parallel current carrying wires
$F = \frac{\mu_0 i_1 i_2}{2\pi d}$
Torque experienced by loop in uniform magnetic field
$\tau = \vec{m} X \vec{B}$
$max\ \tau = NIAB$
Definition of ampere
If two parallel wire carrying same current are kept 1m apart , if experiences a force F=2x10^{-7} N then current is 1A in each wire
Sensitivity
Voltage sensitivity =$\frac{NBA}{CR}$
current sensitivity=$\frac{NBA}{C}$
Galvanometer
Ammeter
$S = \frac{i_g}{i - i_g} G$
Voltmeter
$R = \frac{V}{i_g} - G$
Field due to current carrying circular ring
Field at an axial point
$B = \frac{\mu_0 N I R^2}{2(R^2 + x^2)^{3/2}}$
Field at the centre
$B = \frac{\mu_0 i}{2a}$
Force on a current carrying conductor
$\vec{F} = I(\vec{l} \times \vec{B})$
$F = BIl \sin\theta$

CHAPTER - 4 MOVING CHARGE AND MAGNETISM

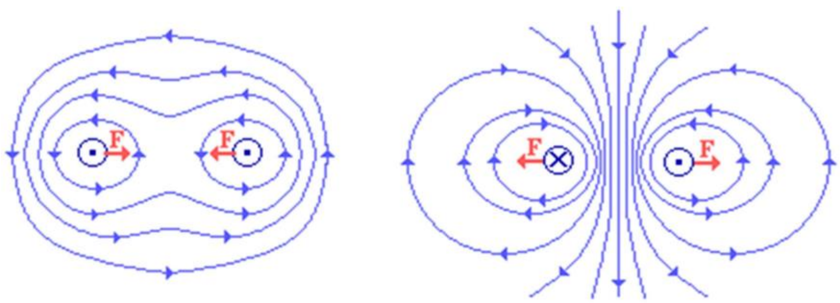
Sr. No.	Term	Formula	Diagram
1	Biot Savart's Law	$dB = \frac{\mu_0 I\ dl\ sin\theta}{4\pi r^2}$	
2	Magnetic field at a point on the axis of a current carrying circular coil	$B = \frac{\mu_0 N I R^2}{2(R^2 + x^2)^{3/2}}$	
3	Magnetic field at a center of a current carrying circular coil	$B = \frac{\mu_0 I}{2r}$	
4	Magnetic field due to a current in a straight conductor	$B_0 = \frac{\mu_0}{4\pi}\frac{I}{r}(sin\phi_1 + sin\phi_2)$	
5	Ampere's circuital law	$\oint \vec{B}.\vec{dl} = \mu_0 I$	
6	Magnetic field due to an infinitely long current carrying straight wire	$B = \frac{\mu_0 I}{2\pi R}$	
7	Magnetic field due to straight solenoid	$B = \mu_0\ n\ I$, where n = N/L n = number of turns per unit length	

8	**Lorentz force** Force on a moving charge in uniform magnetic and electric fields	$\vec{F} = q(\vec{E} + \vec{V} \times \vec{B})$	
9	Force on a current-carrying conductor in a uniform magnetic field	$\vec{F} = I(\vec{l} \times \vec{B})$ $F = BIl\ sin\theta$	
10	Force between two parallel current-carrying conductors	$F = \frac{\mu_0 I_1 I_2 l}{2\pi a}$	
11	Torque experienced by a current loop in uniform magnetic field	$\tau = NIBA\ sin\theta$ $\vec{\tau} = \vec{m} \times \vec{B}$ Where m = IA = magnetic moment	
12	Current loop as a magnetic dipole and its magnetic dipole moment	$B = \frac{\mu_0}{4\pi}\frac{2m}{x^3}$ Where x is the distance along the axis from the center of the loop m = NIA = NIπr^2	
13	Moving coil galvanometer -	1. $I = G\theta$ Where $G = \frac{k}{NAB}$ = galvanometer constant K = torsional N = number of turns A = area of coil B = magnetic field θ = deflection	

14	Moving coil galvanometer Current sensitivity Voltage sensitivity	$I_s = \frac{\theta}{I} = \frac{NAB}{k}$ $V_s = \frac{\theta}{IR} = \frac{NAB}{kR}$	
15	Conversion of galvanometer to ammeter	$S = \frac{I_g}{I - I_g} G$ G = galvanometer resistance	
16	Conversion of galvanometer to voltmeter	$R = \frac{V}{I_g} - G$ G = galvanometer resistance R = high resistance in series	

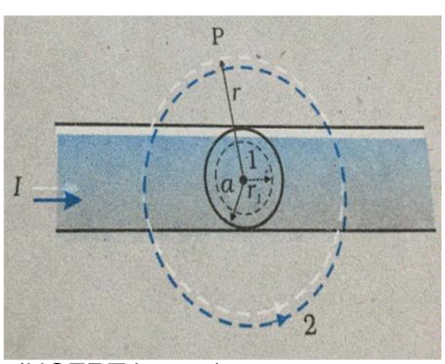
GRAPHS :-

1. Field pattern for force between two parallel current carrying conductors -

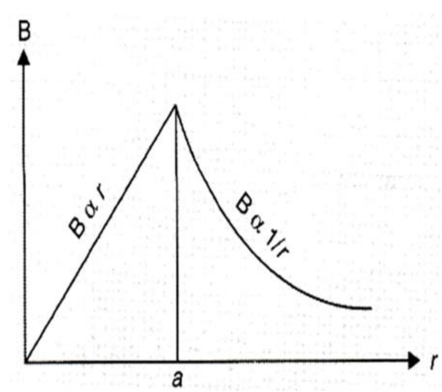


Same direction **Opposite direction**

2. Magnetic field in the region r < a and r > a, for a long straight wire of a circular cross-section



(NCERT image)

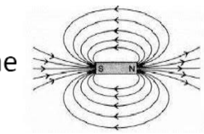


A long straight wire of a circular cross-section

MAGNETISM AND MATTER

Solenoid
- $\mu = NIA$
- N = Number of turns
- I = Current
- A = Area

MAGNETIC FIELD LINES
Continuous imaginary lines which represent the direction of magnetic field.



MAGNETIC TERMS
- **Intensity of magnetization**: $I = \frac{M}{V}$
- **Magnetic susceptibility**: $\chi = \frac{1}{H}$
- **Magnetic permeability**: $\mu = \mu_0(1+\chi_m)$
- **Magnetic intensity**: $H = \frac{B_0}{\mu}$

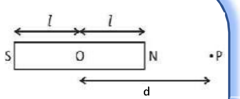
MAGNETIC SUBSTANCES
- **Para-magnetism**: Tendency to increase the magnetic field due to magnetization. e.g. Al, Mn (χ_m low and –ve, $\mu_r > 1$)
- **Diamagnetism**: Tendency to magnetise in a direction opposite to direction of magnetic field. e.g. Bi, Cu, Hg, Ni (μ_r, $\chi_m < 1$)
- **Ferromagnetism**: Tendency to display strong magnetism in the direction of magnetic field. e.g. Fe, Co, Ni (μ_r, $\chi_m >> 1$)

BAR MAGNETIC

MAGNETIC FIELD INTENSITY
End-on-position

$$B = \frac{\mu_0}{4\pi}\frac{2M}{d^2}$$

$d >>> l$

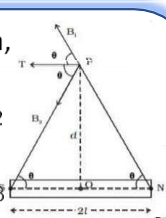


Broad-side position,

$$B = \frac{\mu_0}{4\pi}\frac{M}{(d^2 + l^2)^{3/2}}$$

$d >>> l$

$B = \mu_0 M / 4\pi d^3$



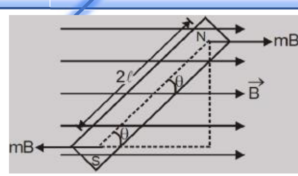
Potential energy of a Field-Magnet System
$U_\theta = U_\theta - U_{90^\circ} = -MB\cos\theta = -\vec{M}.\vec{B}$

We take P.E at $\theta = 90^\circ$ to be zero

Torque
$\vec{\tau} = \vec{M} \times \vec{B} = MB\sin\theta$

M = 2ml

B = Magnetic field



MIND MAP - ELECTRO MAGNETIC INDUCTION

Electromagnetic Induction

Faraday's Law of Electromagnetic Induction

Whenever flux of magnetic field through the area bounded by a closed conducting loop changes, an emf is produced in the loop

The emf is given by $E = -d\phi/dt$

where $\phi = \int \vec{B}.\vec{ds}$

is the flux of the magnetic field through the area.

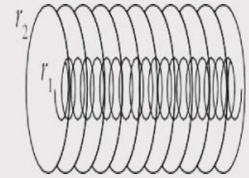
Contribution

In 1831, Michael Faraday discovered electromagnetic induction and James Clerk Maxwell mathematically described it.

Mutual Inductance

$\phi = Mi$

$\frac{d\phi}{dt} = -M\frac{di}{dt}$



$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$

$M_{21} = \mu_0 n_1 n_2 \pi r_2^2 l$

Emf induced in an AC generator, $E = NBA\omega \sin \omega t$

Lenz's Law

The direction of the induced current is such that it opposes the changes that has induced it.

Self Induction

If a solenoid of N turns, the flux through each each turn $= \phi = \int \vec{B}.\vec{ds}$

emf induced between the ends of coil $= E = -N\frac{d}{dt}\int \vec{B}.\vec{ds}$

Self Inductance of long Solenoid

$L = \mu_0 n^2 \pi r^2 l$

n = no. of turns per unit length

ϕ = flux $= (\mu_0 n i)\pi r^2$

r = radius of each loop of solenoid

- **Growth of current in LR Circuit**

  $i = \frac{E}{R}(1 - e^{-tR/L}) = i_0(1 - e^{-t/\tau})$

- **Decay of current**

  $i = i_0 e^{-t/\tau}$

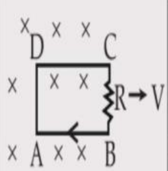
- **Energy stored in an Inductor**

  $U = \frac{1}{2}Li^2$

Eddy Current

It is induced when magnetic flux linked with the conductor changes

Rectangular loop



emf induced

$E = vBl$

$i = \frac{vBl}{R}$

Magnetic force on the loop

$F = B^2 l^2 v/R$

= force required to move the loop with constant velocity (v)

Thermal power developed in the loop is

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

Induced EMF

$E = \frac{d\phi}{dt}$

Induced current

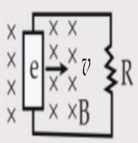
$I = \frac{E}{R} = -\frac{1}{R}\frac{d\phi}{dt}$

Motional EMF

$E = \left|\frac{d\phi}{dt}\right| = \left|Bl\frac{dx}{dt}\right|$

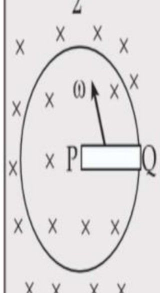
$= Blv$

$i = vbl/(R+r)$



r = resistance of rod moving with velocity v in uniform magnetic field $\vec{B}$

$E = \frac{1}{2}B\omega l^2$

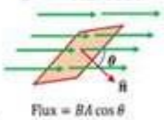


MASTER CARD : CHAPTER 6 ELECTROMAGNETIC INDUCTION

ELECTROMAGNETIC INDUCTION

Magnetic flux

$\varnothing = AB\cos\theta$



Faraday's law of EMI

1st Law - Reason of induced emf or current is change in magnetic flux.

2nd law - $E = -N\frac{d\varnothing}{dt}$

$I = -\frac{N}{R}\frac{d\varnothing}{dt}$

Lenz's law

Direction of induced emf or current is such that it always opposes the change in magnetic flux which produces it.

