UNIT-I [ELECTROSTATICS] 8 MARKS

ELECTRIC CHARGE

If is an intrinsic property of elementary particles of matter which give rise to electric force between various object.
Ii is a scalar quantity whose SI unit is Coulomb (C) and CGS unit is statcoulomb.
i.e 1 C = 3 x 10^9 statcoulomb.
The smallest value of electric charge is the elementary charge, e = 16 C. x 10^{-19} C
Electric charges are of two types:
1 Positive charge – A proton has a positive charge +e
2 Negative charge – An electron has a negative charge –e

ELECTRIFICATION
The process of giving charge to a body is called electrification.
A body is said to be electrified if it gains or loses electrons.

Methods of electrification
1 Charge by rubbing/ friction : It is the process of charging object by rubbing bodies against another body. In these process, electrons are transferred from one body to another. The body which gains electrons posses –ve charge and the other which loses electron posses +ve charge
e.g : wool posses positive charge and glass rod posses negative charge during rubbing
After rubbing the two bodies attract each other.

2. Charge by Conduction : It is the process of charging object by direct contact of an uncharged body with a charge body . e.g: gold leaf electroscope.
After conduction the two bodies repel each other.

3. Charge by induction :
It is the phenomenon of temporarily electrification of a conductor in which opposite charges appear at the nearer end and similar charges appear at the farther end in the presence of a nearby charge body.
The charges so produced are called induced charges. They are of two types:

(i) Free charges - These are the charges that appears at the far end of the body when kept near a charged body.
(ii) Bound charges – These are the charges that appears at the near end of the body when kept near a charged body.

After induction the two bodies attract each other.
Eg : Comb when rub with dry hair can attract small bits of paper by process of induction.

BASIC PROPERTIES OF ELECTRIC CHARGES

i) Charges are additive in nature.
ii) Charges are quantised in nature.
iii) Charges are conserved in nature.

1. **Additivity of charge : It means that the total charge of a system is the algebraic sum of all the individual charges located at different points inside the system.**
2. **Conservation of charge : It means that for an isolated system the total charge should always remain constant. E.g : When glass rod is rub with silk, it develops positive charge. At the same time silk develops equal amount of negative charge. Thus, the net charge of the glass and silk is zero as it was before rubbing.**

3. Quantisation of charge : It states that the total charge on a body should be an integral multiple of elementary charge, e .
OR Fraction of elementary charge, e cannot reside on a body.
Thus the total charge on a body is Q = ne , where n = ± 1, ±2,±3 … e = 1.6 x 10^{-19} C.

COULOMB'S LAW IN ELECTROSTATICS

It states that the force of interaction between two stationary point charges is directly proportional to the product of magnitude of the charges and inversely proportional to the square of the distance between the charges.

LIMITATIONS OF COULOMB'S LAW

i) **It is applicable to only on point charges. ii) It is applicable to only stationary charges.**

SIGNIFICANCE OF COULOMB'S LAW

i) **Electrons revolved around the nucleus due to coulomb's force.**
ii) **Atoms unite together to formed molecule due to coulomb's force.**

PERMITTIVITY OF A MEDIUM

It is the property of a medium which determines the electric force between two charges two charges situated in that medium.
For air or vacuum it is ε_0 and for other medium it is ε.

RELATIVE PERMITTIVITY (ε_R) OR DIELECTRIC CONSTANT (K)

Relative permittivity of a medium is the ratio of permittivity of the medium to the permittivity of free space.
Or
Relative permittivity of a medium is the ratio of force between the two point charges placed in vacuum to the force between the two point charges placed the same distance apart in the given medium.

FORCE DUE TO MULTIPLE CHARGES

The force on a charge due to a number of multiple charges can be obtained by using superposition principle.

SUPERPOSITION PRINCIPLE

It states that when a number of charges are interacting, the total force on a gives charge is the vector sum of the forces exerted on it due to all other charges.

ELECTRIC FIELD

It is the space around a charge body where electric force can be experienced. The charge which is producing the field is called source charge and the charge which test the field of a source charge is called test charge.
The test charge should be of vanishingly small magnitude so that it does not disturb the position of source charge. By convention unit positive charge is consider as the test charge.
Further, repulsion is the sure test for finding electric field due to a source charge.

ELECTRIC FIELD INTENSITY (STRENGTH)

Electric field intensity at a point in an electric field is the force experienced by a unit positive charge placed at that point.
If F is the force experienced by a vanishingly small test charge q_0 placed at a point in an electric field

Then electric field intensity at that point is E = $\frac{F}{q_0}$
It is a vector quantity which is directed along the force experienced by the test charge.
Its SI unit is NC^{-} or Vm-1
Again the force experienced by a charge q in an electric field E is F = qE.

ELECTRIC FIELD INTENSITY DUE TO A POINT CHARGE

ELECTRIC DIPOLE

It is a pair of two equal and opposite charges separated by a certain length. The length of the dipole is called dipole length represented by 2a.
E.g : H_2O, HCl, etc

ELECTRIC DIPOLE MOMENT

Electric dipole moment is defined as the product of magnitude of a charge of dipole and dipole length. It is a vector quantity directed from –ve to +ve charge and its magnitude is given by

$$p = 2aq.$$

ELECTRIC FIELD INTENSITY DUE TO AN ELECTRIC DIPOLE

i) **Electric field intensity along axial line.**
Let q , $-q$ = charges of the electric dipole at A and B.
p = electric dipole moment
r = distance of point P on the axial line from the centre O of the electric dipole
E_A , E_B = electric field intensity at P due to charges at A and B.

ii) **Electric field intensity along equatorial line.**
Let q , $-q$ = charges of the electric dipole at A and B.
p = electric dipole moment
r = distance of point P on the equatorial line from the centre O of the electric dipole
E_A , E_B = electric field intensity at P due to charges at A and B.

ELECTRIC FIELD LINES/ ELECTRIC LINES OF FORCE

It gives the pictorial representation of electric field.
It is defined as a path straight or curved such that tangent to it at any point gives the direction of electric field intensity. Or It is the path followed by a unit positive charge in an electric field.

Electric field lines are given below:

i) **Point charge (ii) Electric dipole (iii) Pair of equal & like charges iv) pair of unequal and like charges.**

v) Uniform electric field lines: They are represented by parallel equi spaced straight lines and are produced from plane sheet of charge with uniform charge distribution.

PROPERTIES OF ELECTRIC FIELD LINES

i) They cannot forms loops.
ii) They start from positive charge and ends at negative charge.
iii) Electric field lines are always perpendicular to the surface of charge body.
iv) Electric field lines cannot have a break point.
v) Two electric field lines cannot intersect each other.
vi) They cannot pass through a conductor.
vii) Electric field lines contract longitudinally between unlike charges. This property explains the attractive nature between unlike charge.
viii) Electric field lines exert lateral pressure between like charges. This property explains the repulsive force between like charges.
ix) The relative closeness between electric field lines gives the strength of electric field. Closer the electric field lines stronger are the electric field and vice-versa.

ELECTRIC FIELD INTENSITY DEFINITION FROM FIELD LINES

It is numerically equal to the number of electric field lines passing normally over a unit area drawn around the given point.

ELECTRIC DIPOLE IN A UNIFORM ELECTRIC FIELD

Let q , $-q$ = charges of the electric dipole
$p = 2aq$ is the electric dipole moment
θ = angle between direction of dipole moment and uniform electric field E.
F_A , F_B = forces experience by the charges at A and B

ELECTRIC FLUX

Electric flux over a surface is the number of electric field lines passing through that surface.
They are of two types:

i) Positive or outward flux. Ii) Negative or inward flux.

1) Electric flux by constant field. 2) Electric flux by variable field.

GAUSS LAW

It states that the total electric flux over a close surface is equal to $1/\varepsilon_0$ times the charge enclosed by the close surface.
Integral form: It states that the surface integral of electric field intensity over a close surface is equal to $1/\varepsilon_0$ times the charge enclosed by the close surface.

GAUSSIAN SURFACE

It is an imaginary surface that we choose for the application of gauss law.

CONTINOUS CHARGE DISTRIBUTION

i) Linear charge distribution : It is the distribution of charge uniformly over a line. The distribution of charge on unit length is called linear charge density given by λ= q/l
ii) Surface charge distribution : It is the distribution of charge uniformly over a surface. The distribution of charge on unit area is called surface charge density given by σ = q/A
iii) Volume charge distribution : It is the distribution of charge uniformly over a volume. The distance of charge on unit volume is called volume charge density given by S =q/v

APPLICATION OF GAUSS LAW

1) Electric field intensity due to an infinitely long charge wire.
2) Electric field intensity due to a infinite plane sheet of charge.
3) Electric field due to a charged spherical shell.

ELECTRIC FIELD BETWEEN TWO CHARGE PARALLEL PLATES

(i) Like charges on the plates (ii) unlike charges on the plates

Note: Using gauss law one cannot determine the electric field due to an electric dipole because a dipole field has no symmetry.

ELECTRIC POTENTIAL (WORK)

It is defined as the amount of work done in bringing a unit +ve charge from infinity upto the given point.
If W is the work done in bringing a test charge q_0 from infinity to a given point, then electric potential at that point is V= w/ q_0.
Its unit is JC^{-1} or volt.

ELECTRIC POTENTIAL DIFFERENCE

Electric potential difference between two points is defined as the amount of work done in bringing a unit +ve charge from one point to another. If W is the work done in moving a test charge q_0 from a point A to another point B, then
V_B- V_A = W/q_0.

ELECTRIC POTENTIAL DUE TO A POINT CHARGE

ELECTRIC POTENTIAL DUE TO AN ELECTRIC DIPOLE

Let q , -q = charges of the electric dipole at A and B.
p = electric dipole moment
r = distance of point P from the centre O of the electric dipole
V_A , V_B = electric potential at P due to charges at A and B.

ELECTRIC POTENTIAL DUE TO A SYSTEM OF CHARGES
RELATION BETWEEN ELECTRIC FIELD AND ELECTRIC POTENTIAL

EQUIPOTENTIAL SURFACE
This are the surface at every point on electric potential is same.
Equipotential surface are given below:

i) Point charge ii) Electric dipole iii) Pair of equal and like charges
ii) Uniform electric field

Properties of equapotential surfaces:

1) No work is done in moving a charge over an equipotential surface.
2) Electric field lines are always perpendicular to equipotential surface.
3) Two equipotential surfaces cannot intersect each other.
4) The spacing between equipotential surfaces determines the strength of electric field. Crowder the equipotential surfaces greater is the electric field.

POTENTIAL ENERGY FOR A SYSTEM OF CHARGES
Potential energy for a system of charges defined as the amount of work done in forming the system of charges. It is also equal to the amount of work done in deforming the system of charges.

POTENTIAL ENERGY FOR A SYSTEM OF TWO POINT CHARGES

POTENTIAL ENERGY OF A DIPOLE IN A UNIFORM ELECTRIC FIELD
It is the work done in rotating the dipole against the torque

ELECTRICAL PROPERTIES OF CONDUCTOR

1) Net electric field in the interior of conductor is 0.
2) Charges cannot reside inside a conductor.
3) Charges reside on the outer surface of the conductor.
4) Electric potential in constant throughout the whole volume of the conductor.
5) Electric field lines are perpendicular to the surface of charge conductor.
6) Surface charge density in high in the regions having smaller radius of curvature.

DIELECTRICS
These are the substances which do not conduct current but induced charges appears on its surface in the presence of electric field

i) Polar dielectrics :- These are made from polar molecules. Eg water.
ii) Non-polar dielectrics:- These are made from non-polar molecules. E.g : CO_2

DIELECTRIC POLARIZATION
When a polar dielectric is placed in an external electric field the centres of positives charges are pulled along the direction of electric field while the centres of negative charges are pulled opp. to the direction of electric field. Thus the +ve and –ve charges centres get separated and is said to be polarized.

NON POLAR DIELECTRIC IN AN UNIFORM ELECTRIC FIELD
When a non polar dielectric is placed in an external electric field, the molecule of the dielectric gets polarized. Due to polarization an electric field is set up inside the dielectric which opposes external electric field. So, the electric inside the dielectric is less than the outside electric field.

POLAR DIELECTRIC IN A UNIFORM ELECTRIC FIELD
When a polar dielectric is placed in an external electric field, the molecules of the dielectric experienced a torque. Due to this an electric field is set up inside the dielectric which opposes the external electric field. So, the electric field inside the dielectric is less than the external electric field.

DIELECTRIC CONSTANT

Dielectric constant of a medium is defined as the ratio of external electric field to the reduced value of electric field inside the dielectric.

i.e K = E_0/E, where E_0 = external electric field. E = electric field inside the dielectric.

CAPACITANCE OF A CONDUCTOR

It is the ability to store charge on a conductor

Capacitance of a conductor is the amount of charge required to raise the potential of the conductor by 1V. Its unit is farad.

CAPACITOR

A capacitor is an arrange of two conductors for storing a large amount of charge.

CAPACITANCE OF A CAPACITOR

It is the amount of charge given to a conductor of the capacitor to raise the potential difference between the conductors by 1V. Its unit is farad.

PARALLEL PLATE CAPACITOR

It consists of two parallel conducting plates separated by a certain distance. The medium between the plates may be air or a dielectrics.

EXPRESSION FOR CAPACITANCE OF A PARALLEL PLATE CAPACITOR

ENERGY STORED IN CAPACITOR

During charging a capacitor external work has to be done. This work done is stored as electrostatic potential energy in the dielectric medium between the plates.

EXPRESSION FOR ENERGY STORED IN CAPACITOR

COMBINATION OF CAPACITORS

1) Series
   Consider three capacitors having capacitance C_1 , C_2 and C_3 connected in series to a source of potential V. The three capacitance have same charge q but of different potentials V_1, V_2 and V_3.

2) Parallel
   Consider three capacitors having capacitance C_1 , C_2 and C_3 connected in parallel to a source of potential V. The three capacitance have same potential V but of different charges q_1, q_2 and q_3.

COMMON POINT OF CAPACITORS COMBINATION

Consider two capacitor having capacitance C_1 and C_2 charge to difference potentials V_1 and V_2.

When they are connected, charges will flow from higher potential to lower potential until they maintain a common potential V.

Total charge after sharing = total charge before sharing

=> $C_1V + C_2V = C_1 V_1 + C_2 V_2$

=> V =($C_1 V_1 + C_2 V_2$)/ $C_1 + C_2$

= total charge/total capacity

VAN DE GRAAF GENERATOR

It is a device used for producing accelerated charges. It is based on the phenomenon of electromagnetc induction and discharging action of charges at sharp points.

Construction : It consists of a large spherical shell supported by an insulating material. There are two pulleys driven by an electric motor and over it an insulating belt is mounted. Two metallic spikes are placed near the two pulley with the upper spike connected to the spherical shell. The lower metallic spike is connected to a high tension source.

Working: Due to high electric field at the pointed ends of lower comb, the air of the neighbourhood gets ionised and positive charges are sprayed to the belt, which moves up into the shell. As it passes close to upper comb, it induces negative charges at the pointed tips and positive charges on the shell. The positive charge spreads uniformly on the outer surface of the shell. The high electric field at the pointed tips ionises the air and neutralises the positive charge on the belt. The belt free from charge returns and then collects the positive charge from the lower comb. This process continues and more and more positive charge is built up on the sphere.

UNIT –II TOPIC – CURRENT ELECTRICITY

ELECTRIC CURRENT

It is defined as the rate of flow of electric charges though a particular region. It is given by $I = q/t = ne/t$

The instantaneous current in a conductor is a given by $I = dq/dt$

In a conductor free electron move from lower potential to higher potential while electric current flows from higher potential of lower potential. Thus, the motion of free electrons and direction of current is opposite.

CURRENT CARRIERS

1) Solid : In metal or conductor free electron are the current carrier. In insulator three are no current carrier. In semi-conductor, free electrons and the holes are current carrier.
2) Liquid : In liquid, +ve and –ve ions are current carrier.
3) Gas : In gases, free electron and ions are the current carriers.

DRIFT VELOCITY OR SPEED

It is the average speed with which the free electrons of the conductor are drifted towards the +ve end of the conductor or opp. to +ve direction of electric field.

RELATION BETWEEN CURRENT AND DRIFT VELOCITY

CURRENT DENSITY

It is defined as the current flowing on unit area of the conductor with the area held ⊥ to the current flow. It is given by $J = I/A$

MOBILITY

Mobility of a current carrier (charge) is defined as the ratio of drift velocity to the applied electric field.

i.e. $\mu = Vd/E = Ee\tau/Em = e\tau/m$.

OHM'S LAW

It states that at constant temperature the current flowing through a conductor is directly proportional to the potential difference applied across its ends.

i.e $V \alpha I$

=> $V = IR$, where R is called resistance of conductor.

OHMIC AND NON-OHMIC SUBSTANCES

Those substances which obey ohm's law are called ohmic substances.

Their V- I graph is linear. E.g : conductor at low current.

Those substances which do not obey ohm's law are called non ohmic substances.

Their V-I graph is non-linear. E.g : semi conductor, diode.

DERIEVATION OF OHM'S LAW FROM DRIFT VELOCITY.

RESISTANCE OF A CONDUCTOR

Resistance of a conductor is defined as the opposition offered to the flow of free electron by the atom or ions of the conductor. It is given by R = V/I

FACTOR AFFECTING RESISTANCE OF A CONDUCTOR

1) Resistance increases with increase in length.
2) Resistance decreases with increases in area of cross section.
3) Resistance increases with rise in temperature.
4) Nature of the material.

SPECIFIC RESISTANCE OR RESISTIVITY

It is defined as the resistance on unit length and unit area of cross section of the conductor.

CONDUCTANCE It is the ease with which free electrons moves in a conductor.
It is the reciprocal of resistance. Its unit is Ω^{-1} or siemen (s).

CONDUCTIVITY: It is defined as the reciprocal of resistivity. Its unit is $\Omega^{-1}\ m^{-1}$.

COMBINATION OF RESISTANCE

1) Series
Consider three resistors having resistances R_1 , R_2 and R_3 connected in series to a source of potential V. The three resistances have same current I but of different potentials V_1, V_2 and V_3.

