Wave Optics - 10

Theories Regarding Nature Of Light

(i) **Descartes And Newton's Corpuscular Theory** ⇒

According to this theory Newton considered light as a stream of weightless particles called corpuscles travelling with a very high speed.

Explanation Of Reflection based Upon this Theory ⇒ He explained reflection by giving reason that there is repulsion between the corpuscles and the reflecting surface

Explanation for Refraction ⇒ He said that when corpuscles fall on an interface separating rarer and denser medium then ~~corup~~ corpuscles are attracted by the denser medium hence light bends towards the normal.

He also argued that speed of light in denser medium is greater than the speed of light in rarer medium.

Reason For Failure ⇒ His theory was proved wrong by Foucault ~~by~~ by proving speed light greater in rarer medium than denser medium.

(ii) **Huygens Wave Theory And Fresnel's** Ether Wave Theory ⇒ According to this theory light is a periodic disturbance transmitted through a medium in the form of wave.

He assumed that light ~~li~~ travels through a medium known as ether.

{ Properties of ether → Massless, high value of elasticity and very less density }

This theory fails because it could never prove the existance of medium ether.

(iii) Maxwell's Electromagnetic Wave Theory ⇒ According to this theory light is a electromagnetic wave which consist of mutually perpendicular time varying electric and magnetic fields which are also perpendicular to the direction of propagation of wave.

* This theory could not explain photoelectric effect. It also fails to explains emission and absorption of radiation.

(iv) Einsteins Quantum Theory ⇒ According to this theory light consist of packets of energy known as photons.
* Photon is a massless particle which move with speed of light.
* This theory was able to explain photoelectric effect but was failed to explain interference, diffraction and polarisation of light.

(v) de-Broglie's Theory Of dual Nature Of light ⇒ According to this theory the light is considered to have dual nature i.e ~~by~~ wave nature and particle nature

Properties that Can be explained on the basis of

(a) Wave Nature ⇒ Reflection, refraction, interference diffraction and polarization of light

(b) Particle Nature ⇒ Photo electric effect.

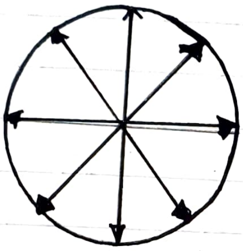
UNIT - 1

Huygen Principle

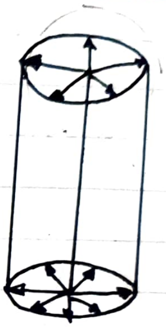
Wave Front ⇒ It is defined as the locus of all the particles of a medium vibrating in the same phase at a given instant.

Types Of Wave Front ⇒

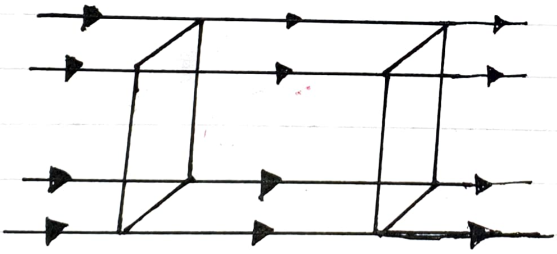
(i) Spherical Wave front ⇒



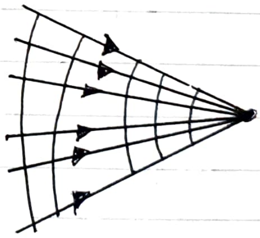
(ii) Cylindrical wave Front



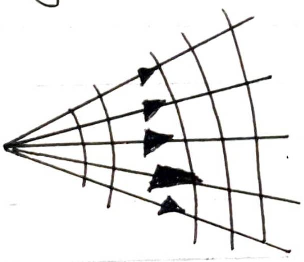
(iii) Plane Wave Front



(iv) Converging Wave Front



(v) Diverging Wave Front ⇒

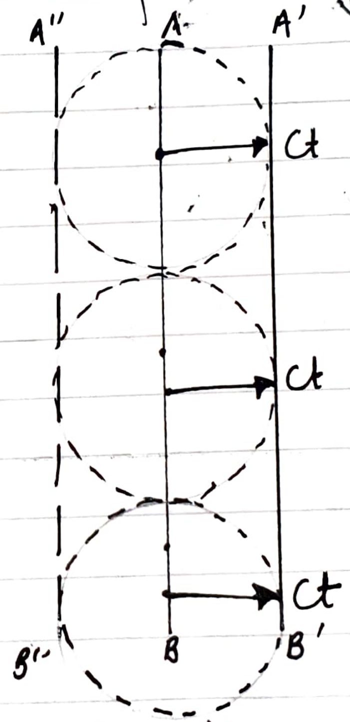


Huygens Principle ⇒

(i) Each source of a light is a ~~source~~ centre of disturbance from which waves spread in all directions. All particles equidistant from the source and vibrating in same phase lies on a surface known as wavefront.

(ii) Every point on a wavefront is a source of new disturbance which produces secondary wavelets. These wavelets are spherical and travell with speed of light in all directions in that medium.

(iii) Only forward envelope enclosing the tangents at the secondary wavelets at any instant gives the new position of wavefront.



Laws Of Reflection On the basis Of Huygens Principle ⇒

Let us consider a plane wavefront AB incident on plane reflecting surface XY. During this time the disturbance from A reaches the point C, the secondary wavelets from B must have spread over a hemisphere of radius BD

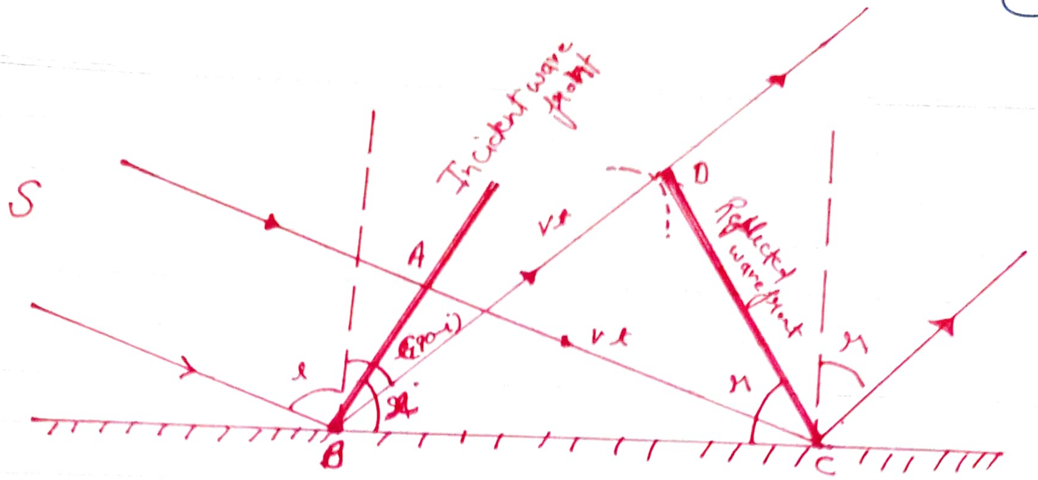
$BD = AC = Vt$ { t = time taken by the disturbance to travel from A to C or B to D
V = speed of light.

