ON TIPS NOTES

Note making is a skill that we use in many walks of life : at school, university and in the world of work. However, accurate note making requires a thorough understanding of concepts. We, at Oswaal, have tried to encapsulate all the chapters from the given syllabus into the following **ON TIPS NOTES**. These notes will not only facilitate a better understanding of concepts, but will also ensure that each and every concept is taken up and every chapter, is covered in totality. So go ahead and use these to your advantage... go get the **OSWAAL ADVANTAGE !!**

Unit-I : Electrostatics

CHAPTER 1 : Electric Charges and Fields

UNITS AND DIMENSIONS

Physical Quantity	Symbol	Dimension	Unit
Vector area elements	$\overrightarrow{\Delta s}$	$[L^2]$	m^2
Electric field	$\overrightarrow{E}$	$[MLT^{-3}A^{-1}]$	V/m Or NC^{-1}
Electric flux	ϕ	$[ML^3T^{-3}A^{-1}]$	Vm
Dipole moment	$\overrightarrow{p}$	$[LTA]$	Cm
Linear Charge density	λ	$[L^{-1}TA]$	Cm^{-1}
Surface Charge density	σ	$[L^{-2}TA]$	Cm^{-2}
Volume Charge density	ρ	$[L^{-3}TA]$	Cm^{-3}

IMPORTANT RESULTS AND FORMULAE

1. Charges developed on bodies, when they are rubbed against each other are called as frictional charges.

2. The charge on a body is expressed as $q = \pm ne$, where n is an integer (*i.e.*, no. of electrons present on the body) and e is the charge on the electron. Charge is additive in nature & always conserved. The charge on electron is $e^- = -1.6 \times 10^{-19}$ C and charge on proton is $e^+ = +1.6 \times 10^{-19}$ C.

3. Total positive or negative charge on an object of mass m having mass number A and atomic number Z, is given as :
$$q = \frac{m\text{N}}{\text{A}} \times \text{Z}$$
Here, N = 6.02×10^{23}, Avogadro number.

4. When two charges q and q_0 separated by a distance r, the electrostatic force experienced by them is given as : F = $\dfrac{1}{4\pi\varepsilon_0} . \dfrac{qq_0}{r^2}$. This is Coulomb's law.

5. $\frac{1}{4\pi\varepsilon_0} \cong 9 \times 10^9 \ Nm^2 \ C^{-2}$, ε_0 has a value of $8.85 \times 10^{-12} \ C^2/Nm^2$ and is a natural constant known as permittivity of free space.

6. The electric field strength due to a point source charge q at an observation point A at a distance r from the source charge is given by :

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2} \hat{r} \ .$$

The unit of electric field is NC^{-1}.

7. If a test charge q_0 is placed at a point where electric field is $\vec{E}$, then force on the test charge is $\vec{F} = q_0 \vec{E}$.

8. The product of the magnitude of the either charge (q) of the dipole and the separation (l) between the charges is called electric dipole moment (p_e), *i.e.*, $p_e = ql$, l = distance (from $-q$ to $+q$).

9. Electric field due to a short dipole at any point, making angle θ with the axial line is given by :

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \times \frac{\vec{p}_e}{r^3}(1+3\cos^2\theta)^{1/2} \ = \ \frac{\vec{p}_e}{4\pi\varepsilon_o r^3}\sqrt{1+3\cos^2\theta}$$

10. For a short dipole, we have $r >> l$, the electric field on the axial line is $\vec{E}_a = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2\vec{p}_e}{r^3}$.

11. For a short dipole, we have $r >> l$, the electric field on the equatorial line is $\vec{E}_e = \frac{1}{4\pi\varepsilon_0} \cdot \frac{\vec{p}_e}{r^3}$

12. Electric field due to circular loop of charge,

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qx}{(a^2+x^2)^{3/2}}$$

if $x >> a$ then, $\quad E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{x^2}$

13. **(a)** A dipole of moment $\vec{p}_e$ in electric field $\vec{E}$, experiences a torque given by : $\vec{\tau} = \vec{p}_e \times \vec{E}$ or $\tau = p_e E \sin\theta$.

    (b) The torque is minimum for $\theta = 0°$ or $180°$. *i.e*, $\tau_{min} = 0$, when $\theta = 0°$ or $180°$. In this position, the dipole is said to be in equilibrium.

    (c) The equilibrium of the dipole is stable for $\theta = 0°$ and it is unstable for $\theta = 180°$.

    (d) The torque is maximum for $\theta = 90°$, *i.e.*, we find $\tau_{max} = p_e E$, when $\theta = 90°$.

    (e) As θ increases from $0°$ to $180°$, τ first increases, becomes maximum and then decreases to zero.

14. The electrostatic potential energy of a dipole of moment $\vec{p}_e$ in uniform electric field $\vec{E}$ is :

    $U_p = -\vec{p}_e . \vec{E} = -p_e E \cos\theta$

    (i) For $\theta = 0°$ we have $U_p = -p_e E$.

    It is the minimum value of the potential energy and the dipole is in stable equilibrium.

    (ii) For $\theta = 90°$, we have $U_p = 0$.

    The dipole is in unstable equilibrium.

    (iii) For $\theta = 180°$, we have $U_p = p_e E$. (Max)

15. The flux ϕ of electric field E through a small area element Δs is given by $\Delta\phi = \vec{E}.\Delta\vec{s}$,

    where $\Delta \vec{s}$ is vector area element. S.I. unit of flux is $Nm^2 \ C^{-1}$.

16. **Gauss's Theorem :** The total electric flux through a closed surface enclosing a charge is equal to $1/\varepsilon_0$ times the charge enclosed.

Mathematically, $\phi_E = \oint \vec{E}.\vec{ds} = \dfrac{q}{\varepsilon_0}$.

17. **Applications of Gauss's Theorem**

Electric field :

(a) Due to an infinitely long straight uniformly charged wire ; $\vec{E} = \dfrac{\lambda}{2\pi\varepsilon_0 r}\hat{n}$.

(b) Due to uniformly charged infinite plane sheet ; $\vec{E} = \dfrac{\sigma}{2\varepsilon_0}\hat{n}$.

**IMPORTANT FIGURES**

Electric Field Lines :

1. In case of Isolated point charges :
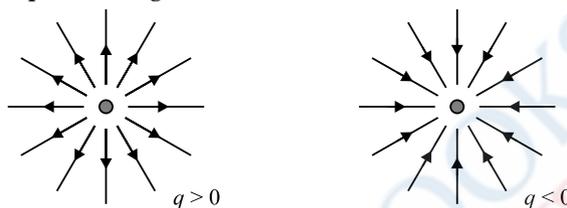
2. In case of a system of two charges :
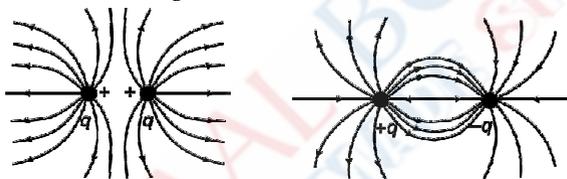
Equipotential Surfaces due to a Dipole :
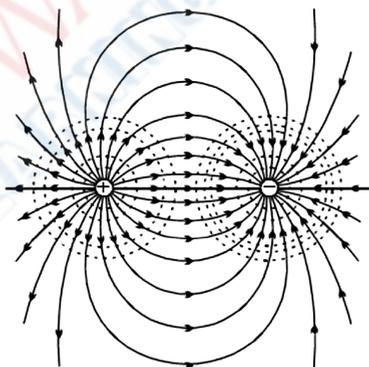
CHAPTER 2 : Electrostatic Potential and Capacitance

UNITS AND DIMENSIONS

Physical quantity	Symbol	Dimension	Unit
Electrical Potential	V	$[ML^2T^{-3}A^{-1}]$	V
Capacitance	C	$[M^{-1}L^{-2}T^4A^2]$	F
Polarisation density	P	$[L^{-2}AT]$	Cm^{-2}
Dielectric constant	K	[Dimensionless]	

IMPORTANT RESULTS AND FORMULAE

1. Electric potential due to a point source charge q at a distance r from it is given by :

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

Unit : $1\ V = 1\ JC^{-1}$

2. The electric field at a point is related to the negative potential gradient as follows :

$$\vec{E} = -\left(\frac{dV}{dr}\right)$$

Unit : Vm^{-1}

(i) Electric potential due to a dipole at a point at distance r and making angle θ with the dipole moment p_e is given by :

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

(ii) On the axial line, the electric potential is given by :

$$V_a = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p_e}{r^2}$$

(iii) On the equatorial line, the electric potential is : $V_e = 0$

3. Electric potential due to an isolated conducting charged sphere of radius R carrying charge Q :

(a) The electric potential at the surface of the sphere and at every point inside the sphere is :

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

(b) The electric potential at a point outside the sphere is

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

where $r > R$ is the distance of the point from the centre of the sphere.

4. Potential energy of system of two point charges : $U = \dfrac{1}{4\pi\varepsilon_0} \cdot \dfrac{q_1 q_2}{r_{12}}$.

5. The ratio of the charge q and potential V of a conductor is called capacitance (C).

$$C = \frac{q}{V}$$

Unit : 1 Farad = 1 coulomb/volt

6. (a) Electrostatic potential energy of a conductor carrying charge q, capacitance C and potential V, is given by :

$$U_p = \int_0^q V dq = \int_0^q \frac{q}{C} dq = \frac{1}{2}\frac{q^2}{C}$$

(b) Since, $\quad q = VC$,

$$\therefore \quad U_p = \frac{1}{2}V^2 C \Rightarrow U_p = \frac{1}{2}qV.$$

7. If a number of capacitors of capacitances C_1, C_2, C_3 .... are connected in series, their equivalent capacitance is given by :

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\ldots\ldots\ldots$$

8. If a number of capacitors of capacitances C_1, C_2, C_3 .... C_n are connected in parallel, then their equivalent capacitance is given by :

$$C_p = C_1 + C_2 + C_3 + ... + C_n$$

9. Let a parallel plate capacitor consists of two plates of area 'A', separated by distance 'd', having slab of same thickness and area with dielectric constant 'K' between the plates. Then the capacitance of the capacitor is given by :

$$C = \frac{K\varepsilon_0 A}{d}$$

10. (i) If we have a number of slabs of same area as the plates of the capacitor with thickness $t_1, t_2, t_3,....$ and dielectric constants $K_1, K_2, K_3 ......$ inserted between the plates, the capacitance of the capacitor is given by :

$$C = \frac{\varepsilon_0 A}{\dfrac{t_1}{K_1} + \dfrac{t_2}{K_2} + \dfrac{t_3}{K_3} + ...}$$

(ii) If a single slab of thickness 't' and dielectric constant 'K' is introduced between the plates having separation 'd' then the capacitance of the capacitor is given by :

$$C = \frac{\varepsilon_0 A}{\dfrac{t}{K} + \dfrac{(d-t)}{1}} = \frac{K\varepsilon_0 A}{K(d-t)+t}$$

(iii) If a single slab of conductor of thickness 't' is introduced between the plates, having separation 'd' then the capacitance of the capacitors is given by :

$$C = \frac{\varepsilon_0 A}{\dfrac{t}{\infty} + \dfrac{(d-t)}{1}} = \frac{\varepsilon_0 A}{d-t}$$

Unit-II : Current Electricity

CHAPTER 3 : Current Electricity

UNITS AND DIMENSIONS

Physical Quantity	Symbol	Dimension	Unit
Electric current	I	$[A]$	A
Charge	Q, q	$[TA]$	C
Electric voltage	V	$[ML^2T^{-3}A^{-1}]$	V
Potential difference	V	$[ML^2T^{-3}A^{-1}]$	V
Electromotive force	E	$[ML^2T^{-3}A^{-1}]$	V
Resistance	R	$[ML^2T^{-3}A^{-2}]$	Ω
Resistivity	ρ	$[ML^3T^{-3}A^{-2}]$	Ωm
Electrical conductivity	σ	$[M^{-1}L^{-3}T^3A^2]$	(ohm^{-1}m^{-1}) or, Sm^{-1}

Electric field	E	$[MLT^{-3}A^{-1}]$	s
Drift velocity	v_α	$[LT^{-1}]$	Am^{-2}
Relaxation time	τ	$[T]$	$m^2V^{-1}s^{-1}$
Current density	$\vec{J}$	$[L^{-2}A]$	Vm^{-1}
Mobility	μ	$[M^{-1}T^2A]$	ms^{-1}

IMPORTANT RESULTS AND FORMULAE

1. **Electric current :** Electric current is defined as the rate of flow of charge, *i.e.,*

$$I = \frac{dq}{dt}$$

When charge flows at a constant rate, the corresponding electric current can be written as :

$$I = \frac{q}{t}$$

Unit : 1 Ampere = 1 coulomb second^{-1}

2. When electric current is set up in a conductor, the electrons drift through the conductor with velocity v_d, which is drift velocity and is given by :

$$v_d = \frac{I}{neA}$$

3. **Ohm's law :** Current I in a conductor is directly proportional to the potential difference V applied across the ends of the conductor provided the physical conditions such as the temperature, mechanical strain, etc. remain unchanged.

$$I \propto V$$

or $$V = RI$$

where, R is a constant called resistance of the conductor.