3) Parallel
Consider three resistors having resistances R_1 , R_2 and R_3 connected in parallel to a source of potential V. The three resistances have same potential V but of different currents I_1, I_2 and I_3.

TEMPERATURE EFFECT ON RESISTANCE

TEMPERATURE CO-EFFICIENT OF RESISTANCE.
It is defined as the increase in resistance on unit resistance of the substance with unit degree rise in temperature.

COLOUR CODE FOR CARBON RESISTANCE
Various colours are coated on carbon resistor to knows their values.

i) The first two colours gives the first two significant digits.
ii) The third colour gives the multiplying factors in powers of ten.
iii) The fourth colour gives the percentage of accuracy or tolerance.

ELECTRIC POWER
It is the rate at which electric work is done by the source in maintaining current in the circuit.

$$\therefore P = VI = I^2R = V^2/R$$

ELECTRIC ENERGY
The total work done by the source in maintaining current in the circuit is called energy consumed. i.e E = W = P x t

$$\therefore E = VIt = I^2Rt = V^2/R\ t$$

CELL: A cell is a device which converts chemical energy into electrical energy.
Types:

1) Primary cell: These are the cells where electrical e4nergy is obtained by irreversible chemical reaction. Such cells cannot be recharged. E.g: Daniel cell.
2) Secondary cell: These are the cells where electrical energy is obtained by reversible chemical reaction. Such cells can be recharged. Eg : Lead accumulators.
The capacity of a cell is measured in ampere hour (Ah).

INTERNAL RESISTANCE OF A CELL

It is the opposition offered to the flow of current by electrodes and electrolyte of the cell. It depends on the following factors.

1) **Nature of the electrodes and electrolytes.** **2. Concentration of the electrolyte.**
3) **Distance between the electrodes.** **4. Temperature of the cell.**

EMF (ELECTROMOTIVE FORCE)

It is the total work done by the cell in taking a unit charge once round the complete circuit.
It is equal to the maximum potential difference across the terminal of the cell in open circuit or no current is drawn from the cell.

TERMINAL POTENTIAL DIFFERENCE

It is the potential drop across the terminal of a cell when current is drawn from the cell or the cell is in closed circuit.

EXPRESSION FOR INTERNAL RESISTANCE (RELATION BETWEEN r, E &V)

COMBINATION OF CELLS **1) Series** **2) Parallel**

ELECTRICAL MEASUREMENT

KIRCHHHOFF'S LAW

This law is used to solve complex electrical network and so in superior to ohm's law.

1) **1st law / current law/ junction law: It states that the algebraic sum of all the currents meeting at a junction is zero. i.e $\sum I = 0$.**
2) **2nd law / loop law/ voltage law: It states that the algebraic sum of all the emfs and product of current and resistance in a closed electrical network is zero.**
   i.e $\sum V = 0$.
   => $\sum E + \sum IR = 0$.

WHEATSTONE BRIDGE

METRE BRIDGE / SLIDE WIRE BRIDGE

POTENTIOMETER

It is a device used for measuring emf of an unknown cell.
Uses of potentiometer
1. Finding emf of an unknown cell. **2. Comparing emf of two cells.** **3. Finding internal resistance of a cell.**

SENSITIVENESS OF A POTENTIOMETER

A potentiometer is sensitive when it can measured small value of potential difference.
The sensitivity of a potentiometer can be increased by decreasing the potential gradient k. Thus, potentiometer of longer wire is preferred.

UNIT -3 TOPIC- MAGNETIC EFFECTS CURRENT MAGNETISM.

MAGNETIC FIELD

It is the space around a current carrying conductor or a magnet where magnetic effect can be experience. Its S.I unit is tesla (T) or weber metre^{-2} (wbm^{-2}) and CGS unit is gauss (G).

BIOT SAVART LAW

This law is used to determine the magnitude field given by a small current element.

CURRENT ELEMENT

It is a portion of a current carrying conductor. It is a vector quantity denoted by $\vec{Il}$.

BIOT SAVART LAW

MAGNETIC FIELD AT THE CENTRE OF A CIRCULAR CURRENT COIL AND ALONG ITS AXIS

Pattern of M.F.: The magnitude field pattern due to a circular current carrying coil are circles around the wire and appear straight at the centre. The direction of M.F is given by Right hand rule.

RIGHT HAND RULE: According to the rule, curl the fingers of our right hand along the direction of current in the loop then the extended thumb gives the direction field or magnetic moment (S →N).

AMPERE'S CIRCUITAL LAW:
It states that the line integral of magnetic field over a closed loop is equal to μ_0 times the current threading the closed loop i.e $\oint \vec{B}.\vec{dl} = \mu_0 I_{enc}$.

AMPERIAN LOOP
It is an imaginary loop that we choose for application of Ampere's circuital law.
Application

M.F. DUE TO A STRAIGHT CURRENT CARRYING CONDUCTOR

RIGHT HAND THUMB RULE
When we hold the current carrying conductor in the grip of our right hand with current pointing along the thumb direction. Then, the curvature of our finger gives the direction of M.F

SOLENOID
A solenoid is a long turn of coil wound in the form of a helix such that its diameter is very small as compared to its length. The M.F. inside the solenoid is very strong and uniform represented by parallel straight lines. Outside the solenoid the M.F is very weak and is considered as zero as compared to the inside M.F.

MAGNETIC FIELD INSIDE STRAIGHT SOLENOID

TOROID/ TORODIAL SOLENOID
A solenoid bend in the form of a circle is called toroid. It is considered as an endless solenoid. A toroid with inner radius 'a' and outer radius 'b' has a mean radius r = a+b/2.Magnetic field inside the toroid are concentric circle.

MAGNETIC FIELD INSIDE A TOROID/TORODIAL SOLENOID

FORCE ON A CHARGE IN A UNIFORM MAGNETIC FIELD

MOTION OF A CHARGE IN A MAGNETIC FIELD

CYCLOTRON
It is a device used for producing accelerated charges.

PRINCIPLE: It is based on the fact that a charge particle can be accelerated to a sufficiently high energy by entering repeatedly in an electric field region with the use of a uniform magnetic field.

CONSTRUCTION
It consists of two D shaped hollow semicircular metal chamber D_1 and D_2 called dees. The two dees are placed horizontally with a small gap separating them and are connected to a source of high frequency oscillator. The whole apparatus is placed between the poles of a strong magnet. The magnetic field acts perpendicular to the plane of dees and the positive ions to be accelerated are produced in the gap between the dees.
WORKING
When the positive ion is produced in the gap between the dees , let D_1 be at negative potential and D_2 at positive potential. Then the ion will be accelerated towards D_1. But due to perpendicular magnetic field the ion will describe a semicircular path. As the ion arrives in the gap between the dees, the polarity of dees gets reversed i.e D_1 becomes positive and D_2 negative. Then the positive ion is again accelerated inside D_2 and it moves with greater speed and describes a semicircular path of greater radius. Thus the positive ion acquires more and more energy when it comes inside the gap. This process is repeated and the charge particle acquires a sufficient energy. Then the ion is removed out of the dees.

LIMITATIONS OF CYCLOTRON

1. Cyclotrons cannot accelerate neutral particles like neutrons.
2. Cyclotrons are suitable to accelerate only heavy particles like protons, deuterons etc.
3. Electrons cannot be accelerated inside a cyclotron.

FORCE ON A CURRENT CARRYING CONDUCTORIN A UNIFORM MAGNETIC FIELD

FORCE BETWEEN TWO PARALLEL CONDUCTORS CARRYING CURRENT

TORQUE ON A CURRENT CARRYING COIL IN A UNIFORM M.F

MOVING COIL GALVANOMETER
It is device used for detection and measurement of small electric current.
Principle: It is based on the fact that a current carrying coil experienced a torque when placed in a uniform magnetic field.

CONSTRUCTION
It consists of a coil PQRS suspended between the poles of a strong permanent magnet NS. The coil is wound on a non metallic frame and has a soft central iron core. The coil is suspended from the torsion head(H) with a phosphor bronze wire. The other end of the coil is attached to a hair spring. The whole arrangement is place in a non magnetic box to avoid disturbance. To connect the galvanometer in the circuit binding screws are provided.

RADIAL M.F

SENSITIVENESS OF A GALVANOMETER
A Galvanometer is said to be sensitive when it produced a large deflection when a small current is passed through the coil.
The sensitivity of a galvanometer can be measured by current sensitivity.
CURRENT SENSITIVITY
It is the deflection produced on the galvanometer coil on passing unit current. If θ is the deflection on the galvanometer coil on passing current I. Then, current sensitivity is $I_s = \theta/I = I/G = nBA/k$.
To increased the current sensitivity we should:

i) Increase the no. of turns n, M.F B and area A of the coil.
ii) Decreased the value of k i.e. the suspension wire should be of low restoring torque per unit turns t.

SHUNT
A shunt is a low resistance connected in parallel with the galvanometer so s to safe the galvanometer from being damaged due to high current.
AMMETER
It is a low resistance device which is connected in series to the circuit.
CONVERSION OF GALVANOMETER TO AMMETER
A galvanometer can be converted into an ammeter by connecting a low resistance in parallel.
VOLTMETER
A voltmeter is a high resistance device connected in parallel to the circuit.
CONVERSION OF GALVANOMETER TO VOLTMETER
A galvanometer can be converted into a voltmeter by connecting a high resistance in series.

Magnetism

PROPERTIES OF MAGNET

1. A magnet can attract magnetic materials like iron, cobalt, nickel etc.
2. A magnet should have two poles. Monopole cannot exist.
3. Like poles repel and unlike poles attract each other.
4. A freely suspended bar magnet always points along north south direction.

COULOMB'S LAW IN MAGNETISM

It states that the force of interaction between two magnetic poles of strength m_1 and m_2 separated by a distance r is directly proportional to the product of the pole strengths and inversely proportional to the square of the distance between the poles.

MAGNETIC FIELD INTENSITY
Magnetic field intensity at a point in a magnetic field is defined as the force experience by a unit north pole placed at that point.

MAGNETIC FIELD LINES
It is a path straight or curve such that tangent to it at any point gives the direction of magnetic field intensity.
Properties:

- **i) They can formed loops.**
- **ii) Outside the magnet they moved from north pole to south pole. and inside the magnet they moved from south pole to north pole.**
- **iii) Closer the M.F lines stronger is the M.F and vice-versa.**
- **iv) Two M.F lines cannot intersect each other, if they intersect then at the point of intersection there will be two different values for magnetic field intensity which is not possible. Thus, two M.F lines cannot intersect each other.**

BAR MAGNET EQUIVALENT TO A CURRENT CARRYING SOLENOID
A bAR magnet is equivalent to a current carrying solenoid due to the following similarities.

- **i) The M.F pattern due to a bar magnet and a current carrying solenoid are almost similar.**
- **ii) Cutting a bar magnet is just like cutting a solenoid obtaining two parts with weaker magnetic properties.**
- **iii) The deflection of magnetic needle around a current carrying solenoid and bar magnet are similar.**

MAGNETIC FIELD INTENSITY DUE TO A MAGNETIC DIPOLE / BAR MAGNET

1. **AT A POINT ON AXIAL LINE OR END ON POSITION**

Let m = magnetic pole strength of the magnetic dipole
2l = magnetic dipole length
r = distance of point P on the axial line from the centre O of the magnetic dipole
B_N , B_S = Magnetic field intensity at P due to N-pole and S-pole of magnetic dipole

2. **At a point on equatorial line or broad side position**
Let m = magnetic pole strength of the magnetic dipole
2l = magnetic dipole length
r = distance of point P on the equatorial line from the centre O of the magnetic dipole
B_N , B_S = Magnetic field intensity at P due to N-pole and S-pole of magnetic dipole

TORQUE ON A MAGNETIC DIPOLE PLACED IN A UNIFORM MAGNETIC FIELD

Let m = magnetic pole strength of the magnetic dipole
M = 2lm is the magnetic dipole moment
θ = angle between direction of dipole moment and magnetic field.
F_N , F_S = forces experience by N-pole and S-pole.

CURRENT LOOP AS A MAGNETIC DIPOLE
Around a current carrying loop there is magnetic field of same strength but opposite in direction. This is similar to two different magnetic poles having same strength separated by the plane of coil. So a current loop can be considered as an magnetic dipole.

MAGNETIC MOMENT DUE TO A REVOLVING ELECTRON
A revolving electron is like a loop of current and so it acts as a magnetic dipole and has a magnetic moment.

BOHR MAGNETON

We have, $M = n\mu_B$, where n =1

$\therefore \mu_B = M$

It is defined as the magnetic moment associated with an electron due to its orbital motion in the first orbit of hydrogen atom.

EARTH MAGNETISM

It is assumed that inside the earth there is a huge magnet buried inside it with its north pole pointing towards geographical south and its south pole pointing towards geographical north.

Geographic axis: It is the straight line that passes through the geographical north and south pole of earth.
Magnetic axis: It is the straight line that passes through the earth's magnet north and south pole.
Geographic meridian: It is the straight line that passes through the geographical axis of earth.
Magnetic meridian: It is the straight line that passes through the magnetic axis of earth.

MAGNETIC ELEMENTS OF EARTH

These are the physical quantities which completely describe the magnitude and direction of earth's magnetic field at a place. The three magnetic elements are

1. Magnetic declination. 2. Magnetic inclination or angle of dip.
3. Horizontal components of earth's magnetic field.

1. Magnetic declination: Magnetic declination at a place is defined as the angle between the magnetic meridian and geographic meridian.

2. Angle of dip: Dip at a place is define as the angle which the direction of earth's magnetic field intensity makes with the horizontal line drawn in the magnetic meridian.
   At the equator it is $0°$ and at the poles it is $90°$.

3. Horizontal components of earh's magnetic field: Horizontal components of earh's magnetic field at a place is defined as the components of earth's magnetic field in the horizontal direction in magnetic meridian.

TERMS RELATED TO MAGNETISM

MAGNETISING FIELD INTENSITY: It is the extent to which the magnetizing field can magnetized a substance.

INTENSITY OF MAGNETISATION: It is the degree or extent to which a substance is magnetized when placed in a magnetizing field.

MAGNETIC PERMEABILITY: It represents the passage of magnetic field lines through a substance.

MAGNETIC SUSCEPTIbILITY: It is the property of the substance which shows how easily the substance can be magnetized when placed in the magnetizing field.

MAGNETIC MATERIALS

Materials which are affected by magnet are called magnetic materials. They are classified as

1. DIA MAGNETIC SUBSTANCES 2. PARAMAGNETIC SUBSTANCES 3. FERROMAGNETIC SUBSTANCES

DIAMAGNETIC SUBSTANCES: These are the materials in which the individual atoms do not possess magnetic moments of their own. When placed in an external magnetic field they are feebly magnetized in a direction opposite to the magnetizing field. They are weakly repelled by magnet. They are temperature independent. Eg. water, copper etc.

PARAMAGNETIC SUBSTANCES : These are the materials in which the individual atoms possess magnetic moments of their own. When placed in an external magnetic field they are feebly magnetized in a direction similar to the magnetizing field. They are weakly attracted by magnet. They are temperature dependent. Eg. Al, Na, Ca etc.

FERROMAGNETIC SUBSTANCES: These are the materials in which the individual atoms possess magnetic moments of their own. When placed in an external magnetic field they are feebly magnetized in a direction similar to the magnetizing field. They are strongly attracted by magnet. They are temperature independent but above a certain temperature called Curie temperature they become temperature dependent. Eg, iron, cobalt, nickel etc.

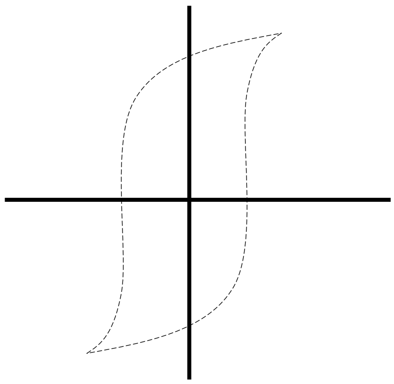
CURIE TEMPERATURE: This is a certain limit of temperature for a ferromagnetic substance such that above this temperature, ferromagnetic substance starts losing their property and behaves as a paramagnetic substance.

DIFFERENTIATE BETWEEN DIA PARA AND FERROMAGNETIC SUBSTANCES

PROPERTY	DIA	PARA	FERRO
Effect of magnet	Weakly repelled by magnet	Weakly attracted by magnet	Strongly attracted by magnet
In external magnetic field	Feebly magnetized in direction opposite to magnetizing field	Feebly magnetized in direction similar to magnetizing field	Strongly magnetized in direction similar to magnetizing field
When placed in non uniform magnetic field			
Magnetic permeability			
Magnetic susceptibility			
Effect of temperature	Temperature independent	Temperature dependent	Temperature independent upto curie temperature and then temperature dependent
Passage of magnetic field lines			
Retentivity			
Coercivity			

HYSTERESIS

It is the behavior shown by a ferromagnetic substance when placed in an external magnetic field. The hysteresis loop of a ferromagnetic substance is shown in the figure.



RETENTIVITY/RESIDUAL MAGNETISM

It is the strength of magnetic field that remains inside the ferromagnetic magnetic substance when the magnetizing filed is removed.

COERCIVITY

It is the value of reversed magnetic field that should be applied to a ferromagnetic substance so as to brought the residual magnetism to zero.

COMPARISION OF HYSTERESIS LOOP OF SOFT IRON AND STEEL

The hysteresis loop of soft iron and steel reveals that

1. **Soft iron has more retentivity than steel. This means that soft iron is more strongly magnetized than steel.**
2. **Steel has more coercivity than soft iron. This means that steel retains its magnetism for a long time than soft iron.**

HYSTERESIS LOSS

It is the energy loss during magnetisation and demagnetisation of a ferromagnetic substance. This loss in energy is equal to the area of the hysteresis loop.

PERMANENT MAGNET: The material for making permanent magnet should possesses the following properties

1. **High retentivity 2. High coercivity 3. High magnetic permeability**

Inspite of low retentivity steel is preferred for making permanent magnet because of its high coercivity.

