CHAPTER 01

Class XII

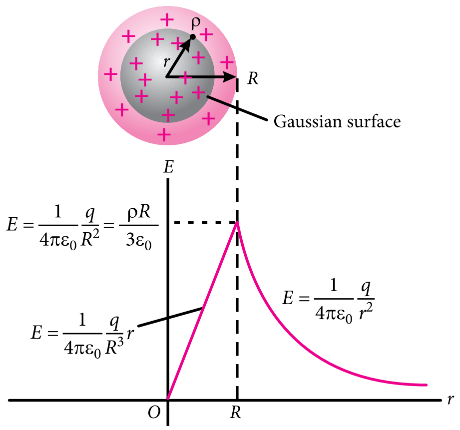
ELECTRIC CHARGES AND FIELDS

Basic Properties of Charges

Quantization of charge : Total charge on a body is always an integral multiple of a basic unit of charge denoted by e and is given by $q = ne$.

Conservation of charge : Total charge of an isolated system remains unchanged with time.

Additivity of charge : Total charge of a system is the algebraic sum (*i.e.* sum taking into account with proper signs) of all individual charges in the system.



For uniformly charged solid sphere

Coulomb's Law

$F = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1 q_2}{r^2}$ Newton

(1 Newton = 10^5 Dyne)

If two stationary point charges q_1 and q_2 are kept at a distance r, then it is found that force of attraction or repulsion between them is

$F \propto \frac{q_1 q_2}{r^2}$

Vector form of Coulomb's law

$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^3}\vec{r}_{12}$ for like charges

$\vec{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\vec{r}_{21}$ for unlike charges

Using Superposition Principle

- The vector sum of forces would give us the total force.
- Force between two charges is unaffected by the presence of the other charges.

Electric Field

The electric field intensity at any point is defined as the force experienced by a unit positive charge placed at that point.

$E = \frac{F}{q_0} = \frac{kq}{r^2}$

S.I. unit = $\frac{\text{newton}}{\text{coulomb}} = \frac{\text{volt}}{\text{metre}}$

Dimension : $[E] = [\text{MLT}^{-3}\text{A}^{-1}]$

Basic Characteristics

- Field lines start from positive charges and end at negative charges.
- Electrostatic field lines do not form any closed loops.
- Two field lines can never cross each other.

Electric Dipole

Every dipole is associated with a dipole moment $\vec{p}$ whose magnitude is equal to the product of the magnitude of either charge (q) and the distance $2a$ between the charges, *i.e.*,

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

Basic Characteristics

At Axial point (End on position)

$E_{\text{axial}} = \frac{2p}{4\pi\varepsilon_0 r^3}$

At Equatorial point

$E_{\text{equitorial}} = \frac{p}{4\pi\varepsilon_0 (r^2 + l^2)^{3/2}}$

If $r >> l$ then,

$E_{\text{equitorial}} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{p}{r^3}$

(directed from $+q$ to $-q$)

At General point

$E_g = \frac{1}{4\pi\varepsilon_0}\cdot\frac{p}{r^3}\sqrt{3\cos^2\theta + 1}$

Dipole in an external field experiences

Torque

The net force experienced by the dipole is zero. Due to torque so produced, dipole aligns itself in the direction of electric field.

$\vec{\tau} = \vec{p} \times \vec{E}$ or $\tau = pE\sin\theta$.

Electric Flux

Electric flux over an area in an electric field represents the total number of electric field lines crossing this area.

Electric flux is a measure of 'flow' of electric field through a surface. It is equal to the product of an area element and the perpendicular component of E, integrated over a surface.

Flux of electric field E through any area A is defined as.

$\phi = EA\cos\theta$ or $\phi = \vec{E}.\vec{A}$

S.I. unit is (volt × m) or $\frac{\text{N} - \text{m}^2}{\text{C}}$

Guass's Theorem

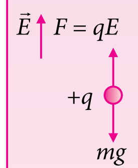
Total normal electric flux over a closed surface S in vacuum is $1/\varepsilon_0$ times the charge (q) contained inside the surface.

$\phi_E = \oint_S \vec{E}.d\vec{S} = \frac{q}{\varepsilon_0}$

Equilibrium of Charges

A charge is said to be in equilibrium, if net force acting on it is zero. A system of charges is said to be in equilibrium if each charge is separately in equilibrium.