4. **Resistance :**

$$R = \rho\frac{l}{A}$$

5. **Resistivity :** $\rho = \dfrac{m}{ne^2\tau}$

6. **Conductivity :** Reciprocal of resistivity

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

Unit = ohm^{-1}, or siemens m^{-1}

7. The temperature coefficient for conductors is positive *i.e.,* resistance increases as the temperature rises.

The temperature coefficient for the insulators and semiconductors is negative *i.e.,* their resistance decreases as the temperature increases.

8. The internal resistance of a cell is

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

9. **Electrical power :**

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

Unit : Watt

10. **The emf and terminal potential difference of a cell :** Let the emf of a cell is 'E' and its internal resistance is r. If an external resistance R is connected across the cell through a key, then IR = V = potential difference across the external resistance R. This is equal to the terminal potential difference across the cell.

$$E = V + Ir$$

$$\Rightarrow \qquad I = \frac{E - V}{r}$$

So, $\qquad V = E - Ir$

$\therefore \qquad V < E.$

When current is drawn from a cell, its terminal potential difference is less than the emf.

11. **Series Combination of Cells :**

In n cells having internal resistance r and emf E for each.

$$I_S = \frac{nE}{R + nr}$$

12. **Parallel Combination of Cells :**

If n cells having internal resistances $r_1, r_2, r_3 \dots r_n$ & of emf $E_1, E_2, E_3 \dots E_n$ respectively.

$$I_P = \frac{\dfrac{E_1}{r_1} + \dfrac{E_2}{r_2} + \dfrac{E_3}{r_3} + \dots \dfrac{E_n}{r_n}}{1 + R\left(\dfrac{1}{r_1} + \dfrac{1}{r_2} + \dfrac{1}{r_3} + \dots \dfrac{1}{r_n} \right)}$$

13. **Mixed Combination of Cells :**

Here nm cells are combined in m rows, each row having n cells such that

$$I_m = \frac{nE}{R + \dfrac{nr}{m}} = \frac{mnE}{mR + nr}$$

14. **Kirchhoff's Laws :**

First law : The algebraic sum of current at a junction is zero *i.e.*, $\Sigma I = 0$. This implies that the total current entering a junction is equal to the total current leaving the junction.

Second law : In a closed loop, the algebraic sum of the emf's is equal to the algebraic sum of the product of resistance and the respective current flowing through them *i.e.*,

$$\Sigma E = \Sigma IR.$$

15. **Wheatstone Bridge :** This is a circuit consisting of four resistances P, Q, R and S, a galvanometer and a battery connected as follows :
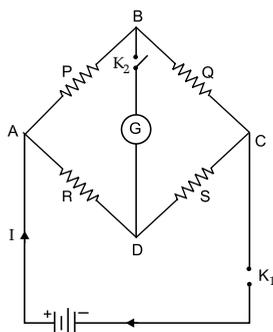

The Wheatstone bridge is balanced when there is no current flow through the galvanometer. It means potential at B is equal to that at D. In such a case

$$\frac{P}{Q} = \frac{R}{S}$$

16. **Slide Wire Bridge or Meter Bridge :** It measures unknown resistance. It works on principle of Wheatstone bridge.

IMPORTANT FIGURES

Meter Bridge :
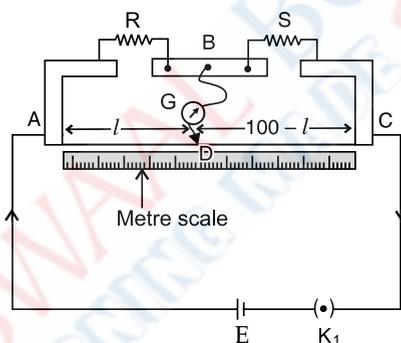
Potentiometer Setup for Comparison of emf's of two cells :
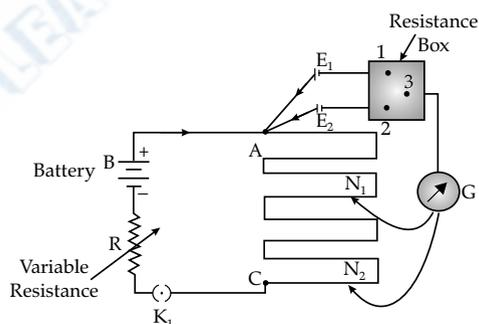
Potentiometer Setup for Evaluation of Internal Resistance of a cell :
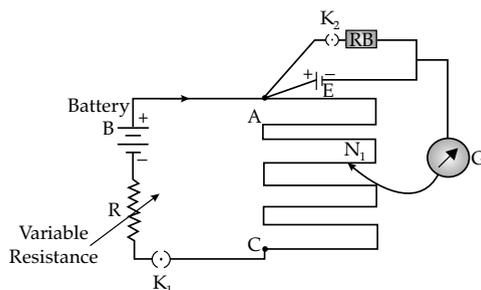
Unit-III : Magnetic effects of current and magnetism
CHAPTER 4 : Moving Charges and Magnetism

UNITS AND DIMENSIONS

Physical Quantity	Symbol	Nature	Dimension	Units
Permeability of free space	μ_0	Scalar	$[MLT^{-2}A^{-2}]$	TmA^{-1}
Magnetic field	$\vec{B}$	Vector	$[MT^{-2}A^{-1}]$	T(tesla)
Magnetic moment	$\vec{m}$	Vector	$[L^2A]$	Am^2 or J/T
Torsion constant	k	Scalar	$[ML^2T^{-2}]$	$Nmrad^{-1}$

IMPORTANT RESULTS AND FORMULAE

1. **Force :** When a test charge q_0 enters a magnetic field $\vec{B}$ directed along the negative Z-axis with a velocity $\vec{v}$ making an angle ϕ with the Z-axis, then

$$\vec{F}_m = q_0(\vec{v} \times \vec{B})$$

$F_{mx} = q_0 v_y B$, $F_{my} = q_0 v_x B$ and $F_{mz} = 0$

2. Force on a current carrying conductor in a magnetic field $\vec{B}$ is $\vec{F}_m = I(\vec{l} \times \vec{B})$, where I is the current, l is the length of conductor and $\vec{l}$ is along the direction of current.

3. Force between current elements :

$$d\vec{F}_{m_{12}} = \frac{\mu_0}{4\pi} \cdot \frac{I_2 d\vec{l_2} \times (I_1 d\vec{l_1} \times \vec{r_{12}})}{r_{12}^3}$$

here, force is on $I_2 d\vec{l_2}$ due to $I_1 d\vec{l_1}$.

4. Force per unit length between infinitely long straight current carrying conductor is :

$$F_m/l = \frac{\mu_0}{4\pi} \cdot \frac{2I_1 I_2}{r}$$

where, F_m/l is the force per unit length.

5. **Lorentz force :** $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$

6. Torque on a magnetic dipole moment $\vec{p}_m$ due to a magnetic field $\vec{B}$ is $\vec{\tau} = \vec{p}_m \times \vec{B}$.

7. Magnetic field due to a straight conductor carrying current I and at a distance 'a' from the conductor is

$$B = \frac{\mu_0}{4\pi} \cdot \frac{I}{a}[\sin\phi_2 + \sin\phi_1]$$

8. Magnetic field due to infinite straight conductor at a distance a from it,

$$B = \frac{\mu_0}{4\pi} \times \frac{2I}{a}$$

9. Magnetic field on the axis of a current (I) carrying coil of turns n, radius R and at a distance x from the centre of the coil is

$$B = \frac{\mu_0}{4\pi} \cdot \frac{In.2\pi R^2}{(R^2 + x^2)^{3/2}}$$

$$\text{and } B_{(centre)} = \frac{\mu_0}{4\pi} \cdot \frac{n.2\pi I}{R}$$

$$B_{(far\ away)} = \frac{\mu_0}{4\pi} \cdot \frac{n.2\pi IR^2}{x^3}$$

10. **Ampere's Circuital law :** The line integral of the magnetic field around a closed path is μ_0 times the total current enclosed by the path and is given as :

$$\oint \vec{B}.d\vec{l} = \mu_0 I.$$

11. The magnetic field due to a straight solenoid well within it and on the axis is given by :

$$B = \mu_0 nI,$$

where, n = number of turns per unit length and I is the current in the coil.

12. Maximum energy by positive ions :

$$E_{max} = \frac{1}{2} \cdot \frac{B^2 q^2 R^2}{m}$$

13. **Biot Savart's law :** The magnetic field due to a current element is given by the following relation :

$$\vec{B} = \frac{\mu_0}{4\pi} \cdot \frac{I\vec{dl} \times \hat{r}}{r^2}$$

   (a) If θ be the angle between $I\vec{dl}$ and $\hat{r}$, then :

$$B = \frac{\mu_0}{4\pi} \cdot \frac{Idl}{r^2} \sin \theta$$

   (b) The unit of magnetic field B is called tesla (T).

   (c) $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}

   (d) B is perpendicular to both $I\vec{dl}$ and $\hat{r}$.

14. **(i) Voltage sensitivity :**

$$\frac{\theta}{V} = \frac{nBA}{kR} \text{ (rad V}^{-1})$$

   (ii) Current sensitivity :

$$\frac{\theta}{I} = \frac{nBA}{k} \text{ (rad A}^{-1})$$

   (iii) Conversion of galvanometer into ammeter

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

   (iv) Conversion of galvanometor into voltmeter

$$R = \frac{V}{I_g} - G$$

IMPORTANT FIGURES

Moving Coil Galvanometer :
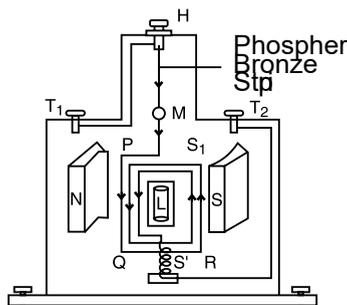
Galvanometer to Ammeter Conversion :
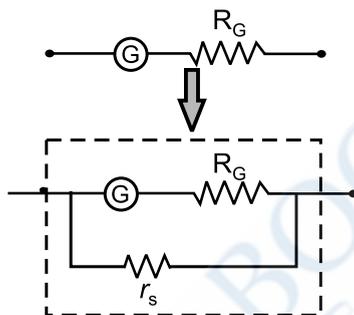
Galvanometer to Voltmeter Conversion :
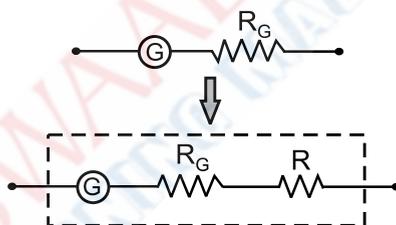
CHAPTER 5 : Magnetism and Matter

UNITS AND DIMENSIONS

Physical quantity	Symbol	Nature	Dimension	Unit
Permeability of free space	μ_0	Scalar	$[MLT^{-2}A^{-2}]$	TmA^{-1}, NA^{-2}
Magnetic field, Magnetic induction, Magnetic flux density	$\vec{B}$	Vector	$[MT^{-2}A^{-1}]$	T (tesla)
Magnetic moment	$\vec{m}$	Vector	$[L^2A]$	Am^2
Magnetic flux	ϕ_B	Scalar	$[ML^2T^{-2}A^{-1}]$	Wb (weber)
Magnetization	$\vec{M}$	Vector	$[L^{-1}A]$	Am^{-1}
Magnetic intensity, Magnetic field strength	$\vec{H}$	Vector	$[L^{-1}A]$	Am^{-1}
Magnetic susceptibility	χ	Scalar	—	—
Relative magnetic permeability	μ_r	Scalar	—	—
Magnetic permeability	μ	Scalar	$[MLT^{-2}A^{-2}]$	TmA^{-1}, NA^{-2}

IMPORTANT RESULTS AND FORMULAE

1. **Magnetic dipole moment :** $\vec{M} = m(\vec{2l})$

2. **(i)** Angle between geographic meridian and the magnetic meridian is called Angle of declination.

   (ii) Angle between horizontal component and total magnetic field of the earth is called dip Angle.

   (iii) Dip is zero at the equator and 90° at the magnetic poles.

3. $\mu = \mu_0 \mu_r$,

   where, μ = permeability of medium, μ_0 = permeability of vacuum and μ_r = relative permeability.