ELECTROMAGNET: The material for making electromagnet should possesses the following properties

1. **High retentivity 2. Low coercivity 3. High magnetic permeability 4. Low hysteresis loss**

Thus soft iron is the best choice for making electromagnet.

Unit -4 Topic:- Electromagnetic Induction & A.C

MAGNETIC FLUX
Magnetic flux over a surface represents the total no. of magnetic field lines passing through a surface.
Its S.I unit is weber and S.I unit is Maxwell.

ELECTROMAGNETIC INDUCTION
It is the phenomenon of production of induced emf and hence induced current in a closed circuit due to a hange of magnetic flux link with the circuit.
The current and emf so produced in a coil by changing magnetic flux are called induced current and induced emf.

FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION
1^{st} law: Whenever magnetic flux link with a closed circuit changes and emf is induced in it which last only so long as the change in flux is taking place.
2^{nd} law: The magnitude of induced emf is directly proportional to the rate of change of magnetic flux link with coil.

LENZ LAW
This law gives the direction of induced current. It states that the direction of induced current in a circuit is such that it opposes the caused which produces it.

LENZ'S LAW AND ENERGY CONSERVATION
When north pole of magnet is moved closer to the coil its face towards the magnet develops north polarity and thus repels the magnet.Work has to be done against the repulsive force in moving the magnet closer to the coil.
Similarly, when north pole of magnet is moved away from the coil its face towards the agnet develops south polarity and hence attract the magnet.Work has to be done against the attractive force in moving the magnet away from the coil.

This work done against the force of attraction or repulsion is converted into electrical energy and appears as induced current.
So, there is energy conservation in Lenz's law

METHODS OF PRODUCING INDUCED EMF

i) By changing strength of M.F linked with the coil (B).
ii) By changing area of the coil linked with the M.F.(A).
iii) By changing orientation of the coil linked with M.F.

MOTIONAL EMF

EDDY'S CURRENT
This are the current induced in solid metallic masses when magnetic flux linked through them changes. Eddy's also opposes the change in magnetic flux and so there direction is given by Lenz law.
Uses law Eddy's current:

1. Induction furnace 2. Electric power meter 3. Electric brake. 4. Speedometer.

UNDESIRABLE EFFECTS OF EDDY'S CURRENT
Eddy's current are produced inside the iron cores of rotating armatures of electric motors and a dynamos when they are in used. Eddy's current caused unnecessary heating and wasted of power. The heat produced by Eddy's current may even damaged the insulation of coil. Eddy's current can be reduced by using laminated core which instead of a single solid mass consist of thin metal sheets insulated from each other by thin layer of varnish.

SELF INDUCTION
It is the phenomenon of production of induced emf in a coil when a changing current passes through it.

SELF INDUCTANCE / COEFFICIENT OF SELF INDUCTION.
It is defined as the magnetic flux linked with the coil when a unit current is passed through it.

It is defined as the emf produced in the coil when current in the coil changes at the rate of 1 ampere per second.
Its unit is henry(H)

SELF INDUCTANCE OF A LONG SOLENOID /COIL.

FACTORS AFFECTING SELF INDUCTANCE.
The factors are:-

i) No. of turns in the coil. Ii) Area of the coil. Iii) Permeability of the core material.

MUTUAL INDUCTION
It is the phenomenon of production of induced emf in a coil when a changing current is passed in a nearby coil.

MUTUAL INDUCTANCE
It is defined as the magnetic flux linked with a coil when a unit current is passed through a nearby coil.

It is defined as the emf produced in one coil when current in the nearby coil changes at the rate of 1 ampere per second.
Its unit is henry(H)

MUTUAL INDUCTANCE OF A PAIR OF CO-AXIAL SOLENOID

FACTORS AFFECTING MUTUAL INDUCTANCE
The factors are:

I) No. of turns in the two coil. Ii) Common cross sectional area.
iii) Permeability of the core material. Iv) Distance between the two coil.

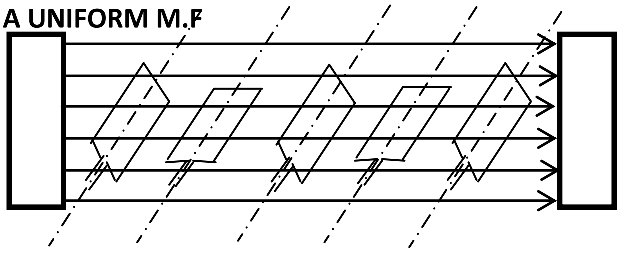
v) Orientation of the two coil.

NON INDUCTIVE WINDING IN RESISTANCE COIL

In resistance coil the wire is first double over ifself and then wound in the form of a coil. Due to this the currents in the two halves of the wire flows in opposite direction. The inductive effects of the two halves of the wire being in opposite direction cancels each other and the net self inductance of the coil is minimum (o).

PRODUCTION OF INDUCED EMF BY ROTATION OF A COIL IN A UNIFORM M.F

Consider a coil free to rotate in a uniform magnetic field.

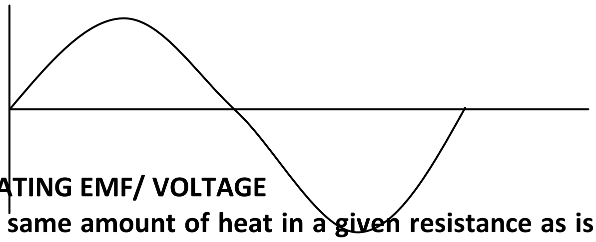


ALTERNATING EMF / VOLTAGE

This are the the emf or voltage which magnitude changes and direction reverses periodically

ALTERNATING CURRENT (A.C)

This are the the currents which magnitude changes and direction reverses periodically.



ROOT MEAN SQUARE/ EFFECTIVE/ VIRTUAL VALUE OF ALTERNATING EMF/ VOLTAGE

It is defined as that value of steady voltage that produces the same amount of heat in a given resistance as is produced by the given alternating voltage when applied to the same resistance for the same time.

ROOT MEAN SQUARE/ EFFECTIVE/ VIRTUAL VALUE OF ALTERNATING CURRENT

It is defined as that value of steady voltage that produces the same amount of heat in a given resistance as is produced by the given alternating voltage when passed to the same resistance for the same time.

PHASOR DIAGRAM

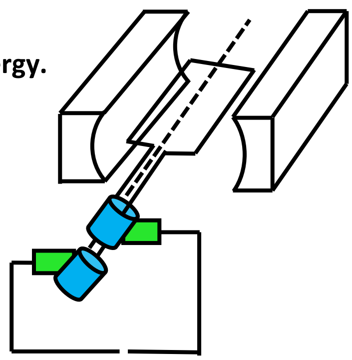
It is a diagram that represents alternating voltage and current of same frequency as rotating vectors along with proper phase angle between them.

AC THROUGH A RESISTOR
AC THROUGH AN INDUCTOR (COIL)
AC IN A CIRCUIT WITH CAPACITOR
AC IN A LCR SERIES CIRCUIT
POWER CONSUMED IN AN AC CIRCUIT WITH RESISTOR
POWER CONSUMED IN AN AC CIRCUIT WITH INDUVTOR
POWER CONSUMED IN AN AC CIRCUIT WITH CAPACITOR
POWER CONSUMED IN LCR SERIES CIRCUIT
RESONANCE IN LCR SERIES CIRCUIT
RESONANT FREQUENCY / RESONANT ANGULAR FREQUENCY
RESONANCE CURVE

FLEMING'S RIGHT HAND RULE

This rule is used to determine the direction of induced current when a conductor moves perpendicularly in a uniform magnetic field.

It states that when we stretched the thumb, middle finger and index finger of our right hand in mutually perpendicular direction such that the thumb gives the motion of conductor and index finger gives the direction of magnetic field, then the direction of middle finger gives the direction of induced current.



AC generator

It is an electrical machine used to convert mechanical energy into electrical energy.

Principle

It is based on the principle of electromagnetic induction.

Constructions

It consists of the following parts.

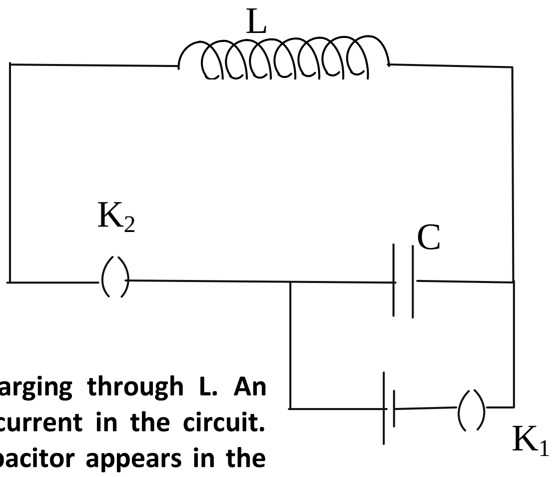
Armature coil: It consists of an armature coil having a large number of turns of insulated copper wire wound on a soft central iron core.

Field magnet: A strong permanent magnet is provided between which the coil is rotated.
Slip rings: The two ends of the coils are connected to two rings.
These rings rotates with the rotation of the coil.
Brushes: There are two brushes which are connected to the slip rings.They collect the current from the coil.

Working

When the armature coil rotates in the magnetic field provided by the strong field magnet, it cuts the magnetic field lines. The magnetic flux linked with the coil changes due to the rotation of the armature coil and hence induced emf is set up in the coil. The direction of the induced emf produced is given by Flemings Right hand rule. The current flows out through one brush in one direction of half of the revolution and through the other brush in the next half revolution in the reverse direction. This process is repeated and the emf produced is alternating in nature.

LC OSCILLATION



When a charged capacitor is allowed to discharged through a non resistive inductor, electrical oscillations of constant amplitude and frequency are produced. This is called LC oscillation.

The circuit diagram for LC oscillation is shown in the fig. A capacitor of capacitance C is connected to an inductor of inductance L through a key K_2. A cell is connected to capacitor through a key K_1.When key K_1 is closed, the cell charges the capacitor. Some energy from the cell is stored in the capacitor in the form of electrostatic energy.

On removing K_1 and putting K_2 the charged capacitor starts discharging through L. An induced emf develops in the circuit which opposes the growth of current in the circuit. When capacitor is completely discharge the energy stored in the capacitor appears in the form of magnetic energy around L.

As soon as discharge of the capacitor is complete, current stops and magnetic flux linked with the inductor starts collapsing. Therefore an induced emf develops in L which starts recharging the capacitor in opposite direction. When recharging is completed, the magnetic energy around L appears as electrostatic energy around C. This entire process is repeated again and again.

Thus energy once taken from the cell and given to the capacitor keeps on oscillating between L and C.

The frequency of the LC oscillation is given by $\nu = 1/2\pi\sqrt{LC}$

TRANSFORMER

It is a device which converts low alt. voltage at high current to high alt voltage at low current or vice versa.
Principle: It is based on the phenomenon of mutual induction.
Types of transformer

i) Step up transformer: It converts low alt voltage at high current to high alt. voltage at low current.
No. of turns in secondary is more than primary.

ii) Step down transformer: It converts high alt. voltage at low current to low alt. voltage at high current.
No. of turns in secondary is less than primary.

CONSTRUCTION

It consists of two separate coils of insulated copper wire having different no. of turns woound on the same laminated iron core. The coil to which electric energy is supply is called primary coil and the coil from which output is taken is called secondary.

THEORY / WORKING

As alternating current flows through the primary coil, it generates an alternating magnetic flux which passes through the secondary coil. The changing magnetic flus sets up an induced emf in the secondary coil and also a self induced emf in the primary coil.

EFFICIENCY OF A TRANSFORMER

It is defined as the ratio of output power of transformer to the input power i.e $\eta = P_0 / P_i$ = output power/ input power.

For an ideal transformer where there is no energy loss η = 1 or 100 % but in actual practice we cannot have a transformer with 100% efficiency because there are many energy loses.

ENERGY LOSES IN A TRANSFORMER

i) Copper losses :- Some energy is loss due to heating of copper wires in the primary and secondary coil. This loss can be minimized by using thick copper wires with low resistance.
ii) Flux loses :- The magnetic linked with the secondary coil produced by the primary coil is not perfect some of the flux is leaked into the air.
This loss can be minimized by winding the 1° and 2° over one another on a iron core.
iii) Eddy current/ Iron loses:- The alt magnetic flux induced eddy current in the iron core which leads to same energy loss in the form of heat. This loss can be minimized by using laminated iron cases.
iv) Hysteresis loses: The alt. magnetic flux carries the iron care through cycles of magnetization and demagnetization . Work is done in each cycle and is loss as heat. This loss can be minimized by selecting core material with low hysteresis loss.

Unit 5 Electro Magnetic Waves

DISPLACEMENT CURRENT
It is that current which comes into play in the region in which the electric field and hence the electric flux is changing with time.
ELECTROMAGNETIC WAVES

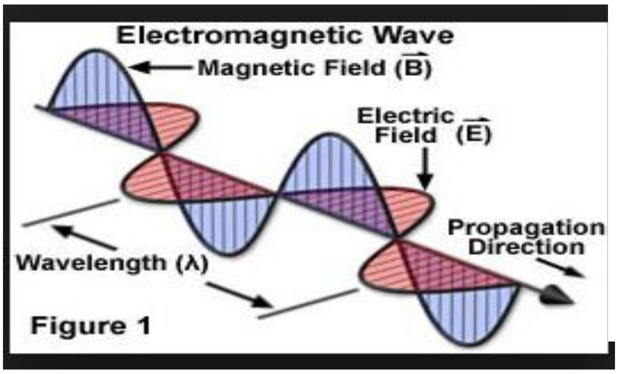


Figure 1

These are the waves which contains sinusoidal variation of electric and magnetic field vectors which are perpendicular to each other and also perpendicular to the direction of wave propagation.
An electromagnetic wave propagating in X direction is shown in the figure.

PROPERTIES OF ELECTROMAGNETIC WAVES
1. They do not require a material medium for their propagation.
2. They are transverse in nature.
3. The oscillation of electric and magnetic field vectors are in same phase.
4. The speed of em waves in vacuum is give $c = \frac{1}{\sqrt{\varepsilon_0 \mu_o}}$ and in other medium $v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{1}{\sqrt{\varepsilon_r \varepsilon_0 \mu_r \mu_o}} = \frac{c}{\sqrt{\varepsilon_r \mu_r}}$
5. They are not deflected by electric and magnetic field.
6. The ratio of amplitude of electric and magnetic field in a medium is v = E/B
7. They obey the phenomenon of reflection, refraction, interference etc.
8. They are produced from accelerated charges.

ELECTROMAGNETIC SPECTRUM
It is the orderly distribution of em waves according to their wavelength or frequency. The electromagnetic spectrum has been broadly classified as
RADIO WAVES: This are the em waves whose frequency ranges from 300Hz to 10^9Hz.
They are produced from oscillating electric circuits containing an inductor and a capacitor.
Uses of radiowaves are
1. They are used in radio and cellular phone communication.
2. They are used in communication purposes.

MICROWAVES: This are the em waves whose frequency ranges from 10^9Hz to 3×10^{11}Hz.
They are produced from special devices like klystron, magnetron vacuum diodes etc.
Uses of microwaves are
1. They are used in radar system for aircraft navigation.
2. They are used in satellite communication.
3. They are used in microwave oven for cooking purposes.

INFRARED (IR) WAVES: This are the em waves whose frequency ranges from 3×10^{11}Hz to 4×10^{14}Hz.

They are produced from very hot bodies like sun, stars etc.

Uses of infrared waves are

1. They are used in remote control.
2. They produced intense heating effect.
3. They are used in physical therapy to treat muscular strain.
4. In weather forecasting through infrared photography.
5. To provide electrical energy to satellite.

VISIBLE RAYS: This are the em waves whose frequency ranges from 4×10^{14}Hz to 8×10^{14}Hz.

They are produced from atomic excitation.

Uses of visible rays are

1. They help us to see the things around us.
2. They are used in photography, microscope etc.

ULTRAVIOLET (UV) RAYS: This are the em waves whose frequency ranges from 8×10^{14}Hz to 5×10^{17}Hz.

They are produced from very hot bodies, sun and special lamps.

Uses of ultra violet rays are

1. To destroy the bacteria in sterilizing the surgical instruments
2. In detection of forged documents, finger prints in forensic laboratory.
3. In food preservation and burglar alarm.

X RAYS: This are the em waves whose frequency ranges from 10^{17}Hz to 10^{19}Hz.

They are produced when fast electrons are stopped by metals having high atomic number.

Uses of X rays are

1. In detective departments for detection of explosives, opium etc in the body of smugglers.
2. In engineering departments for detecting faults , cracks and holes in final metal products.
3. In surgery for detection of fractures, foreign bodies like bullets, diseased organs and stones in human body.

GAMMA RAYS: This are the em waves whose frequency ranges from 10^{19}Hz to 10^{22}Hz.

They are produced from inside the nucleus.

Uses of Gamma rays are

1. They are used for treatment of cancer.
2. To produced nuclear reaction.

Q1. How are foods heated in a microwave oven?

Ans: In a microwave oven , the frequency of microwave much match the resonant frequency of the water molecules so that the energy from the waves is transferred immediately to the water molecules as K.E. Thus the food item gets heated and is cooked

Q2. Why microwave are used in radar system?

Ans: Due to short wavelength, microwaves are not diffracted much by objects of normal dimensions. So they can be transmitted as a beam in a particular direction.

Q3. Which part of the electromagnetic spectrum has the minimum wavelength?

Q4. Arrange x rays, radio waves, UV rays and IR rays in increasing order of wavelength.

Q5. What is the ratio of speed of UV ray to that of Gamma ray in vacuum?

Q6. What is the phase relationship between the electric and magnetic field present in electromagnetic waves?

Q7. What oscillates in an electromagnetic wave?

Q8. Name the em radiation which is (i) used in studying crystal structure (ii) used to photograph in foggy condition (iii) used in satellite communication (iv) absorbed by ozone layer (v) produced during atomic excitation (vi) used for producing intense heating effect. Write one uses of them.