Freely suspended charge

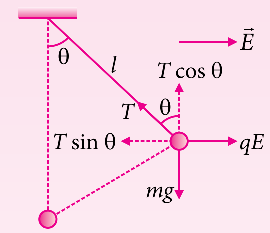


In equilibrium

$qE = mg$

$\Rightarrow E = \frac{mg}{q}$

Suspension of charge from string



In equilibrium

$T\sin\theta = qE$ ...(I)

$T\cos\theta = mg$ ...(ii)

From equations (i) and (ii)

$T = \sqrt{(qE)^2 + (mg)^2}$

and $\tan\theta = \frac{qE}{mg}$

Applications

Electric field using Volume charge density, $\rho = \frac{q}{V}$

Electric field using Surface charge density, $\sigma = \frac{q}{A}$

Electric field using Linear charge density, $\lambda = \frac{q}{l}$

Uniformly charged non-conducting sphere

- Outside the sphere,

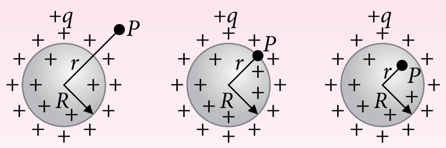
$E_{out} = \frac{q}{4\pi\varepsilon_0 r^2} = \frac{\rho R^3}{3\varepsilon_0 r^2}$

- At the surface of sphere

$E_s = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{R^2} = \frac{\rho R}{3\varepsilon_0}$

- Inside the sphere,

$E_{in} = \frac{1}{4\pi\varepsilon_0}\frac{qr}{R^3} = \frac{\rho r}{3\varepsilon_0}$



Charged conducting sphere

- Outside the sphere

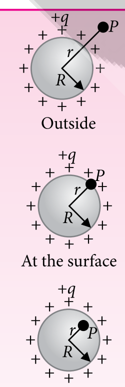
$E_s = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r^2} = \frac{\sigma R^2}{\varepsilon_0 r^2}$

- At the surface of sphere,

$E_s = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{R^2} = \frac{\sigma}{\varepsilon_0}$

- Inside the sphere,

$E_{in} = 0$

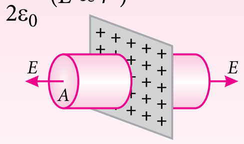


Due to a uniformly charged infinite thin plane sheet,

$E = \frac{\sigma}{2\varepsilon_0}$

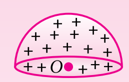
- Infinite thin plane sheet of charge

$E = \frac{\sigma}{2\varepsilon_0}$ $(E \propto r^0)$



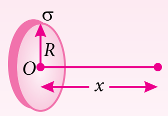
- **Hemispherical charged body**

$E = \frac{\sigma}{4\varepsilon_0}$

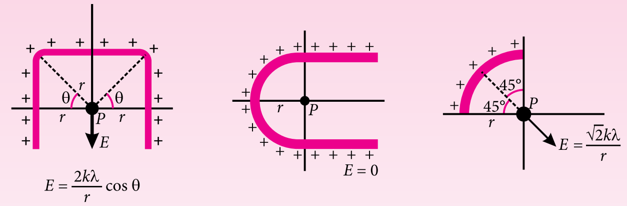


- **Uniformly charged disc**

$E = \frac{\sigma}{4\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2 + R^2}}\right]$



Due to bending of charged rod at point *P*.



Due to **an infinitely long thin uniformly charged straight wire,**

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$.

CHAPTER 02

Class XII

ELECTROSTATIC POTENTIAL AND CAPACITANCE

Electrostatic Potential
Work done per unit positive test charge by an external force in bringing a unit positive charge from infinity to a point in the presence of another point charge.

$V = -\frac{W}{q_0} = \frac{q}{4\pi\varepsilon_0 r}$

Electric Potential Energy
For a system of two charges

$U = \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$

Electrostatic Potential Due to an Electric Dipole
At any arbitrary point, $V = \frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$

At axial point, $V = \frac{p}{4\pi\varepsilon_0 r^2}$

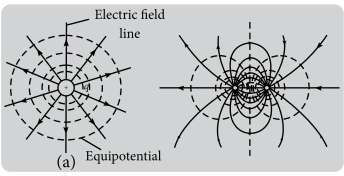
At equatorial point, $V = 0$

Potential energy of a dipole in external field
$U(\theta) = pE(\cos\theta_0 - \cos\theta)$

→ When initially at $\theta_0 = 90°$

$\Rightarrow U = -\vec{p}\cdot\vec{E}$

Equipotential Surface
Surface having same electrostatic potential at every point.



Properties
- Do not intersects each other
- At every point $\vec{E} \perp$ equipotential surface
- Net work done in moving a charge is zero $W_{net} = 0$
- Closely spaced in the region of strong field and vice-versa.