In $\triangle ABC$ and $\triangle DCB$

$\angle BAC = \angle CDB = 90^\circ$

$BC = BC$ {common}

$AC = BD$ [each equal to Vt]



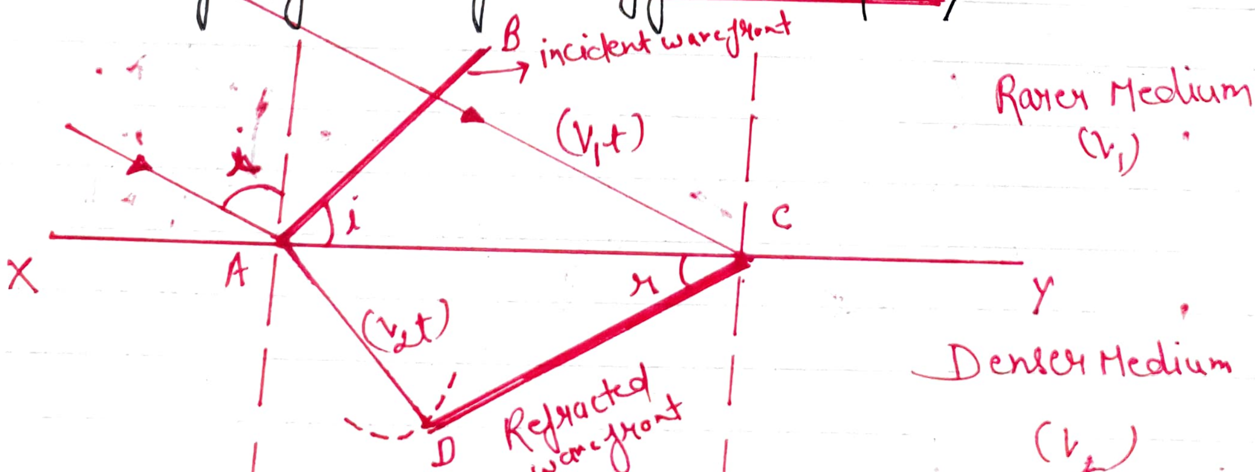
By R.H.S $\Delta ABC \cong \Delta DCB$
By CPCT $\angle i = \angle r$

$\boxed{\angle i = \angle r}$ This proves first law of reflection

Since $SB \perp AB$, $BN \perp XY$, $BD \perp CD$ } All these are perpendicular to the plane of paper

So all lies in the same plane so this proves 2nd law of reflection.

Law Of Refraction from Huygens Principle ⇒



* Consider a plane wave front incident on a plane surface XY seperating two mediums.

* Let v_1 and v_2 be the two velocities of light in two mediums

* The wave front strike at A. According to Huygens principle each point on the plane wavefront Act as a source of new disturbance

* Let the disturbance takes time 't' to travel from B to C then $BC = V_1 t$.

* During this time the disturbance from A must spread over a hemisphere of radius $AD = V_2 t$. The tangent drawn from C to this hemisphere give the new wavefront.

from $\triangle ABC$

$$\sin i = \frac{BC}{AC} \quad -(1)$$

from $\triangle ADC$

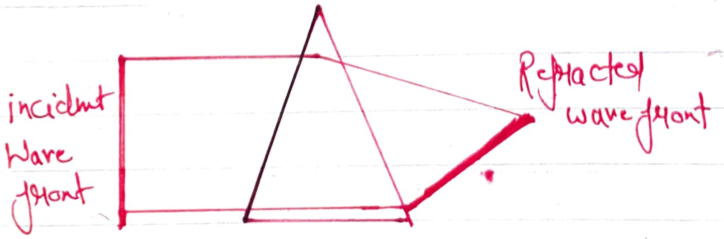
$$\sin r = \frac{AD}{AC} \quad -(2)$$

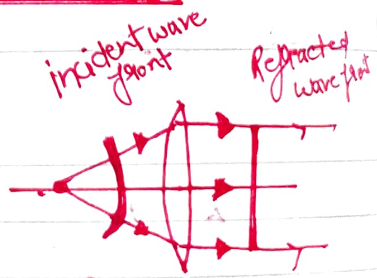
Divide equation (1) by (2)

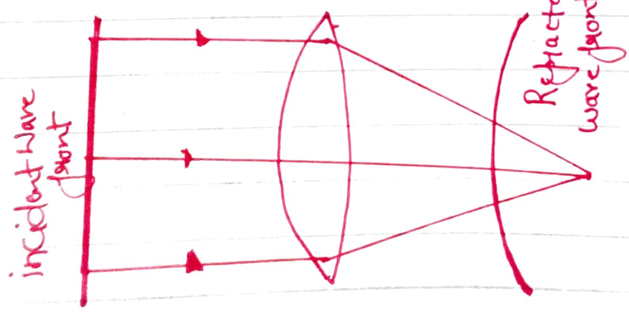
$$\frac{\sin i}{\sin r} = \frac{BC \times AC}{AC \times AD} = \frac{BC}{AD} = \frac{V_1 t}{V_2 t} = \frac{V_1}{V_2}$$

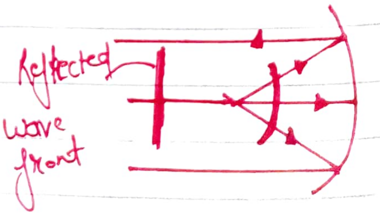
$$\boxed{\frac{\sin i}{\sin r} = \mu_{21}}$$

BEHAVIOR OF A PRISM, LENS And Mirror



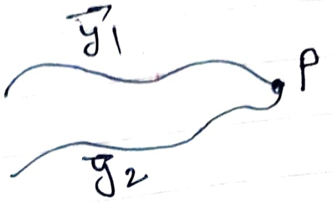






UNIT-2
INTERFERENCE

Superposition Principle ⇒ When a number of waves are travelling in a medium superimpose on each other then resultant displacement at any point is equal to the vector sum of the displacement due to individual waves at that point.



Net displacement at point P
$\vec{y} = \vec{y}_1 \pm y_2$

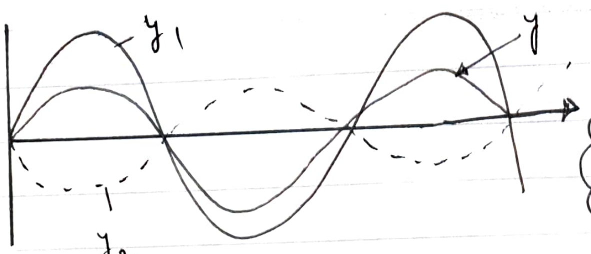
There are two types of superposition

(i) **Constructive Superposition ⇒** When two wave of same wavelength superimpose on each other in phase.

$\vec{y} = \vec{y}_1 + \vec{y}_2$

Crest over crest
Trough over trough
for constructive interference

(ii) **Distructive Interference ⇒** When two waves of same wavelength superimpose on each other out of phase then it is called distructive interference.



$\vec{y} = \vec{y}_1 - \vec{y}_2$

Crest + trough
Trough + crest } → Destructive interference

Coherent Source Of light ⇒ Two source of light are said to be coherent if they emit waves of same frequency and are either in same phase or have constant initial phase difference.

Methods Of producing Coherent Source ⇒

(i) **By Division Of Wave front ⇒** In this method a wave front is divided into two or more parts by use of slits, mirror, prism or lenses. Eg → Young's double slit.

(ii) **By division Of Amplitude ⇒** The amplitude of wave is divided into two or more parts by using partial reflection or refraction. Eg → Colour seen in soap film.