Q9. An electromagnetic wave is travelling along Y-axis. In what direction the electric and magnetic field points?

Q10. Which of the following is a source of electromagnetic wave?(i) A charge moving with constant velocity (ii) A charge moving in a circular path (iii) charge at rest.

Q11. The wavelength of X rays is 1A°. Calculate its frequency.

Q12. How does the speed of electromagnetic wave in vacuum depend on the absolute permittivity and absolute permeability?

Q13. What is the effect on radio wave transmission if the earth has no atmosphere?

Q14. In a certain region in space and time the component of electric field of an em wave travelling at z – axis is 6.3V/m. What is the value of magnetic field component in that region?

Q15. State one method of detecting IR ray.

Q16. Differentiate between radio waves and micro waves.

Q17. State the principle of production of em waves.

UNIT 6 OPTICS

RAY OPTICS: REFLECTION , REFRACTION, DISPERSION AND SCATTERING OF LIGHT

WAVE OPTICS: INTERFERENCE, DIFFRACTION AND POLARISATION OF LIGHT

REFRACTION OF LIGHT

REFRACTION

It is the phenomenon of bending of light as it passes from one medium into another. When light travels from rarer to denser medium it bends towards the normal
When light travels from denser to rarer medium it bends away from the normal
In refraction of light all physical quantity changes, but frequency and phase of light do not change
The basic cause of refraction of light is that light travels with different speed in different media.

REFRACTIVE INDEX (ABSOLUTE REFRACTIVE INDEX)
ABSOLUTE REFRACTIVE INDEX / REFRACTIVE INDEX
The refractive index of a medium is the ratio of the velocity of light in vacuum (3×10^8 m/s) to the velocity through the medium.

$$\eta = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in the medium}}$$

N.B Absolute refractive index of a medium is always greater or equal to 1.

RELATIVE REFRACTIVE INDEX
The relative refractive index of medium 2 w.r.t medium 1 is the ratio of the velocity of light in medium 1 to the velocity through the medium 2.

The factors which affect the refractive index of a medium are

1. **Nature of the medium**
2. **Nature of the surrounding medium**
3. **Wavelength of incident radiation**

LAWS OF REFRACTION

1. The product of refractive index and sine of the angle of incidence for a pair of media is always constant.
2. The incident ray, refracted ray and normal always lie in the same plane.

SNELL'S LAW
The ratio of the sine of the angle of incidence to the sine of the angle of refraction is equal to the ratio of the incident velocity to the refracted velocity .

PRINCIPLE OF REVERSIBILITY OF LIGHT
According to this principle when a ray of light suffers a number of reflection and refraction and reverse its path, it retrace its initial path.

CRITICAL ANGLE
It is the angle of incidence in the denser medium corresponding to which the angle of refraction in the rarer medium is 90°.

TOTAL INTERNAL REFLECTION
Whenever light travels from a denser to a rarer medium with angle of incidence greater than critical angle, then the incident ray is reflected back in the denser medium. This phenomenon is called total internal reflection.

CONDITIONS FOR TOTAL INTERNAL REFLECTION
1. Light should travel from denser medium to rarer medium.
2. The angle of incidence should be greater than the critical angle.

RELATION BETWEEN CRITICAL ANGLE AND REFRACTIVE INDEX OF A MEDIUM

NB. The critical angle of a medium depends on the wavelength of incident radiation and hence on the colour of light incident on it.

APPLICATION OF TOTAL INTERNAL REFLECTION

1. An observer under water can see the outer world only a portion of a circle which depends on the depth of the observer.
2.Totally reflecting right angled isosceles glass prism

3. OPTICAL FIBRE
An optical fibre consist of a core made of glass or plastic fiber which is surrounded by material called cladding whose refractive index is less than that of core. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communications. Fibers are used instead of metal wires because signals travel along them with less loss, they are also immune to electromagnetic interference and data security issues.

4) BRILLIANCE OF DIAMOND
Diamond has a high refractive index and so have a very small critical angle. Light rays once enters inside the diamond suffers multiple total internal reflection inside the diamond and remains within the diamond. The faces of diamond are so cut that light once enters inside the diamond always remain inside the diamond. Hence the diamond sparkles.

5) MIRAGE
It is an optical illusion that happens in desert during hot summer days. According to this illusion a tree looks inverted.

SPHERICAL REFRACTING SURFACE

1. **CONCAVE REFRACTING SURFACE: This is concave towards the rarer medium. Eg. Bubble inside water.**

2. **CONVEX REFRACTING SURFACE: This is convex towards the rarer medium. Eg. Liquid drop**

ASSUMPTIONS IN SPHERICAL REFRACTING SURFACE
1. The objects and image are of point size lying on the principal axis.
2. The angles made by incident and refracted ray are very small.
3. The aperture is made small.

REFRACTION THROUGH SPHERICAL REFRACTING SURFACE
CONVEX and CONCAVE REFRACTING SURFACE

LENSES
A lens is a transparent medium bounded by two surfaces one of it is a curve surface.

TYPES OF LENSES

1. **CONVEX LENS: This are the lens which are thicker at the middle than at the edges.**
2. **CONCAVE LENS: This are the lens which are thicker at the edges than at the middle.**

OPTICAL CENTRE

It is a point on the principal axis so that a ray of light whose refracted path passes through this point will have its emergent ray parallel to the direction of incident ray.

FOCUS

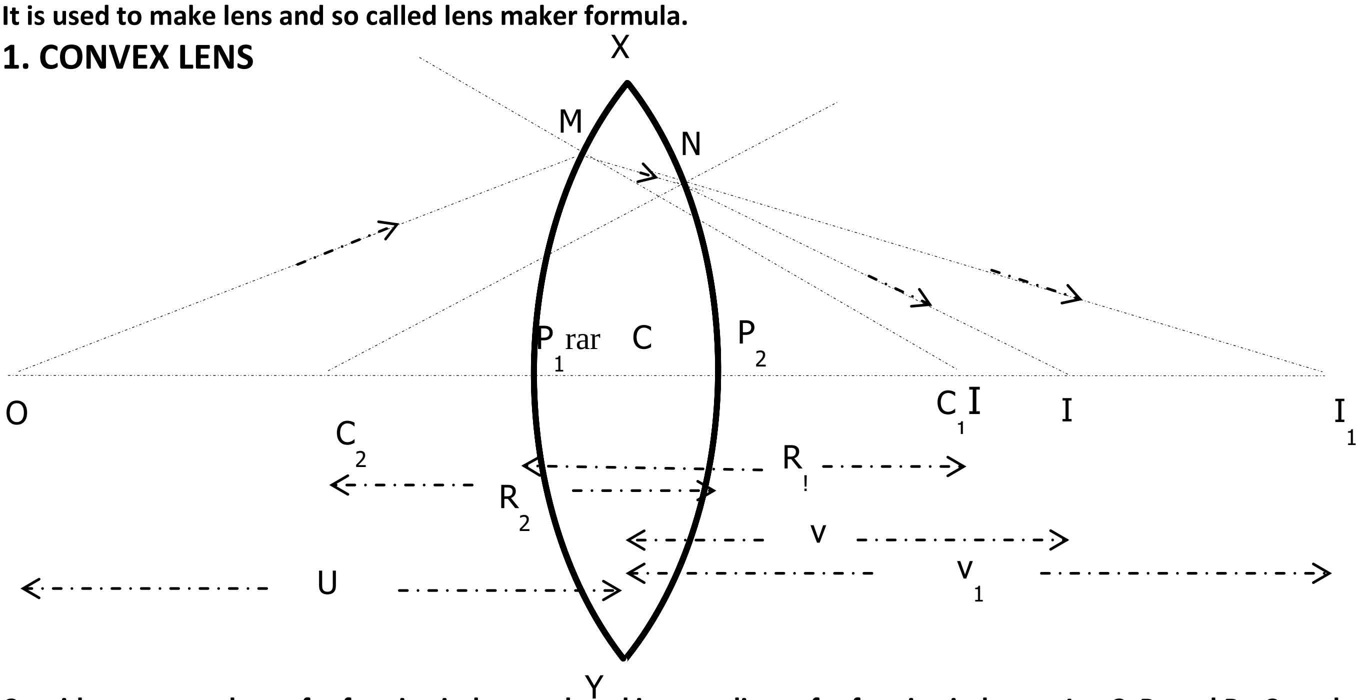
.

It is a point on the principal axis such that light rays coming parallel to the principal axis after refraction from the lens meet at that point or appears to diverge from that point

LENS MAKER FORMULA

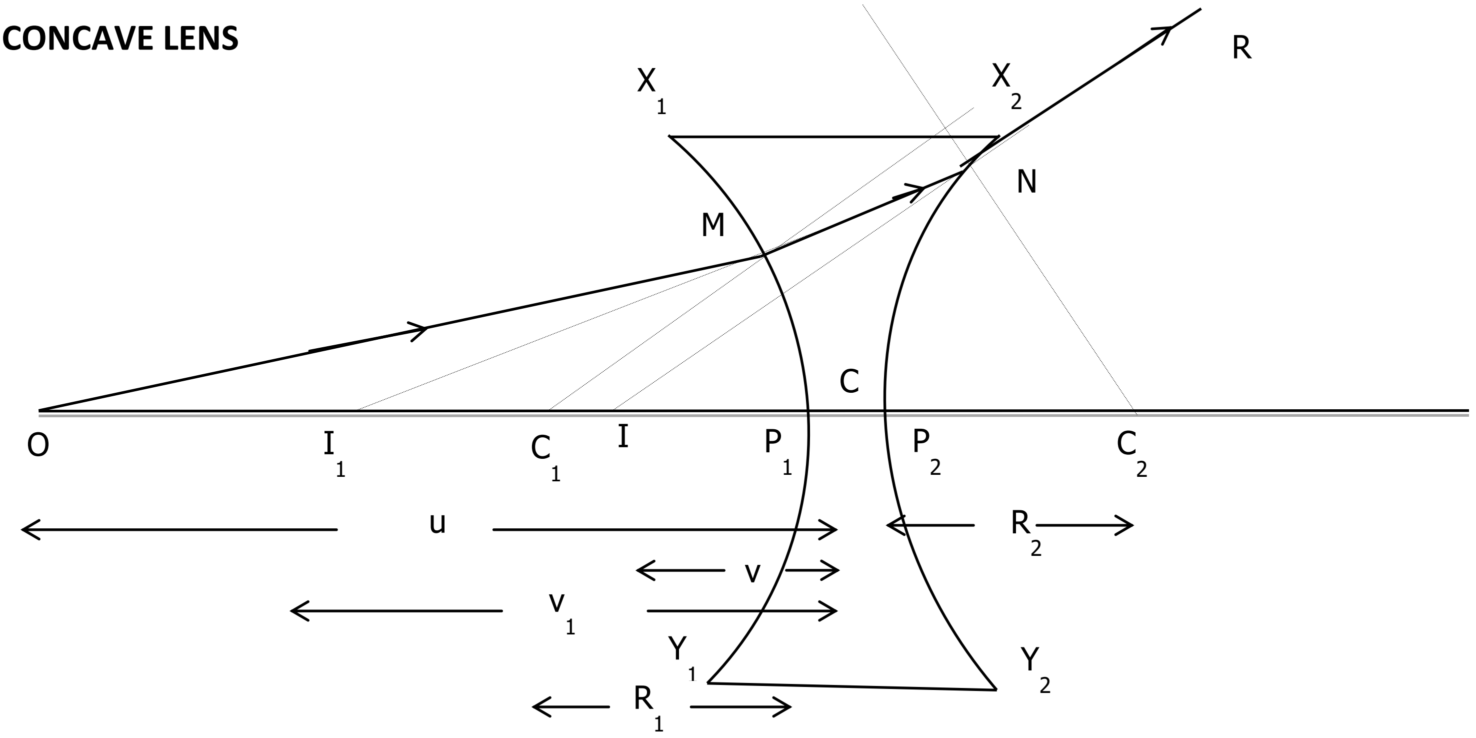
It is a relation between focal length, radius of curvature and refractive index of a lens.
It is used to make lens and so called lens maker formula.

1. CONVEX LENS



Consider a convex lens of refractive index η_2 placed in a medium of refractive index η_1. Let C, P_1 and P_2, C_1 and C_2, R_1 and R_2 be the optical centre, poles, center of curvatures and radii of curvature of the convex lens.

CONCAVE LENS



LENS FORMULA
It is a relation between object distance, image distance and focal length of a lens

CONVEX and CONCAVE LENS

MAGNIFICATION PRODUCED BY A LENS
It is defined as the ratio of image height to the object height.

POWER OF A LENS

It is the ability to converse or diverge a parallel beam of light rays falling on a lens.
It is given by the reciprocal of focal length.

Power for convex lens is positive as focal length of convex lens is positive.
Power for concave lens is negative as focal length of concave lens is negative.

IMAGE FORMATION ON CONVEX AND CONCAVE LENS

CONVEX LENS

Position of Object	Position and Nature of Image
At Infinity	At the focus and point in size
Beyond second focus	Between focus and second focus, smaller than object and inverted
At second focus	At second focus, same size as the object and inverted
Between second focus and focus	Beyond second focus , larger than object and inverted
At focus	At Infinity, larger than object and inverted
Between optical centre and focus	Behind the mirror, larger than object and erect

CONCAVE LENS

Position of Object	Position and Nature of Image
At Infinity	At the focus and point in size
Object between infinity and optical centre	Between focus and optical centre, smaller than object and erect

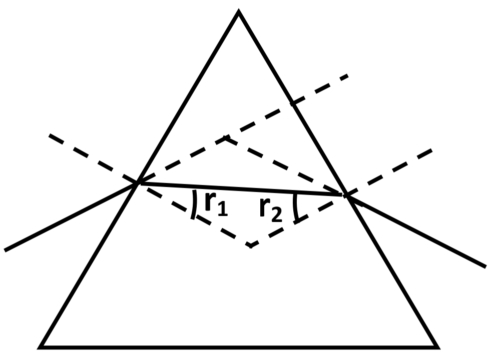
COMBINATION OF THIN LENSES IN CONTACT
Two or more thin lenses are placed in contact to (i) increase the focal length (ii) to make the final image erect (iii) to reduce certain aberration.

EQUIVALENT FOCAL LENGTH FOR COMBINATION OF TWO THIN CONVEX LENSES PLACED CO-AXIALLY IN CONTACT

PRISM
A prism is a refracting medium bounded by two plane surfaces inclined at a certain angle called angle of prism or refracting angle.

REFRACTION THROUGH A PRISM

ABC is the principal section of a prism of refracting angle A. A ray PQ incident on face AB at angle of incidence i is refracted as QR. The ray QR again suffers refraction on face AC and emerges as RS with angle of emergence e.



ANGLE OF DEVIATION

It is the angle between incident ray and emergent ray made by a prism.
Or It is the angle by which the emergent ray is deviated from the incident ray.

DEVIATION PRODUCED BY A THIN PRISM (Thin prism : A prism in which the angles made by the prism is small)

MINIMUM DEVIATION
The value of the deviation produced by a prism which has minimum value is called minimum deviation.

Thus minimum deviation occurs when (i) angle of incidence equals angle of emergence (ii) the angles inside the prism made by the refracted ray are equal (iii) the refracted ray is parallel to the base of prism.

PRISM FORMULA
It is the relation between refractive index of the material of prism and angle of minimum deviation produced by the prism.

DISPERSION PRODUCED BY A PRISM
Dispersion is the splitting of white light into its various spectral components. The band of colours so obtain is called spectrum.
Since different colours of light have different wavelength and so has different angles of deviation, the white light when passed through a prism is dispersed.

ANGULAR DISPERSION
The angular separation between the two extreme colours in the spectrum of a prism is called angular dispersion.

DISPERSIVE POWER
It is the ability of the prism material to cause dispersion.

It is defined as the ratio of angular dispersion to the mean deviation.

OPTICAL INSTRUMENT

SIMPLE MICROSCOPE
It is a device used for viewing small objects. It consists of a convex lens.

1. IMAGE FORMED AT LEAST DISTANCE OF DISTINCT VISION
MAGNIFYING POWER: It is defined as the ratio of angle formed at the eye by the image to the object when both are situated at the least distance of distinct vision from the eye.
2. IMAGE FORMED AT INFINITY

COMPOUND MICROSCOPE

It is a device used for viewing small objects. It consists of two convex lens (i) an objective made of short focal length an short aperture and (ii) an eye piece of moderate focal length and moderate aperture.

1. IMAGE FORMED AT LEAST DISTANCE OF DISTINCT VISION

MAGNIFYING POWER: It is defined as the ratio of angle formed at the eye by the image to the object when both are situated at the least distance of distinct vision from the eye.

2. IMAGE FORMED AT INFINITY

MAGNIFYING POWER: It is defined as the ratio of angle formed at the eye by the image situated at infinity to the angle formed by the object at the eye when situated at the least distance of distinct vision from the eye.

TELESCOPE : It is a device used for viewing distant objects. They are of two types

1. **REFRACTING TYPE TELESCOPE 2. REFLECTING TYPE TELESCOPRE**

REFRACTING TYPE TELESCOPE: In this type the objective is a lens.

ASTRONOMICAL TELESCOPE

It is a device used for viewing distant objects. It consists of two convex lens (i) an objective made of large focal length an large aperture and (ii) an eye piece of moderate focal length and moderate aperture.

1. IMAGE FORMED AT LEAST DISTANCE OF DISTINCT VISION

MAGNIFYING POWER: It is defined as the ratio of angle formed at the eye by the image situated at least distance of distinct vision to the angle formed by object when situated at infinity.

2. IMAGE FORMED AT INFINITY(NORMAL ADJUSTMENT)

MAGNIFYING POWER: It is defined as the ratio of angle formed at the eye by the image situated at infinity to the angle formed by object when situated at infinity.

REFLECTING TYPE TELESCOPE: In this type the objective is a concave mirror.

1. CASSEGRANIAN TYPE TELESCOPE

It consists of a large concave paraboloidal mirror having a hole at its centre. The parallel rays from the distant objects are reflected by the large concave mirror. Before these rays come to focus they are reflected by the small convex mirror
and are converged to an eyepiece where the final image is seen.

