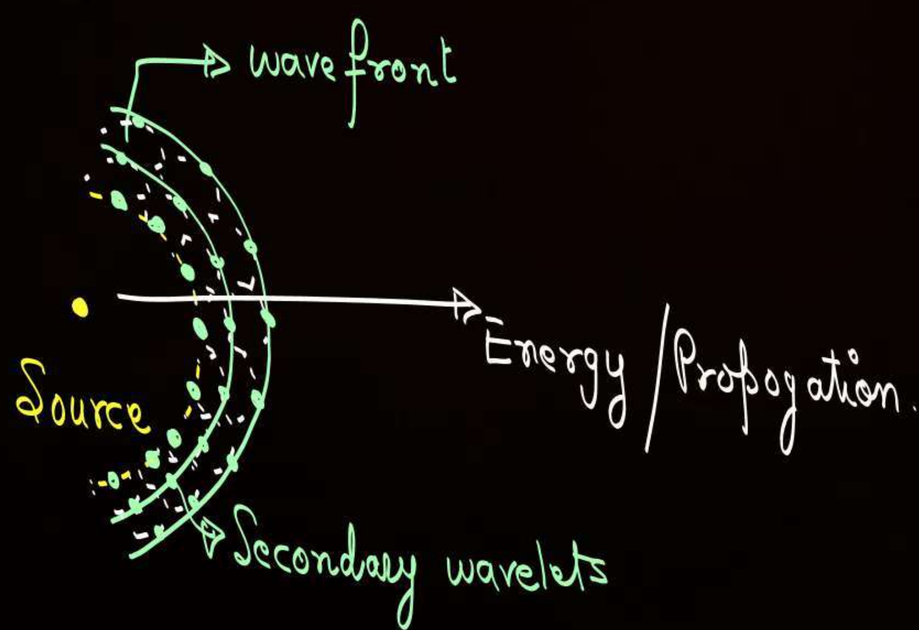
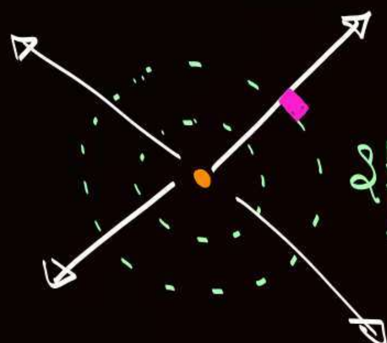
Huygens Principle

Various points of an arbitrary surface, when reached by a wavefront, become secondary sources of light emitting secondary wavelets. The disturbance beyond the surface results from the superposition of these secondary wavelets



Wave Front of Sources

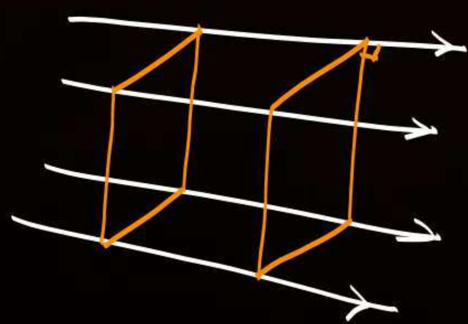
Point Sources



Spherical wavefront

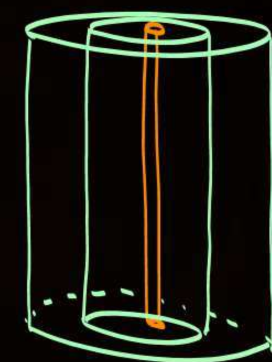
Energy flow.

Parallel Rays



Planar wavefronts.

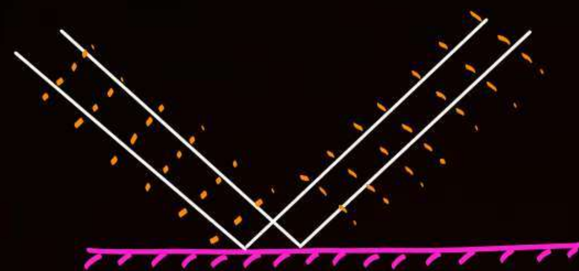
Linear Sources



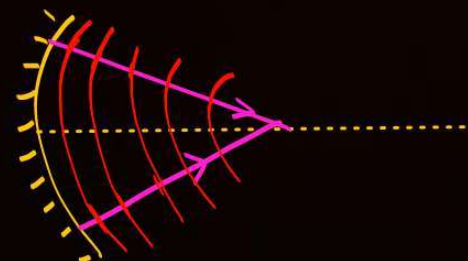
Cylindrical wavefront.