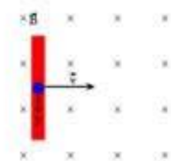
Lenz's law is based on law of conservation of energy.

Fleming Right Hand

Motional EMF due to

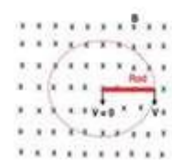
Translatory motion

$E = Blv\sin\theta$



Rotational motion

$E = \frac{1}{2}BR^2\omega$



Self-induction

$\varnothing = LI$

$E = -L\frac{dI}{dt}$

Self-inductance of a long solenoid (L) = $\mu_0 n^2 lA$

where n - no of turns per unit length

Factors on which self-inductance depends

Number of turns.

Area of cross section.

Permeability of core material.

Mutual induction

$\varnothing = MI_P$

$E = M\frac{dI_P}{dt}$

Mutual inductance between two long solenoids of same length(M) = $\mu_0 n_1 n_2 A l$

Factor on which mutual inductance depends

Number of turns

Common cross sectional area

Relative separation.

Relative orientation of two coil

Permeability of core material

Eddy current

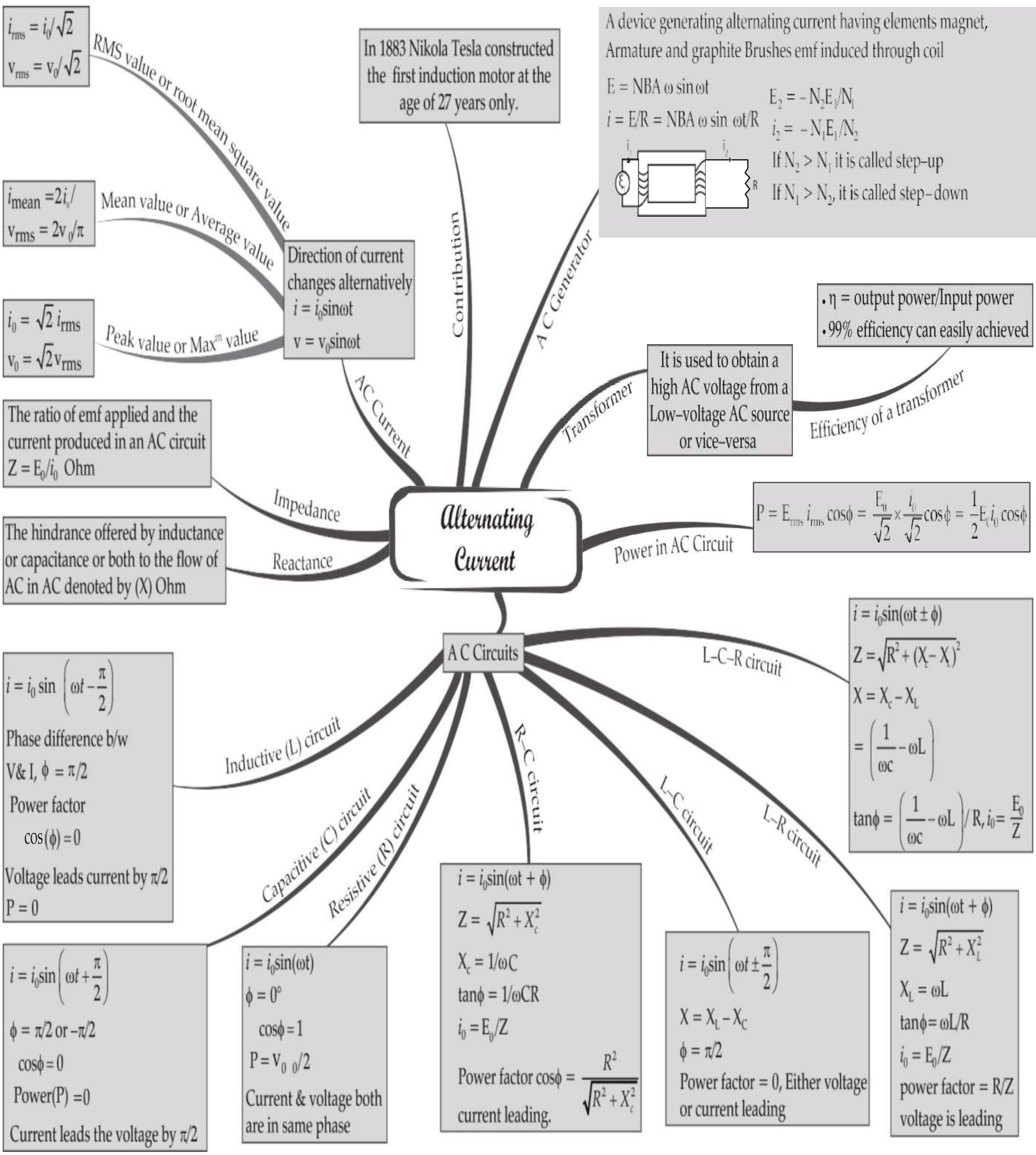
Eddy current – It is induced current set up inside metal body due to change in magnetic flux.

Uses - To produce heat in induction furnace, Electromagnetic damping

Disadvantages - Heat up metallic core, Damage insulation of coil due to heat, Always oppose motion.

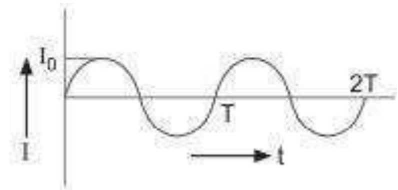
Minimization of eddy current – Using laminating iron core, Using slotted iron blocks.

MIND MAP - ALTERNATING CURRENT



MASTER CARD: CHAPTER 7 ALTERNATING CURRENT

1. <u>AC VOLTAGE AND AC CURRENT</u>: -The voltage and current whose magnitude changes continuously and direction reverses periodically is called alternating voltage and alternating current.



<u>ALTERNATING CURRENT</u>	**<u>ALTERNATING VOLTAGE</u>**
$I = I_m \sin(\omega t + \phi)$	$V = V_m \sin \omega t$
I→instantanious value of current I_m →Peak value of current ω→ angular freq. rad/s ϕ→ phase angle, it gives information about the variation of alternating current with respect to the alternating voltage.	V →instantanious value of voltage V_m →Peak value of voltage ω → angular freq. rad/s

2. <u>Average or mean value of AC over a cycle</u>: -

Average Alternating current or voltage is zero over a complete cycle.

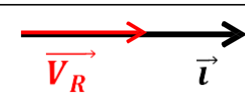
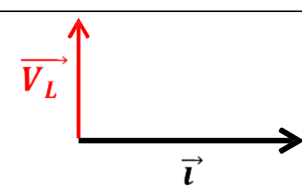
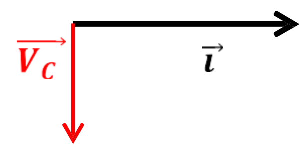
Hence, Average value is measured over half of a cycle is $\boldsymbol{I_{av} = \frac{2I_0}{\pi} = 0.636 I_0}$.

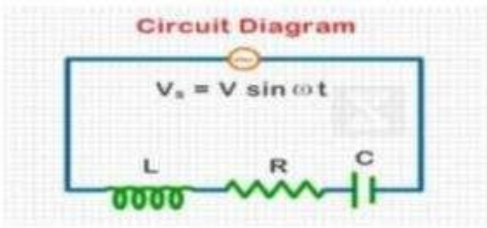
Relation between R.M.S. value and peak value is

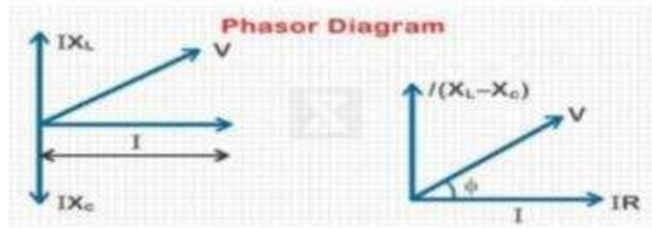
$$I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m \quad and\ V_{rms} = \frac{V_m}{\sqrt{2}} = 0.707\ V_m$$

3. Phase Difference between Voltage and Current

If $V = V_m \sin \omega t$ is AC voltage is connected to a circuit having reactive components like **<u>RLC</u>** in series, then the current is $I = I_m\ \sin(\omega t + \varphi)$ where φ is the phase difference between the voltage across the source and the current in the circuit.

AC SOURCE CONNECTED WITH	PHASE φ	Phase relation with AC source voltage	IMPEDENCE Z	PHASOR DIAGRAM
A pure RESISTOR	0	**voltage and current are in phase**	Z=R	
A pure INDUCTOR	$\frac{\pi}{2}$	**voltage leads current by 90^o**	$Z = X_L = \omega L$	
A pure CAPACITOR	$\frac{\pi}{2}$	**Voltage lags current by 90^o**	$Z = X_C = \frac{1}{\omega C}$	





$$V_m = \sqrt{(I_m R)^2 + (I_m X_C - I_m X_L)^2} \qquad Z = \frac{V_m}{I_m} = \sqrt{(R)^2 + (X_C - X_L)^2}$$

The effective resistance in series RLC circuit is called the **Impedance Z.**

$$Phase\ difference\ between\ i\ and\ V\ , \qquad \tan\varphi = \frac{X_L - X_C}{R}$$

4. **Impedance and Reactance Impedance:**
   The effective resistance to alternating current in series RLC circuit is called the **Impedance Z.**

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

Reactance: The opposition offered by inductance and capacitance or both in ac circuit is called reactance.
It is denoted by X_C or X_L.

The opposition due to inductor alone is called the inductive reactance while that due to capacitance alone is called the capacitive reactance.

Inductive reactance, $X_L = \omega L$

Capacitive reactance $X_C = \dfrac{1}{\omega C}$

If capacitor is charged initially and ac source is removed, then electrostatic energy of capacitor ($\dfrac{q^2}{2C}$) isconverted into magnetic energy of inductor ($\dfrac{1}{2}Li^2$) and vice versa periodically; such oscillations of energy are called LC oscillations. The frequency is given by $\boldsymbol{\omega} = \dfrac{1}{\sqrt{LC}}$

5. **AC Generator:-** It is a device used to convert mechanical energy into electrical energy and is based on the phenomenon of electromagnetic induction. If a coil of N turns, area A is rotated at frequency ν in uniform magnetic field then motional induced EMF in coil (if initially it is perpendicular to field) is $E = E_o \sin\omega t$ with angular frequency $\omega = 2\pi f$ and Peak EMF $E_o = NBA\omega$.

ELECTROMAGNETIC WAVES
Master card

Electromagnetic Waves

Maxwell's Equations

(i) $\oint \boldsymbol{E}.\boldsymbol{dS} = q/\epsilon_o$ (Gauss's law in electrostatics)

(ii) $\oint \boldsymbol{B}.\boldsymbol{dS} = 0$ (Gauss's law in magnetism)

(iii) $\oint \boldsymbol{E}.\boldsymbol{dl} = -d\phi_B/dt$ (Faraday's law of induction)

Conduction Current

The current due to flow of charge is often called conduction current,

$I_c = dq/dt$

Displacement current

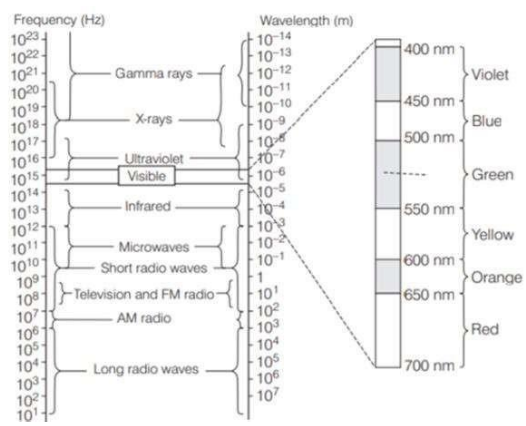
The current which arises due to time rate of change of electric flux (ϕ_E) in some part of the electric circuit.