Condition for Obtaining two coherent sources ⇒

(i) Two source of light must be obtained from a single source by some method.
(ii) The two source must be ~~coherent~~ monochromatic.
(iii) The path difference b/w two waves arriving on the screen from two sources must not be large.

Q → Why two independent source of light can not be coherent.

Interference Of light ⇒

The phenomenon of redistribution of light energy due to superposition of light wave from two coherent source is known as interference of light.

Example of Interference ⇒ Soap bubbles appear coloured in sunlight due to interference.

Condition for interference Of light ⇒

(i) Sources Must be Coherent
(ii) two sources must be close to each other
(iii) The amplitude of the two wave must be equal.
(iv) The distance between source and screen must not be small.

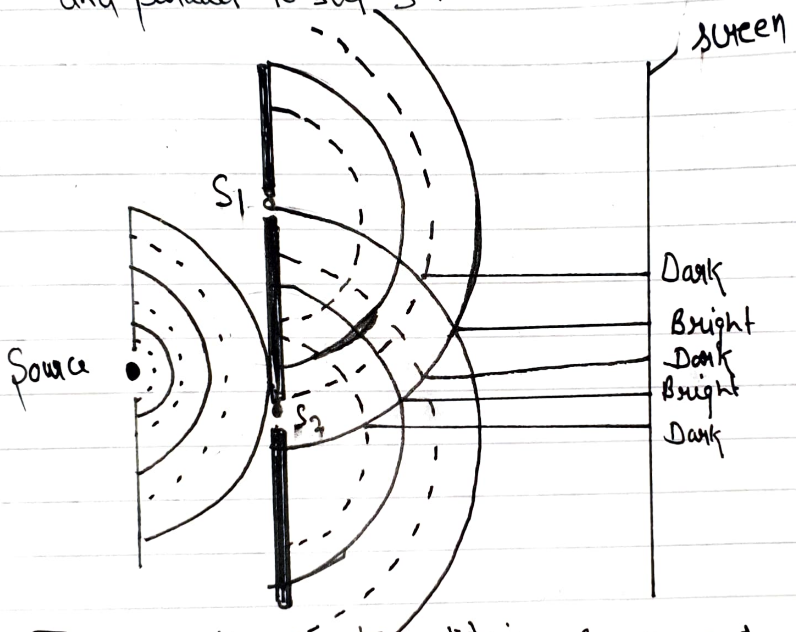
Young's Double Slit Experiment ⇒ Young performed his double slit experiment to demonstrate the phenomenon of interference.

This experiment proves wave nature of light.

Experiment Set Up

(i) In this experiment a source of monochromatic light (e.g. sodium lamp) illuminates a rectangular narrow slit S about 1 mm wide.

(ii) S_1 and S_2 are two parallel narrow slits which are arranged symmetrically and parallel to slit S.



(iii) The separation b/w two slits is 2 mm and width of each slit is 0.3 mm.

(iv) A screen is placed at a distance of 2 m from two slits.

Explanation

(i) Acc to Huygen's principle, slit S sends waves fronts in all direction. In this fig. dotted arc represent trough and solid ones represent crest of the wave.

(ii) Slit S_1 and S_2 becomes the source of secondary wavelets which are in phase and of same frequency.

(iii) Suppose when the waves from S_1 and S_2 reaches point P their crest fall on each other then Bright fringe will form.

(iv) If crest of one wave superimpose on trough of another wave then dark fringe will form.

★★★ Important Observations

(i) If one of the two slit is closed ⇒ Interference pattern will disappears.

(ii) If white light is used ⇒ The fringes formed will be of unequal width and will be coloured.

Central bright fringe will be white. Since the wavelength of ~~Red~~ colour is ~~least~~ large so fringe on either side of central white fringe will be of ~~Red~~ Red Coloured and last fringe will be of Voilet ~~Red~~ Colour.

white

R	O	Y	G	B	I	V		V	I	B	G	R	Y	O	R

(iii) If two Independent source are used ⇒ No interference pattern will be obtained.

Even if interference pattern will be formed They will not be stable.

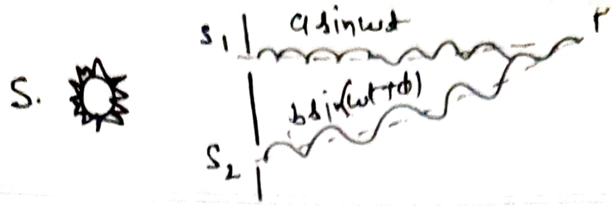
INTENSITY AT ANY POINT IN INTERFERENCE

Suppose the displacements of two light waves from two Coherent sources S_1 and S_2 at any point P on the screen at any instant ~~it~~ is are given by

$$y_1 = a\sin\omega t \quad , \quad y_2 = a\sin(\omega t + \phi)$$

According to principle of superposition the resultant displacement at P is y

$$y = y_1 + y_2$$



$y = a\sin\omega t + b\sin(\omega t + \phi)$

$y = a\sin\omega t + b\sin\omega t\cos\phi + b\cos\omega t\sin\phi$

$y = (a + b\cos\phi)\sin\omega t + b\sin\phi\cos\omega t$ — ☆

Let $a + b\cos\phi = A\cos\theta$ — ①

$b\sin\phi = A\sin\theta$ — ②

substitute the value of ① and ② in ☆ equation

$y = A\cos\theta\sin\omega t + A\sin\theta\cos\omega t$

$\boxed{y = A\sin(\omega t + \theta)}$ → Equation of resultant wave

where A = Amplitude of resultant wave

θ = Phase angle difference with respect to wave emitted by source S_1

To Determine A ⇒ Square and add equation

$A^2\cos^2\theta + A^2\sin^2\theta = b^2\sin^2\phi + (a + b\cos\phi)^2$

$A^2[\cos^2\theta + \sin^2\theta] = b^2\sin^2\phi + a^2 + b^2\cos^2\phi + 2ab\cos\phi$

$A^2 = b^2[\sin^2\phi + \cos^2\phi] + a^2 + 2ab\cos\phi$

$\boxed{A^2 = b^2 + a^2 + 2ab\cos\phi}$

To Determine θ ⇒ Divide equation ② by ①

$\frac{A\sin\theta}{A\cos\theta} = \frac{b\sin\phi}{a + b\cos\phi}$

$\tan\theta = \frac{b\sin\phi}{a + b\cos\phi}$

$\boxed{\theta = \tan^{-1}\left(\frac{b\sin\phi}{a + b\cos\phi}\right)}$

Formula In terms Of Intensity

⇒ Intensity of a wave is directly proportional to the square of its amplitude.

$I_1 \propto a^2$ $\quad$ $I_2 \propto b^2$

$I_1 = Ka^2$ $\quad$ $I_2 = Kb^2$ $\quad$ $I = KA^2$

$A^2 = a^2 + b^2 + 2ab\cos\phi$

multiplying both side by K

$KA^2 = Ka^2 + Kb^2 + 2abK\cos\phi$

$$\boxed{I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi}$$

$\left\{ \begin{array}{l} \sqrt{I_1} = \sqrt{K}a \\ \sqrt{I_2} = \sqrt{K}b \end{array} \right.$

For Constructive Interference

In constructive interference intensity is maximum

$\cos\phi = 1$

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

$$\boxed{\phi = 2n\pi}$$

$n = 0, 1, 2, 3, \ldots$

for 2π phase ang path difference $= \lambda$

1 " " " $= \dfrac{\lambda}{2\pi}$

$2n\pi$ " " $= \dfrac{\lambda}{2\pi} \times (2n\pi)$

P.d. for constructive interference $= n\lambda$

$$\boxed{P.d = n\lambda}$$

For destructive Interference

In destructive interference intensity will be minimum

$\cos\phi = -1$

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

$\phi = (2n-1)\pi$ $\quad n = 1, 2, 3$

Phase angle for destructive interference is $(2n-1)\pi$

Path difference for minimum interference is

$$\boxed{P.d = (2n-1)\frac{\lambda}{2}}$$

For Young's Double slit Experiment

Amplitude of wave emitted by both the source will be same.