Wave-fronts After Reflection and Refraction

Plane Mirror

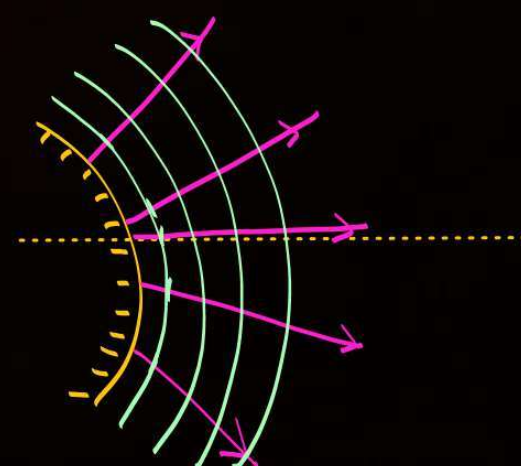


Concave Mirror



Converging Mirror

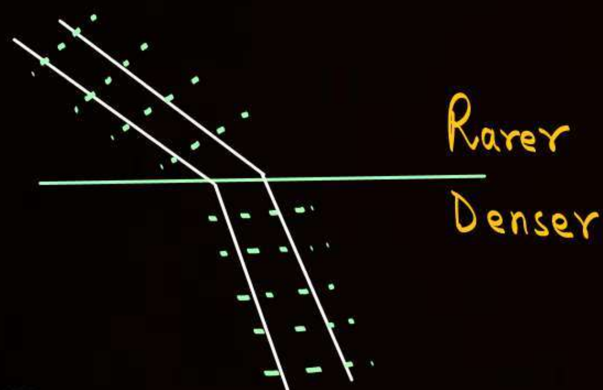
Convex Mirror



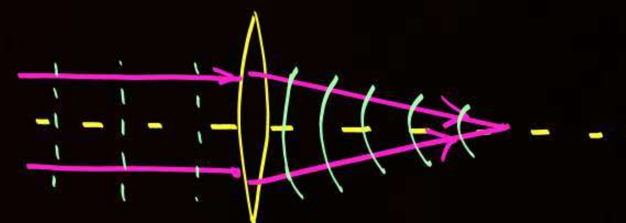
Wave-fronts After Reflection and Refraction

Lens nature depends on Surrounding Medium as well.

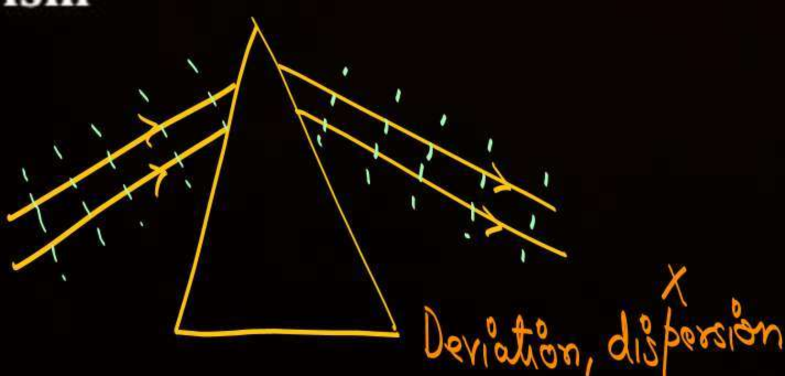
Refraction from Plane Surfaces



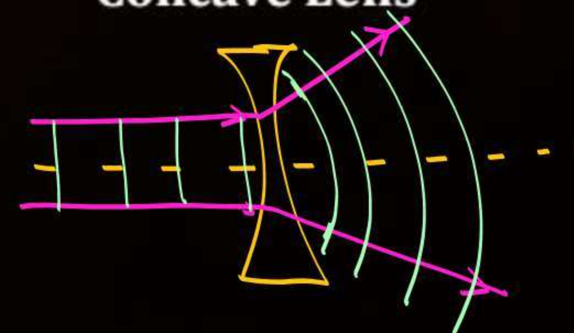
Convex Lens



Prism



Concave Lens



Question 1

A parallel beam of light strikes a piece of transparent glass having cross section as shown in the figure below. Correct shape of the emergent wave front will be (figures are schematic and not drawn to scale)

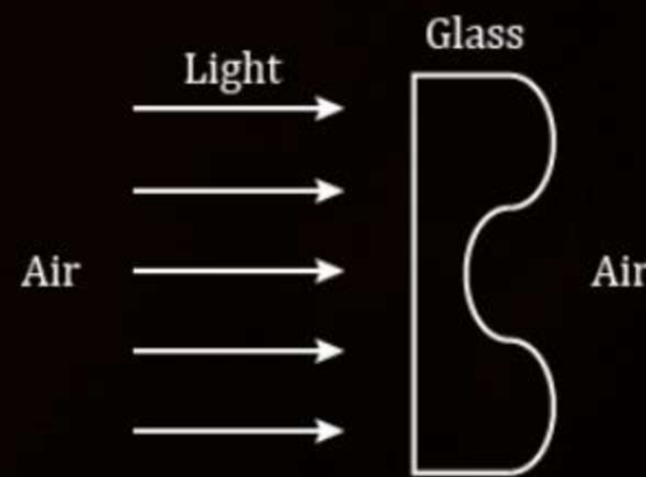
[JEE Adv, 2020]