$I_d = \epsilon_0\, d\phi_E/dt$

Characterstics of EM waves

*Combination of mutually perpendicular Electric and magnetic fields is referred as an EM wave.
*Do not need any material for propagation.
*Travel with speed of light (c)= $1/\sqrt{\mu_o \epsilon_o} = 3 \times 10^8$ m/s
*Produced by accelerated charged particle
*Transverse in nature
*Oscillation Electric and magnetic field are in phase and ratio is equal to constant.

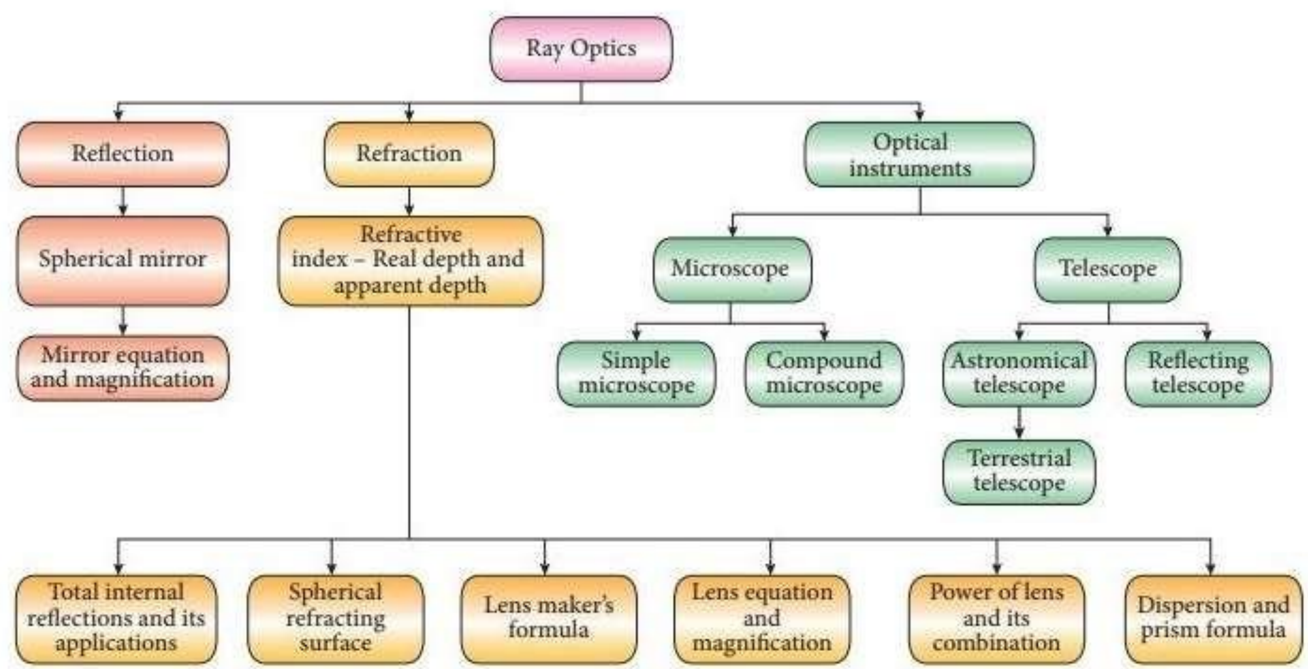
Electromagnetic Spectrum



Energy Density

U,(Total energy per unit volume) = Electrostatic energy density ($\epsilon_o E^2/2$) +Magnetostatic energy density($B^2/2\mu_o$).
(Electrostatic and magnetic Energy is equally distributed)

CONCEPT MAP


Ray Optics
Reflection
Spherical mirror
Mirror equation and magnification
Refraction
Refractive index – Real depth and apparent depth
Optical instruments
Microscope
Simple microscope
Compound microscope
Telescope
Astronomical telescope
Terrestrial telescope
Reflecting telescope
Total internal reflections and its applications
Spherical refracting surface
Lens maker's formula
Lens equation and magnification
Power of lens and its combination
Dispersion and prism formula

APPLICATIONS OF TIR

- Fiber optics communication
- Medical endoscopy
- Periscope (Using prism)
- Sparkling of diamond

TOTAL INTERNAL REFLECTION

TIR conditions

- Light must travel from denser to rarer.
- Incident angle $i >$ critical angle i_c

Relation between μ and i_c: $\mu = \frac{1}{\sin i_c}$

REFRACTION OF LIGHT

Snell's law: When light travels from medium a to medium b, ${}^a\mu_b = \frac{\mu_b}{\mu_a} = \frac{\sin i}{\sin r}$

Refractive index,

$$\mu = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in medium}} = \frac{c}{v}$$

Real and apparent depth

$$\mu = \frac{\text{real depth}(x)}{\text{apparent depth }(y)}$$

REFLECTION OF LIGHT

According to the laws of reflection, $\angle i = \angle r$

If a plane mirror is rotated by an angle θ, the reflected rays rotates by an angle 2θ.

SIMPLE MICROSCOPE

Magnifying power

For final image is formed at D (least distance) $M = 1 + \frac{D}{f}$

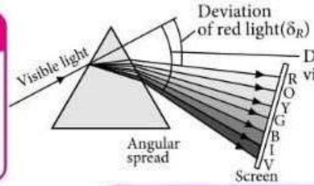
For final image formed at infinity

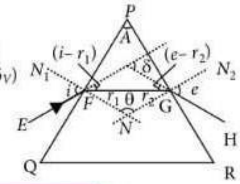
$$M = \frac{D}{f}$$

REFLECTING TELESCOPE

Magnifying power

$$M = \frac{f_o}{f_e} = \frac{R/2}{f_e}$$





REFRACTION THROUGH PRISM

Relation between μ and δ_m

$$\mu = \frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$$

(where, δ_m = angle of minimum deviation, A = angle of prism)

or $\delta = (\mu - 1)A$ (Prism of small angle)

Angular dispersion

$$= \delta_V - \delta_R = (\mu_V - \mu_R)A$$

Dispersive power,

$$\omega = \frac{\delta_V - \delta_R}{\delta} = \frac{\mu_V - \mu_R}{\mu - 1}$$

Mean deviation, $\delta = \frac{\delta_V + \delta_R}{2}$

RAY OPTICS

OPTICAL INSTRUMENTS

TELESCOPE

Astronomical telescope

For final image formed at D (least distance) $M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$

In normal adjustment, image formed at infinity $M = f_o/f_e$

POWER OF LENSES

Power of lens: $P = \frac{1}{f\text{ (in m)}}$

Combination of lenses:

Power: $P = P_1 + P_2 - dP_1P_2$

(d = small separation between the lenses)

For $d = 0$ (lenses in contact)

Power: $P = P_1 + P_2 + P_3 + ...$

THIN SPHERICAL LENS

Thin lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Magnification: $m = \frac{v}{u} = \frac{h_i}{h_o}$

REFRACTION BY SPHERICAL SURFACE

Relation between object distance (u), image distance (v) and refractive index (μ)

$$\frac{\mu_{denser}}{v} - \frac{\mu_{rarer}}{u} = \frac{\mu_{denser} - \mu_{rarer}}{R}$$

(Holds for any curved spherical surface.)

Lens maker's formula

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

REFLECTION BY SPHERICAL MIRRORS

Mirror formula, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} = \frac{2}{R}$

Magnification, $m = -\frac{v}{u} = \frac{h_i}{h_o}$

COMPOUND MICROSCOPE

Magnifying power, $M = m_o \times m_e$

For final image formed at D (least distance) $M = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$

For final image formed at infinity

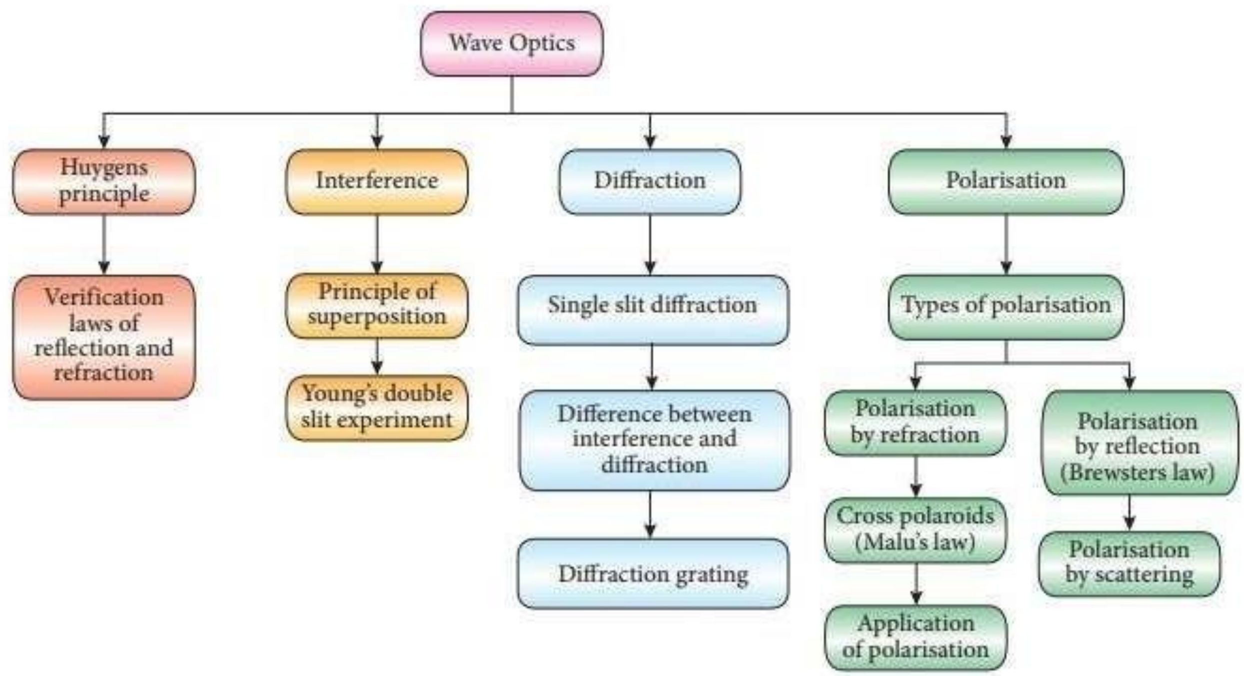
$$M = \frac{L}{f_o} \cdot \frac{D}{f_e}$$

TERRESTRIAL TELESCOPE

For normal adjustment $M = \frac{f_o}{f_e}$

Distance between objective and eyepiece $d = f_o + 4f + f_e$

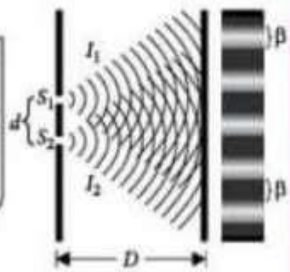
CONCEPT MAP



Wave Optics
Huygens principle
Verification laws of reflection and refraction
Interference
Principle of superposition
Young's double slit experiment
Diffraction
Single slit diffraction
Difference between interference and diffraction
Diffraction grating
Polarisation
Types of polarisation
Polarisation by refraction
Cross polaroids (Malu's law)
Application of polarisation
Polarisation by reflection (Brewsters law)
Polarisation by scattering

REFLECTION AND REFRACTION

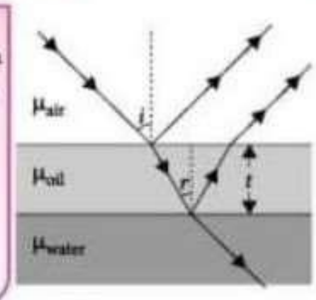
Law of reflection $\angle i = \angle r$ & law of refraction $\frac{\sin i}{\sin r} = \mu$ can be explained by Huygens wave theory.