2. NEWTONIAN TYPE TELESCOPE

It consists of a large concave paraboloidal mirror of large focal length. A beam of light from distant star is incident on the concave mirror. Before the rays are focussed a plane mirror inclined at 45° intercepts them and turns them towards an eye piece where the final image is seen.

ADVANTAGE OF REFLECTING TYPE TELESCOPE OVER REFRACTING TYPE TELESCOPE

1. **As the objective is a mirror reflecting type telescope does not suffer from chromatic aberration.**
2. **High resolution is obtained by using reflecting type telescope.**
3. **Light gathering power is more in case of reflecting type telescope.**

WAVE OPTICS

WAVE FRONT

A wavefront is a continuous locus of all the points of the medium which are vibrating in the same phase at any instant.

TYPES OF WAVEFRONT

1. SPHERICAL WAVEFRONT: If the source of light is a point source then the wave front produced is called spherical wave front.
2. CYLINDRICAL WAVEFRONT: If the source of light is a linear then the wave front produced is called cylindrical wave front.
3. PLANE WAVEFRONT: If the wave front is very far away from the source, a small portion of it appears plane. Such a wave front is called plane wave front.

HUYGEN'S PRINCIPLE

This principle tells us how a wave front propagates in a medium. According to this principle
1. Every point on a given wave front acts as a fresh source of new disturbance , called secondary waves or wavelets.

2. The secondary wavelets spread out in all directions with the speed of light in the given medium

3. A tangential surface drawn in the forward direction gives the secondary wavefront at that time.

REFLECTION OF LIGHT ON THE BASIS OF WAVE THEORY (HUYGEN'S PRINCIPLE)

Consider a plane wavefront AB incident on a plane reflecting surface MN. In accordance with Huygen's principle, from each point on AB secondary wavelets starts growing with the speed of light c. The wavefront first touches the reflecting surface at B and then at successive points towards C. During the time the disturbance from A reaches C, the secondary wavelets from B must have spread over a hemisphere of radius BD = AC = ct, where t is the time taken by the disturbance to travel from A to C. The tangent plane CD drawn from the point C over this hemisphere will be the new reflected wavefront.

Further the incident wavefront, reflected wavefront and normal to the surface are all perpendicular to a plane, so the incident ray reflected ray and normal all lie in the same plane. This is second law of reflection.

REFRACTION OF LIGHT ON THE BASIS OF WAVE THEORY(HUYGEN'S PRINCIPLE)

Consider a plane wavefront AB incident on a plane refracting surface MN which separates a rarer medium of refractive index η_1 from a denser medium of refractive index η_2. Let v_1 and v_2 be the speed of light in rarer and denser medium. Then ${}^1\eta_2 = v_1/ v_2$. In accordance with Huygen's principle, from each point on AB secondary wavelets starts growing in the denser medium with the speed of light v_2. The wavefront first touches the reflecting surface at B and then at successive points towards C. During the time the disturbance from A reaches C, the secondary wavelets from B must have spread over a hemisphere of radius BD = v_2t, where t is the time taken by the disturbance to travel from A to C .The tangent plane CD drawn from the point C over this hemisphere will be the new refracted wavefront.

Further the incident wavefront, refracted wavefront and normal to the surface are all perpendicular to a plane, so the incident ray refracted ray and normal all lie in the same plane. This is second law of refraction.

COHERENT SOURCES

Two or more sources are said to be coherent if they have same wavelength, same frequency and zero phase difference or having a constant phase difference.
Two independent sources of light cannot be coherent because the phase difference between the two light waves changes with time.
This is because
1. Light is emitted by individual atoms and not by bulk of matter acting as a whole.
2. Even a tiniest source consists of millions of atoms and emission of light by them takes place independently.
So coherent sources are produced from a single source by some methods.

The methods are

1. **Young's double slit experiment. 2. Lloyds mirror method. 3. Fresnel biprism.**

SUPERPOSITION OF LIGHT WAVES

When a number of waves travelling through a medium superimpose on each other, the resultant displacement at any point is equal to the vector sum of the displacements due to the individual waves at that point.
If y1, y2 ……. are the displacement due to the individual light waves, then the resultant displacement is given by

1. When crest of one wave falls on crest of the other, the resultant displacement increases.

2. When crest of one wave falls on trough of the other, the resultant displacement decreases.

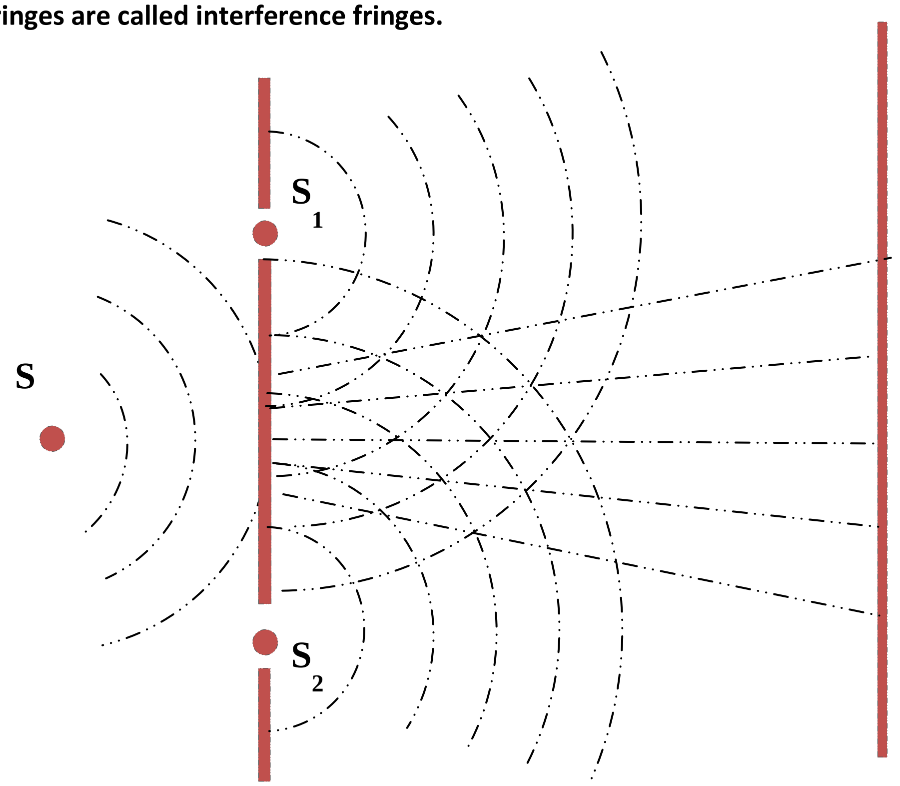
INTERFERENCE OF LIGHT

When light waves from two coherent sources travelling in the same direction superimpose each other, the intensity in the region of superposition gets redistributed, becoming maximum at some points and minimum at others. This phenomenon is called interference of light.

The points where the intensity of light is maximum is called constructive interference.
The points where the intensity of light is minimum is called destructive interference.

YOUNG'S DOUBLE SLIT EXPERIMENT

S_1 and S_2 are two fine slits which are illuminated by a strong source of monochromatic light S and they act as coherent sources. The light waves from the two coherent sources superimpose each other and produce interference. The points where crest of one wave falls on crest of the other or trough on trough leads to bright fringes on the screen. And the points where crest of one wave falls on trough of the other leads to dark fringes on the screen. This fringes are called interference fringes.

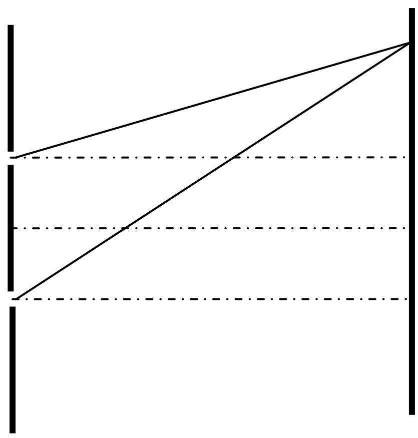


RESULTANT AMPLITUDE AND INTENSITY FOR SUPERPOSITION OF LIGHT WAVES FROM TWO COHERENT SOURCES

RELATION BETWEEN PHASE DIFFERENCE AND PATH DIFFERENCE

CONDITIONS FOR CONSTRUCTIVE AND DESTRUCTIVE INTERFERENCE

EXPRESSION FOR FRINGE WIDTH IN INTERFERENCE FRINGES
(WIDTH OF DARK AND BRIGHT FRINGES)



S_1 and S_2 are two coherent sources separated by a distance d. A screen is placed at a distance D where interference fringes are observed. Point O is the position of central maximum and P is a point on the screen distant y from the central maximum O.

Path difference from S_1 and S_2 reaching P is

DIFFRACTION

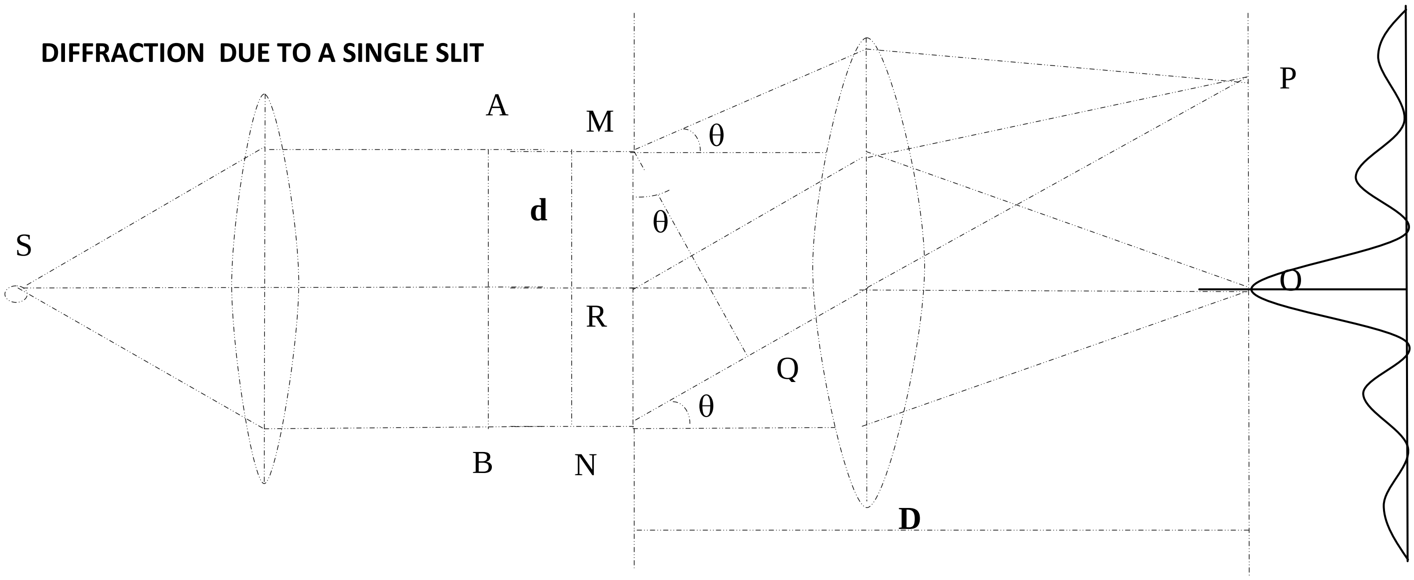
The phenomenon of bending of light around corners of small obstacles or apertures and its consequent spreading into the regions of geometrical shadow is called diffraction of light.

The diffraction of light is much more pronounced only when the size of obstacle or aperture is comparable with the wavelength of light.
Diffraction are of two types: 1. Fresnel diffraction 2. Fraunhoffer diffraction.

FRESNEL DIFFRACTION: It is the type of diffraction in which the source and screen are close to the slit or obstacle.

FRAUNHOFFER DIFFRACTION: It is the type of diffraction in which the source and screen are at infinite distance from the slit or obstacle.

DIFFRACTION DUE TO A SINGLE SLIT



The fig. shows the diffraction due to a single slit. S is a monochromatic source of light held at the focus of a collimating lens L_1. A parallel beam of light and hence a plane wavefront AB gets incident on a narrow rectangular slit MN of width d. The diffraction pattern is focussed on a screen placed at a distance D from the slit by using a convex lens L_2.
All the secondary wavelets from the slit MN reach O in same phase and O is the point of central maximum. Suppose the secondary wavelets diffracted at an angle θ are focussed at P, then P will be of maximum and minimum intensity depending on the path difference of light waves from M and N reaching P.

WIDTH OF CENTRAL MAXIMUM IN DIFFRACTION PATTERN

INTERFERENCE AND DIFFRACTION PATTERN

DIFFERENTIATE BETWEEN INTERFERENCE AND DIFFRACTION

INTERFERENCE	DIFFRACTION
1. The fringes are of equal width .	1. The fringes are of unequal width.
2. The dark fringes are perfectly dark.	2. The dark fringes are not perfectly dark.
3. There is a good contrast between dark and bright fringes	3. There is a poor contrast between dark and bright fringes.
4. The bright fringes are of same intensity.	4. The bright fringes are of unequal intensity.
5. Coherent sources are required.	5. Monochromatic source is required.

RESOLVING POWER: It is the ability of an optical instrument to produce distinctly separate images of two close objects.

LIMIT OF RESOLUTION: The minimum distance between two objects which can just be seen as separate by the optical instrument is a called Limit of Resolution of the instrument.

Thus , $$\text{R.P} = \frac{1}{\text{limit of resolution}}$$

i.e smaller the limit of resolution greater is the resolving power and vice versa. For human eye the limit of resolution is one minute or 1/60 degree.

RESOLVING POWER OF A MICROSCOPE:

The resolving power of a microscope is the ability of the microscope to show as separate the images of two point objects lying close to each other. The limit of resolution of a microscope is measured by the distance between the two objects (d) . It varies (i) directly as the wavelength of light used and (ii) inversely as the cone angle of light rays from any one object entering the microscope.
Thus to increase the R.P of a microscope light of shorter wavelength (blue) should be used.

RESOLVING POWER OF A TELESCOPE:

The resolving power of a telescope is the ability to show distinctly the images of two distant objects lying close to each other. The limit of resolution of a telescope is measured by the angle (dθ) substended at the objective. It varies (i) directly as the wavelength of light used and (ii) inversely as aperture or diameter D of the objective.

Thus to increase the R.P of a telescope the aperture/ diameter of the telescope objective should be made large.

HUMAN EYE

The essential parts of a human eye is shown in the figure. It consists of a crystalline lens which is held in position by the cilliary muscles. In front of the eye lens is a contractable diaphragm called iris which has a circular aperture called pupil. The pupil controls the amount of light rays entering the eye. The light rays coming to the eye after refraction from the lens is focus at the retina where the image is formed.

Far point: The farthest point from the eye at which an object can be seen clearly by the eye is called far point of the eye. For normal eye it is infinity.

Near point: The nearest point from the eye at which an object can be seen clearly by the eye is called near point of the eye. For normal eye it is 25 cm.

Least distance of distinct vision: The nearest point from the eye at which an object can be seen clearly by the eye without any strain is called least distance of distinct vision. For normal eye it is 25 cm.

Accomodation : It is the ability of eye lens due to which it can change its focal length so that images of objects at various distances can be formed on the retina.

DEFECTS OF VISION **The defects are**

1. Myopia or short sightedness 2. Hypermetropia or long sightedness 3. Presbyopia 4. Astigmatism

1. **Myopia or short sightedness: It is that defect of eye in which the nearby objects can be seen clearly but the distant objects cannot be seen clearly. The image for a myopic eye is formed in front of the retina.**
   Correction: To correct a myopic eye the person has to use spectacles having a concave lens with suitable focal length. The focal length of the corrected lens should be equal to the far point of the myopic eye.

2. Hypermetropia or long sightedness It is that defect of eye in which the nearby objects can not be seen clearly but the distant objects can be seen clearly. The image for a hypermetropic eye is formed behind the retina.
Correction: To correct a hypermetropic eye the person has to use spectacles having a convex lens with suitable focal length.

3. PRESBYOPIA
With increasing age the cilliary muscles gets weaken and the eye lens loses some of its properties. Due to this the person cannot see the far as well as the nearby objects. This defect is known as presbyopia. This defect can be corrected by using spectacles having a bifocal lens.

4 TISM

It is that defect of eye in which the horizontal and vertical lines are not seen simultaneously with same clarity. It arises when curvature of cornea is irregular. This can be corrected by using cylindrical lens.

UNIT 7 DUAL NATURE OF MATTER AND RADIATION

WORK FUNCTION: It is the minimum energy required to removed an electron from a metal surface. It is measured in electronvolt (eV).

ELECTRON VOLT: One electron volt is the kinetic energy gain by an electron when accelerated from rest by a potential difference of 1V. i.e 1eV = Kinetic energy = workdone by 1V = qV = 1.6×10^{-19} C $\times$ 1V = 1.6×10^{-19} J

ELECTRON EMISSION

It is the phenomenon of emission of electrons from a metal surface.

TYPES OF ELECTRON EMISSION

They are of the following types

1. Thermoinic emission : It is the phenomenon of emission of electrons from a metal surface when heated suitably.
2. Field emission or cold cathode emission : It is the phenomenon of emission of electrons from a metal surface under the application of strong electric field.
3. Photoelectric emission : It is the phenomenon of emission of electrons from a metal surface when light radiation of suitable frequency falls on it.
4. Secondary emission : It is the phenomenon of emission of electrons from a metal surface when fast moving electrons strike the metal surface.