Electric field E between plates

Charge on the inside of each plate: $+Q$ on the top, $-Q$ on the bottom

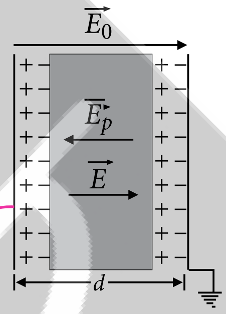
Capacitor and Capacitance
Capacitor is used to store electrical energy. Capacitance is defined as the ratio of the charge stored to the potential between the plates.

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

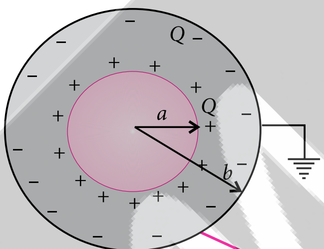
Relation between $\vec{E}$ and $\vec{V}$
$\vec{E} = -\vec{\nabla}V$

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

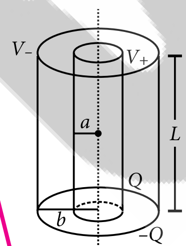
Capacitances of different types of capacitors



- Parallel plate capacitor with dielectric slab of thickness t with dielectric constant K: $C = \frac{\varepsilon_0 A}{d - t\left(1-\frac{1}{K}\right)}$
- Air filled parallel plate capacitor: $C = \frac{\varepsilon_0 A}{d}$
- Parallel plate capacitor filled with dielectric: $C = \frac{K\varepsilon_0 A}{d}$
- Spherical capacitor: $C = 4\pi\varepsilon_0 \frac{ab}{b-a}$



- Parallel plate capacitor with metallic conductor of thickness t inserted in it: $C = \frac{\varepsilon_0 A}{(d-t)}$
- Cylindrical capacitor: $C = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{b}{a}\right)}$



Combination of Capacitor
Series combination: $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + ... \frac{1}{C_n}$

Parallel combination: $C_p = C_1 + C_2 + ... C_n$

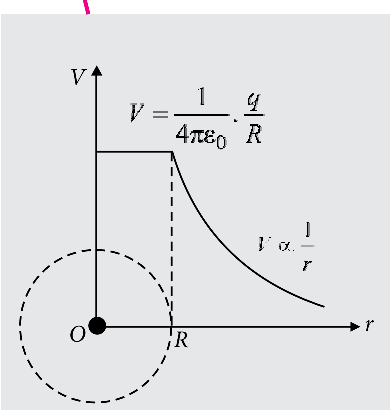
Electrostatic Shielding
The phenomenon of making a region free from any electric field is called electrostatic shielding. It is based on the fact that electric field vanishes inside the cavity of a hollow conductor.

Lightning Conductor
Lightning conductors fitted above the highest part of a building to protect a tall building from being struck by lightning.

Electric Potential due to Uniformly Charged Spherical Shell
Outside the shell: $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}; r > R$

On the shell: $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}; r = R$

Inside the shell: $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$



Electric Potential Due to a Non-Conducting Solid Sphere
Outside the sphere: $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}; \; r > R$

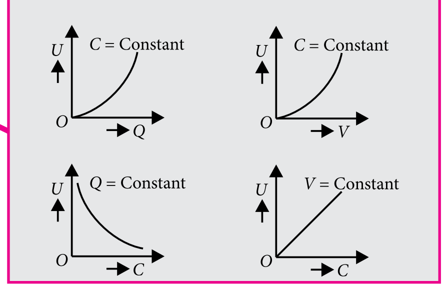
On the sphere i.e., $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}; \; r = R$

Inside the sphere: $V = \frac{1}{4\pi\varepsilon_0}\frac{q(3R^2 - r^2)}{2R^3}; \; r < R$

Energy Stored in a Capacitor
$U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}$

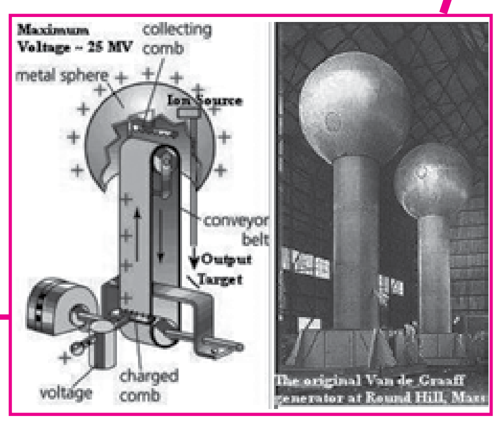
Energy Density
$u = \frac{U}{V} = \frac{1}{2}\varepsilon_0 E^2$

Energy Variation in Different Cases



Van de Graaff Generator
An electrostatic generator designed to produce high voltage of the order of 10 million volt, used to accelerate charged particles.