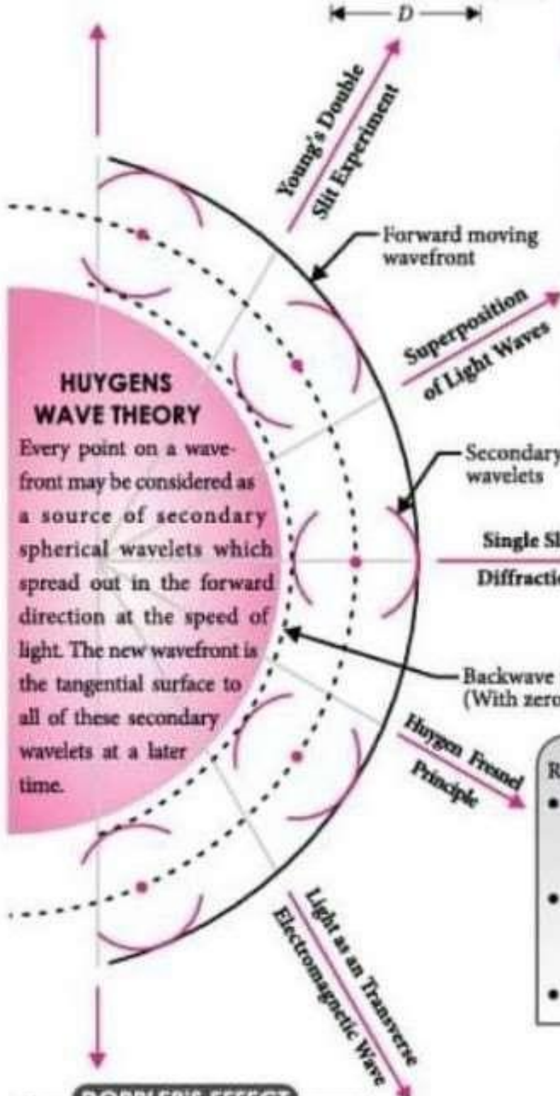


INTERFERENCE OF LIGHT

The superposition of two coherent waves resulting in a pattern of alternating dark and bright fringes of equal width.

- Position of bright fringes $x_n = \frac{n\lambda D}{d}$
- Position of dark fringes $x'_n = \frac{(2n-1)\lambda D}{2d}$
- Fringe width $\beta = \frac{\lambda D}{d}$
- Ratio of slit width with intensity : $\frac{w_1}{w_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$





HUYGENS WAVE THEORY

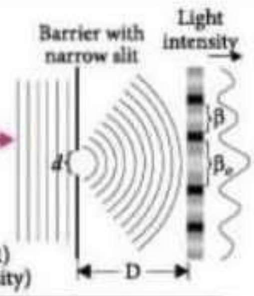
Every point on a wavefront may be considered as a source of secondary spherical wavelets which spread out in the forward direction at the speed of light. The new wavefront is the tangential surface to all of these secondary wavelets at a later time.

ADDITION OF COHERENT WAVE

- Resultant intensity
  $I_R = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$
  for bright fringes,
  $I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$ at $\phi = 0°, 2\pi, 4\pi...$
  for dark fringes,
  $I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$ at $\phi = \pi, 3\pi, 5\pi...$
  for $I_1 = I_2 = I_0$; $I_R = 4I_0\cos^2\frac{\phi}{2}$

INTERFERENCE IN THIN FILM

- For reflected Light
  Maxima $\rightarrow 2\mu t\cos r = (2n+1)\frac{\lambda}{2}$
  Minima $\rightarrow 2\mu t\cos r = n\lambda$
- For transmitted light
  Maxima $\rightarrow 2\mu t\cos r = n\lambda$
  Minima $\rightarrow 2\mu t\cos r = (2n+1)\frac{\lambda}{2}$
  Shift in fringe pattern
  $\Delta x = \frac{\beta}{\lambda}(\mu - 1)t = \frac{D}{d}(\mu - 1)t$
  (t = thickness of film, μ = R.I. of the film)



DIFFRACTION

- Single slit experiment
  - Angular position of n^{th} minima, $\theta_n = \frac{n\lambda}{d}$
  - Angular position of n^{th} maxima, $\theta'_n = \frac{(2n+1)\lambda}{2d}$
  - Width of central maximum $\beta_o = 2\beta = \frac{2D\lambda}{d}$

FRESNEL'S DISTANCE

Ray optics as a limiting case of wave optics

- Diffraction at circular aperture
  Linear spread, $x = D\theta$
  Areal spread, $x^2 = (D\theta)^2$ $\left\{\theta = \frac{1.22\lambda}{d}\right\}$
- Fresnel's distance : Distance at which diffraction spread is equal to the size of aperture, $D_F = \frac{d^2}{\lambda}$
- Size of Fresnel zone, $d_F = \sqrt{\lambda D}$

RESOLVING POWER (R.P.)

The ability to resolve the images of two nearby point objects distinctly.

R.P. = $\frac{1}{\text{Limit of resolution}}$

R.P. of a microscope $= \frac{1}{d} = \frac{2\mu\sin\theta}{\lambda}$

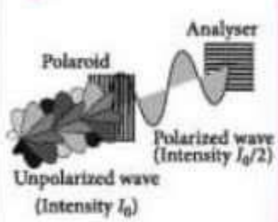
θ = Semi vertical angle subtended at objective.

R.P. of a telescope $= \frac{1}{d\theta} = \frac{D}{1.22\lambda}$

D = Diameter of objective lens of telescope.

DOPPLER'S EFFECT

- Apparent frequency received during relative motion of source and observer
  $\upsilon' = \upsilon\left(1 - \frac{v}{c}\right)$; (red shift)
  $\upsilon' = \upsilon\left(1 + \frac{v}{c}\right)$; (blue shift)
  Doppler shift : $\Delta\upsilon = \pm\frac{v}{c}\times\upsilon$
  $\Delta\lambda = \pm\frac{v}{c}\times\lambda \Rightarrow \lambda' - \lambda = \pm\frac{v}{c}\lambda$



POLARISATION OF LIGHT

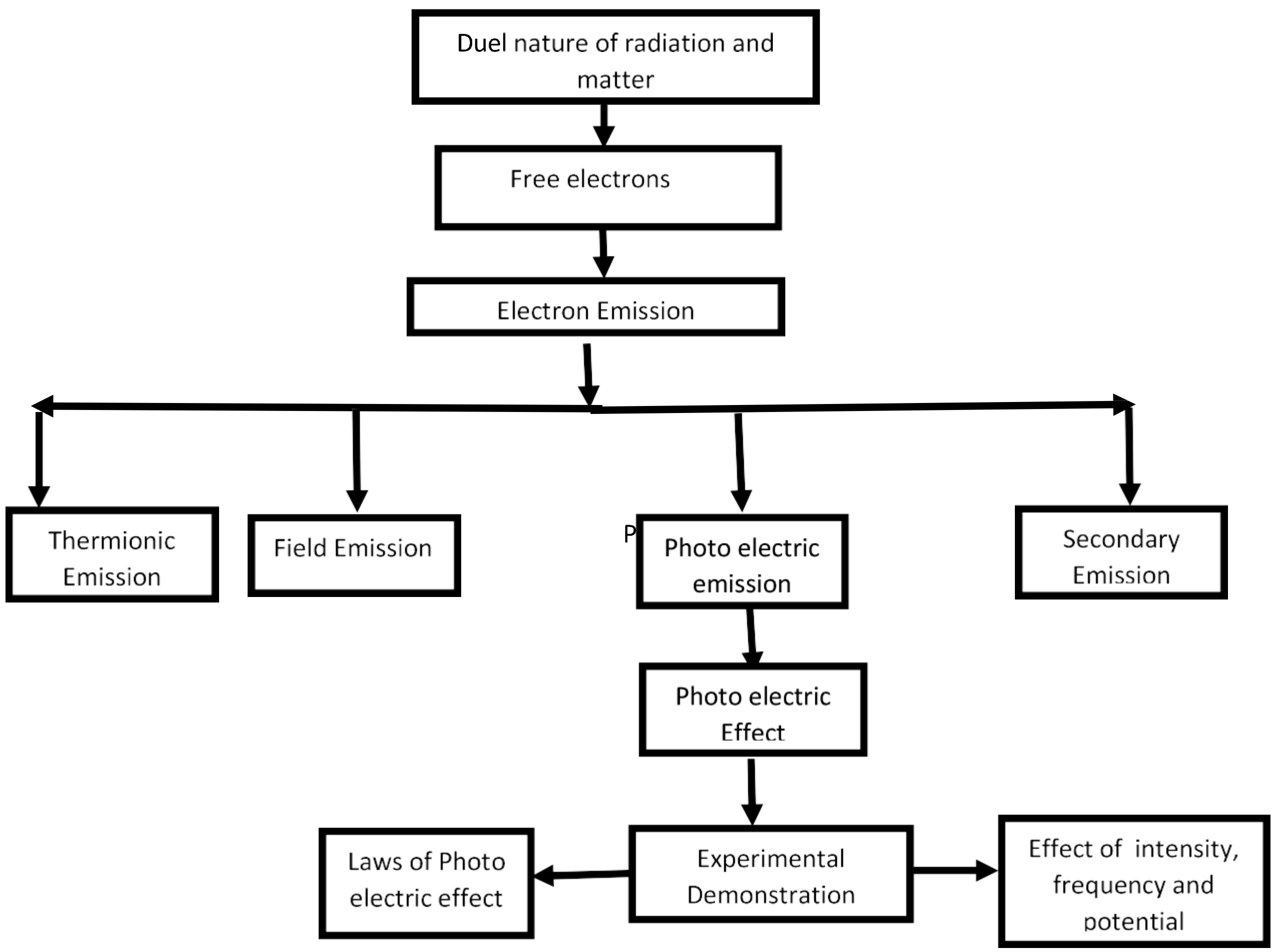
Malus Law: The intensity of transmitted light passed through an analyser is $I = I_0\cos^2\theta$ (θ = angle between transmission directions of polariser and analyser)

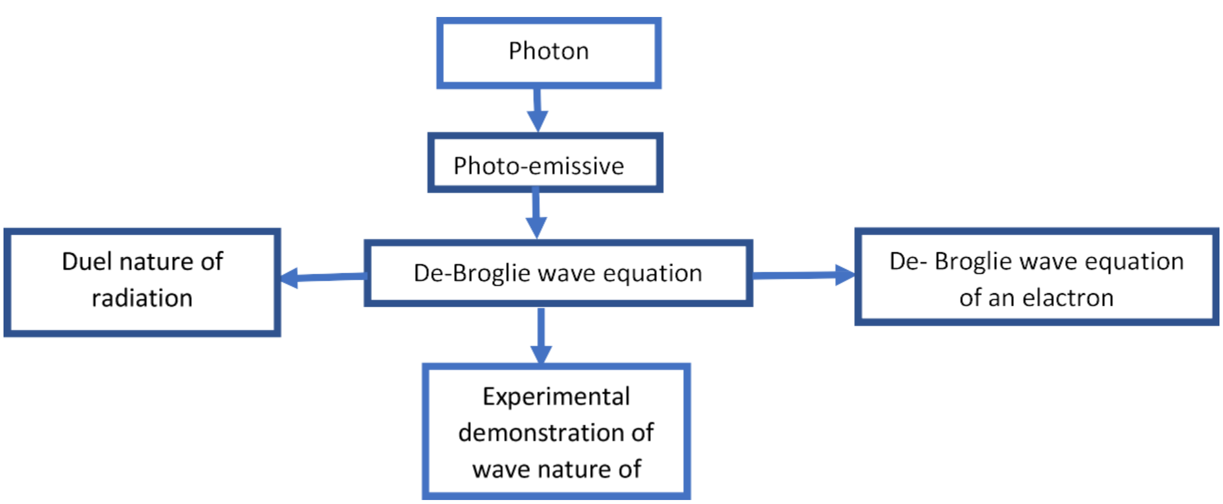
POLARISATION BY REFLECTION

- **Brewster's Law:** The tangent of polarising angle of incidence at which reflected light becomes completely plane polarised is numerically equal to refractive index of the medium
  $\mu = \tan i_p$; i_p = Brewster's angle.
  and $i_p + r_p = 90°$

MIND MAP – DUAL NATURE OF RADIATION AND MATTER

Flow Chart





MASTER CARD
CHAPTER 11 DUAL NATURE OF RADIATION AND MATTER

Photon. It is a packet of energy. A photon of frequency v possesses energy h$\boldsymbol{\nu}$.The rest mass of a photon is zero.