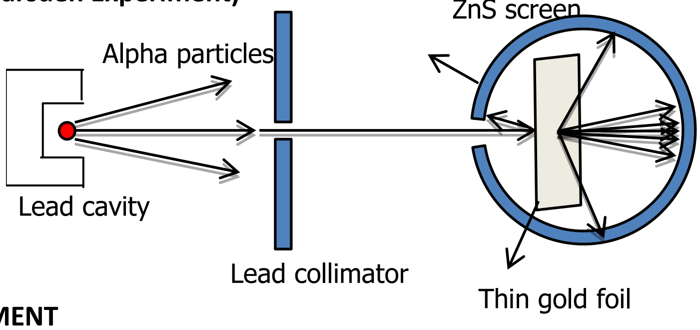
PHOTONS Photons are the packets of energy which travels with the speed of light.The properties of photon are

1. The energy of a photon is $E = h\nu$ where, $h = 6.6 \times 10^{-34}$ Js is the Plank's constantν = frequency of incident radiation
2. They travel with the speed of light in any medium.
3. Their frequency does not change when it travels from one medium to another but speed changes.
4. The rest mass of a photon is zero.
5. The charge of a photon is zero. They are not deflected by electric and magnetic field.
6. The momentum of a photon is p = mc.

ATOMS AND NUCLEI

ALPHA PARTICLE SCATTERING EXPERIMENT (Geiger and Marsden Experiment)

The experimental arrangement is shown in the figure. Alpha particles from a radioactive source are collimated into a narrow beam through a narrow slit. The beam is allowed to fall on a thin gold foil. The alpha particles scattered in different directions are observed with the help of a rotatable detector which consists of a zinc sulphide screen.



OBSERVATIONS OF ALPHA PARTICLE SCATTERING EXPERIMENT

1. Most of the alpha particles pass straight through the gold foil or suffer only small deflections.
2. A few alpha particles get deflected through 90° or more.
3. Ocassionally, an alpha particle gets rebounded from the gold foil, suffering a deflection of nearly 180°.

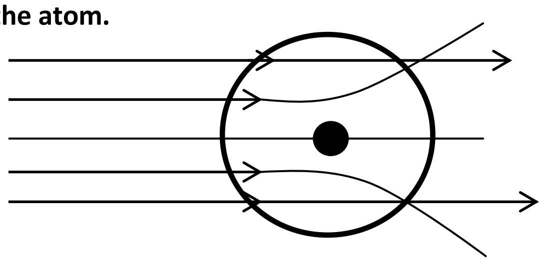
RESULTS OF ALPHA PARTICLE SCATTERING EXPERIMENT

1. As most of the alpha particles pass straight through the gold foil so most of the space within atoms must be empty.
2. To explain large scattering angles of alpha particles, Rutherford suggested that all the positive charge and the mass of the atom is concentrated in a very small region called the atomic nucleus of the atom.

3. The nucleus is surrounded by a cloud of electrons whose total negative charge is equal to the total positive charge on the nucleus so that the atom as a whole is neutral.

DISTANCE OF CLOSEST APPROACH :The minimum distance upto which a energetic alpha particle travelling directly towards a nucleus can move before coming to rest and then retracing its path is known as distance of closest approach. At the distance of closest approach the kinetic energy of alpha particle is completely converted into electric potential energy of the system.

IMPACT PARAMETER : The impact parameter is defined as the perpendicular distance of the velocity vector of the alpha particle from the centre of nucleus, when it is far away from the atom.



1. If the impact parameter is small the scattering angle will be large.
2. If the impact parameter is large the scattering angle will be small.
3. For head on collision impact parameter is 0 and the alpha particle will reversed back.

RUTHERFORDS ATOM MODEL

1. An atom consists of a small and massive central core in which the entire positive charge and almost whole mass of the atom is concentrated. This core is called the nucleus.
2. The size of the nucleus is very small as compared to the size of the atom.
3. The nucleus is surrounded by a suitable number of electrons so that their total negative charge is equal to the total positive charge on the nucleus and the atom as a whole is electrically neutral.
4. The electrons revolve around the nucleus in various orbits. The required centripetal force is provided by the electrostatic attraction between electron and nucleus.

DRAWBACKS OF RUTHERFORDS ATOM MODEL

1. When the electrons revolve around the nucleus it will radiate energy and will move in decreasing radii. The electron will follow a spiral path and then collapse into the nucleus. This means that this atom model cannot explain the stability of atom.
2. As electrons revolves in all possible radii, it will emits a continuous energy spectrum. But in H-atom discrete energy spectrum are emitted. This means that this model cannot explain the origin of line spectrum.

BOHR ATOM MODEL

POSTULATES OF BOHR'S ATOM MODEL

1. An atom consists of a small and massive central core, called nucleus around which planetary electrons revolve. The centripetal force required is provided by electrostatic force between electrons and nucleus.

2. Of all the possible circular orbits, the electrons are permitted to revolve in those orbits in which the angular momentum of the electron is an integral multiple of $h/2\pi$.

   i.e $L = mvr = n\dfrac{h}{2\pi}$ This is the Bohr's quantisation condition.

3. While revolving in the permitted orbits, an electron does not radiate energy. These non radiating orbits are called stationary orbits.
4. An atom can emit or absorb radiation in the form of discrete energy photons only when an electron jumps from a higher to a lower orbit or from a lower to a higher orbit.

   If E_1 and E_2 are the energies associated with the permitted orbits, then the frequency of the emitted or absorbed radiation is $h\nu = E_2 - E_1$ This is the Bohr's frequency condition.

ORIGIN OF SPECTRAL LINES

When an electron jumps from a higher energy state (n_i) to a lower energy state (n_f) in the hydrogen atom. The radiation of a particular wavelength or frequency is emitted. This radiation is called spectral line.

The spectral lines arising from the transition of electron from the higher energy states to a particular lower energy state form a spectral series.

EXCITATION ENERGY:

The amount of energy absorbed by the electron to go from the ground state to the higher energy state is called excitation energy.

Eg. ion energy of an electron of H-atom from ground state to third excited state is

IONISATION ENERGY:

The amount of energy required to knock out an electron from an atom is called ionisation energy.

Eg. The ionisation energy of an electron of H-atom in the second excited state is

DRAWBACKS OF BOHR'S MODEL

1. **This model can explain only hydrogen like atoms (H,He^{+},Li^{++}) i.e this model cannot explain many electrons atom.**
2. **This model cannot explain the origin of fine structure splitting.**
3. **This model cannot explain the splitting of spectral lines in a magnetic field. (Zeeman effect)**
4. **This model cannot explain the splitting of spectral lines in a electric field. (Stark effect)**

BOHR'S THEORY OF HYDROGEN ATOM

Consider an electron of hydrogen atom revolving around a nucleus of charge Ze in a circular orbit of radius r with speed v.

RADIUS OF ORBIT

BOHR RADIUS: This is the radius of the innermost orbit of hydrogen atom.

For innermost orbit n = 1

VELOCITY OF ELECTRON IN AN ORBIT

ENERGY OF AN ELECTRON

The energy of an electron in an orbit is the sum of its K.E and P.E

ORIGIN OF SPECTRAL LINES(FREQUENCY/ WAVELENGTH OF EMITTED RADIATION)

ENERGY LEVEL DIAGRAM OF HYDROGEN ATOM.

SPECTRAL SERIES OF HYDROGEN ATOM

1. **LYMAN SERIES: It is the spectral series that originate when an electron make a transition from a higher energy state to the first orbit n=1.This wavelength/frequency lies in the UV region of the electromagnetic spectrum.**
2. **BALMER SERIES: It is the spectral series that originate when an electron make a transition from a higher energy state to the first orbit n=2. This wavelength/frequency lies in the visible region of the electromagnetic spectrum.**
3. **PASCHEN SERIES: It is the spectral series that originate when an electron make a transition from a higher energy state to the first orbit n=3. This wavelength/frequency lies in the infra red region of the electromagnetic spectrum.**
4. **BRACKETT SERIES: It is the spectral series that originate when an electron make a transition from a higher energy state to the first orbit n=4. This wavelength/frequency lies in the infra red region of the electromagnetic spectrum.**
5. **PFUND SERIES: It is the spectral series that originate when an electron make a transition from a higher energy state to the first orbit n=5. This wavelength/frequency lies in the far infra red region of the electromagnetic spectrum.**

NUCLEI

ATOMIC MASS UNIT (a.m.u): One atomic mass unit is defined as $1/12^{th}$ of the mass of C-12 isotope.

RELATION BETWEEN amu and MeV

COMPOSITION OF NUCLEUS:

1. PROTON ELECTRON HYPOTHESIS

2. PROTON NEUTRON HYPOTHESIS According to this hypothesis, a nucleus of mass number A and atomic number Z contains Z protons and (A-Z) neutrons. As atom is electrically neutral number of electrons much be equal to the number of protons.A nucleus of an atom is specified by the symbol $_{Z}X^{A}$ or $^{A}_{Z}X$

NUCLEAR SIZE: Experimentally it is observed that the volume of a nucleus is proportional to its mass number. If R is the radius of the nucleus which is assumed to be spherical, then its volume

NUCLEAR DENSITY

ISOTOPES: Isotopes of an element are the atoms of the element which have the same atomic number but different mass number.Examples: Isotopes of H are $_1H^1$, $_1H^2$, $_1H^3$ Isotopes of He are $_2He^3$, $_2He^4$, $_2He^6$Isotopes of C are $_6C^{10}$, $_6C^{11}$, $_6C^{12}$, $_6C^{13}$, $_6C^{14}$

ISOBARS: Isobars are the atoms of different element which have the same mass number but different atomic number.
Examples: Isobars are $_{11}Na^{22}$, $_{10}Ne^{22}$

ISOTONES: Isotones are the nuclides which contains the same number of neutrons.

MASS DEFECT: When a nucleus of an atom is formed by bringing protons and neutrons together, the mass of the nucleus so formed is always less than the sum of the masses of the constituent protons and neutrons (nucleons) in the free state. This difference in mass is called mass defect. sIt is denoted by Δ m.

BINDING ENERGY: It is basically the energy required to hold the nucleons inside the nucleus.
When nucleons forms a nucleus, the mass of the nucleus is less than the sum of masses of the constituent nucleons. This decrease in the mass of nucleons called mass defect is converted into energy in accordance with the equation $E = mc^2$ which is responsible to hold the nucleons inside the nucleus.

BINDING ENERGY PER NUCLEON and its CURVE

1. The binding energy per nucleon curve determines the stability of the nucleus.
2. The intermediate nuclei have large value of binding energy per nucleon, so they are more stable.
3. The B.E per nucleon has low value for both and heavy and light nuclei. This means that they are less stable. The B.E per nucleon has maximum value of 8.8 MeV corresponding to iron, and drops to 7.5 MeV to the element Uranium.
4. When a heavy nucleus splits up into lighter nuclei, then binding energy per nucleon of lighter nuclei is more than that of the original heavy nucleus. Thus energy is released in this process. This process is called nuclear fission.
5. When two very light nuclei combines to form a relatively heavy nucleus, then binding energy per nucleon of combined nucleus becomes more than the lighter nuclei. Thus energy is released in this process. This process is called nuclear fusion.

NUCLEAR FISSION

It is the phenomenon of splitting a heavy nucleus into two or more lighter nuclei.
When uranium was bombarded by a thermal (slow moving neutron) the products obtained were Ba and Kr along with the emission of three neutrons and a large amount of energy.

$$_{92}U^{235} + {_0}n^1 \longrightarrow {_{56}}Ba^{141} + {_{36}}Kr^{92} + 3{_0}n^1 + Q$$

ENERGY RELEASED PER FISSION OF U-235

The fission of $_{92}U^{235}$ is $_{92}U^{235} + {}_0n^1 \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_0n^1 + Q$

Mass of $_{92}U^{235}$ = 235.124 a.m.u Mass of $_{56}Ba^{141}$ = 140.958 a.m.u Mass of $_{36}Kr^{92}$ = 91.926 a.m.u

Mass of reactant = (235.124 + 1.009) a.m.u = 236.133 u

Mass of product = (140.958 + 91.926 + 3 $\times$ 1.009) a.m.u = 235.911 a.m.u

Mass defect = (236.133 - 235.911) = 0.222 u

Energy released = 0.222 $\times$ 931 MeV = 206.6 MeV = 200MeV

NUCLEAR CHAIN REACTION

It is a series nuclear transformation initiated by a single nuclear fission reaction. Types of chain reaction are

1. Uncontrolled chain reaction: If more than one neutrons produced in a fission can cause further fissions in each stage, then the number of fissions and energy released multiply rapidly. Such a chain reaction is called uncontrolled chain reaction. Eg. Atom bomb

2. Controlled chain reaction: If only one neutron is available to cause further fission in each stage, then a constant amount of energy is released. Such a chain reaction is called controlled chain reaction. E.g Nuclear reactor.

NUCLEAR FUSION

A process in which two very light nuclei combine to form a nucleus with a larger mass number along with simultaneous release of energy is called nuclear fusion.

e.g 1. two nuclei of deuterium fuse together to form helium nucleus.

2. Four hydrogen nuclei fuse together to form helium nucleus. This is the reaction occurred at sun.

ENERGY RELEASED IN FUSSION OF 4 HYDROGEN NUCLEI

$$4{}_1H^1 \longrightarrow {}_2He^4 + 2\,{}_{+1}e^0 + 2\nu + Q$$

Energy released Q = (mass of $4{}_1H^1$ - mass of $_2He^4$)

= (4 $\times$ 1.0073 – 4.0026) $\times$ 931 MeV

= 24.76 MeV

NUCLEAR FUSION IS KNOWN AS THERMO NUCLEAR REACTION

Nuclear fusion cannot take place easily. When two light nuclei are brought closer to each other, they exert a repulsive force on each other due to their positive charges. These nuclei can fuse together if they have enough kinetic energy to overcome the force of repulsion between them. Thus high temperature is required. For this The condition for high temperature reason nuclear fusion is also known as thermonuclear reaction.

DIFFERENCE BETWEEN NUCLEAR FISSION AND NUCLEAR FUSION REACTION

NUCLEAR FISSION

The phenomenon of splitting a heavy nucleus into two or more lighter nuclei.

1. and is pressure is not required.
2. Neutrons are the link particles.
3. It is a quick process.
4. Its products are harmful.
5. Stocks of fissionable material is limited.
6. Energy available per nucleon is smaller than nuclear fusion

NUCLEAR FUSION

1. A process in which two very light nuclei combine t form a nucleus with a larger mass number.
2. The condition for high temperature and pressure required.
3. Protons are the link particles.
4. It occurs in several steps.
5. Its products are harmless.
6. Fuel required for fusion are available in plenty.
7. Energy available per nucleon is larger than nucle fission.

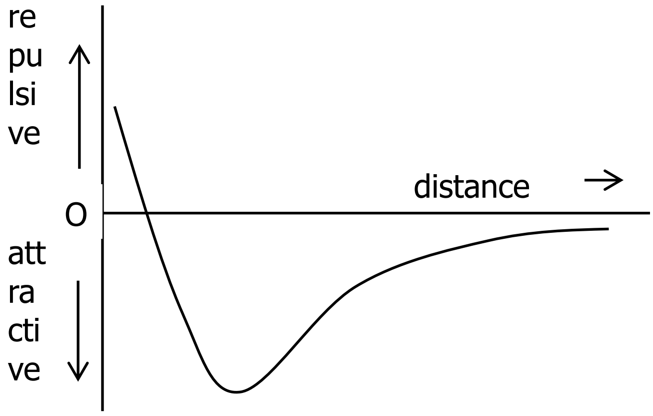
NUCLEAR FORCE

This are the forces which bind the nucleons inside the nucleus. The properties of nuclear force are

1. These is the strongest force in nature. 2. They are independent of charges.
3. They are short range forces. 4. They are saturated forces.
5. They are non central forces.

VARIATION OF NUCLEAR FORCE WITH DISTANCE

When the distance between the nucleons is large, the attractive force between them is weak. When the distance between the nucleons decreases, the attractive force goes on increasing up to a certain maximum value and then decreases with decreasing distance. As the distance between the nucleons decreases further, the force becomes repulsive and it increases rapidly to avoid collapsing of the nucleus.



UNIT 9 SEMICONDUCTOR DEVICES

ENERGY BAND

In an isolated atom, the electrons have well defined energy levels. But due to interatomic interactions in a crystal, the electrons of the outer shells are forced to have energies different from those in isolated atoms. Each energy level splits into a number of energy levels forming a continuous band called energy band.

TYPES OF ENERGY BAND

1. Valence band: These are the energy band which is occupied by the valence electrons. This band cannot be empty. Electrons in this band are not free to move and cannot conduct current.

2. Conduction band: These are the energy band which is occupied by the free electrons. This band can be empty or partially filled. Electrons in these band are free to move and can conduct current.

3. Forbidden energy gap/band: The energy gap between the top of valence band and the bottom of conduction band is called energy gap. Electrons are not found in this band. Electrons in the valence band after acquiring this energy can jump to the conduction band.

DISTINCTION BETWEEN METAL, INSULATOR AND SEMICONDUCTOR ON THE BASIS OF BAND THEORY

METAL: In metal there is either energy gap between the completely filled valence band and the partially filled conduction band (Cu, Au etc.) or the conduction band and valance band partially overlap(Zn, Mg etc.).

INSULATOR: In insulator there is large energy gap between the valance band and conduction band (more than 3eV). For diamond E_g = 6 eV

SEMICONDUCTOR: In semiconductor there is small energy gap between the valance band and conduction band (about 1eV). For Silicon E_g = 1.1 eV and Germanium E_g = 0.74 eV

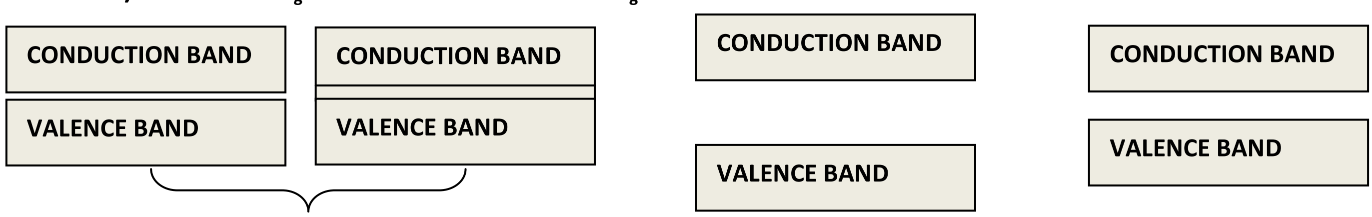


fig. metal fig. insulator fig. semioconductor

SEMICONDUCTOR

A semiconductor is a substance whose conductivity lies between conductor and insulator. It belongs to the group 14 elements in the periodic table. The electronic configuration of silicon and germanium is given below.