Principle
- If an electric charge is imparted to the inside of a spherical conductor, it is distributed entirely on its outer surface.
- Pointed ends cannot retain charge due to high charge density on them.



CHAPTER 07

Class XI

GRAVITATION

Newton's Law of Gravitation

Newton's Law of Gravitation

- Gravitational force (F) between two bodies is directly proportional to product of their masses and inversely proportional to square of the distance between them.

$$\vec{F} = -\frac{Gm_1m_2}{r^2}\cdot\hat{r}$$

Characteristics of gravitational force

- It is always attractive.
- It is independent of the medium.
- It is a conservative and central force.
- It holds good over a wide range of distance.

Acceleration due to gravity

- For a body falling freely under gravity, the acceleration in the body is called acceleration due to gravity.
- Relationship between g and G

$$g = \frac{GM_e}{R_e^2} = \frac{4}{3}\pi G R_e \rho$$

where G = gravitational constant

ρ = density of the earth

M_e and R_e be the mass and radius of earth

Variation of acceleration due to gravity (g)

Due to height (h)

if $h << R_e$; $g_h = g\left(1 - \frac{2h}{R_e}\right)$

The value of g decreases with height.

Due to depth (d)

if $d << R_e$; $g_d = g\left(1 - \frac{d}{R_e}\right)$

The value of g decreases with depth.

Due to rotation of earth

$g_\lambda = g - R_e\omega^2\cos^2\lambda$

At equator, $\lambda = 0°$; $g_{\lambda_{min}} = g - R_e\omega^2$

At poles, $\lambda = 90°$; $g_{\lambda_{max}} = g_p = g$

Weightlessness

- A body is said to be in a state of weightlessness when the reaction of the supporting surface is zero or its apparent weight is zero.
- In the weightlessness state, though the bodies have no weight but they do possess inertia on account of their mass. The bodies floating inside the spacecraft may collide with each other and crash.

Gravitational Field and Intensity

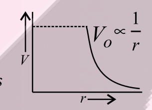
- The gravitational field intensity (I) at any point in the gravitational field due to a given mass is, $I = \frac{Gm}{r^2}$

For any point on the surface of the Earth, $r = R$, $m = M$ So, $I_{surface} = \frac{GM}{R^2} = g$

Gravitational Potential of

- **Hollow Sphere**

$V_o = \frac{-GM}{r}$; $V_s = \frac{-GM}{r}$; $V_i = V_s$



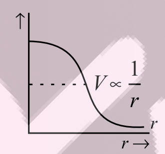
- **Solid Sphere**

$V_o = \frac{-GM}{r}$; $V_s = \frac{-GM}{R}$

$V_i = \frac{-GM}{2R^3}[3R^2 - r^2]$

At centre $r = 0$

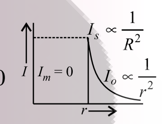
$V_c = \frac{3}{2}\frac{GM}{R}$; $V_c = \frac{3}{2}V_s$



Gravitational Field Intensity of

- **Hollow Sphere**

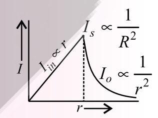
$I_o = \frac{GM}{r^2}$; $I_s = \frac{GM}{R^2}$; $I_{in} = 0$



- **Solid Sphere**

$I_o = \frac{GM}{r^2}$; $I_s = \frac{GM}{R^2}$;

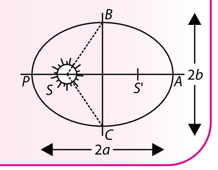
$I_{in} = \frac{GMr}{R^3}(r < R)$



Kepler's Laws of Planetary Motion

Law of orbits :

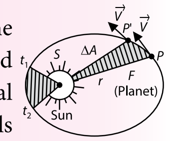
Every planet revolves around the sun in an elliptical orbit and the Sun is situated at one of its foci.