Work function of a metal. The minimum energy, which must be supplied to the electron so that it can just come out of a metal surface, is called the work function of the metal. It is denoted by W

Photoelectric effect. The phenomenon of ejection of electrons from a metal surface, when light of sufficiently high frequency falls on it, is known as photoelectric effect. The electrons so emitted are called photoelectrons.

Threshold frequency. The minimum frequency ($\boldsymbol{\nu_O}$), which the incident light must possess so as to eject photoelectrons from a metal surface, is called threshold frequency of the metal. Mathematically- W = h$\boldsymbol{\nu_O}$

Laws of photoelectric effect. 1. Photoelectric emission takes place from a metal surface, when the frequency of incident light is above its threshold frequency.

2. The photoelectric emission starts as soon as the light is incident on the metal surface.

3. The maximum kinetic energy with which an electron is emitted from a metal surface is independent of the intensity of light and depends upon its frequency.

4. The number of photoelectrons emitted is independent of the frequency of the incident light and depends only upon its intensity.

Cut off potential. It is that minimum value of the negative potential (V_O), which should be applied to the anode in a photo cell so that the photoelectric current becomes zero.

Mathematically- e$\boldsymbol{V_o}$ = $\mathbf{1}$ /$\mathbf{2}$ $\boldsymbol{mv_{max}}^{\mathbf{2}}$ where $\boldsymbol{v_{max}}$ is the maximum velocity with which the photoelectrons are emitted Einstein's photoelectric equation. When light of frequency ν is incident on a metal surface, whose work function is W (i.e. h$\boldsymbol{\nu_O}$), then the maximum kinetic energy ($\mathbf{1}$/ $\mathbf{2}$ $\boldsymbol{mv_{max}}^{\mathbf{2}}$) of the emitted photoelectrons is given by h$\boldsymbol{\nu}$ = $\mathbf{h}\boldsymbol{\nu_O}$ +$\mathbf{1}$/ $\mathbf{2}$ $\boldsymbol{mv_{max}}^{\mathbf{2}}$ e$\boldsymbol{V_O}$ = hc ($\mathbf{1}$ /$\boldsymbol{\lambda}$ – $\mathbf{1}$/ $\boldsymbol{\lambda o}$) It is called Einstein's photoelectric equation. It can explain the laws of photoelectric emission.

Photoelectric cell. A photocell is an arrangement, which produces electric current, when light falls on its cathode. de-Broglie hypothesis. Both radiation and matter have dual nature. A particle of momentum p is associated with de-Broglie wave of wavelength λ = $h\ p = h\ mv$ The above relation is called de-Broglie relation and the wavelength of the wave associated is called de-Broglie wavelength of the particle.

de-Broglie wavelength of electron. An electron of kinetic energy E possesses de-Broglie wavelength, λ = $\boldsymbol{h}$ √$\mathbf{2}\boldsymbol{mE}$ If electron is accelerated through a potential difference V, so as to acquire kinetic energy E (=e V), then λ = $\boldsymbol{h}$ √$\mathbf{2}\boldsymbol{meV}$ = $\mathbf{12.27}$ √$\boldsymbol{V}$ $\boldsymbol{A}$ °

MASTER CARD

Light behaves as particle called photon, it is packet of energy.

E= $h\nu$=h c/ λ= $\frac{1242}{\lambda(\text{nm})}$ eV

Momentum of Photon ($p=h\nu/c= h/\lambda$)

Plank's constant $h=6.626\times10^{-34}$Js

De-Broglie wave equation $\lambda = h/mv = h/p$,

$\lambda = \boldsymbol{h}\ \sqrt{2mE}$

For electron

$\lambda = \mathbf{12.27}/\sqrt{\boldsymbol{V}}$ Å

Threshold frequency. The minimum frequency (ν_0), which the incident light must possess so as to eject photoelectrons from a metal surface

$\phi = W = h\nu_0$

Photoelectric effect takes place for $\nu \geq \nu_0$, $KE_{max}=h(\nu - \nu_0)$

Photon

Photoelectric Effect

Saturation Current:- The maximum value of photoelectric current is called saturation current

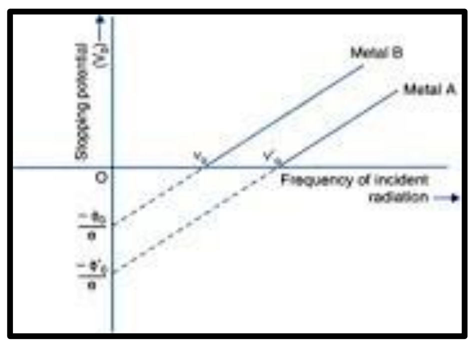
Work Function ϕ :- minimum energy required to exit an electron from metal surface

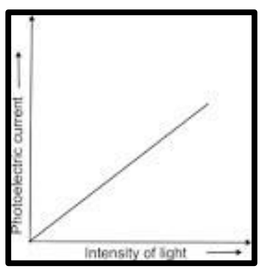
$0 \leq KE \leq h\nu - \phi$

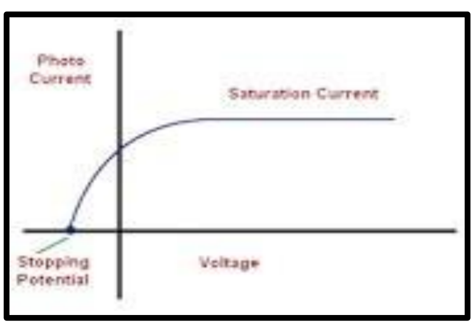
$KE_{max} = h\nu - \phi = eV_0$

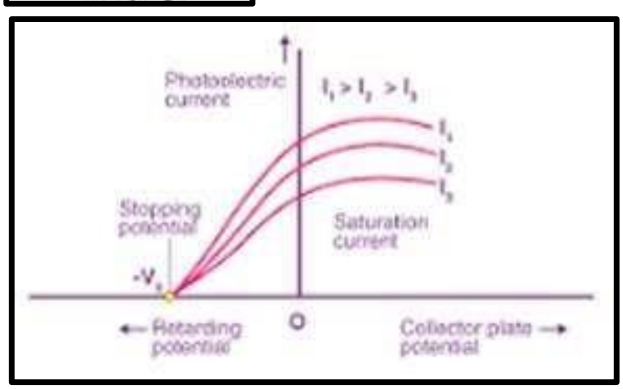
(Einstein's

Stopping Potential V_0:-The value of applied potential at which photoelectric current just stop is called stopping potential

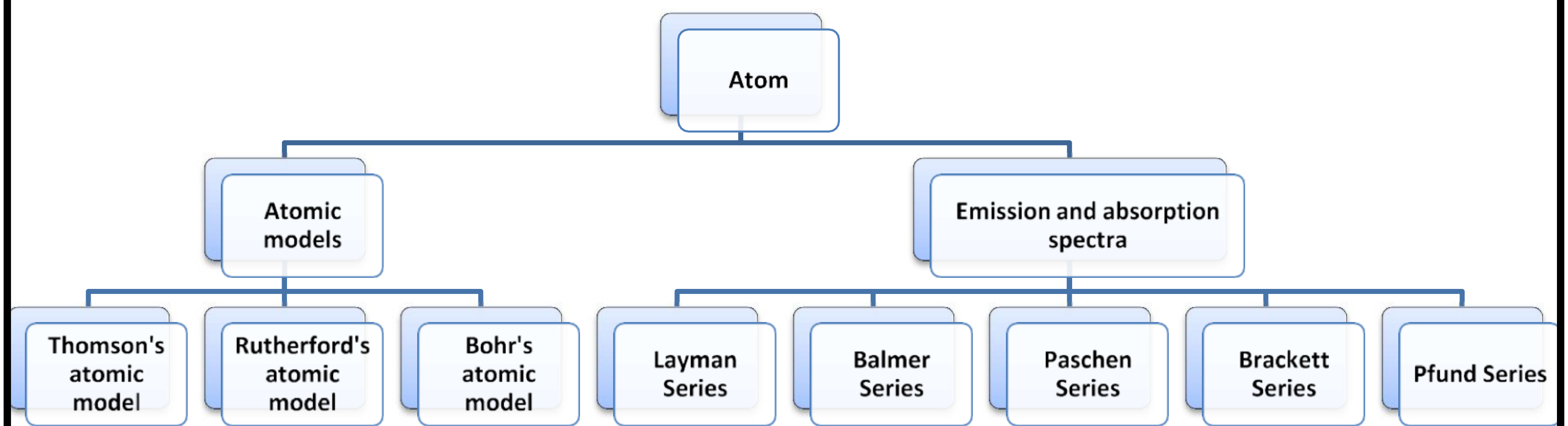








MIND MAP - ATOMS



ATOMS-MASTER CARD

- Radius of orbit $r = \frac{e^2}{4\pi\varepsilon_0 mv^2}$
- Kinetic energy of electron in its orbit $K = \frac{e^2}{4\pi\varepsilon_0 r}$
- Potential energy of an electron $U = -\frac{e^2}{4\pi\varepsilon_0 r}$
- Velocity of electron in its orbit $v = \frac{e}{\sqrt{4\pi\varepsilon_0 mr}}$
- Total energy of an electron in an orbit $E = \frac{e^2}{8\pi\varepsilon_0 r}$

Relation between speed, total energy of an electron and its radius with respect to orbital number n:

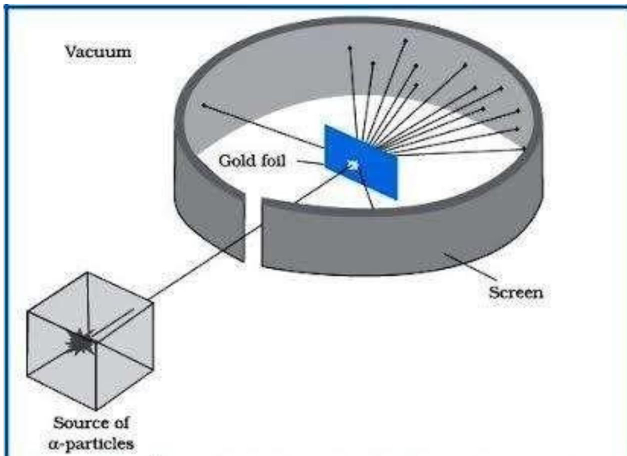
Speed of electron $$v_n = \frac{1}{n}\frac{e^2}{4\pi\epsilon_0}\frac{1}{h/2\pi}$$

Radius of orbit $$r_n = \frac{n^2}{m}\frac{h}{2\pi}\frac{4\pi\varepsilon_0}{e^2}$$

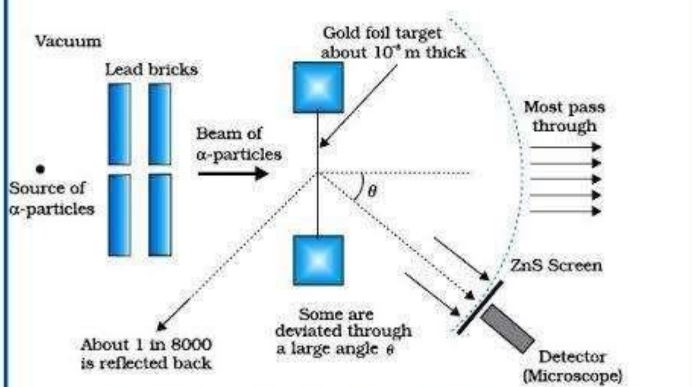
Bohr Radius $(n = 1)$ $$r_1 = a_0 = \frac{h^2\epsilon_0}{\pi me^2} = 0.53\dot{A}$$

Energy for nth orbit electron $$E_n = \frac{-13.6}{n^2}eV$$

Alpha particle scattering Experiment



Geiger-Marsden scattering experiment. The entire apparatus is placed in a vacuum chamber (not shown in this figure).