4. Magnetic induction B and magnetic intensity H are related as B = μH.

5. **Curie's law in magnetism :** The intensity of magnetization I of a paramagnetic material is directly proportional to the strength of the external magnetic field H, called the magnetising field and is inversely proportional to the absolute temperature of the material.

$$I \propto \frac{H}{T}$$

$$\therefore \qquad I = \frac{CH}{T}$$

$$\therefore \qquad \frac{I}{H} = \frac{C}{T}$$

or $\qquad \chi = \frac{C}{T}$

where, C is known as Curie constant.

6. **Magnetic intensity :** $\quad H = \frac{B_0}{\alpha_0}$

7. **Magnetic susceptibility :** $\qquad \chi = \frac{I}{H}$

8. **Magnetic permeability :** $\qquad \mu = \frac{B}{H}$

9. The force between two magnetic poles of strength q_m and q'_m, separated by r is given by

$$F = \frac{\mu_0}{4\pi} \cdot \frac{q_m q'_m}{r^2}$$

10. **Tangent law :** When a short bar magnet is suspended freely under the combined action of two uniform magnetic fields of intensities B and B_H acting at 90° to each other, the magnet comes to rest making an angle θ with the direction of the magnetic field B_H.

$$B = B_H \tan θ$$

IMPORTANT GRAPHS AND FIGURES

Angle of declination :
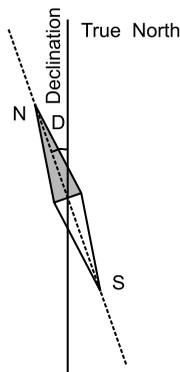
Magnetic elements of earth :
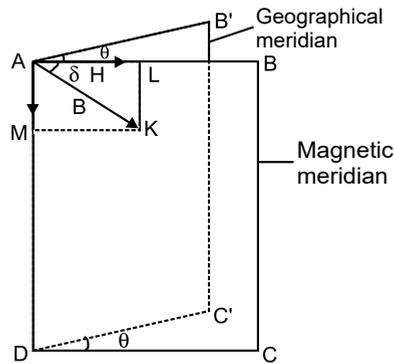
where, θ = Magnetic declination, δ = Magnetic inclination or Magnetic dip and H = Horizontal component

Magnetic field lines :

Bar magnet   A current carrying finite solenoid
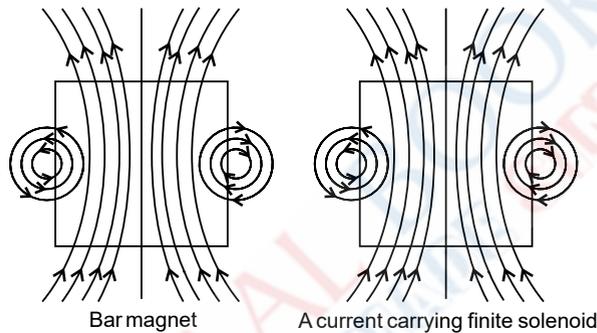
Hysteresis loop :
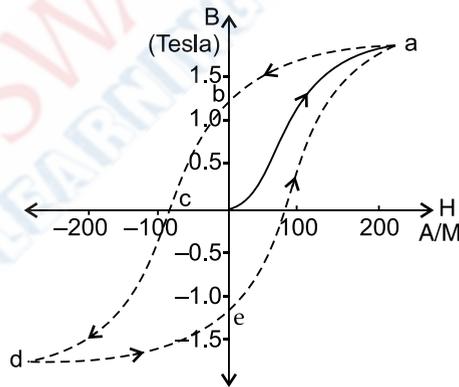
Unit-IV : Electromagnetic Induction and Alternating Currents

CHAPTER 6 Electromagnetic Induction

UNITS AND DIMENSIONS

Quantity	Symbol	Dimension	Unit
Magnetic flux	ϕ	$[ML^2T^{-2}A^{-1}]$	Wb (weber)
EMF	E	$[ML^2T^{-3}A^{-1}]$	V (volt)

| Mutual inductance | M | $[ML^2T^{-2}A^{-2}]$ | H (henry) |
| Self inductance | L | $[ML^2T^{-2}A^{-2}]$ | H (henry) |

IMPORTANT RESULTS AND FORMULAE

1. The inductance of a coil depends on the following factors :

   (a) area of cross-section

   (b) number of turns

   (c) permeability of the core.

2. Self induction

   $$\phi \propto I \text{ or } \phi = LI$$

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

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

   The inductance of a circular coil is given by :

   $$L = \frac{\phi}{I} = \frac{BAN}{I} = \frac{\mu}{4\pi} \cdot \frac{(2\pi NI)}{rI} \times AN \qquad \left[\because B = \frac{\mu}{4\pi} \cdot \frac{2\pi NI}{r}\right]$$

   $$= \frac{\mu N^2}{2r} A = \frac{\mu N^2}{2r} \times \pi r^2$$

   or $\qquad L = \frac{\mu N^2 \pi r}{2}$

   here, ϕ = magnetic flux from the coil, I = current through the coil, A = area of coil, r = radius of coil, N = total number of turns of the coil, μ = permeability of the medium.

3. The inductance of a solenoid of length l, is given by :

   $$L = \frac{\phi}{I} = \frac{BAN}{I} = \left(\frac{\mu NI}{l}\right)\frac{AN}{I} \qquad \left[\because B = \frac{\mu NI}{l}\right]$$

   or $\qquad L = \frac{\mu N^2 A}{l} = \mu n^2 Al = \mu n^2 V \qquad \left[\because n = \frac{N}{l}\right]$

   here, $n = N/l$ = number of turns per unit length and V = Al = volume of the solenoid.

4. The inductance in series combination is given by :

   $$L_s = L_1 + L_2 + L_3 + \ldots\ldots$$

   The inductance in parallel combination is given by :

   $$\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots\ldots$$

5. If two coils of inductance L_1 and L_2 are coupled together, then their mutual inductance is given by :

   $$M = k\sqrt{L_1 L_2}$$

6. Mutual inductance :

   $$\phi \propto I \text{ or } \phi = MI$$

   $$E = -\frac{d\phi}{dt} = -M\frac{dI}{dt}$$

$$M = -E/(dI/dt)$$

$$M = \frac{-E}{dI/dt}$$

The mutual inductance of two coils is given by :

$$M = \frac{\mu N_p N_s A_p}{l} = \frac{\mu_0 N_p N_s A_s}{l}$$

7. Magnetic flux is number of magnetic field lines crossing a surface normally.

   The magnetic flux is denoted by ϕ. If $\vec{B}$ be the magnetic field through the area element $d\vec{A}$. Then, the flux through the area is given by :

   $$d\phi = \vec{B} \cdot d\vec{A}.$$

8. **Faraday's laws of electromagnetic induction :**
   (a) Whenever, the magnetic flux linked with a circuit changes, an emf is induced.
   (b) The induced emf lasts as long as the change in magnetic flux continues.
   (c) The magnitude of induced emf (E) is directly proportional to the rate of change in magnetic flux.

      Thus, if $d\phi$ be the change in magnetic flux during the time dt, then :

      $$E \propto \frac{d\phi}{dt} \text{ or } E = k\frac{d\phi}{dt}$$

      where, k is the constant of proportionality. In SI, $k = -1$, hence, $E = -\frac{d\phi}{dt}$

9. **Lenz's law :**

   It states that induced current produced in a circuit always flows in such a direction that it opposes the change or the cause that produces it.

   The Lenz's law explains the negative sign in the Faraday's flux rule, $E = -\frac{d\phi}{dt}$

10. If a rod of length l moves perpendicular to a magnetic field B with a velocity v, then the induced emf produced across it is given by :

    $$E = v\text{B}l$$

    In general, we have $E = \vec{B}.(\vec{v} \times \vec{l})$

11. If a current I is set up in a coil of inductance L, then the magnetic field energy stored in it is given by

    $$U_p = \frac{1}{2}LI^2$$

12. Instantaneous value of emf produced by AC generator, $e = NBA\omega\sin \omega t$

CHAPTER 7 : Alternating Current

UNITS AND DIMENSIONS

Physical quantity	Symbol	Dimension	Unit
rms voltage	V_{rms}	$[ML^2T^{-3}A^{-1}]$	V
rms current	I_{rms}	$[A]$	A
Inductive reactance	X_L	$[ML^2T^{-3}A^{-2}]$	Ω
Capacitive reactance	X_C	$[ML^2T^{-3}A^{-2}]$	Ω
Impedance	Z	$[ML^2T^{-3}A^{-2}]$	Ω
Resonant frequency	ω_r or ω_0	$[T^{-1}]$	Hz
Quality factor	Q	Dimensionless	
Power factor	$\cos \phi$	Dimensionless	

IMPORTANT RESULTS AND FORMULAE

1. **(a)** Instantaneous value of alternating current

    $$I = I_0 \sin \omega t \quad \text{or} \quad I = I_0 \cos \omega t$$

    (b) Peak value of a.c. $= I_0$

    (c) Alternating emf, $\quad E = E_0 \sin \omega t$

    or $\qquad\qquad\qquad E = E_0 \cos \omega t$

    (d) Mean or average value of a.c.

    $$I_m \text{ or } I_a = \frac{2I_0}{p} = 0.636 \, I_0.$$

    (e) r.m.s. value of a.c. $I_{rms} = I_0/\sqrt{2} = 0.707 \, I_0.$

2. The part of the impedance in which the phase difference between the current and emf is $\pi/2$, is called reactance.

    If the emf leads the current by $\pi/2$, the reactance is called purely inductive.

    If the emf lags behind the current by $\pi/2$, the reactance is called purely capacitive.

    If the emf is in phase with the current, the circuit is called purely resistive.

3. **Sign for phase difference (ϕ) between I and E for series LCR circuit :**

    ϕ is positive, when $\quad X_L > X_C.$

    ϕ is negative, when $\quad X_L < X_C.$

    ϕ is zero, $\qquad$ when $\quad X_L = X_C.$

4. The LCR circuit is said to be resonance when :

    $$X_L = X_C. \text{ } i.e., \text{ when } \omega L = \frac{1}{\omega C}$$

    and $\omega = \omega_0 = \dfrac{1}{\sqrt{LC}}$ is called resonant frequency.

5. At series resonant frequency, $\omega_0 = \dfrac{1}{\sqrt{LC}}$, we have :

    (i) $Z = R = $ minimum value of impedance.

    (ii) $I_0 = E_0/R = $ maximum value of peak current.

    (iii) $\phi = 0$, *i.e.,* I and E are in phase with each other.

    (iv) V_L is equal and opposite to V_C.

    (v) Potential drop across C and L together is zero.

    (vi) $E = V_R$.

6. **Energy stored in an inductor :**

    $$U = \frac{1}{2} L I_0^2$$

7. **Energy stored in a capacitor :**

    $$U = \frac{1}{2} C V^2 = \frac{1}{2} \frac{q_0^2}{C} = \frac{1}{2} q_0 V$$

8. **Power in a.c. circuit :** The power in LCR circuit is given by

    $$P = EI = E_0 I_0 \sin \omega t \sin (\omega t - \phi).$$

    Power in LCR circuit consists of two components :

    (i) Virtual power component

$$= \frac{1}{2} E_0 I_0 \cos(2\omega t - \phi).$$

It has frequency twice as that of a.c. Its value over the complete cycle is zero.

(ii) Real power component $= \frac{1}{2} E_0 I_0 \cos\phi$. It dissipates power.

$\cos\phi$ is called power factor.

9. Inductive reactance : $X_L = \omega L$

Inductive susceptance : $B_L = \dfrac{1}{\omega L}$

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

Capacitive susceptance : $B_C = \omega C$

Reactance : $X = X_L - X_C = \omega L - \dfrac{1}{\omega C}$

Susceptance : $B = B_C - B_L = \omega C - \dfrac{1}{\omega L}$

10. **Impedance of LCR circuit :**

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

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

$$\tan\phi = \frac{V_L - V_C}{V_R}$$

$$= \frac{IX_L - IX_C}{IR}$$

$$= \frac{X_L - X_C}{R}$$

$$= \frac{\omega L - \dfrac{1}{\omega C}}{R}$$

Power, $P = E_{rms} \times i_{rms} \times \dfrac{R}{Z}$

11. Band width $= \omega_2 - \omega_1 = 2\Delta\omega$

12. Sharpness of resonance $= \dfrac{\omega_r}{2\Delta\omega}$

or $\qquad \dfrac{\omega_r}{2\Delta\omega} = \dfrac{\omega_r L}{R}$

13. **Q factor :** $\quad Q = \dfrac{\text{Voltage across L or C}}{\text{Applied voltage}}$

$$Q = \frac{\omega_0 L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

14. Transformer :

(i) $\dfrac{E_s}{E_p} = \dfrac{N_s}{N_p} = k$ (say) (transformer ratio)

(ii) $\dfrac{N_s}{N_p} = k$ is called transformer ratio.

(iii) For step up transformer, $k > 1$ and for step down transformer, $k < 1$.