$a = b$ or $I_1 = I_2 = I_0$

$I = I_0 + I_0 + 2\sqrt{I_0}\sqrt{I_0}\cos\phi$

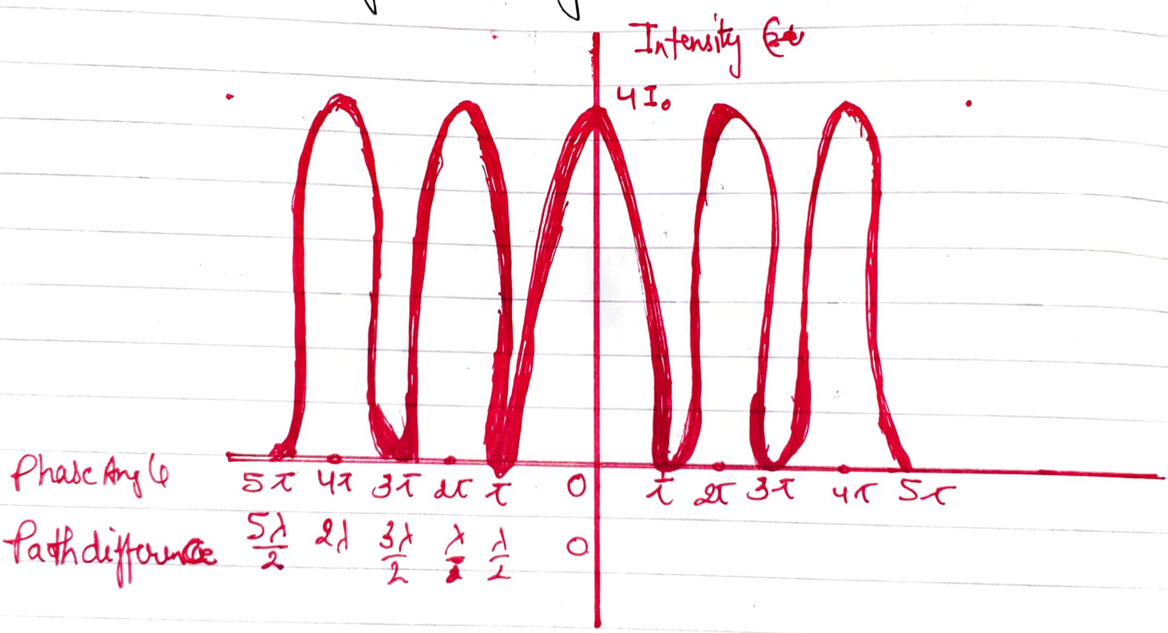
$I = 2I_0 + 2I_0\cos\phi$

$I = 2I_0(1+\cos\phi)$

$\boxed{I = 4I_0\cos^2\frac{\phi}{2}}$ ★★★

$\{ (1+\cos\theta) = 2\cos^2\frac{\theta}{2}$

Variation Of Intensity With Phase Angle and Path difference



Ratio of max intensity And Minimum Intensity

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

for $I = I_{max}$ $\cos\phi = 1$

$I_{max} = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}$

$\{ (a+b)^2 = a^2 + b^2 + 2ab\cos\phi$

$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

similarly

$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$

$$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2} = \frac{(a+b)^2}{(a-b)^2}$$

$$\frac{I_{max}}{I_{min}} = \frac{b^2\left(\frac{a}{b}+1\right)^2}{b^2\left(\frac{a}{b}-1\right)^2} = \frac{(r+1)^2}{(r-1)^2} \quad \left\{ r = \frac{a}{b} \right.$$

$$\boxed{\frac{I_{max}}{I_{min}} \quad \frac{(r+1)^2}{(r-1)^2}}$$

As we know that intensity of light is directly proportional to the width of source

$$\frac{I_1}{I_2} = \frac{\omega_1}{\omega_2} \Rightarrow \boxed{\frac{a^2}{b^2} = \frac{\omega_1}{\omega_2}}$$

Q Prove that during interference energy is conserve.

After interference $I_{max} \propto (a+b)^2$ $\qquad I_{min} \propto (a-b)^2$

$$I_{av} \propto \frac{I_{max}+I_{min}}{2} \propto \frac{(a+b)^2+(a-b)^2}{2}$$

$$\boxed{I_{av} \propto a^2+b^2} \quad \text{—} \ (1)$$

Before interference $I \propto I_1+I_2$

$$\boxed{I \propto a^2 + b^2} \quad \text{—} \ (2)$$

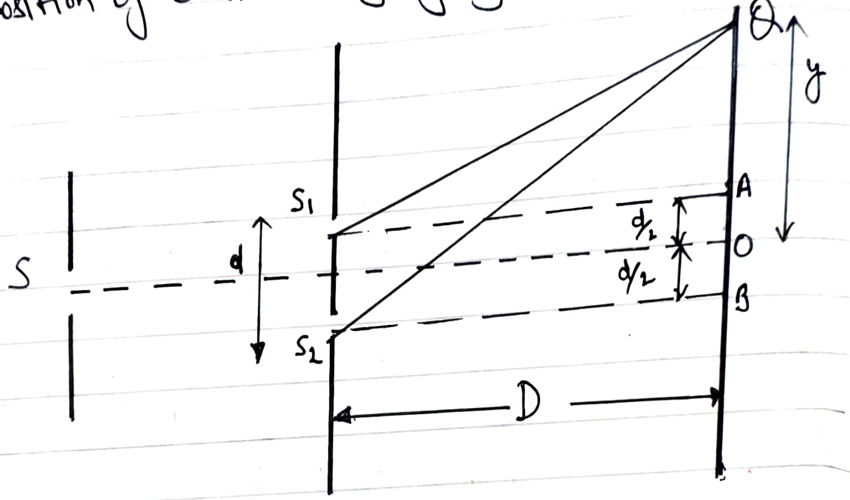
from equation (1) and (2) we can see that energy remains conserved during interference.

When two waves are incoherent then the intensity of wave on screen at any point will be equal to $I = I_1 + I_2$

Theory Of Fringes [Fringe Width]

Dark and bright bands in the interference pattern are called interference fringes.