Schematic arrangement of the Geiger-Marsden experiment.

Source of α-particles -	Radioactive element $^{214}_{83}Bi$
Target	Very thin Gold foil (Almost transparent)
Properties of Gold	Heavy metal and highest malleability
Screen	ZnS

Experimental Observations:	Conclusions:
Most of the α-particles passed roughly in a straight line	Most of the space in the atom is mostly empty
A very small number of α-particles were deflected	Nucleus has all the positive charges and the mass
Force between α-particles and gold nucleus	$F = \frac{1}{4\pi\varepsilon_0}\frac{(2e)(Ze)}{r^2}$

Atomic Spectral Series:

- The atom shows range of spectral lines. Hydrogen is the simplest atom and has the simplest spectrum.
- Balmer Series: Balmer observed the first hydrogen spectral series in visible range of the hydrogen spectrum. It is known as Balmer Series.

The series of spectra for hydrogen were as follows

- Lyman Series : $\frac{1}{\lambda}$=R$\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$ n=2,3,4,5….This is in UV range
- Balmer Series: $\frac{1}{\lambda}$=R$\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ where n=3,4,5… This is in visible range
- Paschen Series: $\frac{1}{\lambda}=R\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$ n=4,5,6….This is in IR range
- Brackett Series: $\frac{1}{\lambda}=R\left[\frac{1}{4^2} - \frac{1}{n^2}\right]$ n=5,6,7….This is in IR range
- Pfund Series: $\frac{1}{\lambda}=R\left[\frac{1}{5^2} - \frac{1}{n^2}\right]$ n=6,7,8….This is in IR range

R is Rydberg's constant. The value of R is $1.097\times10^7 m^{-1}$;

Limitations of Rutherford model:

- **It could not explain the stability of the atom:**.
- **It could not explain the nature of energy spectrum:**

BOHR'S MODEL AND POSTULATES:

- An electron can revolve in certain stable orbits without emission of radiant energy. These orbits are called stationary states of the atom.
- Electron revolves around nucleus only in those orbits for which the angular momentum is the integral multiple of $\frac{h}{2\pi}$, where, h is Planck's constant. Hence, angular momentum,$L = \frac{nh}{2\pi}$
- When an electron makes a transition from one of its specified non-radiating orbit to another of lower energy. When it does so, a photon of energy $h\upsilon$ is radiated having energy equal to energy difference between initial and final state.

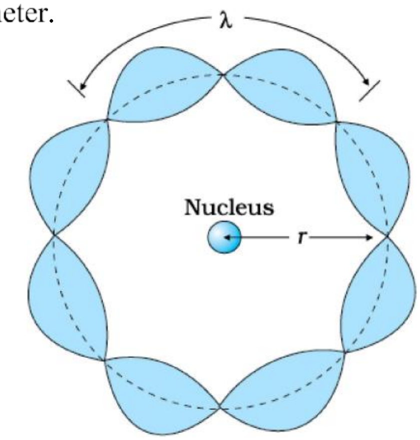
$$h\upsilon = E_i - E_f \text{ (where, } \upsilon \textit{ is frequency)}$$

De-Broglie's explanation of Bohr's second postulate by quantization theory:

- In analogy to waves travelling on a string, particle waves can lead to standing waves under resonant conditions. Resonant condition is $l = 2\pi r$ where, l= perimeter of orbit.

For a hydrogen atom, length of the innermost orbit is its perimeter.

Hence $2\pi r = n\lambda$ ……..(i)



According to de-Broglie's wavelength of electron,

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

Here $p=mv$, Now equation (i) can be written as

$$2\pi r = n\frac{h}{p} = n\frac{h}{mv} ----(ii)$$

Hence, equation (ii) can be reduced as,

$$mvr = n\frac{h}{2\pi} \quad \Rightarrow \quad L = \frac{nh}{2\pi}$$

This is Bohr's second postulate.

Limitation of Bohr's atomic model:

Bohr's model is for hydrogenic atoms. It does not hold true for a multi-electron model

NUCLEI
Master Card

Nucleus

Composition
- Protons
- Neurons

Size of Nucleus
- $R = R_0 A^{1/3}$

\

Nuclear force
- Force among the nucleons inside nucleus

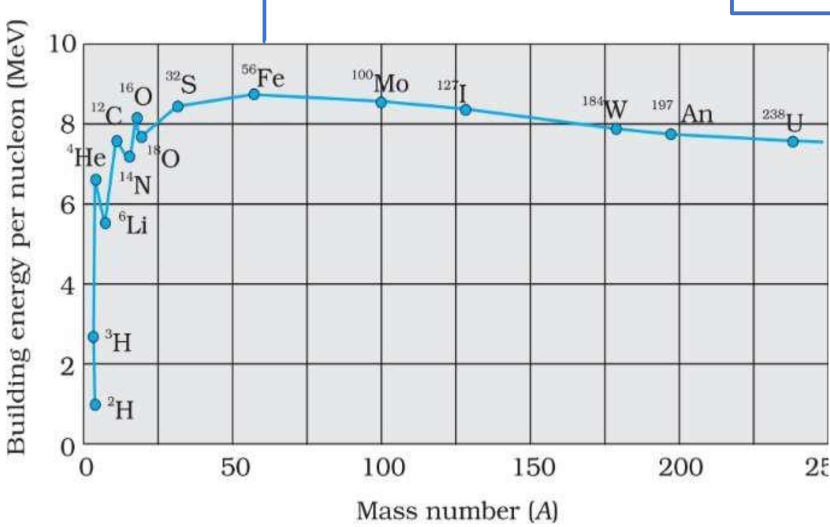
Mass Defect
- ΔM = Theoretical mass – Practical mass
- $\Delta M = [Zm_p + (A - Z) m_n] - M$

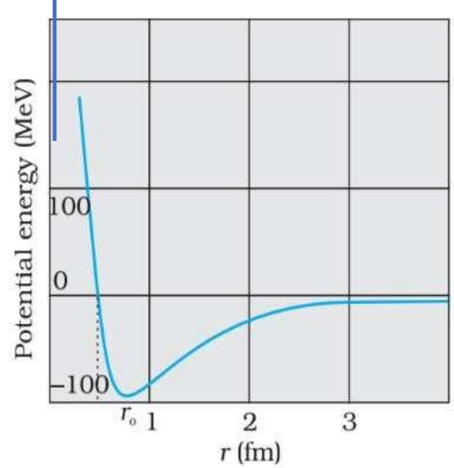
Mass Energy Relation
- $E = mc^2$

Nuclear reactions
- Fission
- Fusion

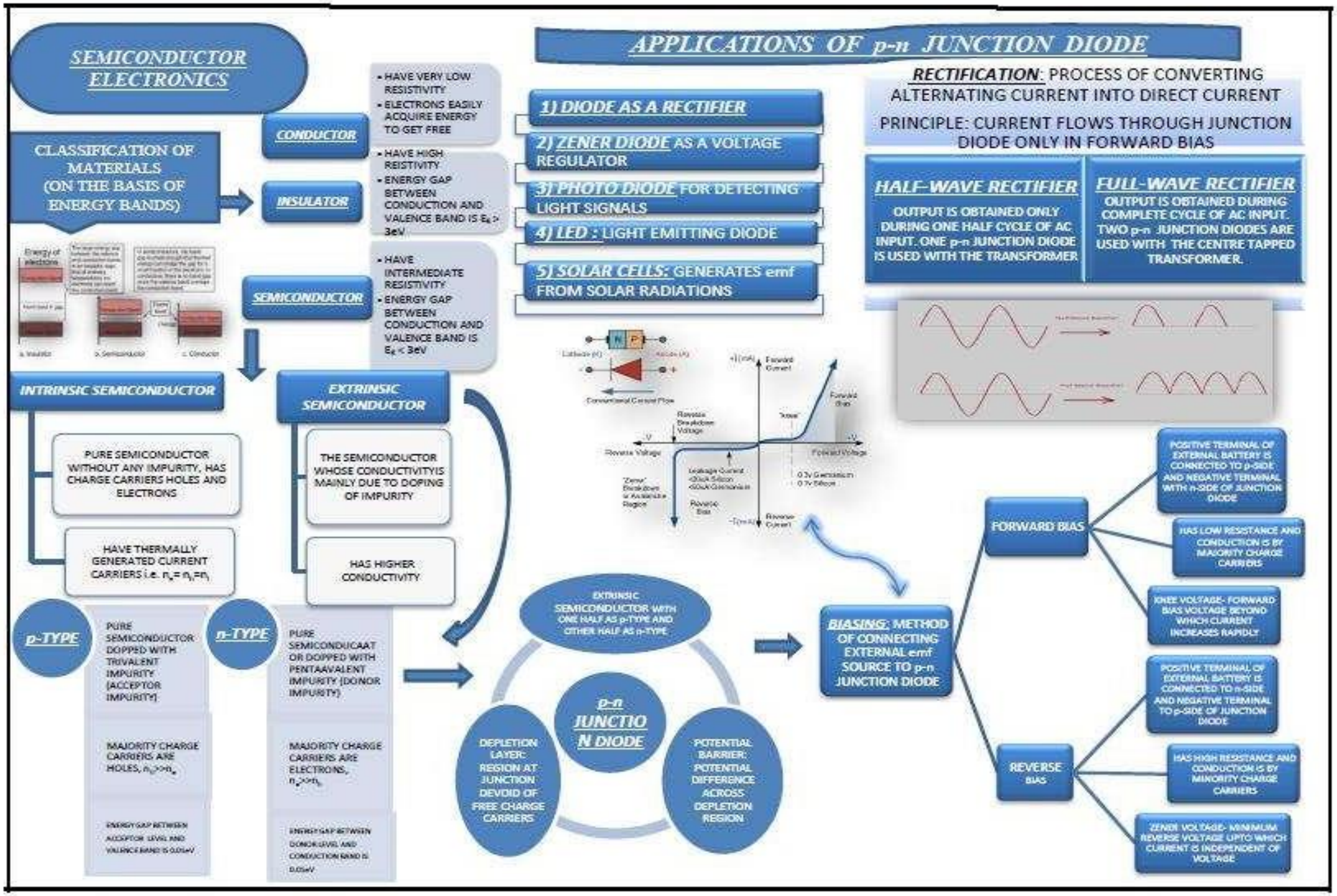
Binding energy
- If a certain number of neutrons and protons are brought together to form a nucleus of a certain charge and mass, an energy E_b will be released in the process. This is called Binding Energy