Law of areas :

The line joining the centre of a planet and the Sun sweeps equal areas in equal intervals of time, *i.e.*, the areal velocity of the planet around the Sun is constant.

i.e., $\frac{dA}{dt}$ = a constant



Law of periods :

The square of the time period of revolution of a planet is directly proportional to the cube of semi major axis of the elliptical orbit.

$$T^2 = \left(\frac{4\pi^2}{GM_S}\right)R^3$$

Gravitational Potential Energy and Gravitational Potential

Gravitational Potential Energy

- Work done in bringing the given body from infinity to a point in the gravitational field. $U = V_m \times m$

$U = -GMm/r$

Gravitational potential energy = Gravitational potential × mass of the body

Gravitational Potential

- The gravitational potential at a point in the gravitational field of a body is defined as the amount of work done in bringing a body of unit mass from infinity to that point.

$$V = \frac{-GM}{r}$$

Gravitational Potential and Gravitational Field Intensity

Field intensity $\vec{I} = \frac{\vec{F}}{m} = \frac{GM}{r^2}\times\hat{r}$, $V = \frac{-GM}{r}$

$\because$ $\vec{I} = \frac{-V}{r}\times\hat{r}$; Potential $V = \vec{I}\cdot\vec{r}$.

Escape Velocity & escape energy

- Escape velocity is the minimum velocity with which a body must be projected so that it may just escape from the gravitational field of the Earth.

$v_e = \sqrt{2gR} = \sqrt{\frac{2GM}{R}} = 11.2\ \text{km s}^{-1}$

Escape energy, $E_e = \frac{GM_e m}{R_e}$

Earth's Satellite

Orbital Speed

- Orbital speed of a satellite is the minimum speed required to put the satellite into a given orbit around the Earth.

$$v_0 = \sqrt{\frac{GM}{R+h}}$$

The direction of orbital speed of a satellite at an instant is along the tangent to the orbital path of the satellite at that instant.

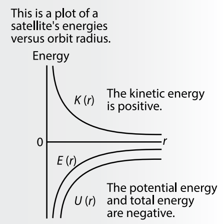
Energy

- Energy of an orbiting satellite is the sum of its potential energy (U) and kinetic energy (K).

$$E = U + K = \frac{-GMm}{(R+h)} + \frac{GMm}{2(R+h)} = \frac{-GMm}{2(R+h)} = -K$$

- Binding energy is the energy required to remove the satellite from its orbit around the Earth to infinity.

$$E_B = -E = \frac{GMm}{2(R+h)}$$



Time Period

- Time period of a satellite is the time taken by a satellite to complete one revolution around the Earth.

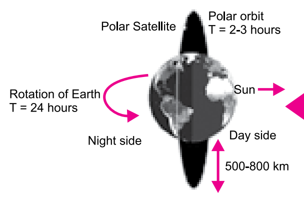
$$T = \frac{2\pi(R+h)^{3/2}}{\sqrt{GM}}$$

For $h << R$, $T = 2\pi\sqrt{\frac{R}{g}} = 84.6$ minutes

Types of Satellite

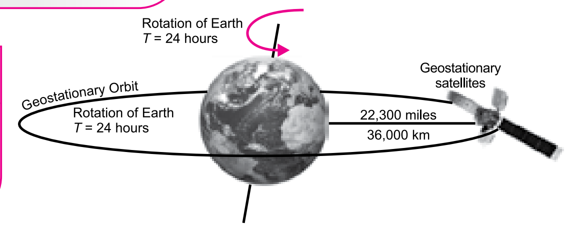
Polar satellite

- Time period : 100 min.
- Revolves in polar orbit around the Earth.
- Height : 500-800 km.
- Uses : Weather forecasting, military spying.



Geostationary satellite

- Time period : 24 hours.
- Same angular speed in same direction with the earth.
- Height : 36000 km.
- Uses : GPS, satellite communication (TV)



CHAPTER
08
Class XII

RAY OPTICS AND OPTICAL INSTRUMENTS

RAY OPTICS & OPTICAL INSTRUMENTS

THIN SPHERICAL LENS

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

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

REFLECTION FROM PLANE SURFACE

- The image formed by a plane mirror is laterally inverted.
- The image formed by a plane mirror is virtual, erect w.r.t. object and of the same size as the object.
- If keeping the incident ray fixed, the plane mirror is rotated through an angle θ, the reflected ray turns through double the angle *i.e.*, 2θ in that direction.
- Deviation suffered by a light ray incident at an angle *i* is given by $\delta = (180° - 2i)$

POWER OF LENSES

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

- The SI unit of power of lens is dioptre (D).
- For a convex lens, *P* is positive.
- For a concave lens, *P* is negative.
- When focal length (*f*) of lens is in cm, then $P=\frac{100}{f\text{ (in cm)}}$ dioptre.