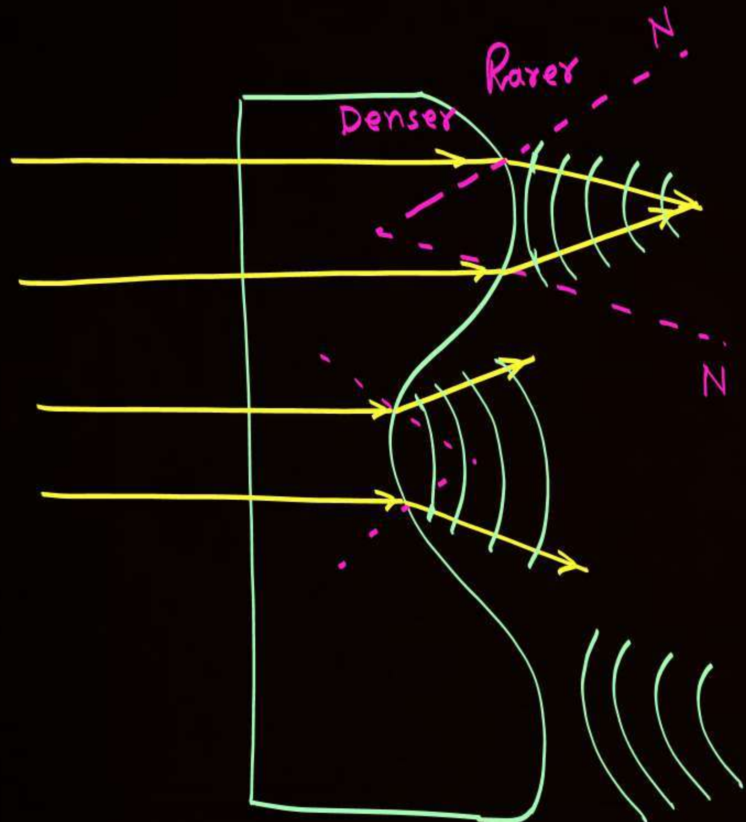
1.  Ans

2. 

3. 

4. 




Rarer
Denser
N
N

Wave Equation, Phase difference and Path Difference

EM Waves.
- Transverse Wave.
- $\vec{E} \perp \vec{B}$, $\vec{E} \times \vec{B}$ = dir of prop of wave.
- Light Vector = $\vec{E}$

(+) wave travelling in −ve dir

(−) wave traveling in +dir

$$\boxed{y = A\sin(\omega t \pm \phi)}$$

Equation of travelling wave.

y → Electric field

A → Amplitude of EF

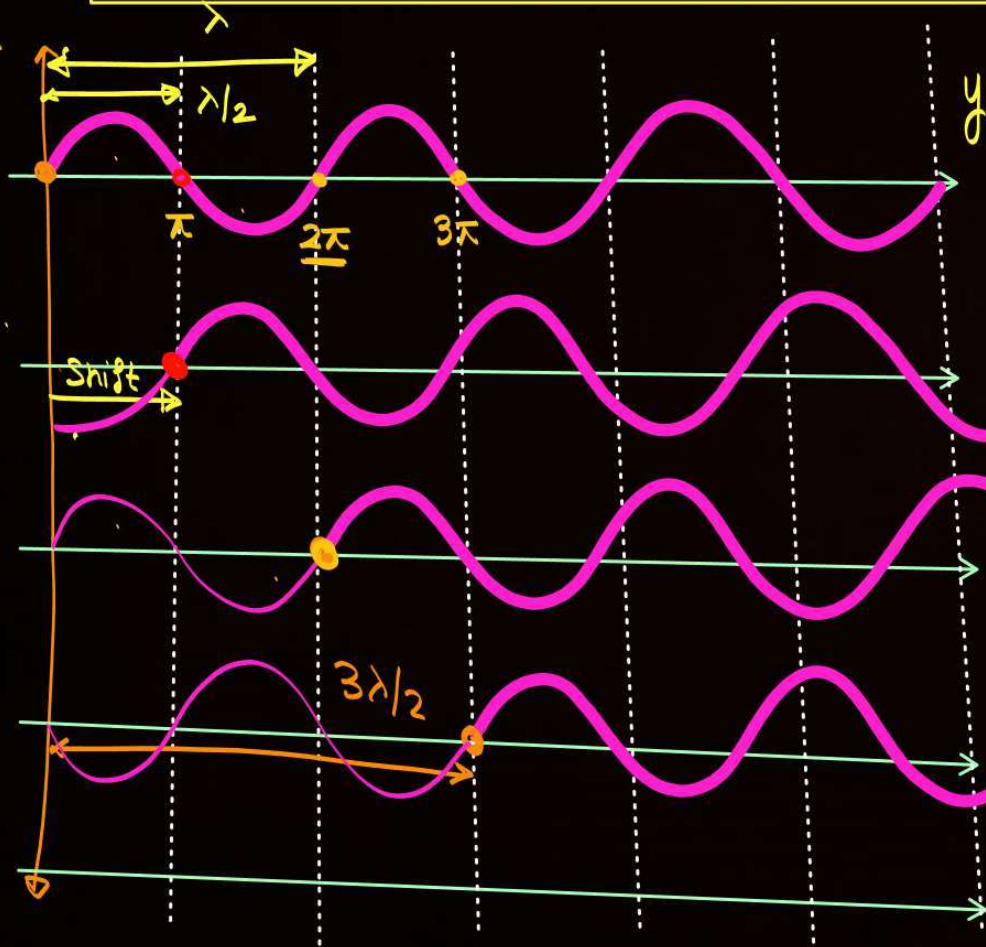
ω → Ang freq = $\omega = 2\pi\nu$ $= 2\pi/T$ (Source dependent Property)