Si (14) = 2 8 4 Ge (32) = 2 8 18 4

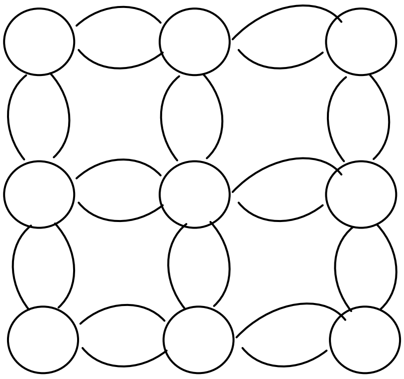
Both Si and Ge atom has four valence electrons. The four valence electrons of Si/Ge forms four covalent bonds by sharing electrons from the neighbouring four Si/Ge atoms.

Types of Semiconductor

1. Intrinsic or pure Semiconductor. 2. Extrinsic or doped semiconductor.

INTRINSIC SEMICONDUCTOR

A semiconductor in its pure form is called intrinsic semiconductor. The crystal structure of a pure Si semiconductor is shown in the figure.



At low temperature there are no free electrons and a pure semiconductor behaves as an insulator. Due to thermal agitation some covalent bonds may get ruptured producing free electrons in the crystal. The bond from where an electron is freed a vacancy is created. This vacancy is called a hole. A hole can be filled by an electron from a nearby covalent bond and again creating a hole. Thus a pure semiconductor has free electrons and holes at room temperature with the holes wandering in random direction. When a potential difference is applied across the semiconductor the movement of holes is opposite to that of free electrons. Thus a hole is taken as a positive charge carrier.

In a semiconductor the current is constitute due to flow of holes and free electrons. If n_e and n_h are the number of free electrons and holes and n_i the intrinsic carrier. Then

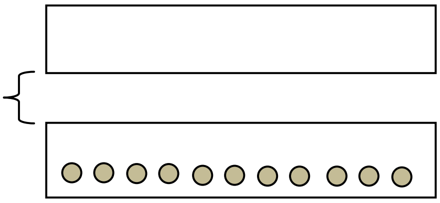
$$n_e = n_h \quad \text{and} \quad n_i = n_e = n_h$$

The energy band diagram of an intrinsic semiconductor is shown in the figure.

Conduction band

Forbidden energy gap

Valence band



DOPING

Doping is the process of deliberate additions of impurity atoms in a pure semiconductor to modify its properties in a controlled manner.

The impurity atoms so added are called dopants and the resulting semiconductor is called doped or extrinsic semiconductor.

DOPED OR EXTRINSIC SEMICONDUCTOR

This are the semiconductors obtained by adding impurity atoms to a pure semiconductor.

The types of extrinsic semiconductor are

1. N-type semiconductor 2. P-type semiconductor

TYPES OF IMPURITIES

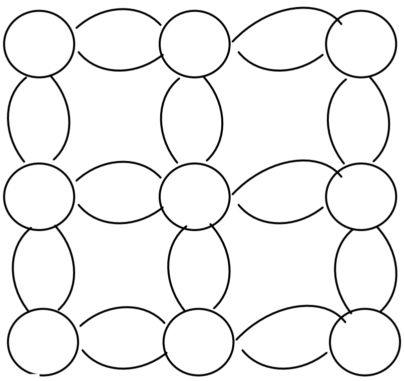
The types of impurities are

1. Pentavalent impurities: These are the impurities which have five valence electrons. Examples are Arsenic(As), Phosphorous (P), Bismuth (Bi), Antimony (Sb).
2. Trivalent impurities : These are the impurities which have three valence electrons. Examples are Indium(In), Boron(B), Aluminum (Al) and Gallium(Ga).

N-TYPE SEMICONDUCTOR

This are the extrinsic semiconductors which are obtained by adding pentavalent impurity atoms to a pure semiconductor.

When pure semiconductor of Si is doped with a pentavalent impurity atoms like As which has five valence electrons, the As atoms replaced some of the Si atoms. Four of the five valence electrons of As forms four covalent bond while the fifth electron is loosely bound to the parent atom and is comparatively free to move. For each As atom added it donates one electron. Again due to thermal agitation some of the covalent bonds may get ruptured thereby producing equal number of electrons and holes. But the total number of free electrons is more than the number of holes. Since the crystal is dominated with negative charge carrier, the resulting semiconductor is called N-type semiconductor.



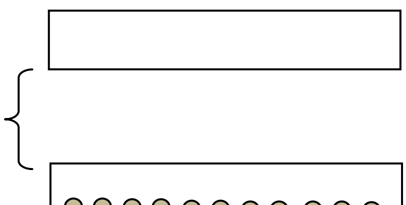
ENERGY BAND DIAGRAM OF N-TYPE SEMICONDUCTOR

The energy band diagram of n-type semiconductor is shown in the figure. In the energy band diagram a new energy level called donor energy level arises just below the conduction band which is occupied by the electrons donated by the pentavalent (donor) impurity atoms.

Conduction

E_g

Valence band



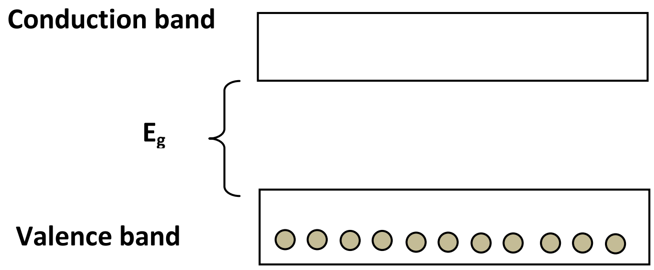
P-TYPE SEMICONDUCTOR

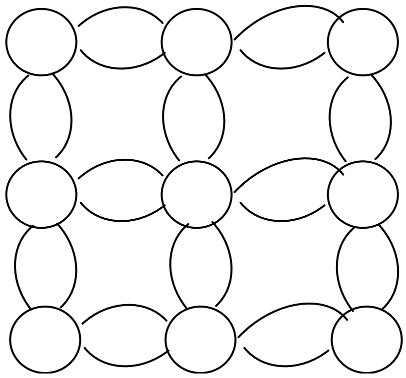
These are the extrinsic semiconductors which are obtained by adding trivalent impurity atoms to a pure semiconductor.

When pure semiconductor of Si is doped with a trivalent impurity atom like In which has three valence electrons, the In atoms replaced some of the Si atoms. The three valence electrons form three covalent bonds by sharing electrons from three adjoining Si atoms, while a bond is incomplete. This bond is completed by taking an electron from nearby Si-Si bond and creates a hole. For each In atom added it creates a hole. Again due to thermal agitation some of the covalent bonds may get ruptured thereby producing equal number of electrons and holes. But the total number of holes is more than the number of free electrons. Since the crystal is dominated with positive charge carrier, the resulting semiconductor is called P-type semiconductor.

ENERGY BAND DIAGRAM OF P-TYPE SEMICONDUCTOR

The energy band diagram of p-type semiconductor is shown in the figure. In the energy band diagram a new energy level called acceptor energy level arises just above the valence band.





DIFFERENTIATE BETWEEN INTRINSIC AND EXTRINSIC SEMICONDUCTOR

INTRINSIC SEMICONDUCTOR	ExTRINSIC SEMICONDUCTOR
1. It is a pure form of semiconductor.	1. It is an impure form of semiconductor.
2. Doping is not required.	2. Doping is required.
3. Conductivity is low.	3. Conductivity is high .
4. Number of free electrons and holes are equal.	4. Number of free electrons and holes are not equal.

DIFFERENTIATE BETWEEN P TYPE AND N TYPE SEMICONDUCTOR

P type SEMICONDUCTOR	N type SEMICONDUCTOR
1. Trivalent impurities are added.	1. Pentavalent impurities are added.
2. Number of holes is more than number of free electrons.	2. Number of holes is less than number of free electrons.
3. Holes are the majority charge carriers.	3. Free electrons are the majority charge carriers.
4. Acceptor energy level arises just above the valence band.	4. Donor energy level arises just below the conduction band.

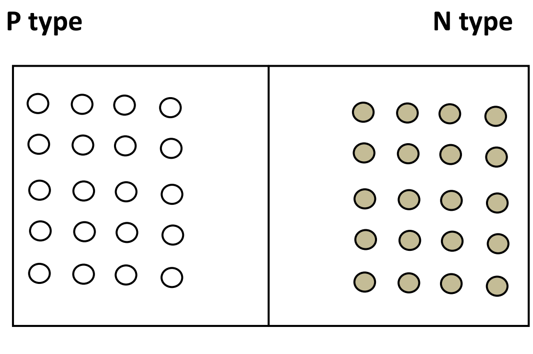
PN JUNCTION /DIODE/SEMICONDUCTOR DIODE

When a p type semiconductor is placed in contact with a n type semiconductor so that there is no discontinuous boundary at the junction, then the resulting arrangement is called PN junction.

DEPLETION LAYER: It is a region around the junction of a pn junction diode where there is no free charge carrier.

Formation of depletion layer:

When a pn junction is formed, due to difference in charge concentration at the two regions, holes from p-region diffuse to the n-region and electrons from n-region diffuse to the p-region. At the junction electron hole recombination occurs and a region is created around the junction where there is no free charge carrier. This region is called depletion region.

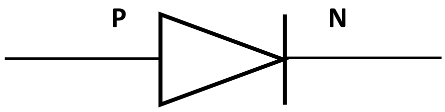


POTENTIAL BARRIER: The potential difference that develop around the junction of a pn junction diode is called potential barrier.

<u>Formation of potential barrier:</u>When an electron diffuse from n-region to p-region it leaves behind an ionised donor atom in n-region and when an a hole diffuse from p-region to n-region it leaves behind an ionised acceptor atom in p-region. Thus around the junction there is positive and negative immobile ions which sets up an electric field and further opposes the movement of majority charge carriers at the junction. This electric field sets a barrier called potential barrier.

<u>TYPES OF CURRENT IN A DIODE</u>

<u>Symbol of a diode</u>



Diffusion current : It is the current that arises due to diffusion of majority charge carriers towards the junction.

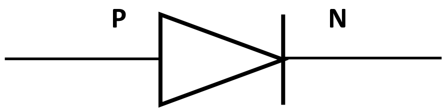
Drift current : Due to the electric field that develop at the junction, the minority charge carrier are drifted towards the junction. This is called drift current.

<u>BIASING</u>

Biasing of a diode means connecting it to an external circuit.

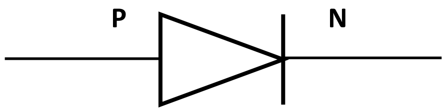
The modes of biasing are 1. Forward Biasing 2. Reverse biasing

<u>FORWARD BIASING</u>



A pn junction diode is said to be forward bias if the P side of the diode is connected to the positive terminal of the battery and N side to negative terminal of the battery . In forward bias the width of the depletion layer decreases due to decrease in potential barrier.

<u>REVERSE BIASING</u>



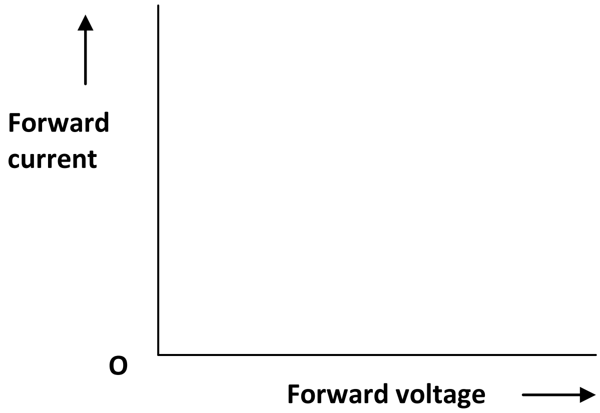
A pn junction diode is said to be reverse bias if the P side of the diode is connected to the negative terminal of the battery and N side to positive terminal of battery. In reverse bias the width of the depletion layer increases due to increase in potential barrier.

<u>CHARACTERISTICS OF A DIODE</u>

Characteristics of a diode is a graphical relationship between various voltage and currents of a diode.

A diode has two characteristics. 1. Forward Characteristics 2. Reverse Characteristics

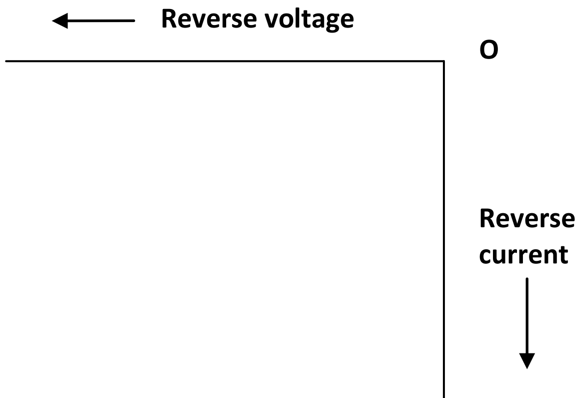
<u>FORWARD CHARACTERISTICS</u>



It is the graphical relationship between the forward voltage and forward current. The forward characterstics is shown in the figure.

When the battery voltage is low, diode does not conduct current.When battery voltage increases, a small current begins to flow. The forward current increases slowly at first but as soon as the battery voltage increases, the forward current increases rapidly. The battery voltage at which the forward current increases rapidly is known as knee voltage.

<u>REVERSE CHARACTERISTICS</u>



It is the graphical relationship between the reverse voltage and reverse current. The reverse characterstics is shown in the figure.

When the reverse voltage is low no current flows through the junction, but a very small current called reverse saturation current flows through the junction due to minority charge carriers. When the reverse voltage is increased to a certain value, called breakdown voltage, large amount of covalent bonds in p and n regions are broken. As a result of this, large electron hole pairs are produced which diffuse through the junction and hence there is a sudden rise in the reverse current. Once breakdown is reached, the high reverse current may damage the ordinary junction diode.

RECTIFIER

A rectifier is a device which is used to convert alternating current into direct current.

Principle : It is based on the fact that a pn junction conducts current when forward bias and do not conducts current when reversed biased.

Types of Rectifier 1. Half wave rectifier 2. Full wave rectifier

HALF WAVE RECTIFIER

A rectifier which converts only one half of a.c into d.c is called half wave rectifier.

The a.c input signal to be rectified is fed to the primary coil of the transformer. The secondary coil is connected to the junction diode through a load resistance R_L.The output signal is obtained across the load resistance.

When positive half cycle of input ac flows in the diode, the diode is forward bias and conducts current. The output current is taken across the load resistance. Again when negative half cycle of input ac comes the diode is reversed bias and do not conducts current and no output is taken across the load. Thus the current in the load flows in one direction and is dc. The input and output waveform is shown in the figure. Since only half of the input ac is rectified the arrangement is called half wave rectifier.

FULL WAVE RECTIFIER

A rectifier which converts both half of a.c into d.c is called full wave rectifier.

The a.c input signal to be rectified is fed to the primary coil of the central tapping transformer. The p regions of both diodes D_1 and D_2 are connected to the two ends of secondary coil. The load resistance R_L across which output voltage is obtained is connected between the common point of n regions of diodes and central tapping of the secondary coil.

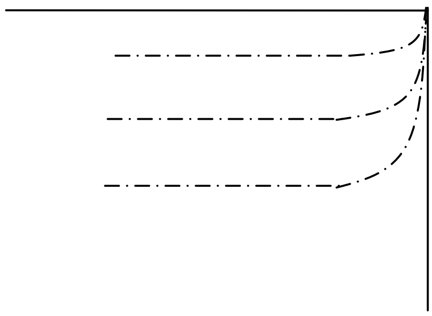
When positive half cycle of input ac flows the diode D_1 is forward bias and D_2 reversed bias. Thus diode D_1 conducts and the output current is taken across the load resistance.

Again when negative half cycle of input ac comes the diode D_1 is reversed bias and diode D_2 forward bias. Thus diode D_2 conducts current and output current is taken across the load in the same direction. Thus the current in the load flows in one direction and is dc. The input and output waveform is shown in the figure. Since both half of the input ac is rectified the arrangement is called full wave rectifier.

PHOTO DIODE

A photo diode is a pn junction diode made from a photo sensitive semiconducting material in such a way that light can fall on its junction. It is always connected in reversed bias. When light of suitable frequency falls on the junction of photo diode, it creates large electron hole pair which results in conduction of current. The current on a photo diode depends on the intensity of incident radiation.

Dark current: It is the value of reverse current that flows in the photo diode when no light is incident on the diode.



LIGHT EMITTING DIODE It is a forward bias pn junction diode which emits light when forward bias.

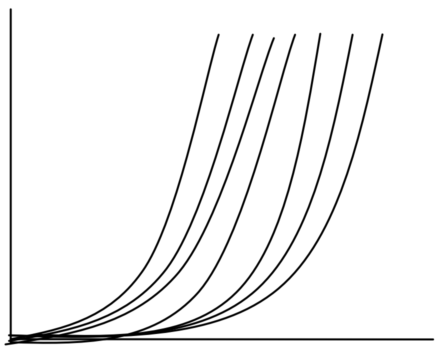
When a pn junction diode is forward bias the electrons and holes recombine at the junction. During recombination of the electrons with the holes energy is emitted in the photon.

Some advantages of LED are

1. **They have low operating voltage.**
2. **They have low power consumption.**
3. **They do not require warm up time.**
4. **They are very cheap than other form of lamp.**

Some uses of LED are

1. **They are used in lamp.**
2. **They are used in decorating lamps.**
3. **They are used for optical modulation and remote control.**
4. **They are used in traffic signals.**



LLS

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels.

USES OF SOLAR CELLS

1. Solar cells are very useful in powering space vehicles such as satellites and telescopes.
2. They provide a very economical and reliable way of powering objects .

TRANSISTOR

A transistor is a three terminal device obtained by growing a narrow section of one type semiconductor in between two relatively thick layer of other type of semiconductor.