Important Graphs





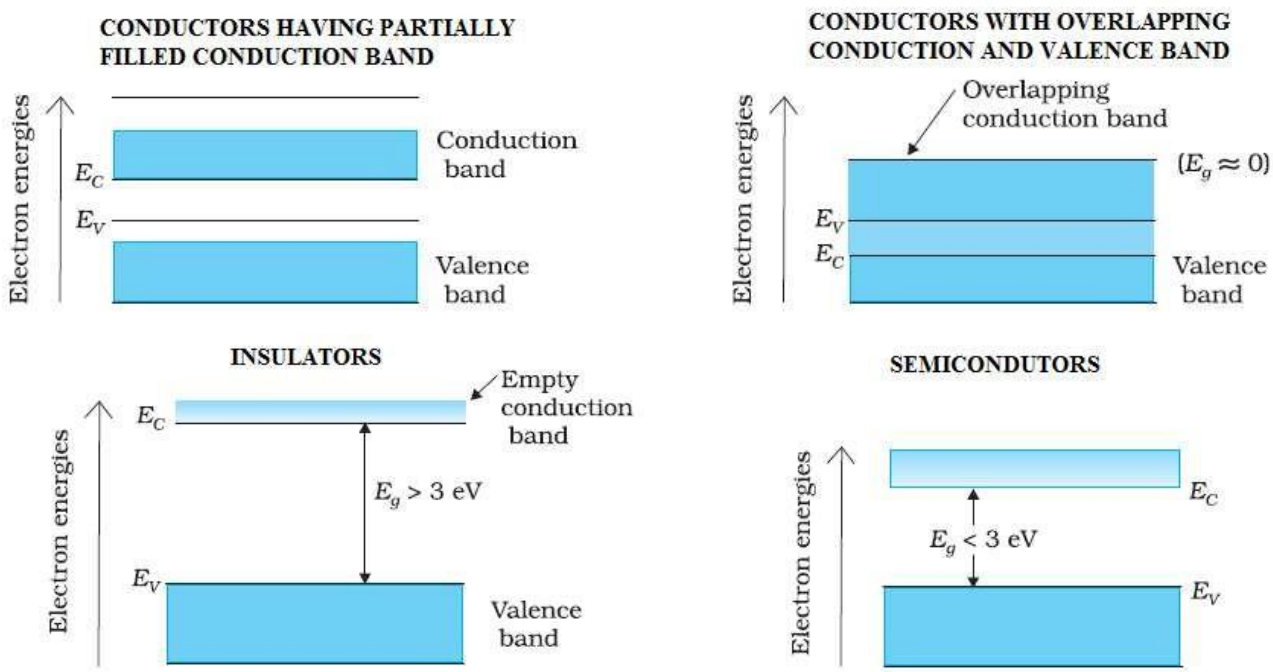
MIND MAP


SEMICONDUCTOR ELECTRONICS
CLASSIFICATION OF MATERIALS (ON THE BASIS OF ENERGY BANDS)
CONDUCTOR
• HAVE VERY LOW RESISTIVITY
• ELECTRONS EASILY ACQUIRE ENERGY TO GET FREE
INSULATOR
• HAVE HIGH REISTIVITY
• ENERGY GAP BETWEEN CONDUCTION AND VALENCE BAND IS E_g > 3eV
SEMICONDUCTOR
• HAVE INTERMEDIATE RESISTIVITY
• ENERGY GAP BETWEEN CONDUCTION AND VALENCE BAND IS E_g < 3eV
INTRINSIC SEMICONDUCTOR
PURE SEMICONDUCTOR WITHOUT ANY IMPURITY, HAS CHARGE CARRIERS HOLES AND ELECTRONS
HAVE THERMALLY GENERATED CURRENT CARRIERS i.e. $n_e = n_h = n_i$
EXTRINSIC SEMICONDUCTOR
THE SEMICONDUCTOR WHOSE CONDUCTIVITYIS MAINLY DUE TO DOPING OF IMPURITY
HAS HIGHER CONDUCTIVITY
p-TYPE
PURE SEMICONDUCTOR DOPPED WITH TRIVALENT IMPURITY (ACCEPTOR IMPURITY)
MAJORITY CHARGE CARRIERS ARE HOLES, $n_h >> n_e$
ENERGY GAP BETWEEN ACCEPTOR LEVEL AND VALENCE BAND IS 0.05eV
n-TYPE
PURE SEMICONDUCAAT OR DOPPED WITH PENTAAVALENT IMPURITY (DONOR IMPURITY)
MAJORITY CHARGE CARRIERS ARE ELECTRONS, $n_e >> n_h$
ENERGY GAP BETWEEN DONOR LEVEL AND CONDUCTION BAND IS 0.05eV
p-n JUNCTION DIODE
EXTRINSIC SEMICONDUCTOR WITH ONE HALF AS p-TYPE AND OTHER HALF AS n-TYPE
DEPLETION LAYER: REGION AT JUNCTION DEVOID OF FREE CHARGE CARRIERS
POTENTIAL BARRIER: POTENTIAL DIFFERENCE ACROSS DEPLETION REGION
BIASING: METHOD OF CONNECTING EXTERNAL emf SOURCE TO p-n JUNCTION DIODE
FORWARD BIAS
POSITIVE TERMINAL OF EXTERNAL BATTERY IS CONNECTED TO p-SIDE AND NEGATIVE TERMINAL WITH n-SIDE OF JUNCTION DIODE
HAS LOW RESISTANCE AND CONDUCTION IS BY MAJORITY CHARGE CARRIERS
KNEE VOLTAGE- FORWARD BIAS VOLTAGE BEYOND WHICH CURRENT INCREASES RAPIDLY
REVERSE BIAS
POSITIVE TERMINAL OF EXTERNAL BATTERY IS CONNECTED TO n-SIDE AND NEGATIVE TERMINAL TO p-SIDE OF JUNCTION DIODE
HAS HIGH RESISTANCE AND CONDUCTION IS BY MINORITY CHARGE CARRIERS
ZENER VOLTAGE- MINIMUM REVERSE VOLTAGE UPTO WHICH CURRENT IS INDEPENDENT OF VOLTAGE
APPLICATIONS OF p-n JUNCTION DIODE
1) DIODE AS A RECTIFIER
2) ZENER DIODE AS A VOLTAGE REGULATOR
3) PHOTO DIODE FOR DETECTING LIGHT SIGNALS
4) LED : LIGHT EMITTING DIODE
5) SOLAR CELLS: GENERATES emf FROM SOLAR RADIATIONS
RECTIFICATION: PROCESS OF CONVERTING ALTERNATING CURRENT INTO DIRECT CURRENT
PRINCIPLE: CURRENT FLOWS THROUGH JUNCTION DIODE ONLY IN FORWARD BIAS
HALF-WAVE RECTIFIER
OUTPUT IS OBTAINED ONLY DURING ONE HALF CYCLE OF AC INPUT. ONE p-n JUNCTION DIODE IS USED WITH THE TRANSFORMER
FULL-WAVE RECTIFIER
OUTPUT IS OBTAINED DURING COMPLETE CYCLE OF AC INPUT. TWO p-n JUNCTION DIODES ARE USED WITH THE CENTRE TAPPED TRANSFORMER.

MASTER CARD

Chapter–14: Semiconductor Electronics: Materials, Devices and Simple Circuits

- VALANCE BAND : The energy band containing valance electrons.
- CONDUCTION BAND The lowest unfilled energy level just above the valance band
- **FORBIDDEN GAP** Energy gap between valance band and conduction band..



INTRINSIC SEMICONDUCTORS: A pure semiconductor.

Examples: Si: $1s^2$, $2s^2$, $2p^6$,$3s^2$, $3p^2$. (Atomic No. is 14) and The energy gap in Si is 1.1 eV

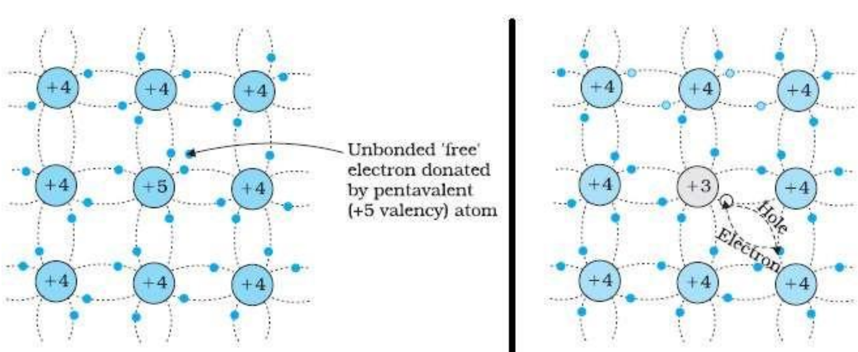
Ge: $1s^2$, $2s^2$, $2p^6$,$3s^2$, $3p^6$, $3d^{10}$, $4s^2$, $4p^2$. (Atomic No. is 32) and energy gap in Si is 1.1 eV

MNEMONICS-TO REMEMBER NAMES OF IMPURITIES IN SEMICONDUCTORS

BIG PAA - Boron, **I**ndium, **G**allium **(all three are trivalent impurities)**

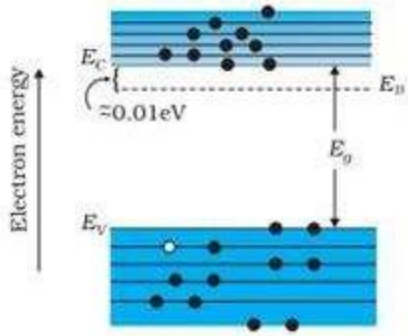
Phosphorus**, A**ntimony**, A**rsenic **(all three are pentavalent impurities)**

ENERGY BAND DIAGRAMS IN EXTRINSIC SEMICONDUCTORS

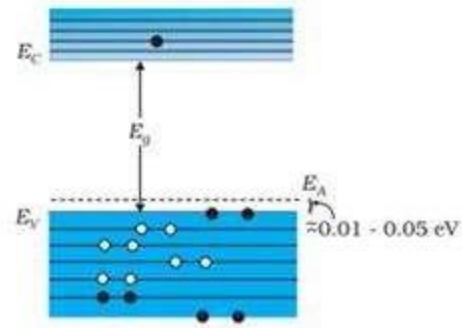


n-type semiconductor   p-type semiconductor

1) n-TYPE SEMICONDUCTOR



2) p-TYPE SEMICONDUCTOR



Electrical conductivity of a semiconductor:

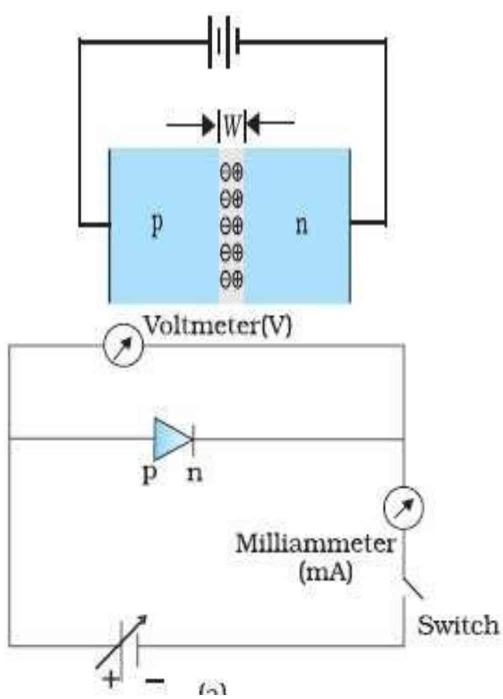
The conductivity of a semiconductor is determined by the mobility (μ) of both electrons and holes and their concentration. Mathematically- $\sigma = e\,(n_e\mu_e + n_h\,\mu_h)$.