Consider two coherent sources S_1 and S_2 separated by a distance 'd'. Let 'D' be the distance b/w screen and plane of slits. O is the position of central bright fringe because path diff is zero



from ΔS_2QB

$$S_2Q = \left[D^2 + \left(y+\frac{d}{2}\right)^2\right]^{1/2}$$

$$S_2Q = D\left[1 + \frac{\left(y+\frac{d}{2}\right)^2}{D^2}\right]^{1/2}$$

According to Bionomial theorem

$$(1+x)^n = (1+nx)$$

$$S_2Q = D\left[1 + \frac{1}{2D^2}\left(y+\frac{d}{2}\right)^2\right]$$

$$S_2Q = \left[D + \frac{\left(y+\frac{d}{2}\right)^2}{2D}\right]$$

Similiarly $S_1Q = D + \frac{\left(y-\frac{d}{2}\right)^2}{2D}$

$P.d = S_2Q - S_1Q$

$$P.d = \frac{D + (y+\frac{d}{2})^2}{2D} - \frac{D - (y - \frac{d}{2})^2}{2D}$$

$$P.d = \frac{2yd}{2D}$$

$$\boxed{P.d = \frac{yd}{D}}$$

Position of Bright fringe

$$P.d = \frac{yd}{D} = n\lambda$$

$$\boxed{y = \frac{n\lambda D}{d}} \qquad n = 0, 1, 2, 3 \ldots$$

for $n = 0$ $\quad y_0 = 0$ Central Bright fringe

$n = 1$ $\quad y_1 = \frac{\lambda D}{d}$ first bright fringe.

$$\boxed{y_n = \frac{n\lambda D}{d}}$$

Position of Dark fringe

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

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

$$\boxed{y = \frac{1}{2}(2n-1)\frac{\lambda D}{d}} \qquad n = 1, 2, 3 \ldots$$

Fringe width ⇒ Separation b/w any two consecutive successive bright fringe is known as fringe width.

$$\beta = y_2 - y_1$$

$$\beta = \frac{2\lambda D}{d} - \frac{\lambda D}{d}$$

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

factor on which β depends

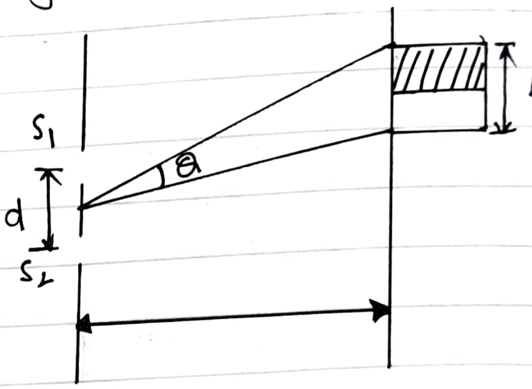
(i) $\beta \propto \lambda$

(ii) $\beta \propto \frac{1}{d}$

(iii) $\beta \propto D$

Sustained Interference ⇒ Interference is said to be sustained if the position of bright and dark fringe remains fixed on the screen.

Angular Fringe Width ⇒ Angle suspendend by two fringe at the ~~center~~ centre of two slits.



$$\theta = \frac{\text{arc length}}{\text{radius}}$$

$$\theta = \frac{B}{D} = \frac{\lambda D}{d D}$$

$$\boxed{\theta = \frac{\lambda}{d}}$$

☆ Angular fringe width does not depend upon distance b/w plane of slit and screen.

UNIT-3

DIFFRACTION

Diffraction ⇒ The phenomenon of Bending of light around the corners of small obstacles or apertures and spreading of it into the geometrical shadow of the obstacle is called diffraction of light.

Types Of Diffraction ⇒

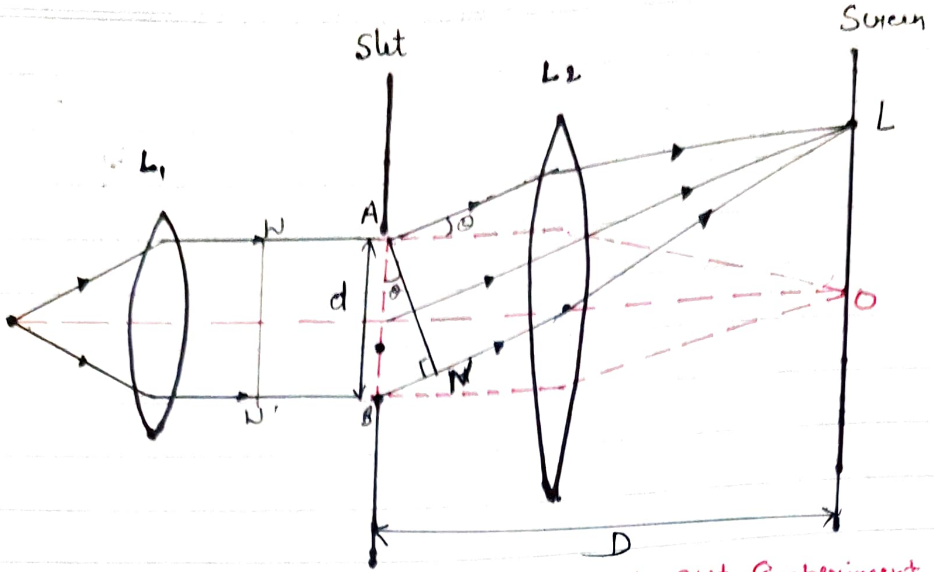
(i) **FRESNEL DIFFRACTION** ⇒ The source and screen are placed close to aperture and light after diffraction converges towards the screen hence no lens is required to observe it. The incident wave fronts are either spherical or cylindrical.

(ii) **FRAUNHOFFER'S DIFFRACTION** ⇒ Source and screen are placed at large distances (infinity) from the aperture and converging lens is required to observe the pattern.

The incident wave front is planar.

DIFFRACTION AT A SINGLE SLIT ⇒

A source S of monochromatic light is placed at the focus of of convex lens L_1. A parallel beam hence a plane wave front WW' get incident on a narrow rectangular slit AB of width 'd'. Suppose diffraction pattern from slit is formed by convex lens L_2 on a screen placed in its focal plane.



Young Single Slit Experiment Arrangement

Path Difference ⇒ Let θ be the angle from which secondary wavelets are diffracted and focused at L. Draw AN ⊥ to ray from B. Then Path difference (P)

$$P = BL - AL = BN = AB\sin\theta$$

$$P = d\sin\theta$$

For Maximum Intensity

→ **CENTRAL MAXIMUM** ⇒ The wavelets from any two corresponding point of the two half of the slit reach at point O in the same phase, they add constructively to produce a central bright fringe.

→ **SECONDARY MAXIMUM** ⇒ Suppose point L is located at path difference of $\frac{3\lambda}{2}$

Now we can divide the slit into three equal parts. The path difference b/w two corresponding points of the first two parts will be $\frac{\lambda}{2}$. The wavelets from these two points will interfere distructively.

The wavelets from third part will contribute to same same intensity forming a secondary maximum.

Condition for I^{st} ~~Max~~ secondary Maximum $= d\sin\theta_1 = \frac{3}{2}\lambda$

Similiarly " " 2^{nd} " " $= d\sin\theta_2 = \frac{5}{2}\lambda$

" " n^{th} " " $= d\sin\theta_n = (2n+1)\frac{\lambda}{2}$

So in general $d\sin\theta_n = (2n+1)\frac{\lambda}{2}$

where $n = 1, 2, 3 \ldots$

since angle is small $\sin\theta_n \simeq \theta_n$

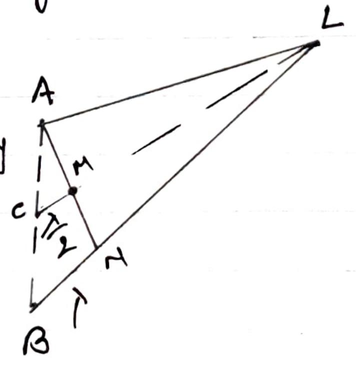
$$d\,\theta_n = (2n+1)\frac{\lambda}{2}.$$

Position for secondary Maximum

$$\theta_n = (2n+1)\frac{\lambda}{2d}$$

For Minimum Intensity ⇒ Let point L is located at path difference λ for the first dark fringe.