(iv) For step up transformer, $N_s > N_p$, therefore $E_s > E_p$. And for the step down transformer, $N_s < N_p$ therefore $E_s < E_p$.

(v) The efficiency of the transformer is given by :

$$\eta = \dfrac{\text{Output power}}{\text{Input power}}$$

If I_p and I_s be the currents in the primary and secondary circuits, then

$$\eta = \dfrac{E_s I_s}{E_p I_p}$$

For ideal transformer $\eta = 1 = 100\%$. Therefore,

$$E_s I_s = E_p I_p$$

or $\quad \dfrac{I_s}{I_p} = \dfrac{N_p}{N_s} = \dfrac{1}{k}$

Hence for step-up transformer, current in the secondary is less than that in the primary ($I_s < I_p$) and in a step down transformer, we have $I_s > I_p$.

IMPORTANT FIGURES

Type of circuit	Phasor diagram & wave diagram
Only Resistor :	
Only Inductor :	
Only Capacitor :	
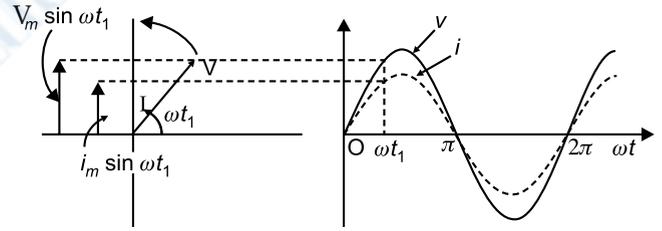
LCR circuit :
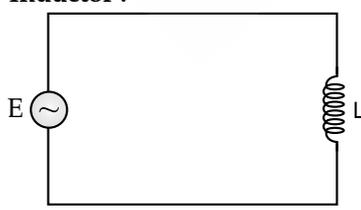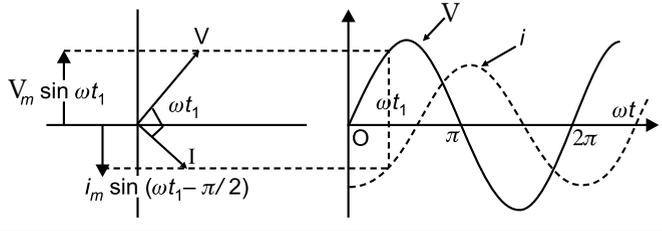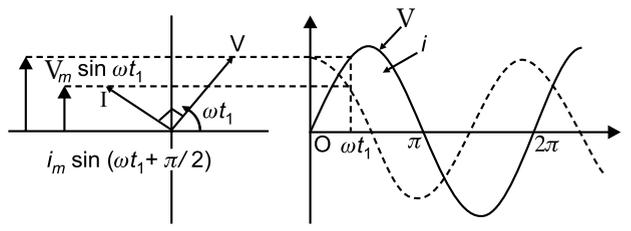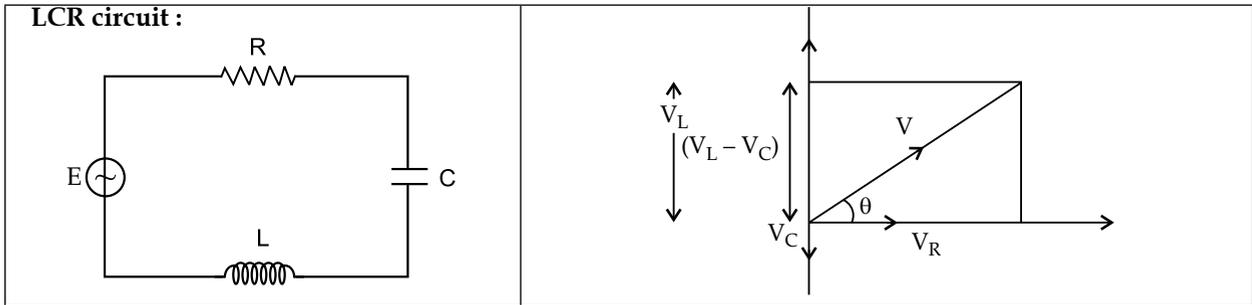
Impedance triangle :
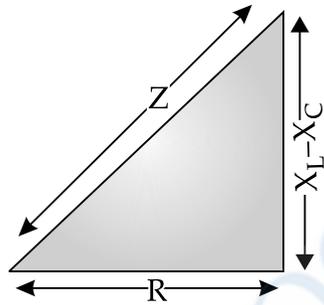
Transformer :
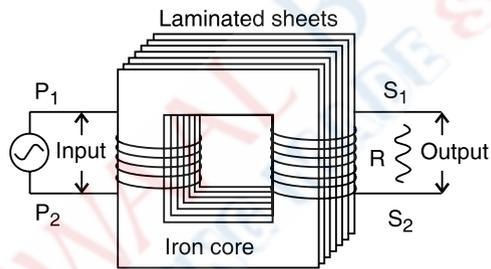
Illustration of Lenz's law :

AC generator :
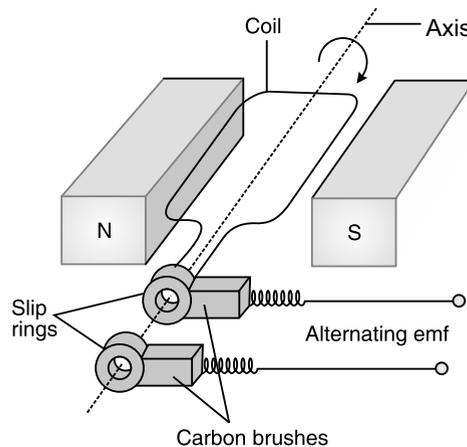
Working of AC generator :
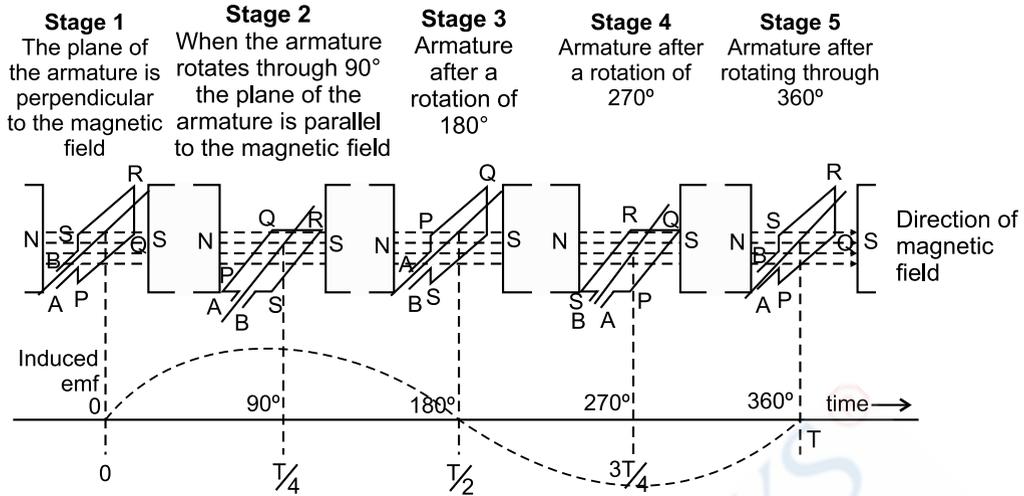
Unit-V : Electromagnetic Waves

CHAPTER 8: Electromagnetic Waves

IMPORTANT RESULTS AND FORMULAE

1. **Characteristics of electromagnetic waves:**

   (a) In electromagnetic wave, electric and magnetic field vectors are perpendicular to each other in the direction of propagation of wave which shows its transverse nature.

   (b) Relation between electric and magnetic field components is:

   $$B_0 = E_0/c$$
   $$c = f\lambda$$
   $$c = \frac{1}{\sqrt{\mu_o \in_o}}$$

   (c) EM waves travel in vacuum along a straight line with the velocity 3×10^8 m/s.

2. **EM wave spectrum:**

Type	Wavelength range	Production	Detection
Radio	> 0.1 m	Rapid acceleration and de acceleration of electrons in aerials	Receiver's aerials
Microwave	0.1 m to 1 mm	Klystron valve or magnetron valve	Point contact diodes
Infra-red	1 mm to 700 nm	Vibration of atoms and molecules	Thermopiles, Bolometer, Infra photographic film
Visible light	700 nm to 400 nm	Electrons in atoms emit light when they move from a higher energy level to a lower energy level	The eye, photocells photographic film
Ultraviolet	400 nm to 1 nm	Inner shell electrons in atoms moving from a higher energy level to a lower energy level	Photocells, Photographic films

| X-rays | 1 nm to 10^{-3} nm | X-ray tubes or inner shell electrons | Photographic films, Geiger tubes, Ionisation chamber |
| Gamma rays | $< 10^{-3}$ nm | Radioactive decay of the nucleus | Observing the effects they have on matter |

IMPORTANT GRAPH

Electric and magnetic field for EM waves

Direction of propagation of wave
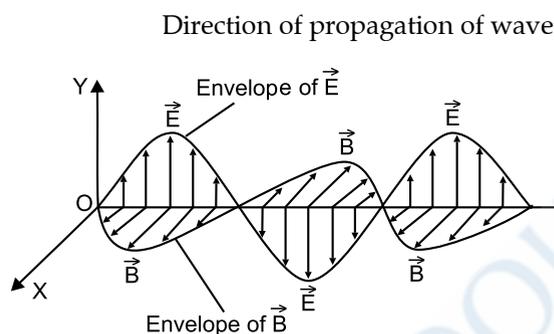
Unit-VI : Optics

CHAPTER 9: Ray Optics and Optical Instruments

IMPORTANT RESULTS AND FORMULAE

1. **Snell's law:**
   (a) The incident ray, the refracted ray and the normal all lie in the same plane.
   (b) The ratio of sine of the angle of incidence to sine of the angle of refraction is constant.

   i.e.,
   $$\frac{\sin i}{\sin r} = \text{constant.}$$

2. **The refractive index** is also defined as the ratio of the velocity of light in the medium of incidence to that in the medium of refraction. For example, if v_1 be the velocity of light in the medium of incidence (1) and v_2 be that in the medium of refraction (2), then

   $$^1\mu_2 = \frac{v_1}{v_2}$$

   (a) The refractive index of a medium when the light is incident from vacuum is called **absolute refractive index.** It is denoted by μ.

   Thus,
   $$\mu = \frac{\sin i}{\sin r} = \frac{c}{v},$$

   where,

   i = angle of incidence in vacuum or air,

   r = angle of refraction in the medium,

   c = velocity of light in vacuum and

   v = velocity of light in the medium.

   (b) Absolute refractive index of vacuum is 1 and that of air is very-very near to 1.

3. **The conditions for total internal reflection:**
   (a) The light must travel from the denser medium to the rarer medium.

(b) Angle of incidence should be larger than critical angle.

Relation between refractive index and critical angle:

$$^1\mu_2 = \frac{1}{\sin C}$$

4. If a slab of thickness t is placed over an object, then the image of the object is raised. The apparent depth and real depth of the object are related as follows:

$$\frac{\text{Real depth}}{\text{Apparent depth}} = \mu$$

where, μ is the absolute refractive index of the slab.

5. **Lens formula:**

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

6. **Power of a lens:**

(a) $P = \dfrac{1}{f}$

(b) $P = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

7. **Lens Maker's formula:**

$$\frac{1}{v} - \frac{1}{u} = \frac{\mu_2 - \mu_1}{\mu_1}\left[\frac{1}{R_1} - \frac{1}{R_2}\right] = \frac{1}{f}$$

8. For refraction through prism,

$$i + e = A + \delta,$$

Here, i = angle of incidence,

e = angle of emergence,

A = angle of prism,

δ = angle of deviation
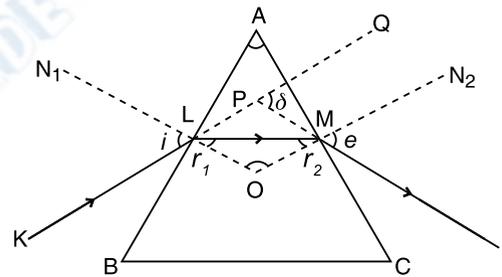
If r_1 be the angle of refraction at the first surface and r_2 be the angle of incidence at the second surface, then

$$A = r_1 + r_2$$

For minimum angle of deviation,

$$i = e \text{ and } r_1 = r_2 = r$$

Hence, $i = \dfrac{A + \delta_m}{2}$ and $r = \dfrac{A}{2}$

So, $\mu = \dfrac{\sin i}{\sin r} = \dfrac{\sin \dfrac{A + \delta_m}{2}}{\sin \dfrac{A}{2}}$

9. The magnifying power of the simple microscope is given by:

$$M = 1 + \frac{D}{f}.$$

10. **(a)** The magnifying power of the compound microscope is given by

$$M = \frac{v_o}{u_o}\left[1 + \frac{v_e}{f_e}\right]$$

Or, $M = \dfrac{v_o}{u_o}\left[1 + \dfrac{D}{f_e}\right]$

Here, D is the distance of distinct vision.