TYPES OF TRANSISTOR

1. PNP transistor: It consists of a thin layer of n-type semiconductor sandwitched in between two thicker sections of p-type semiconductor.

2. NPN transistor: It consists of a thin layer of p-typ semiconductor sandwitched in between two thicke sections of n-type semiconductor.

REGIONS OF A TRANSISTOR

The various regions of a transistor are

Emitter: It is a section on one side of the transistor which is of moderate size and heavily doped. It supplies a large number of majority charge carriers for the flow of current through the transistor.

Base: It is the middle section which is very thin and lightly doped. It controls the flow of majority charge carriers from emitter to collector.

Collector: It is a section on other side of the transistor which is of moderately doped and larger in size as compared to emitter. It collects the majority charge carriers for circuit operation.

BIASING OF A TRANSISTOR

Emitter Base (EB) junction	CollectorBase (CB) junction	Emitter Base (EB) junction	CollectorBase (CB) junction
1. Forward	Reversed	3. Reversed	Reversed
2. Forward	Forward	4. Reversed	Forward

ACTIONS OF A TRANSISTOR

NPN transistor

The EB junction is forward bias using V_{EE} and CB junction is reversed using V_{cc}. As EB junction is forward bias, electrons in the emitter are repelled towards the base. About 5% of these electrons combine with the holes in the base region. The remaining electrons enter the collector region because of high positive potential of collector. For each electron entering the positive terminal of V_{cc} an electron from the negative terminal of V_{EE} enters the emitter region. Thus continuous flow of electrons from emitter to the collector through the base begins. If I_e, I_b and I_c are the emitter current, base current and collector current respectively. Then, $I_e = I_b + I_c$

PNP transistor

The EB junction is forward bias using V_{EE} and CB junction is reversed using V_{cc}. As EB junction is forward bias, holes in the emitter are repelled towards the base. About 5% of these holes combine with the electrons in the base region. The remaining holes enter the collector region because of high negative potential of collector. As one hole reach the collector, it is neutralized by an electron from the negative terminal of V_{cc} .As soon as one electron an a hole gets neutralized at the collector, a hole in the emitter is pushed towards the collector. Thus continuous flow of holes from emitter to the collector through the base begins. If I_e, I_b and I_c are the emitter current, base current and collector current respectively. Then, $I_e = I_b + I_c$

CONFIGURATION OF A TRANSISTOR

1. Common base(CB) configuration: In this mode the base is common to both the input and output circuit.
2. Common Emitter(CE) configuration: In this mode the emitter is common to both the input and output circuit.
3. Common Collector(CC) configuration: In this mode the collector is common to both the input and output circuit.

CHARACTERISTICS OF A TRANSISTOR IN CE CONFIGURATION

It is a graphical relationship between the various currents and voltages of a transistor. It is of two types.

1. **Input characteristics** 2. **Output characteristics**

The circuit diagram for studying characteristics of an npn transistor is shown in the figure.

INPUT CHARACTERISTICS

It is a graphical relationship between the base emitter voltage(V_{BE}) and base current (I_b) keeping V_{CE} constant. The input characteristics is shown in the figure. From the input characteristics we have the following conclusion.

1. The input characteristics are similar to forward bias characteristics of a junction diode.

2. For a given value of emitter base voltage the base current decreases with the increase in collector emitter voltage.

OUTPUT CHARACTERISTICS

It is a graphical relationship between the collector emitter voltage(V_{CE}) and collector current (I_c) keeping I_b constant. The output characteristics is shown in the figure. From the output characteristics we have the following conclusion

1. For a given value of base current, collector current increases rapidly with the collector emitter voltage in the beginning but at high value of V_{CE},collector current becomes constant.

2. For a given value of V_{CE} the collector current is higher for higher values of base current.

The output characteristics of a transistor in CE mode can be classified into three region.

1. Active region: It is the region that lies above $I_B = 0$. A transistor is operated as an amplifier in this region.

2. Cut off region: It is the region that lies below $I_B = 0$. A transistor is operated as an open switch in this region.

3. Saturation region: It is the region that lies close to zero voltage axis. A transistor is operated as an closed switch in this region.

USES OF TRANSISTOR **1. AMPLIFIER 2. SWITCH 3. OSCILLATOR**

AMPLIFIER

It is a device with increases the amplitude of input signal.

NPN TRANSISTOR AS AN AMPLIFIER IN CE CONFIGURATION

The figure shows the use of a npn transistor as a CE amplifier. The emitter is forward bias using V_{BB} and the collector is reversed bias using V_{CC} . The low a.c input signal V_i is superimposed on the forward bias V_{BE}. A load resistance R_L is connected between the collector and the d.c supply and the amplified output is obtained between the collector and the ground. When I_C flows in the output circuit, the potential drop across the load resistance is I_CR_L. Hence the output voltage is

$$V_0 = V_{CE} = V_{CC} - I_CR_L \text{ and } I_E = I_C + I_B .$$

When the input signal is fed to the base emitter circuit, the base emitter voltage changes. This changes the emitter current and hence the collector current. The output voltage V_O varies in accordance with the above relation. These variations in the collector voltage appear as amplified output.

PHASE RELATIONSHIP BETWEEN INPUT AND OUTPUT SIGNAL

When an ac signal is fed to the input circuit, its positive half cycle increases the forward bias of the input circuit which in turn increases the emitter current and hence the collector current. The increase in collector current increases the potential drop across R_L, which makes the output voltage V_O less positive or more negative. So as the input signal goes through its positive half cycle, the amplified output signal goes through a negative half cycle. Similarly, as the input signal goes through its negative half cycle , the amplified output signal goes through its positive half cycle. Hence in CE amplifier, the input and output signal are 180° out of phase or in opposite phases.

VARIOUS GAIN IN A TRANSISTOR **A.C current gain: It is defined as the ratio of small change in collector current to the small change in base current when the CE voltage is kept constant.**

D.C current gain: It is defined as the ratio of collector current to base current when the CE voltage is kept constant.

A.C voltage gain: It is defined as the ratio of small change in output voltage to the small change in input voltage.

ain: It is defined as the ratio of small change in output power to the small change in input power.

NPN TRANSISTOR AS AN AMPLIFIER IN CE CONFIGURATION

The figure shows the use of a pnp transistor as a CE amplifier. The emitter is forward bias using V_{BB} and the collector is reversed bias using V_{CC} . The low a.c input signal V_i is superimposed on the forward bias V_{BE}. A load resistance R_L is connected between the collector and the d.c supply and the amplified output is obtained between the collector and the ground. When I_C flows in the output circuit, the potential drop across the load resistance is I_CR_L. Hence the output voltage is

$$V_0 = V_{CE} = V_{CC} - I_CR_L \text{ and } I_E = I_C + I_B .$$

When the input signal is fed to the base emitter circuit, the base emitter voltage changes. This changes the emitter current and hence the collector current. The output voltage V_O varies in accordance with the above relation. These variations in the collector voltage appear as amplified output.

PHASE RELATIONSHIP BETWEEN INPUT AND OUTPUT SIGNAL

When an ac signal is fed to the input circuit, its positive half cycle decreases the forward bias of the input circuit which in turn decreases the emitter current and hence the collector current. The decrease in collector current decreases the potential drop across R_L, which makes the output voltage V_O more negative. So as the input signal goes through its positive half cycle, the amplified output signal goes through a negative half cycle. Similarly, as the input signal goes through its negative half cycle , the amplified output signal goes through its positive half cycle. Hence in CE amplifier, the input and output signal are 180° out of phase or in opposite phases.

CURRENT AMPLIFICATION FACTOR

1. **Common base current amplification factor: It is defined as the ratio of collector current to the emitter current. It is denoted by α and is always less than 1.**

2. **Common emitter current amplification factor: It is defined as the ratio of collector current to the base current. It is denoted by β and lies between 50 and 500.**

RELATION BETWEEN THE TWO CURRENT AMPLIFICATION FACTOR

BINARY OPERATION

It is an operation which works on two numbers namely 0 and 1.

DIGITAL CIRCUIT

A signal in which current and voltage can take only two discrete values is called a digital circuit.

LOGIC GATES

It is digital circuit that is designed for performing a particular logical operation.

TRUTH TABLE

It is a table that shows all possible input combinations and the corresponding outputs of a logic gate.

BOOLEAN EXPRESSION

It is a method to describe the functioning of a logic gate in the form of an equation or an expression.

FUNDAMENTAL LOGIC GATE AND COMBINATIONAL LOGIC GATE

TRANSISTOR AS SWITCH

A transistor can be used as a switch if it is operated in its cutoff and saturation states only. As long as the input voltage is low and unable to forward bias the transistor i.e in cutoff state, the output voltage is high and the transistor is said to be in non conducting state i.e switched off state. If the input voltage is high enough to drive the transistor into saturation, then the output voltage is low. Then the transistor is said to be in conducting state.

TRANSISTOR AS OSCILLATOR

An oscillator is an electronic device which produces electric oscillation of constant frequency and amplitude without requiring any external input signal.

CONSTRUCTION

The fig shows the basic circuit using a common emitter npn transistor as an oscillator. A tank circuit consisting of an inductance and a variable capacitor C is connected in the input or the emitter base circuit which is

forward biased. A small coil L' called feedback is connected in the output and the emitter collector circuit which is reversed bias. The coil L' is inductively coupled with the coil L of the tank circuit.

WORKING

When the switch S is closed, a small collector current starts growing through coil L'. This increases the magnetic flux linked with coil L' and hence with coil L. This induces emf in coil L in the direction of forward bias and a positive charge begins to build up on the upper plate of capacitor C. The emitter current increases and also the collector current . This increases the magnetic flux linked with L' and hence with L . Consequently, the forward bias increases which further increases the emitter and collector currents and charging of capacitor continues. This process continues till the collector current becomes maximum. When the current through L' stops changing, the induced emf linked with L vanishes. This decreases the emitter current and hence the collector current. The decreasing current through L' induces emf in L in the opposite direction of forward bias. This results in the decrease of emitter current and hence the collector current. At the same time positive charge on the lower plate of capacitor C begins to build up. The process continues till the collector current becomes zero. The induced emf linked with L again becomes zero i.e the forward bias is now not being opposed by induced emf. The emitter current and hence the collector current will starts increasing. This cycle repeats again and again to give electric oscillations of constant amplitude and of constant frequency.

UNIT X COMMUNICATION SYSTEM 5 MARKS

COMMUNICATION: It is the process by which information is transferred from one point to the other point.

INFORMATION: It is basically the news which one wishes to convey.

MESSAGE: It is the physical manifestation of the information produced by the source.

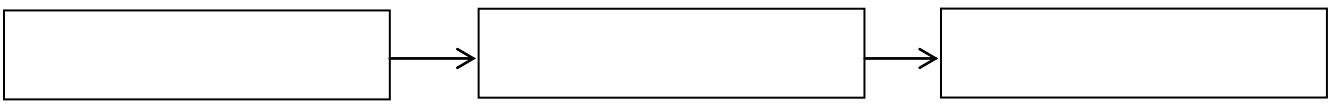
SIGNAL: It is defined as the single valued function of time which conveys the information.

Q. What is a communication system? Describe briefly the major components of a communication system.

Ans: A set up used for transmission of signal from one place to another is called communication system.

The essential parts of a communication system are

1. Transmitter: It is a set up that transmits the message to the receiving end through a communication channel. Its main function is to convert the message signal produced by the information source into a form suitable for transmission.
2. Communication channel or transmission medium: It is the medium or the physical path that connects a transmitter to a receiver. It carries the signal from the transmitter to the receiver.
3. Receiver: It is a set up that receives the transmitted signal from the transmission medium and convert those signal back to the original form.



Q. What are the two basic modes of communication?

The modes are

1. Point to point communication: In this mode, communication occurs over a link between a single transmitter and receiver. E.g telephony.
2. Broadcast mode: In this mode a large number of receivers are linked to a single transmitter. E.g radio and television.

TRANSDUCER: Any device which converts energy from one form to another is called transducer. E.g a microphone converts sound signal to electrical signal at the transmission station and a loud speaker converts electrical signal into sound signal at the receiving station.

NOISE: The unwanted electrical signal which get interfered with the information signal during its propagation through the transmission medium is called noise.

ATTENUATION: The loss of strength of a signal during its propagation through the transmission medium is called attenuation.

AMPLIFICATION: It is the process of increasing the amplitude and hence the strength of an electrical signal by using amplifier.

BAND WIDTH: The range over which frequencies in an information signal vary is called bandwidth. It is equal to the difference between the highest and lowest frequencies present in the signal.
Eg. Speech signal contains frequencies between 300Hz to 3100 Hz. Such signal requires a bandwidth of (3100 Hz – 300Hz)= 2800 Hz for telephonic transmission .
Audio signal have frequencies between 20Hz to 20kHz. So bandwidth = 20kHz – 20 Hz

MODULATION: It is the phenomenon of superimposing the low frequency message signal on a high frequency wave.
The low frequency message signal is called modulating signal and the high frequency wave is called carrier wave. The resulting wave after modulation is called modulated wave.
MODULATOR: A device used for modulation is called modulator.

REPEATER: A repeater is a combination of a transmitter, an amplifier and a repeater which picks up a signal from the transmitter, amplifies and retransmits it to the receiver sometimes with a change in carrier frequency.

AMPLITUDEMODULATION: It is the process in which the amplitude of the high frequency carrier wave changes in accordance with the instantaneous value of modulating signal.

MODULATION INDEX: It is defined as the change in amplitude of the carrier wave to the amplitude of the original carrier wave.

BAND WIDTH of a signal in AM
The difference of the highest and the lowest frequencies present in the AM wave is called its bandwidth.
Band width in AM is $W= f_{max} - f_{min} = (f_c + f_m) - (f_c - f_m) = 2 f_m$

<u>VARIOUS FREQUENCY RANGES</u>
FREQUENCY BAND ON WIRELESS COMMUNICATION
SPACE COMMUNICATION
The term space communication refers to sending, receiving and processing of information through space as communication medium. Frequencies used in space communication lies in the range 10^4 to 10^{11} Hz.

TYPES OF SPACE COMMUNICATION
They are of three types
1. Ground Wave propagation. 2. Space Wave propagation. 3. Sky Wave propagation.

GROUND WAVE PROPAGATION

It is a mode of wave propagation in which the radio wave travel directly from one point to another following the surface of earth.
While progressing along the surface of earth, the ground wave loses energy with distance as they are absorbed by earth. So ground waves are not suited for long distance transmission and they are generally used for local broadcasting.
It is possible at low frequencies (500kHz to 1500kHz) and not for high frequency. The region of the AM band is called medium wave band. The maximum range of ground wave propagation depends on two factors (i) frequency of the transmitted wave (ii) power of the transmitter.

SPACE WAVE PROPAGATION
It is a mode of wave propagation in which the radio wave emitted from the transmitter antenna reach the receiver antenna through space. The space wave are the radio waves of frequency range from 54 MHz to 4.2 GHz.
The range of space wave propagation is limited by (i) line of sight distance i.e the distance at which the transmitting antenna can see each other (ii) the curvature of earth.

SKY WAVE PROPAGATION

It is a mode of wave propagation in which the radio wave emitted from the transmitter antenna reach the receiver antenna after reflection from the ionosphere. The sky waves are the radio waves of frequency range from 1840kHz to 30MHz.

The em waves of frequency more than 30MHz are not reflected back from atmosphere but gets refracted through it. Thus sky wave propagation is limited to radio waves below 30MHz. In a single reflection from the ionosphere, the radio waves cover a distance not less than 4000km. So a very long distance communication round the globe is possible using sky wave.

EMODULATION

It is the reverse process of modulation.

The process of retrieval of information from the carrier wave at the receiver end is called demodulation.

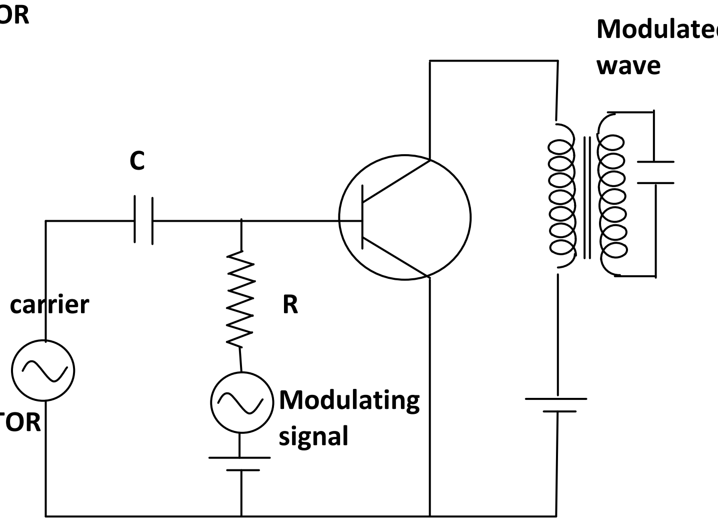
DEMODULATOR

A device which is used for modulation is called demodulator.

RANGE OF TV transmission

PRODUCTION OF AMPLITUDE MODULATED WAVE/MODULATOR

The fig shows an amplitude modulator. The modulating signal is applied to the base. Thus the base biasing voltage is a sum of constant dc voltage and the modulating voltage. As the base biasing changes the amplification produced is also changes. The output voltage is a carrier signal varying in amplitude in accordance with the biasing modulating voltage. This gives an amplitude modulated wave.



DETECTION OF AMPLITUDE MODULATED WAVE/ DEMODULATOR

The above figure shows a demodulator. The input circuit consists of a tuned circuit comprising of an inductor L and a variable capacitor C. This circuit selects the desired AM wave signal from the different signals picked up by the receiver antenna. When this wave is passed through a diode, rectified modulated wave containing only +ve half cycles is obtained. It is then fed to the parallel combination of a capacitor C' and a resistor R. the value of C' is so chosen that its reactance to high frequency carrier wave is low and high for low frequency modulating signal. Thus the capacitor C' acts as a bypass for the carrier waves and audio frequency modulating voltage appears across R. This sends current to the loud speaker and the original speech is produced.