For the first dark fringe we can divide the slit (AB) into two half AC and BC. Then the path difference b/w two wavelets from A and C is $\frac{\lambda}{2}$



Now the wavelets from the corresponding half will reach the point L where they are having p.d $\frac{\lambda}{2}$ and will interfere distructively and will form minima.

$$d\sin\theta_1 = \lambda$$

Similiarly condition for secondary minimum or second dark fringe will be when

$$d \sin\theta_2 = 2\lambda$$

Condition for n^{th} dark fringe

$$d \sin\theta_n = n\lambda$$

since θ_n is small so $\sin\theta_n \approx \theta_n$

$$d\theta_n = n\lambda$$

$$\theta_n = \frac{n\lambda}{d} \qquad n = 1, 2, 3, 4$$

Intensity Distribution Curve ⇒ The intensity of secondary maximum are in ratio relating to the intensity of central maximum

$$1 : \frac{1}{21} : \frac{1}{61} : \frac{1}{121}$$

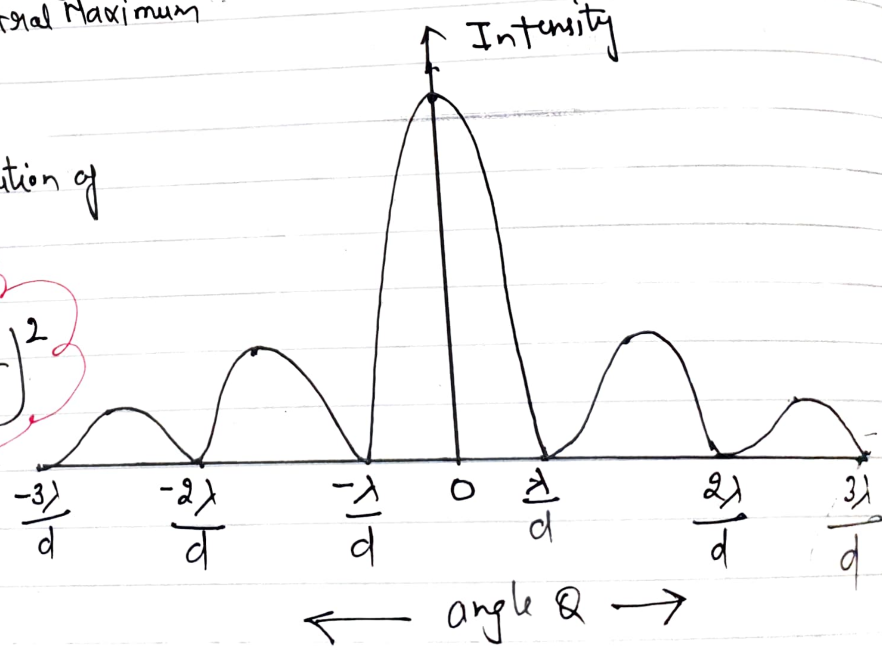
The intensity of secondary maximum is just 4% of central Maximum

Intensity distribution of single is given by

$$I = I_0\left(\frac{\sin \beta/2}{\beta/2}\right)^2$$

where

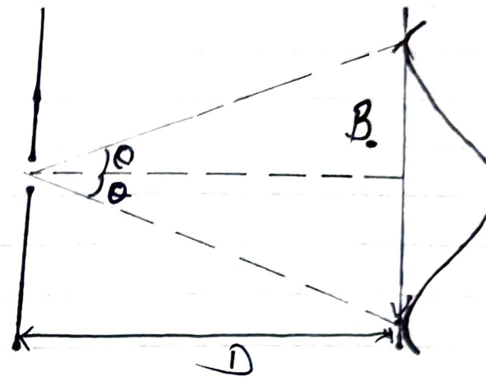
$$\frac{\beta}{2} = \frac{\pi d \sin\theta}{\lambda}$$



Width Of Central And Secondary Maxima

Angular Width ⇒ The angular separation b/w the direction of first minima on the two sides of ~~either~~ the central maximum.

For Minima on both side



$\theta = \frac{\lambda}{d}$ { Position of dark fringe

Angular width = $\frac{2\lambda}{d}$

Angular width = $2\theta = \frac{2\lambda}{d}$

LINEAR Width of Central Maximum (β_0)

$\theta = \frac{\text{length of Arc}}{\text{Radius}}$

∴

$2\theta = \frac{\beta_0}{D}$

$\beta_0 = 2\theta D$

$\beta_0 = \frac{2\lambda D}{d}$

{ $\theta = \frac{\lambda}{d}$
D = Distance b/w slit and screen
d = size of aperture of slit

Q → Prove that linear width of central maximum is twice of linear width of any secondary maximum.

Sol

Direction of n^{th} secondary Minima = $\theta_n = \frac{n\lambda}{d}$

Direction $(n+1)^{th}$ secondary ~~maxi~~ minimum = $\theta_{n+1} = (n+1)\frac{\lambda}{d}$

Angular width of Secondary Maximum = n^{th} dark − $(n-1)^{th}$ dark

Angular width of secondary Maximum is = $\theta_{n+1} - \theta_n$

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

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

Now Linear Width = β = Angular Width × D

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

$$\beta_0 = \frac{2\lambda D}{d} \quad \neq 0 \qquad \beta_0 = 2\beta$$

FRESNEL Distance ⇒ [VALIDITY OF RAY OPTICS]

The distance at which the diffraction spread of a beam is equal to the size of aperture is called fresnel distance.

When $x = d$, $D = D_F$

where $x = \frac{\lambda D}{d}$ { beam spread of a linear width x?

$d = \frac{\lambda D_F}{d}$ or $D_F = \frac{d^2}{\lambda}$

If $D < D_F$ Then there will not be too much broadening by diffraction i.e the light will travel in a straight line and the concept of ray optics will be valid.

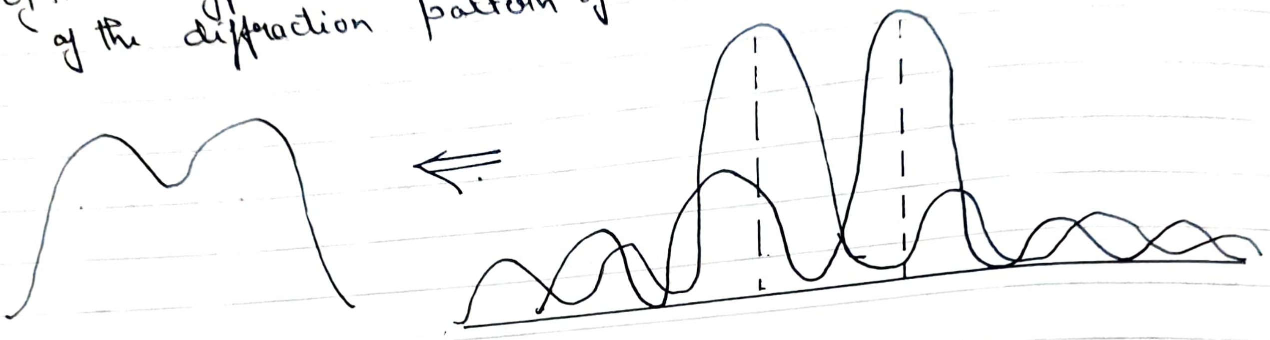
As $D < D_F \Rightarrow$ $D < \frac{d^2}{\lambda}$ or $d > \sqrt{\lambda D}$

Size of fresnel zone.

$$d_F = \sqrt{\lambda D}$$

Resolving Power ⇒ The resolving power of an optical instrument is its ability to resolve or separate the images of two nearby point object so that they can be seen distinctly.