COMBINATION OF LENSES

- Power: $P = P_1 + P_2 - dP_1P_2$ (d = small separation between the lense)
- For $d = 0$ (lenses in contact)
- Power: $P = P_1 + P_2 + P_3 + ...$

COMMON DEFECTS OF EYES ↔ CORRECTING LENSES

- Myopia (short-sightedness) ↔ Concave lens
- Hypermetropia (long-sightedness) ↔ Convex lens
- Presbyopia ↔ Bifocal lens
- Astigmatism ↔ Cylindrical lens

REFRACTION BY SPHERICAL SURFACE

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

$$\frac{\mu_{denser}}{v}-\frac{\mu_{rarer}}{u}=\frac{\mu_{denser}-\mu_{rarer}}{R}$$ (Holds for any curved spherical surface)

Lens maker's formula

$$\frac{1}{f}=\left(\frac{\mu_{denser}-\mu_{rarer}}{\mu_{rarer}}\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

for the lens placed in air

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

REFLECTION OF LIGHT

Laws of reflection:

- The angle of incidence *i* equals the angle of reflection *r*.

$\angle i = \angle r$

- Incident ray, the normal and the reflected ray lie in the same plane.

SIMPLE MICROSCOPE

Magnifying power

For final image is formed at *D* (least distance),

$$m=\frac{\text{Angle subtended by the image at } D}{\text{Angle subtended by the object at infinity}}=\frac{\beta}{\alpha}=1+\frac{D}{f}$$

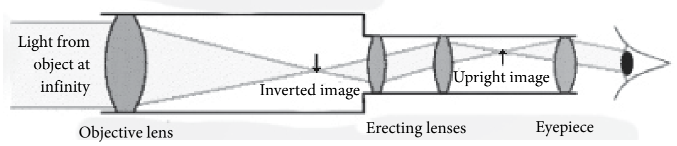
For final image formed at infinity, $m=\frac{D}{f}$

TERRESTRIAL TELESCOPE

For final image is formed at *D*, $m=\frac{f_o}{f_e}\left(1+\frac{f_e}{D}\right)$

For final image is formed at infinity, $m=\frac{f_o}{f_e}$

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



REFRACTION THROUGH PRISM

Relation between μ and δ_m

$$\mu=\frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$$ where, δ_m = angle of minimum deviation, A = angle of prism

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

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

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

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

ASTRONOMICAL TELESCOPE

Magnifying power

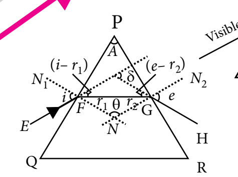
- For final image is formed at *D* (least distance),

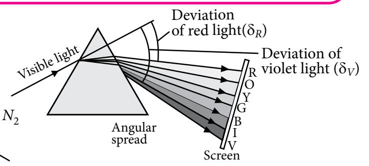
$$m=\frac{\text{Angle subtended by the image at } D}{\text{Angle subtended by the object at infinity}}=\frac{\beta}{\alpha}=\frac{-f_o}{f_e}\left(1+\frac{f_e}{D}\right)$$

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

DISPERSION OF LIGHT

The phenomenon of splitting of white light into its constituent colours on passing through a prism.





REFLECTION BY SPHERICAL MIRRORS

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

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

If the image is upright or erect with respect to the object then *m* is positive. And *m* is negative if the image is inverted with respect to the object.

REFRACTION OF LIGHT

Laws of refraction :

- The incident ray, the normal to the interface at the point of incidence and the refracted ray all lie in the same plane.
- Snell's law: $\frac{\sin i}{\sin r}=\text{constant}={}^1\mu_2$

(${}^1\mu_2$ = refractive index of medium 2 w.r.t. 1)

COMPOUND MICROSCOPE

Magnifying power, $m=m_o\times m_e$

For final image formed at *D* (least distance)

$$m=\frac{\beta}{\alpha}=\frac{v_o}{u_o}\left(1+\frac{D}{f_e}\right)=\frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$$

For final image formed at infinity

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

REFLECTING TELESCOPE

Magnifying power

When the final image is formed at *D*,

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

When the final image is formed at infinity

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

RELATION BETWEEN μ AND i_C

The angle of incidence in the optically denser medium for which the angle of refraction is 90°. It is denoted by i_c.

$$\mu=\frac{1}{\sin i_c}$$

- If $i < i_c$, then refraction takes place.
- If $i = i_c$, then grazing emergence takes place.
- If $i > i_c$, then total internal reflection takes place.

TOTAL INTERNAL REFLECTION

The phenomenon in which a ray of light travelling from an optically denser into an optically rarer medium at an angle of incidence greater than the critical angle for the two media is totally reflected back into the same medium.

TIR conditions

- Light must travel from denser to rarer.
- Angle of incidence is greater than critical angle.