P-N JUNCTION.

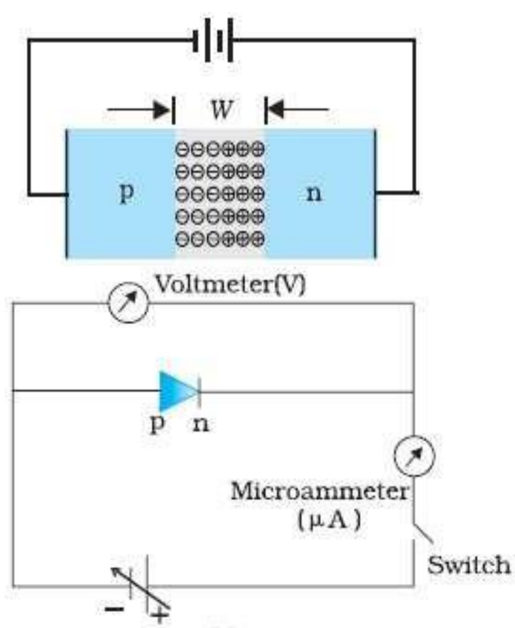
Depletion layer. It is a thin layer formed between the p and n-sections and devoid of holes and electrons. Its width is about 10^{-8} m. A potential difference of about 0.7 V is produced across the junction, which gives rise to a very high electric field (= 10^6 V/ m).

Potential Barrier: The difference in potential between p and n regions across the junction makes it difficult for the holes and electrons to move across the junction. This acts as a barrier and hence called 'potential barrier'. **Potential barrier for Si is nearly 0.7 V and for Ge is 0.3 V. The potential barrier opposes the motion of the majority carriers.**

Forward biasing:

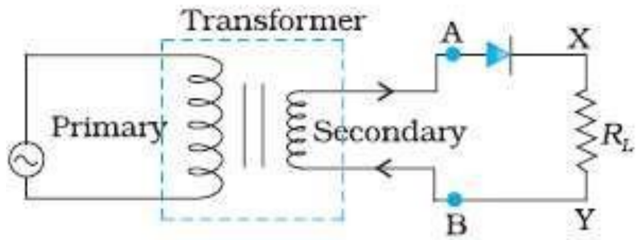


Reverse biasing:

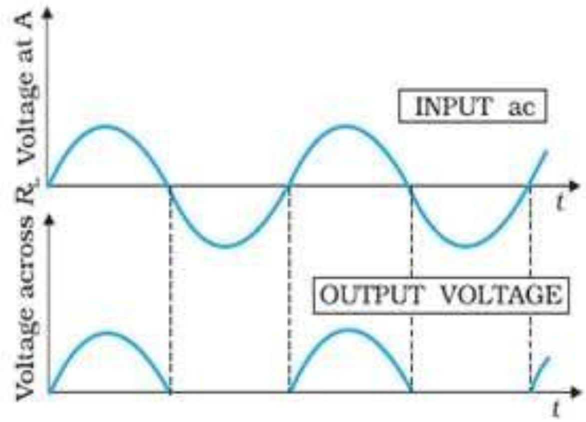


Junction diode as rectifier:

1. **Half wave rectifier:** A rectifier, which rectifies only one half of each a.c. input supply cycle, is called a half wave rectifier. A half wave rectifier gives discontinuous and pulsating d.c. output. As alternative half cycles of the a.c. input supply go waste, its efficiency is very low.

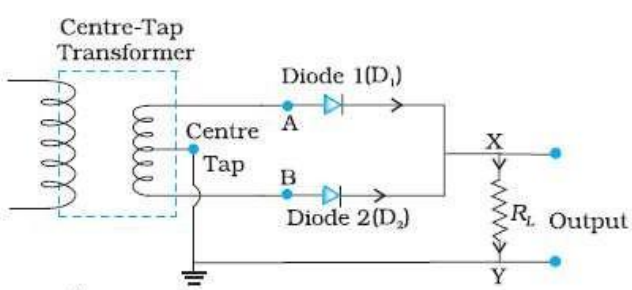


Circuit Diagram

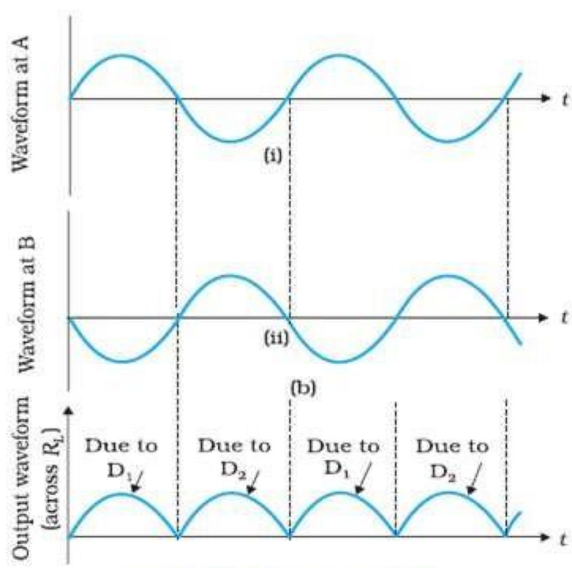


Input- Output Waveform

2. **Full wave rectifier:** A rectifier which rectifies both halves of each a.c. input cycle is called a full wave rectifier. The output of a full wave rectifier is continuous but pulsating in nature. However, it can be made smooth by using a filter circuit.



Circuit Diagram

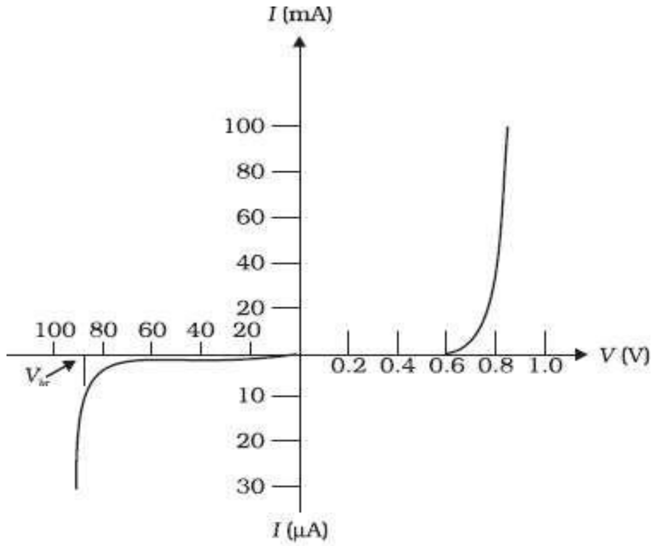


Input- Output Waveform

GRAPHS

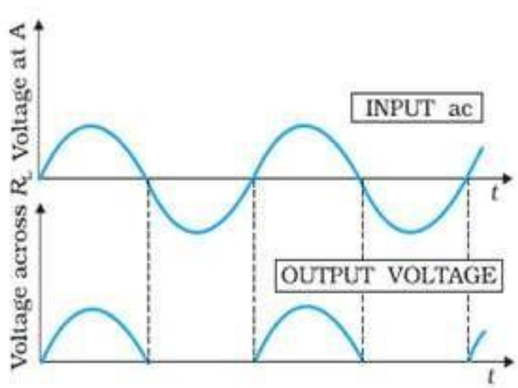
1) I -V CHARACTERISTICS:

Forward Bias & Reverse Bias Characteristics of a P-N Junction Diode

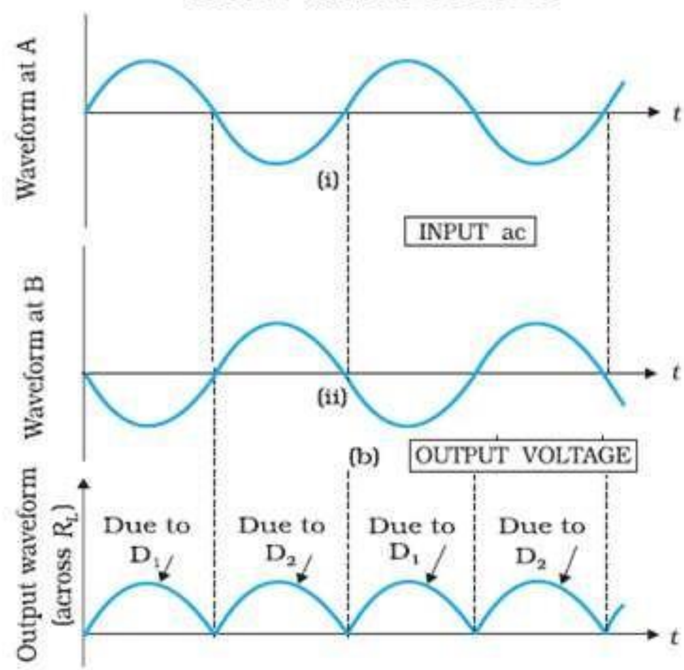


2) INPUT AND OUTPUT VOLTAGE GRAPHS OF

A HALF WAVE RECTIFIER



A FULL WAVE RECTIFIER



TABLES

1) DIFFERENCE BETWEEN INTRINSIC AND EXTRINSIC SEMICONDUCTORS

S.NO	INRINSIC SEMICONDUCTOR	EXTRINSIC SEMICONDUCTOR
1	Pure form of semiconductor.	Impure form of semiconductor.
2	Conductivity is low	Conductivity is higher than intrinsic semiconductor.
3	The no of holes is equal to no of free electrons	In n-type, the no. of electrons is greater than that of the holes and in p-type, the no. holes is greater than that of the electrons.
4	The conduction depends on temperature.	The conduction depends on the concentration of doped impurity and temperature.

2) DIFFERENCE BETWEEN HALF WAVE AND FULL WAVE RECTIFIER

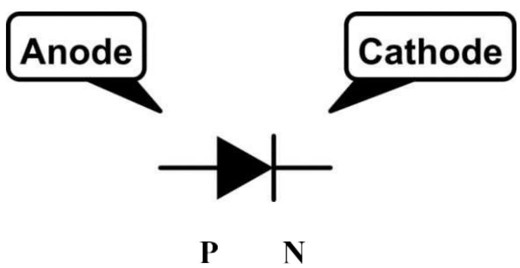
S.NO	HALF WAVE RECTIFIER	FULL WAVE RECTIFIER
1	Only half cycle of AC is rectified.	Both cycles of AC are rectified.
2	Requires only one diode	Requires two diodes.
3	The output frequency is equal to input supply frequency. (F)	The output frequency is double of the input supply frequency. (2F)
4	The electric current through the load is not continuous	A continuous electric current flow through the load.

FORMULAE

1) Electron and hole concentration in a semiconductor in thermal equilibrium
   $n_e n_h = n_i^2$
2) Resistance of a Diode:
   a) Static or DC Resistance $R_{dc} = V/I$
   b) Dynamic or AC Resistance

   $R_{a.c} = \Delta V / \Delta I$

1) **TO REMEMBER THE P AND N SECTIONS OF A DIODE.**
   The arrow in the schematic symbol for diodes points in the direction of Conventional (positive) current flow.



2) Current is **unidirectional** in a diode**. It flows from anode to cathode only.** To remember this, remember the mnemonics **'ACID' (ANODE CURRENT IN DIODE)**