Also,
$$\frac{v_o}{u_o} = \left[1 + \frac{v_o}{f_o}\right]$$

Hence,
$$M = \left(1 + \frac{v_o}{f_o}\right)\left(1 + \frac{D}{f_e}\right)$$

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

When final image is formed at D.

(b) The length of compound microscope tube is:
$$L = v_o + u_e.$$

(c) Generally object is placed very near to the principal focus of the objective, hence
$$u_o \approx f_o.$$

The eye-piece is also of small focal length and the image formed by the objective is also very near to the eye piece.

So, $v_o \approx L$, the length of the tube.

Hence, we can write the magnifying power,
$$M = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$$

11. (a) The magnifying power of the telescope is given by
$$M = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{v_e}\right),$$

where,

f_o = focal length of the objective,

f_e = focal length of the eye piece,

v_e = distance of the final image from the eye piece.

(b) When the final image is at infinity, we find
$$v_e = \infty,$$

and hence,
$$M = \frac{f_o}{f_e}$$

This is called normal adjustment of the telescope.

(c) When the final image is at the distance of distinct vision, we have $v_e = D$,

Hence,
$$M = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right),$$

The length of the telescope tube $L = f_o + f_e$. For normal Adjustment

IMPORTANT GRAPHS AND FIGURES

(a)
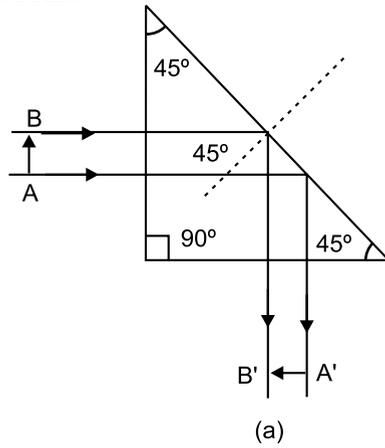
Triangular glass prism:
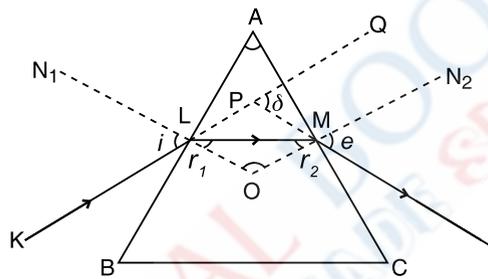
Angle of deviation versus angle of incidence for a triangular prism:
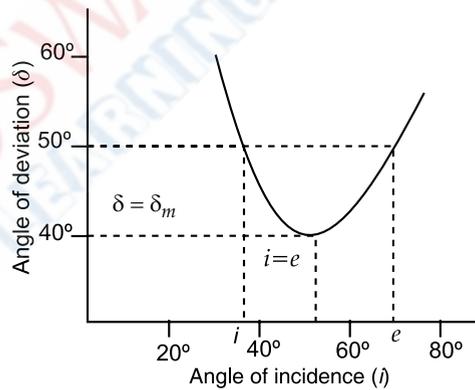
Simple microscope:
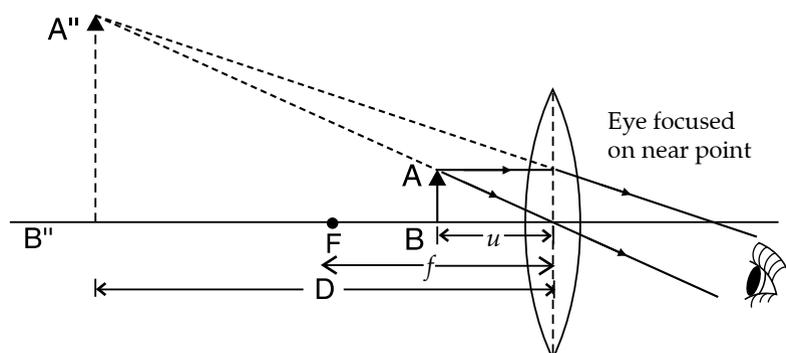
Compound microscope:
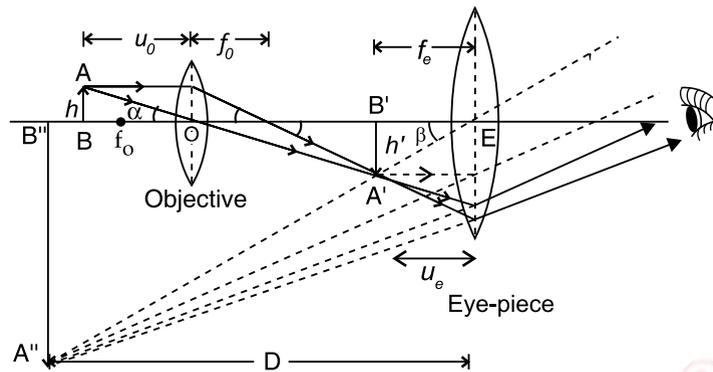
Refracting telescope:
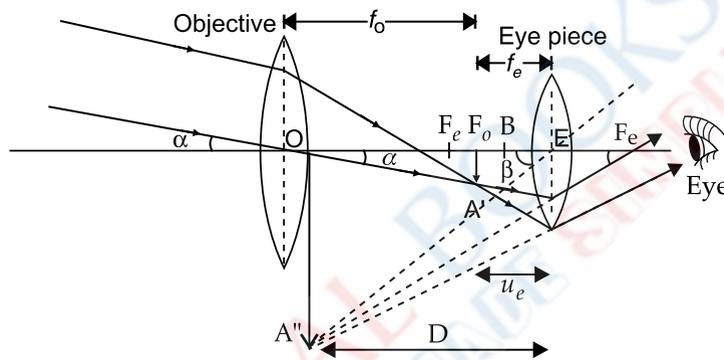
Reflecting telescope:
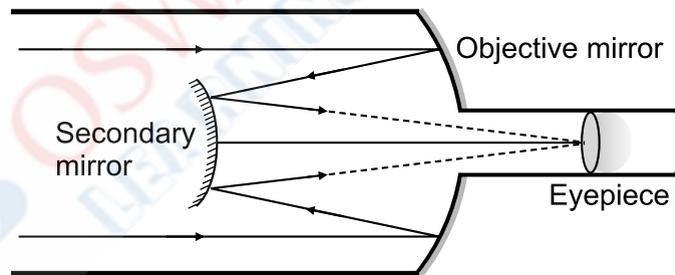
CHAPTER 10: Wave Optics

IMPORTANT RESULTS AND FORMULAE

1. **Young's double slit experiment:**

$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2} \, \cos\phi$$

$$R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$$

$$I \propto R^2$$

$$I \propto (a^2 + b^2 + 2ab\cos\phi)$$

For bright fringes:

$$\cos \phi = \max = + 1$$

$$\phi = 0, 2\pi, 4\pi \ ....$$

$$\phi = 2n\pi$$

Path difference $= \dfrac{xd}{D} = n\lambda$

where, $\quad n = 0, 1, 2, 3, ...$

or $\quad x = n\lambda \dfrac{D}{d}$

For dark fringes:

$$\cos \phi = \min = - 1$$

$$\phi = \pi, 3\pi, 5\pi \ ....$$

$$\phi = (2n - 1)\pi$$

Path difference $= \dfrac{xd}{D} = (2n - 1)\dfrac{\lambda}{2}$

or $\quad x = (2n - 1)\dfrac{\lambda}{2}\dfrac{D}{d}$

2. **Ratio of maximum & minimum intensities:**

$$\dfrac{I_{max}}{I_{min}} = \dfrac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$$

a_1 & a_2 = amplitudes of interfering waves

3. **Fringe width in Young's double slit experiment:**

$$\beta = \dfrac{\lambda D}{d}$$

4. **Single slit diffraction:**

Angular width of central maximum:

$$\theta = \dfrac{x}{D}$$

Width of central maximum:

$$2x = \dfrac{2D\lambda}{a}$$

IMPORTANT GRAPHS AND FIGURES

Refraction of Light by Huygens' Principle:

(From rarer to denser medium)
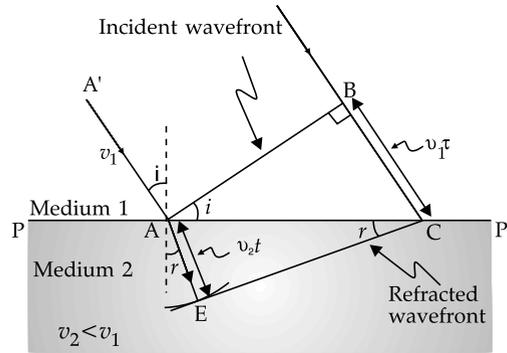
Reflection of Light by Huygens' Principle:
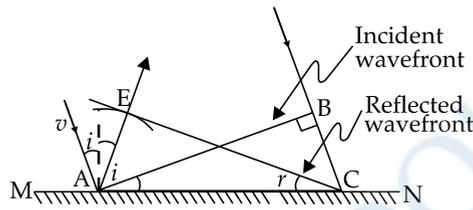
Interference and diffraction:

C is known as Central Maxima
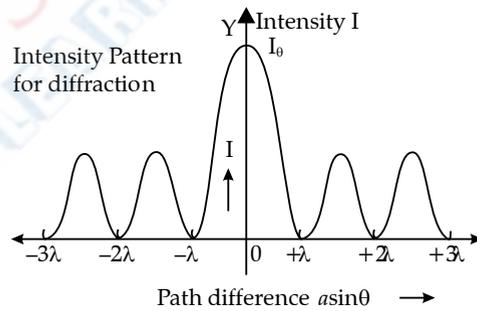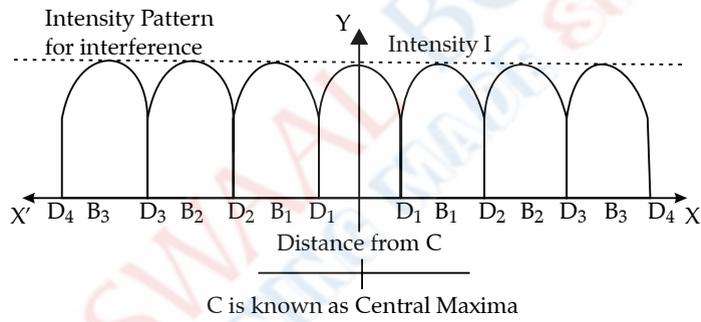
Single slit diffraction:
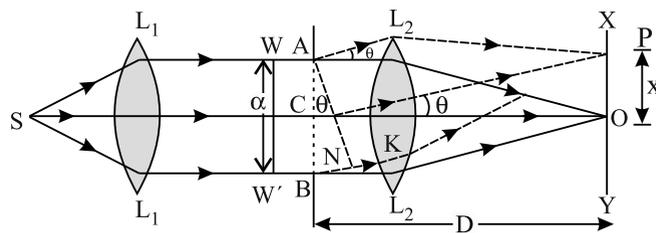
Unit-VII : Dual Nature of Matter and Radiation
Chapter 11: Dual Nature of Matter and Radiation

UNITS AND DIMENSIONS

Physical quantity	Symbol	Dimension	Unit
Planck's constant	h	$[ML^2T^{-1}]$	Js
Stopping potential	V_0	$[ML^2T^{-3}A^{-1}]$	V
Work function	ϕ_0	$[ML^2T^{-2}]$	J; eV
Threshold frequency	$\upsilon_0\,(f_0)$	$[T^{-1}]$	Hz
de-Broglie wavelength	λ	$[L]$	m