APPLICATIONS OF TIR

- Fiber optics communication
- Medical endoscopy
- Periscope (Using prism)
- Sparkling of diamond
- Mirage
- Totally reflecting glass prisms

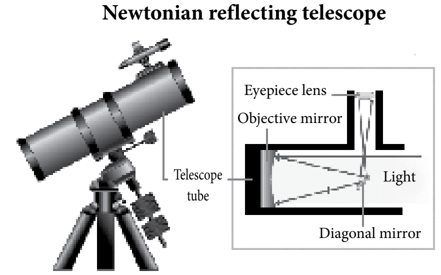
REFRACTIVE INDEX

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

Real and apparent depth

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

Newtonian reflecting telescope



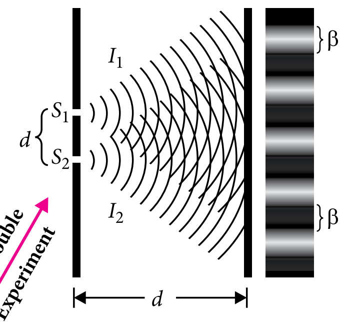
CHAPTER 09

Class XII

WAVE OPTICS

REFLECTION AND REFRACTION

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



Young's Double Slit Experiment

INTERFERENCE OF LIGHT

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

- Position of bright fringes $x_n = \frac{n\lambda D}{d}$
- Position of dark fringes $x'_n = \frac{(2n-1)\lambda D}{2d}$
- Fringe width $\beta = \frac{\lambda D}{d}$
- Ratio of slit width and intensity : $\frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$

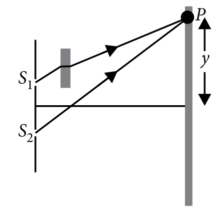
CONDITION FOR SUSTAINED INTERFERENCE

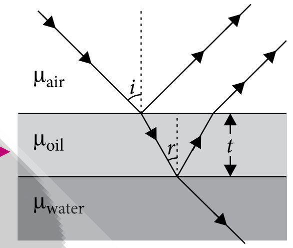
The interference pattern, in which the positions of maxima and minima of intensity on the observation screen do not change with time, is called a sustained or permanent inter ference pattern.

- Intensity ratio of maxima and minima, $\frac{I_{max}}{I_{max}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \left(\frac{r+1}{r-1}\right)$ where $r = \frac{a_1}{a_2}$

SHIFTING OF FRINGES

- Path difference produced by a slab $\Delta x = (\mu - 1)t$
- Fringe shift, $\Delta x = \frac{\beta}{\lambda}(\mu - 1)t = \frac{D}{d}(\mu - 1)t$
- Number of fringes shifted $= \frac{\text{shift}}{\text{fringe width}} = \frac{(\mu-1)tD/d}{\lambda D/d} = \frac{(\mu-1)t}{\lambda}$