According to Rayleighs criteria, the image of the two point objects are just resolved when the central maxima of the diffraction pattern of one fall over the first minima of the diffraction pattern of other



Resolving Power Of Microscope ⇒ The resolving power of a microscope is defined as reciprocal of the smallest distance b/w two point objects at which they can be just resolved when seen through the microscope.

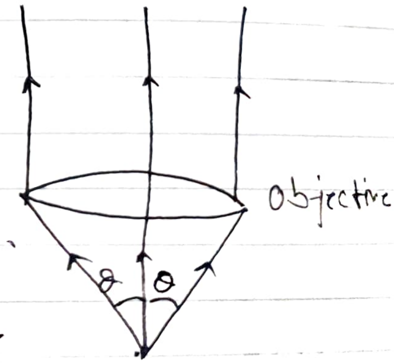
This smallest distance is given by $d = \frac{\lambda}{2\mu \sin\theta}$

$$\text{Resolving Power} = \frac{1}{d} = \frac{2\mu\sin\theta}{\lambda}$$

here: λ = the wavelength of light used

μ = Refractive index of medium b/w point object and objective lens.

θ = half the angle of cone of light from each point object.



the factor $\mu\sin\theta$ is called numerical aperture

for eye $\mu\sin\theta = 0.004$

Resolving Power Of Telescope ⇒ It is defined as reciprocal of smallest angular separation b/w two distant object whose image can be seen just resolved by it.

The Limit of resolution is given by $d\theta = \frac{1.22\lambda}{D}$

Resolving power $= \frac{1}{d\theta} = \frac{D}{1.22\lambda}$

λ = The wavelength of light
D = Diameter of telescope objective
$d\theta$ = Angle subtended by two distance object at the objective.

The limit of resolution of human eye = 1'

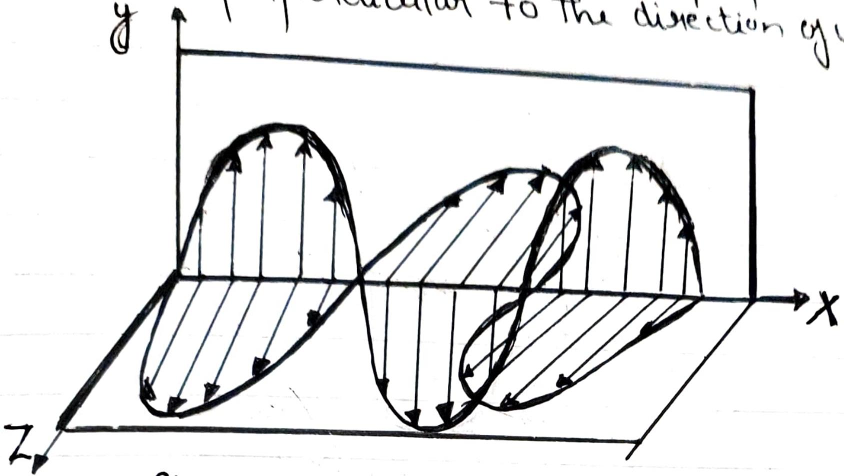
The human eyes can see two objects separated by 30 cm just resolved from a distance of 1 km

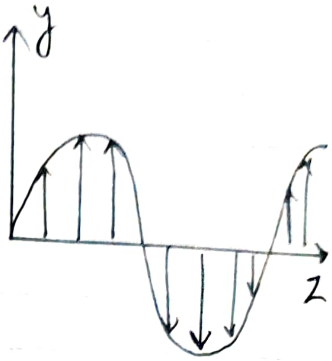
T

POLARISATION

The phenomenon of restricting the vibration of a light wave in a particular direction in a plane perpendicular to the direction of propagation of light is called polarisation of light.

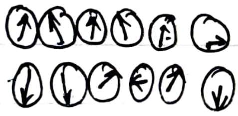
A light is having both electric field and magnetic field component which are perpendicular to each other and perpendicular to the direction of wave





Electromagnetic Wave

Only electric field component is visible to human being.

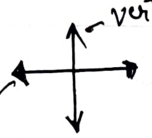
① 

Electromagnetic wave is produced by oscillating atom is a bulb or candle.

② Since electric and magnetic field are vector quantity They can be represented by

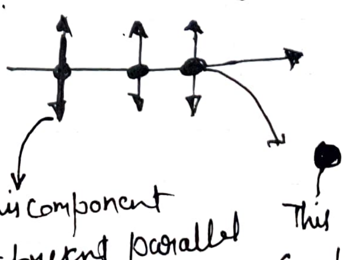
from the above diagram we can see that light oscillates in all possible directions.

③ Since it is a vector quantity it can be resolved into horizontal and vector component



Horizontal Component

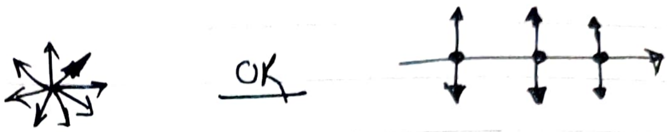
④ When it is viewed from any side.



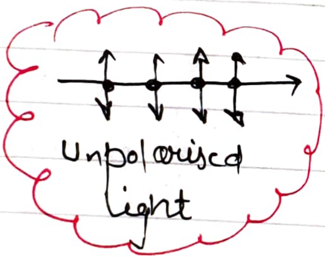
↕ This component Represent parallel to the plane of the paper

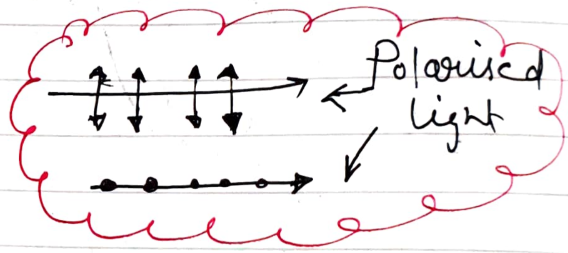
● This Component Represent perpendicular to plane of paper

Unpolarised light ⇒ A light which has vibrations in all directions in a plane perpendicular to the direction of propagation of light is called unpolarised light.



Plane Polarised light ⇒ If the electric field vector of a light wave vibrates just in one direction in a plane perpendicular to the ~~xi~~ propagation of light wave is called plane polarised light.





Polarisers ⇒ A device that plane polarises unpolarised light passed through it is called polariser. (i) Tourmaline crystal (ii) Polaroid (iii) Nicol Prism

Analyser ⇒ A device which is used to confirm wether the given light is polarised or Not.