IMPORTANT RESULTS AND FORMULAE

1. **Energy of a photon:**

$$E = hf = \frac{hc}{\lambda}$$

2. **Momentum of the photon:**

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

3. **Work function:**

$$W_0 = hf_0 = hc/\lambda_0.$$

4. **Cut off potential:**

$$eV_0 = \frac{1}{2}mv^2_{max}$$

where, v_{max} = maximum velocity of photoelectrons

5. **Einstein equation:**

$$h_f = W_0 + K_m.$$
$$K_m = hf - W_0 = hf - hf_0$$

6. The de-Broglie's wavelength of the particle of mass m and moving with velocity v is given by:

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

7. The de-Broglie wavelength of a particle of mass m and kinetic energy K is given by:

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

8. If a particle of mass m carrying charge q_0 is accelerated through potential V, then its de-Broglie wavelength is given by:

$$\lambda = \frac{h}{\sqrt{2mq_0V}}$$

9. The de-Broglie wavelength associated with the orbital electron in the nth orbit of hydrogen atom is given by:

$$\lambda_n = \frac{12.27}{\sqrt{V}} \text{ Å}$$

IMPORTANT GRAPHS AND FIGURES

Photoelectric effect:
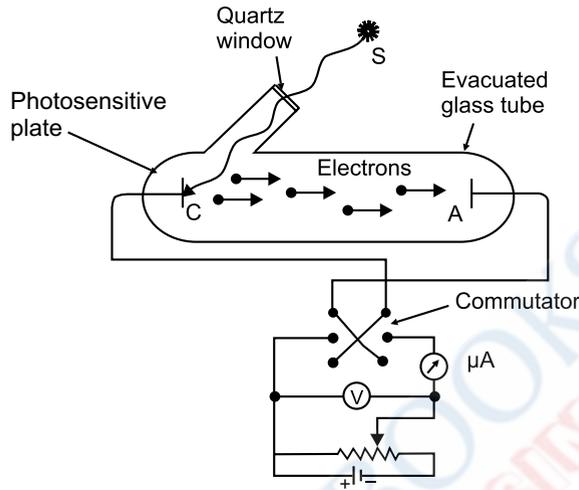

Effect of intensity of light on photocurrent:
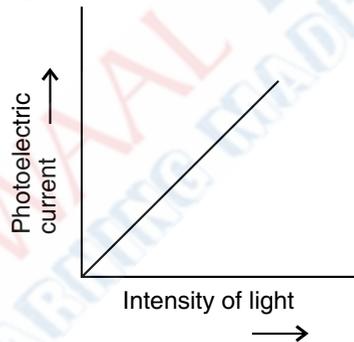
Effect of potential on photocurrent:
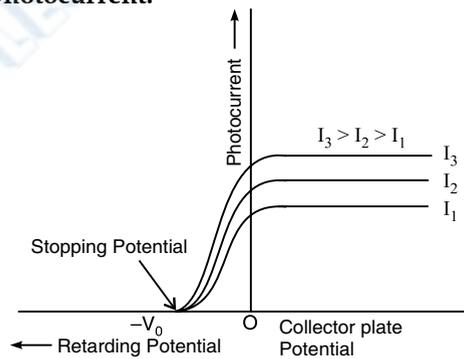
Effect of frequency of incident radiation on stopping potential:
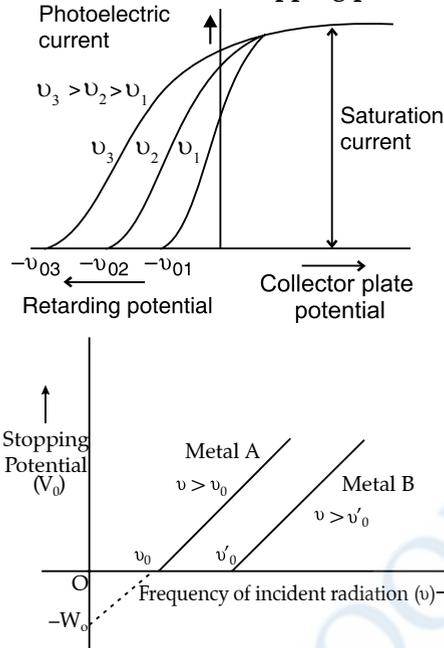
Unit-VII : Atoms

CHAPTER 12: Atoms

IMPORTANT RESULTS AND FORMULAE

1. Distance of closest approach is given by,

$$r_0 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2Ze^2}{K}$$

2. The orbital radius of the electron is given by,

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

3. The orbital velocity of electron in n^{th} orbit is given by,

$$v_n = \frac{1}{4\pi\varepsilon_0} \frac{2\pi e^2}{nh}$$

4. Orbital frequency is given by,

$$f = \frac{1}{T} = \frac{v_n}{2\pi r} = \frac{m e^4}{4\varepsilon_0^2 n^3 h^3}$$

5. The total energy of the orbital electron is given by,

$$E = -\left(\frac{1}{4\pi\varepsilon_0}\right)^2 \left[\frac{2\pi^2 m e^4}{h^2}\right]\left[\frac{1}{n^2}\right]$$

$$\text{K.E.} = \frac{m e^4}{8n^2 h^2 \varepsilon_0^2}$$

$$\text{P.E.} = -\frac{m e^4}{4n^2 h^2 \varepsilon_0^2}$$

6. The kinetic, potential and total energies of the electron with r as the radius of the orbit are as follows:

$$\text{K.E.} = \frac{1}{2}\left[\frac{1}{4\pi\varepsilon_0}\cdot\frac{Ze^2}{r}\right]; \ \text{P.E.} = -\frac{1}{4\pi\varepsilon_0}\cdot\frac{Ze^2}{r}$$

and $\quad E = -\frac{1}{2}\left[\frac{1}{4\pi\varepsilon_0}\cdot\frac{Ze^2}{r}\right]$

Therefore they are related to each other as:

$\quad$ K.E. = –E $\quad$ and $\quad$ P.E. = 2E.

7. The energy of orbital electron in the nth orbit is given by,

$$E_n = -\frac{13.6}{n^2}\text{ eV}$$

So, energy associated with the different orbits is as follows:

$$E_1 = -\frac{13.6}{1^2}\text{ eV} = -13.6\text{ eV}$$

$$E_2 = -\frac{13.6}{2^2}\text{ eV} = -3.4\text{ eV}$$

$$E_3 = -\frac{13.6}{3^2}\text{ eV} = -1.51\text{ eV}$$

and $\quad E_\infty = -\frac{13.6}{\infty^2} = 0$

8. (i) For the Lyman series $n_i = 1$ and $n_0 = 2, 3, 4$ ......

The wavelength of the radiations is given by,

$$\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{n_0^2}\right]$$

They lie in the ultraviolet region.

(ii) The Balmer series of the radiations corresponds to $n_i = 2$ and $n_0 = 3, 4, 5$ ......

The wavelength of the radiations is given by,

$$\frac{1}{\lambda} = R_H\left[\frac{1}{2^2} - \frac{1}{n_0^2}\right]$$

They lie in the visible region.

(iii) For Paschen series $n_i = 3$ and $n_0 = 4, 5, 6$ ......

The wavelength of the radiations is given by,

$$\frac{1}{\lambda} = R_H\left[\frac{1}{3^2} - \frac{1}{n_0^2}\right]$$

They lie in the infrared region.

(iv) For Brackett series $n_i = 4$ and $n_0 = 5, 6, 7$ ....

The wavelength of the radiations is given by,

$$\frac{1}{\lambda} = R_H\left[\frac{1}{4^2} - \frac{1}{n_0^2}\right]$$

They lie in the far infrared region.

(v) Pfund series of radiation corresponds to $n_i = 5$ and $n_0 = 6, 7, 8, 9$..........

The wavelength of the radiations, is given by,

$$\frac{1}{\lambda} = R_H \left[\frac{1}{5^2} - \frac{1}{n_0^2} \right]$$

They lie in infrared region.

9. Angular momentum of the electron in the nth orbit of hydrogen atom is given by,

$$L = n \frac{h}{2\pi}.$$

IMPORTANT GRAPHS AND FIGURES

Energy level diagram (Line spectra):
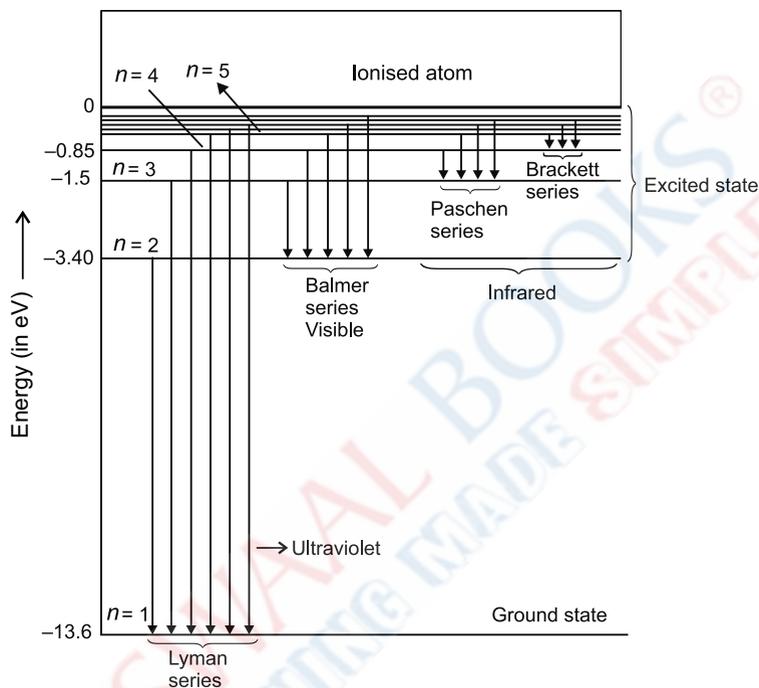
CHAPTER 13: Nuclei

UNITS AND DIMENSIONS

Physical Quantity	Symbol	Dimension	Unit
Atomic mass unit	u	[M]	u

IMPORTANT RESULTS AND FORMULAE

1. The volume of the nucleus is proportional to the mass number (A). Therefore, radius (R) of the nucleus is proportional to $A^{1/3}$.

   i.e., $R \propto A^{1/3}$

   or $R = R_0 A^{1/3}$

   where, $R_0 \cong 1.2 \times 10^{-15}$ m.

2. The difference in the sum of the masses of the neutrons and protons in the nucleus and the actual mass of the nucleus is called mass defect.

   Consider nucleus $_Z X^A$. It has Z protons and (A – Z) neutrons. Suppose its mass is M. Let the mass of the neutron be m_n, and that of proton be m_p, then mass defect is given by,

   $$\Delta m = [Z m_p + (A - Z) m_n] - M$$

3. If Δm be the mass defect of a nucleus, then its binding energy is given by Δmc^2.

   where, c = speed of light.

4. **Isotopes:**

   (a) $_1H^1, _1H^2, _1H^3$ **(b)** $_8O^{16}, _8O^{17}, _8O^{18}$

   (c) $_{17}Cl^{35}, _{17}Cl^{37}$ **(d)** $_{92}U^{235}, _{92}U^{238}$

5. **Isobars:**

   (a) $_1H^3, _2He^3$ **(b)** $_3Li^7, _4Be^7$

   (c) $_{18}Ar^{40}, _{20}Ca^{40}$ **(d)** $_{32}Ge^{76}, _{34}Se^{76}$

6. **Isotones:**

   (a) $_1H^3, _2He^4$ **(b)** $_7N^{17}, _8O^{18}, _9F^{19}$
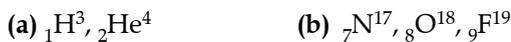
7. $1\ amu \cong 1.66 \times 10^{-27}\ kg = 931\ MeV.$

8. The process of splitting the heavy nucleus by bombarding it with neutron is called **fission**. The most commonly discussed fission is that of $_{92}U^{235}$. The process occurs as follows:

   $$_0n^1 + _{92}U^{235} \rightarrow [_{92}U^{236}] \rightarrow _{56}Ba^{141} + _{36}Kr^{92} + 3\ _0n^1 + 200\ MeV$$
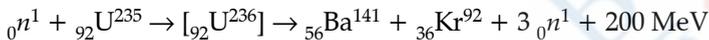
9. The combination of lighter nuclei to form a heavy nucleus with the release of energy is called **fusion**.

   Simplest example is the fusion of hydrogen atom to helium:

   $$4\ _1H^1 \rightarrow _2He^4 + 2\ _{+1}e^0 + Q$$
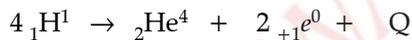
   4 Hydrogen → Helium + 2 positron + energy

   Similarly, $_1H^2 + _1H^2 \rightarrow _2He^3 + _0n^1 + Q$

   $$_1H^2 + _1H^3 \rightarrow _2He^4 + _0n^1 + Q$$
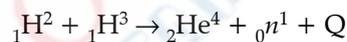
IMPORTANT GRAPHS AND FIGURES

   Relation between BE/A and Stability of elements:
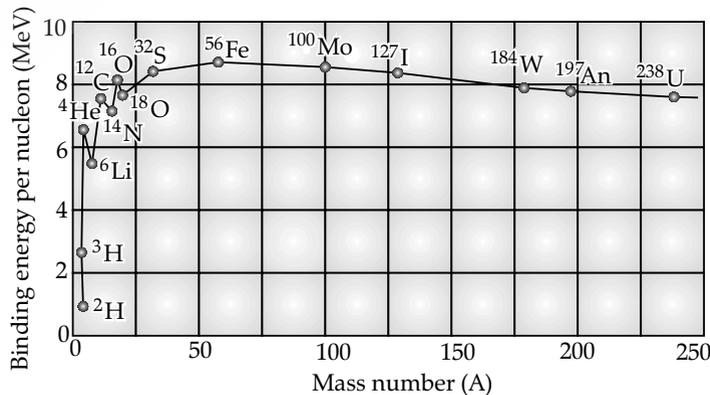
Effect of separation on nuclear force:
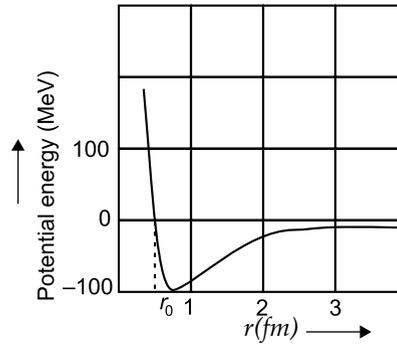
Unit-IX : Electronic Devices

CHAPTER 14 : Electronic Devices

↑ **Important Results and Formulae**

1. The majority (charge) carriers in the *n*-type semiconductor are electrons and that in *p*-type semiconductor are holes.