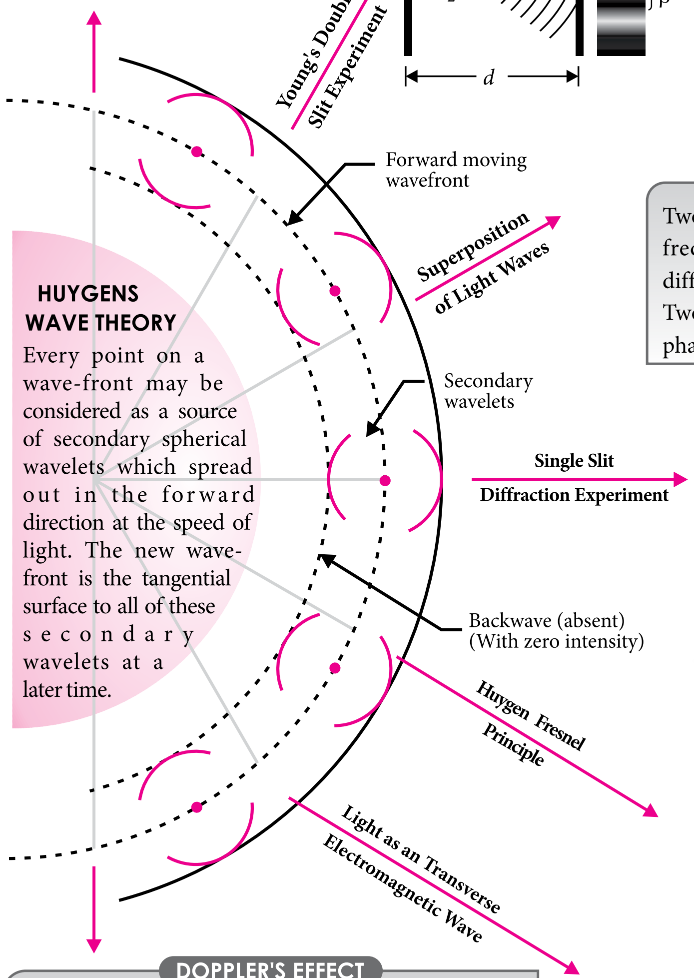




INTERFERENCE IN THIN FILM

- For reflected Light:
  Maxima $\rightarrow 2\mu t \cos r = (2n+1)\frac{\lambda}{2}$
  Minima $\rightarrow 2\mu t \cos r = n\lambda$
- For transmitted light :
  Maxima $\rightarrow 2\mu t \cos r = n\lambda$
  Minima $\rightarrow 2\mu t \cos r = (2n+1)\frac{\lambda}{2}$

(t = thickness of film, μ = R.I. of the film)



HUYGENS WAVE THEORY

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

COHERENT & INCOHERENT SOURCES

Two sources of light which continuously emit light waves of same frequency (or wavelength) with a zero or constant phase difference between them, are called **coherent sources**.

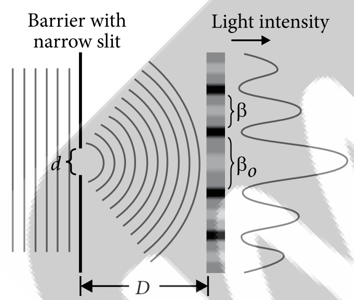
Two sources of light which do not emit light waves with a constant phase difference are called **incoherent sources**.

COHERENT & INCOHERENT ADDITION OF WAVES

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

SINGLE SLIT EXPERIMENT

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



DIFFRACTION

- **Fresnel's diffraction :** In Fresnel's diffraction, the source and screen are placed close to the aperture or the obstacle and light after diffraction appears converging towards the screen and hence no lens is required to observe it. The incident wave fronts are either spherical or cylindrical.
- **Fraunhofer's diffraction :** The source and screen are placed at large distances from the aperture or the obstacle and converging lens is used to observe the diffraction pattern. The incident wavefront is planar one.

R.P. OF MICROSCOPE AND TELESCOPE

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

θ = Semi vertical angle subtended at objective.

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

D = Diameter of objective lens of telescope.

FRESNEL'S DISTANCE

Ray optics as a limiting case of wave optics
Diffraction at circular aperture

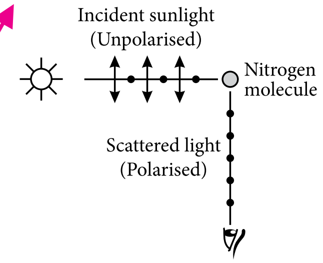
- Linear spread, $x = D\theta$, Areal spread, $x^2 = (D\theta)^2$ $\left\{\theta = \frac{1.22\lambda}{d}\right\}$
- Fresnel's distance : Distance at which diffraction spread is equal to the size of aperture, $D_F = \frac{d^2}{\lambda}$
- Size of Fresnel zone $d_F = \sqrt{\lambda D}$

RESOLVING POWER (R.P.)

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

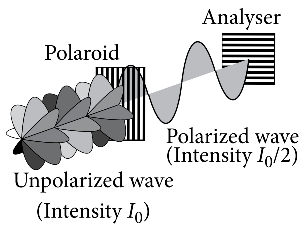
$$\text{R.P.} = \frac{1}{\text{Limit of resolution}}$$

Limit of resolution : The smallest linear or angular separation between two point objects at which they can be just separately seen or resolved by an optical instrument is called the limit of resolution of the instrument.



DOPPLER'S EFFECT

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



POLARISATION OF LIGHT

If the vibrations of a wave are present in just one direction in a plane perpendicular to the direction of propagation, the wave is said to be **polarised or plane polarised**. The phenomenon of restricting the oscillations of a wave to just one direction in the transverse plane is called **polarisation of waves**.

MALUS LAW

Malus Law: The intensity of transmitted light passed through an analyser is

$I = I_0\cos^2\theta$

(θ = angle between transmission directions of polariser and analyser)

POLARISATION BY REFLECTION

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

POLARISATION BY SCATTERING

If we look at the blue portion of the sky through a polaroid and rotate the polaroid, the transmitted light shows rise and fall of intensity.

The scattered light seen in a direction perpendicular to the direction of incidence is found to be plane polarised.