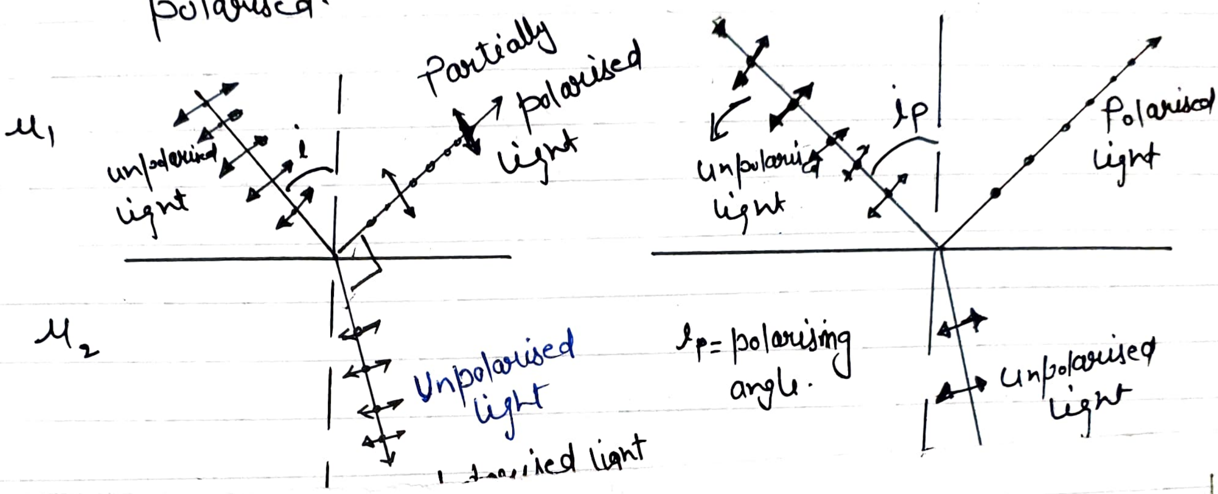
Methods Of producing Plane polarised light ⇒

(i) Reflection (ii) Double refraction (Nicol prism)
(iii) Scattering (iv) Selective absorption [Polaroid]

Polarisation By Reflection = This method was discovered by Malus. In this method if a light is incident on a transparent medium then light partially reflects ~~and~~ back and rest refracted through the medium.

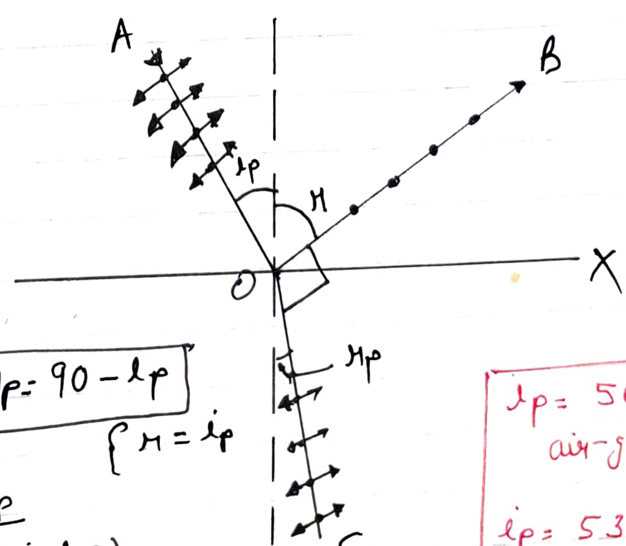
* It was observed that the reflected light is polarised partially.

* Now if the angle of incident is increased then at some particular angle the reflected light gets completely polarised.



Brewester's law ⇒ According to Brewester law the tangent of polarising angle of incidence of a transparent medium is equal to its refractive index.

~~from fig~~



$$\angle BOX + \angle COX = 90^\circ$$

$$(90 - r) + (90 - r_p) = 90^\circ$$

$$180 - (r + r_p) = 90$$

$$r + r_p = 90^\circ$$

$$\boxed{r_p = 90 - r} \Rightarrow \boxed{r_p = 90 - i_p}$$

$\{ r = i_p$

from snells law

$$\mu = \frac{\sin i_p}{\sin r_p} = \frac{\sin i_p}{\sin(90 - i_p)}$$

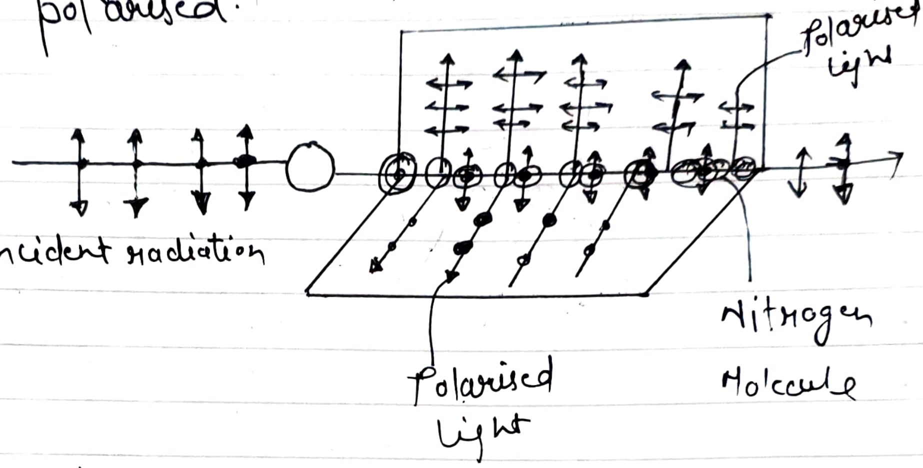
$$\mu = \frac{\sin i_p}{\cos i_p} \Rightarrow \mu = \tan i_p$$

$i_p = 56.3^\circ$ air-glass

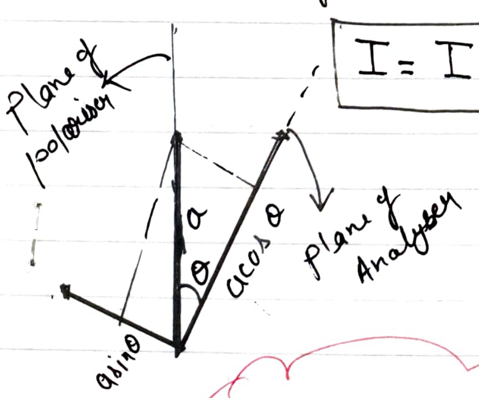
$i_p = 53^\circ$ air-water

③ <u>Polarisation By Scattering</u> ⇒ When unpolarised light incident on nitrogen molecule, the electrons in the molecule begin to vibrate in both planes i.e parallel to the plane of paper and perpendicular to the plane of paper. These vibration will send energy in all possible directions.

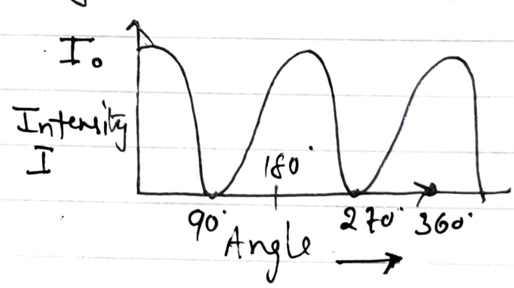
But the light coming perpendicular to the direction of ~~vibration~~ of propagation of wave gets completely polarised.



<u>Malus Law</u> ⇒ When a beam of completely polarised light is passed through analyser the intensity 'I' of transmitted light varies directly as the square of cosine of the angle θ b/w the transmission direction of polariser and analyser



$$\boxed{I = I_0 \cos^2 \theta}$$



<u>Uses Of Polaroids</u> ⇒ (i) In sun glasses.
(ii) In 3-D movies
(iii) In LCD
(iv) In photoelectricity