2. For intrinsic semiconductor : $n_e = n_h = n_i$
   For doped semiconductor : $n_e \times n_h = n_i$
   For *n*-type semiconductor : $n_e >> n_h$
   For p-type semiconductor : $n_e << n_h$

3. **Efficiency of a diode rectifier :**

$$\eta = \frac{\text{Output d.c. power}}{\text{Input a.c. power}} \times 100$$

$$= \frac{P_{d.c.}}{P_{a.c.}} \times 100$$

(a) For half wave rectifier :

$$\eta = \frac{40.6}{\left(1 + \dfrac{r_f}{R_L}\right)}\%$$

where, r_f is the forward bias resistance.

For $r_f = R_L, \eta = 20.3\%.$
and for $r_f << R_L, \eta = 40.6\%.$

(b) For full wave rectifier :

$$\eta = \frac{81.2}{\left(1 + \dfrac{r_f}{R_L}\right)}\%$$

For $r_f = R_L, \ \eta = 40.6\%.$
and for $r_f << R_L, \eta = 81.2\%.$

4. **Ripple factor :**

$$\gamma = \frac{I_{a.c.}}{I_{d.c.}} = \left[\left(\frac{I_{rms}}{I_{d.c.}}\right)^2 - 1\right]^{\frac{1}{2}}$$

$$= \frac{\text{r.m.s. value of fluctuating current}}{\text{average d.c. value of current}}$$

The ripple factor for half wave rectifier is 121% and that of the full wave rectifier is 48.2%.

5. **The root mean square current of rectifier :**

(a) **For half wave rectifier :** $\qquad I_{rms} = \dfrac{I_0}{2}$

(b) **For full wave rectifier :** $\qquad I_{rms} = \dfrac{I_0}{\sqrt{2}}$

6. **(i) Metals :** They possess very low resistivity (or high conductivity).

$\qquad \rho \sim 10^{-2} - 10^{-8} \ \Omega\text{-m}$

$\qquad \sigma \sim 10^2 - 10^8 \ \Omega\text{-m}^{-1}$

(ii) Semiconductors : They have resistivity or conductivity intermediate to metals and insulators.

$\qquad \rho \sim 10^{-5} - 10^6 \ \Omega\text{-m}$

$\qquad \sigma \sim 10^5 - 10^{-6} \ \Omega\text{-m}^{-1}$

(iii) Insulators : They have high resistivity (or low conductivity).

$\qquad \rho \sim 10^{11} - 10^{19} \ \Omega - m$

$\qquad \sigma \sim 10^{-11} - 10^{-19} \ \Omega - m^{-1}$

7. **For the common emitter transistor amplifiers :**

(i) Current gain : It is of two types :

(a) **The d.c. gain (β) :** It is defined as the ratio of the collector current (I_C) to the base current (I_B).

i.e., $\qquad \beta = \dfrac{I_C}{I_B}$

(b) **The a.c. gain ($\beta_{a.c.}$) :** It is defined as the ratio of change in collector current (ΔI_C) to the change in base current (ΔI_B) at constant collector emitter voltage.

i.e., $\qquad \beta_{a.c.} = \left[\dfrac{\Delta I_C}{\Delta I_E}\right]_{V_{CE} = constant}$

(ii) Voltage gain (A_V) : It is defined as the ratio of the change in output voltage (ΔV_0) to that of the input voltage (ΔV_i).

i.e., $\qquad A_V = \dfrac{\Delta V_0}{\Delta V_i}$

here, $\quad V_0$ = collector emitter voltage and V_i = base emitter voltage.

(iii) Resistance gain (A_R) : It is defined as the ratio of output resistance (R_o) to the input resistance (R_i).

i.e., $\qquad A_R = \dfrac{R_o}{R_i}.$

(iv) Power gain (A_P) : It is defined as the ratio of the change in output power (ΔP_0) to that in the input power (ΔP_i).

i.e., $\qquad A_P = \dfrac{\Delta P_o}{\Delta P_i}.$

8. **For the common base transistor amplifiers :**

(i) Current gain : It is of two types :

(a) **The d.c. gain (α) :** It is defined as the ratio of collector current (I_C) to the emitter current. (I_E)

i.e., $\qquad \alpha = \dfrac{I_C}{I_E}$

(b) **The a.c. gain ($\alpha_{a.c.}$) :** It is defined as the ratio of change in collector current (ΔI_C) to the change in emitter current (ΔI_E) at constant collector base voltage.

i.e., $\qquad \alpha_{a.c.} = \left[\dfrac{\Delta I_C}{\Delta I_E}\right]_{V_{CE} = \text{constant}}$

(ii) Voltage gain (A_V) : It is defined as the ratio of the change in output voltage (ΔV_o) to that in the input voltage (ΔV_i).

i.e., $\qquad A_V = \dfrac{\Delta V_0}{\Delta V_i}$

here, V_o = collector base voltage and
   V_i = emitter base voltage.

(iii) Resistance gain (A_R) : It is defined as the ratio of the output resistance (R_o) to the input resistance (R_i)

i.e., $\qquad A_R = \dfrac{R_o}{R_i}.$

(iv) Power gain (A_P) : It is defined as the ratio of the change in output power (ΔP_o) to that in the input power (ΔP_i)

i.e., $\qquad A_P = \dfrac{\Delta P_o}{\Delta P_i}.$

9. α and β are related as follows :

$$\alpha = \dfrac{\beta}{1+\beta} \text{ and } \beta = \dfrac{\alpha}{1-\alpha}$$

10. Boolean algebra or digital gates :

(i) OR gate $\qquad \rightarrow \quad y = A + B$

(ii) AND gate $\qquad \rightarrow \quad y = A \cdot B$

(iii) NOT gate $\qquad \rightarrow \quad y = \overline{A}$

(iv) NAND gate $\qquad \rightarrow \quad y = \overline{A.B}$

(v) NOR gate $\qquad \rightarrow \quad y = \overline{A+B}$

(vi) XOR gate $\qquad \rightarrow \quad y = A.\overline{B} + \overline{A} \cdot B$

↑ **Important Graphs and Figures**
  Band theory :

(a)
Metals

Insulators
(b)

Semiconductors
(c)

p-n Junction diode :

Metallic contact

Depletion layer
(a)

Metallic contact

(b)
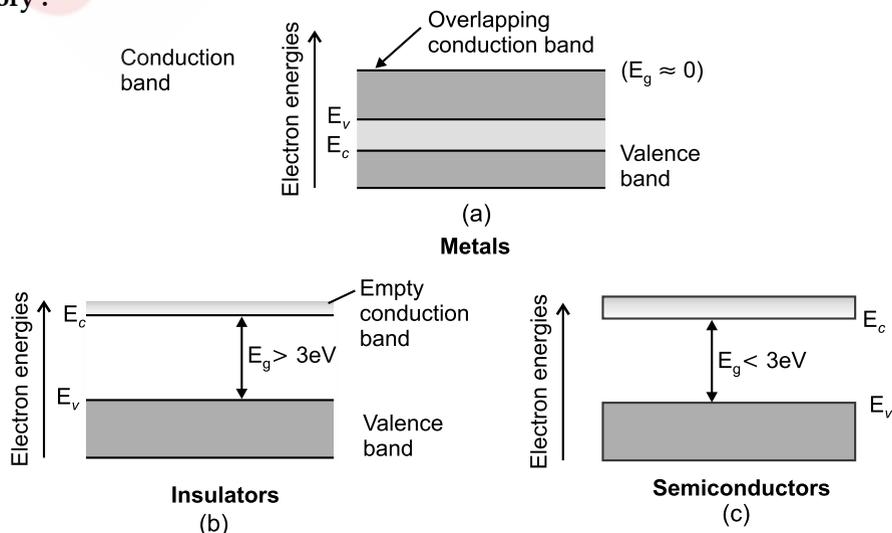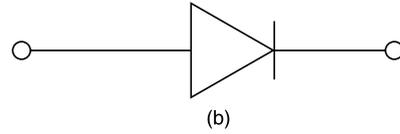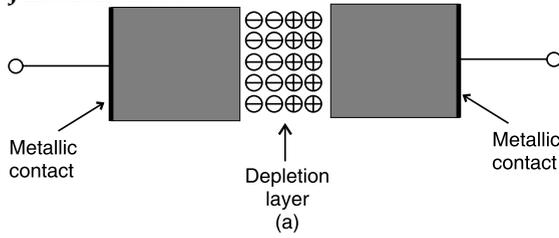
Biasing and V-I characteristics :

Voltmeter (V)

p   n

ammeter (mA)

Switch

Forward Biasing

Voltmeter (V)

p   n

ammeter (µA)

Switch

Reverse Biasing

I (mA)

100
80
60
40
20

100 80 60 40 20

0.2 0.4 0.6 0.8 1.8 V (V)

F_B

V_{br}

10
20
30

R_B

i (μA)
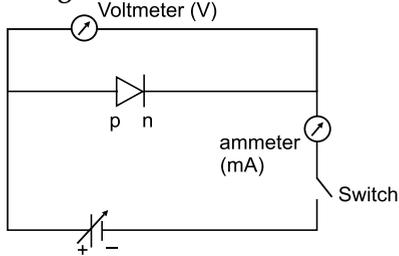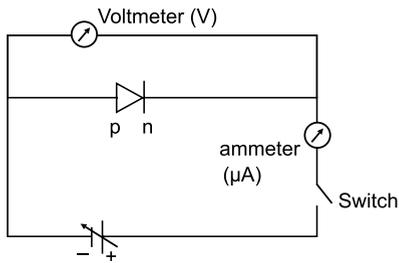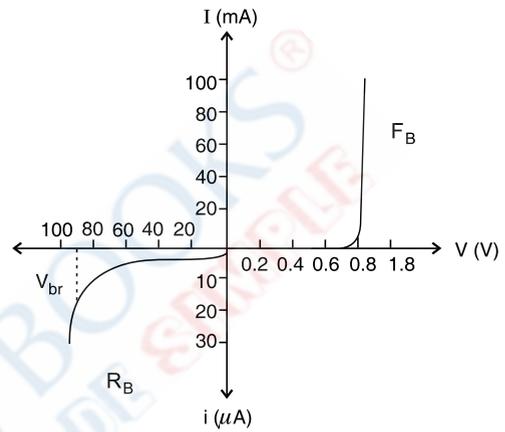
V - I Characteristics

Photodiode :

$h\nu$

p-side   n-side

μA

Half wave rectifier :

B (Tesla)

1.5
1.0
0.5

a
b

c

−200 −100   100   200 H

Voltage at A

Input (a.c.)

t

Voltage across R_L

Output voltage

t
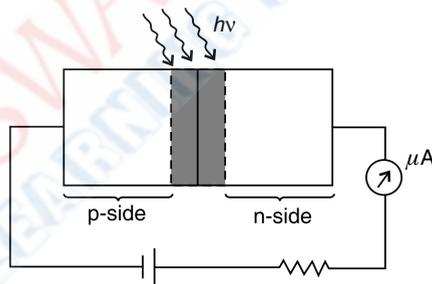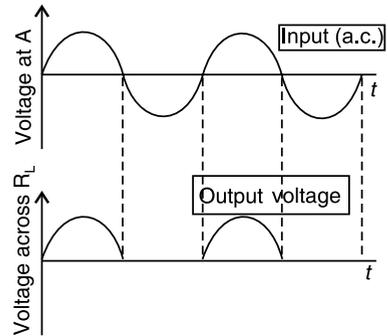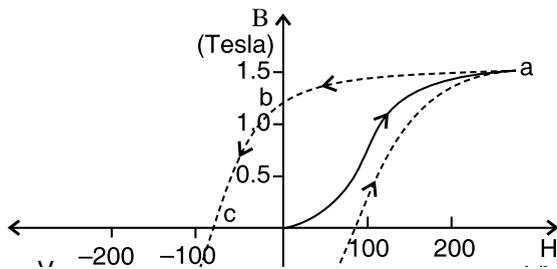
Full wave rectifier :
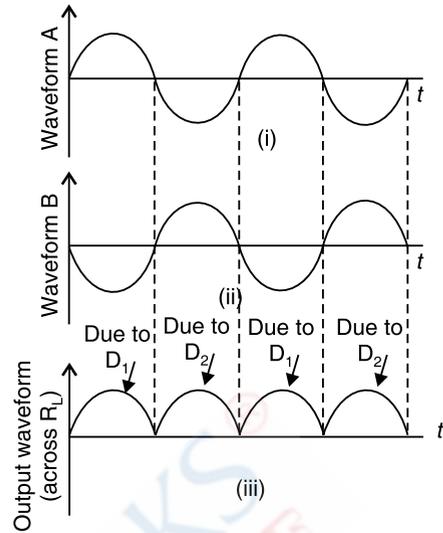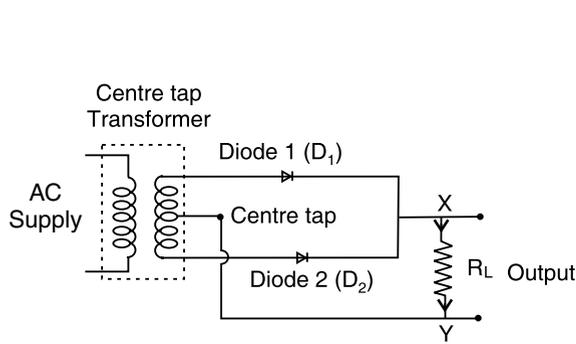
Filter Circuit :
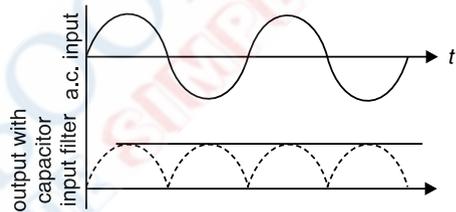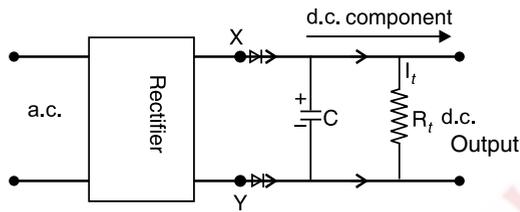
CE configuration and its Characteristics :
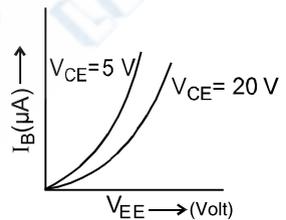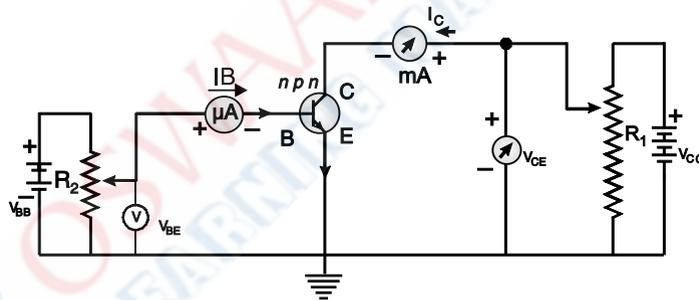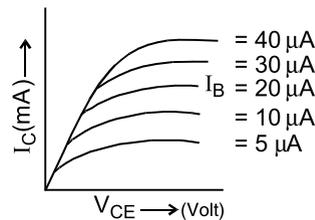
I/P Characteristies- curve   O/P Characteristies- curve

n-p-n **Transistor as amplifier in CE mode :**
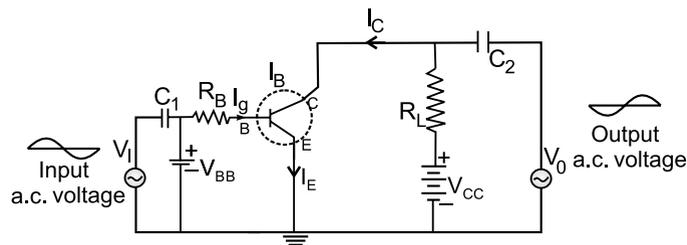
Transistor as an oscillator :
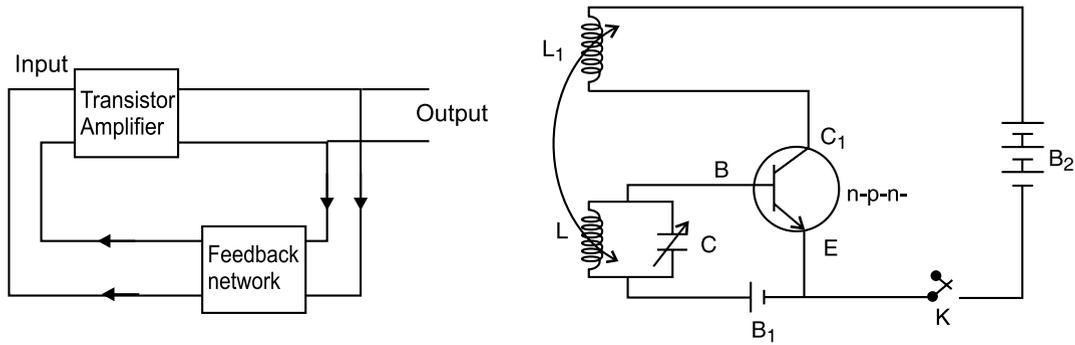
Unit-X : Communication Systems

CHAPTER 15 : Communication Systems

↑ **Important Results and Formulae**

1. The various frequency ranges used in radio waves or micro waves communication system are as follows :

(a) Medium frequency band (M.F.) —
 300 to 3000 kHz.

(b) High frequency band (H.F.) —
 3 to 30 MHz.

(c) Very high frequency band (V.H.F.) —
 30 to 300 MHz.

(d) Ultra high frequency band (U.H.F.) —
 300 to 3000 MHz.

(e) Super high frequency band (S.H.F.) —
 3000 to 30,000 MHz.

(f) Extra high frequency band (E.H.F.) —
 30 to 300 GHz.

2. The radius of the region covered by the T.V. broadcast is

$$d = \sqrt{2h\text{R}},$$

where, R is the radius of the earth and h is the height of the tower.

Population covered

$= \pi d^2 \times$ population density.

3. For AM, modulation index :

(a) $$m_a = \frac{E_m}{E_c}$$

$$= \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

(b) Band width :

2 × Frequency of modulating signal

4.   For FM, modulation index :

$$m_f = \frac{\delta}{f_m} = \frac{f_{max} - f_c}{f_m}$$

$$= \frac{f_c - f_{min}}{f_m}$$

↑ **Important Graphs and Figures**

**Block diagram of a generalised communication system :**
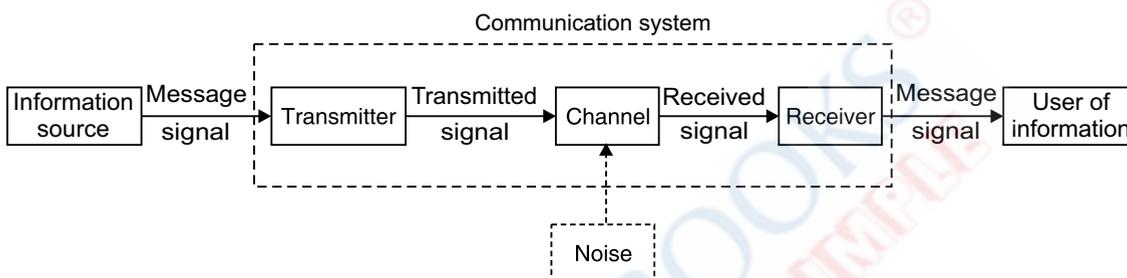

Various propagation modes for EM waves :

Various propagation modes of EM waves
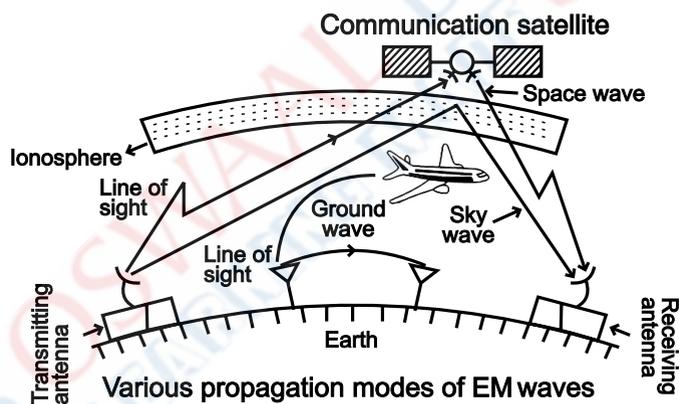
Types of modulation :
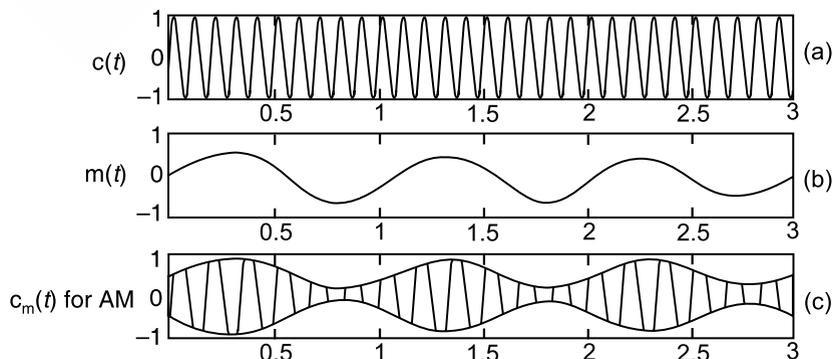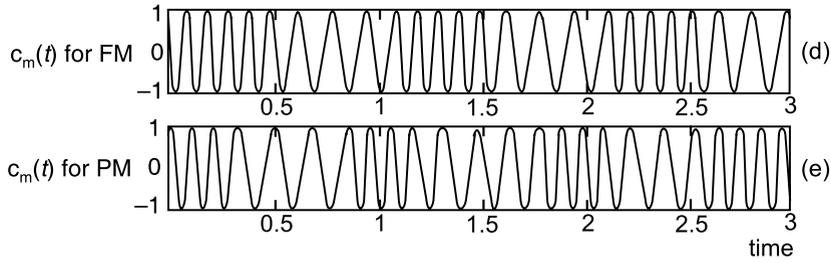
(a) Sinusoidal carrier wave

(b) Modulating signal

(c) Amplitude modulation

(d) Frequency modulation

(e) Phase modulation

**Production of amplitude modulated wave :**

**(a)** Block diagram of simple modulator for getting AM signal.
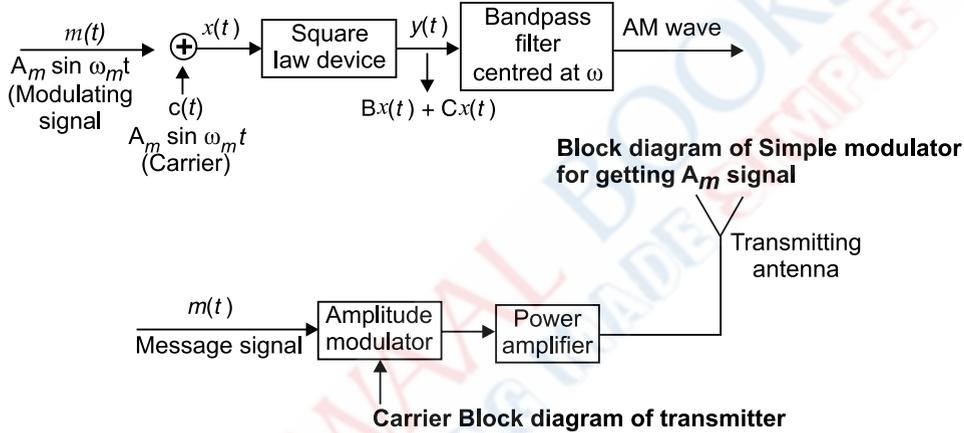
(b) Block diagram of transmitter.

Detection of amplitude modulated wave :

(i) Block diagram of receiver.
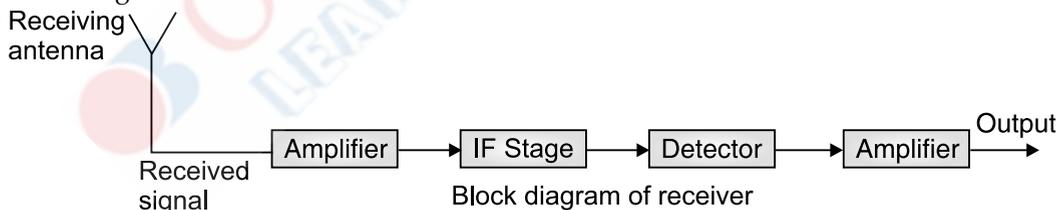
(ii) Block diagram of detector for AM signal.

Block diagram of detectar for A_m signal

☐☐☐