$Kx = \phi$

K → $\frac{2\pi}{\lambda}$ (angular wave no)

ϕ → Phase.

Path difference & Phase difference



$y = A\sin\omega t$

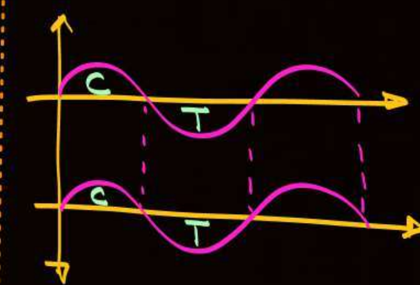
Destructive Interference.

$\Delta x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$

Const Intor.

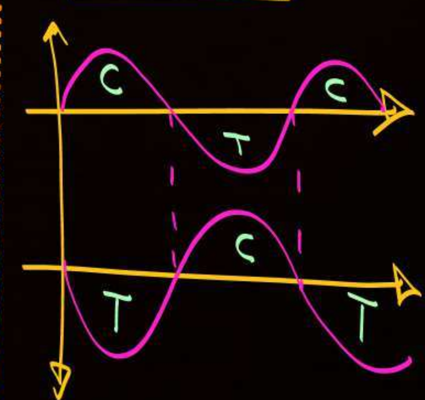
$\Delta x = 0, \lambda, 2\lambda, 3\lambda$

Constructive



Resultant Amp ↑

Destructive



Amplitude ↓

Path difference between two waves

Constructive Int.

$$\boxed{\Delta x = 0, \lambda, 2\lambda, 3\lambda - - - N\lambda}$$

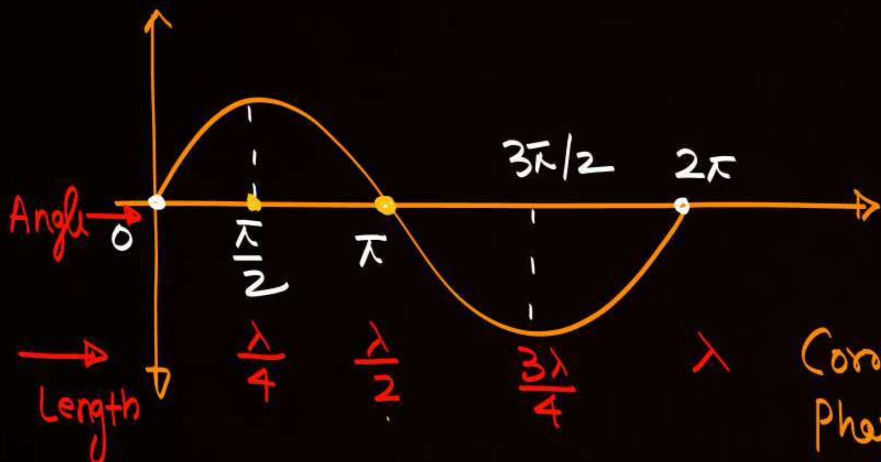
$N=0, N=1, N=2 - - - -$

Destructive Interf.

$$\boxed{\Delta x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2} - - - (2N-1)\frac{\lambda}{2}}$$

$N=1, N=2, N=3 - - - -$

Phase difference.



→ Destructive $\Delta\phi = \pi, 3\pi, 5\pi$ ----
$(2N-1)\pi$

→ Constructive $\Delta\phi = 0, 2\pi, 4\pi$ -- $2N\pi$

Corresponding Phase diff.

→ Path diff is x

$$\boxed{\begin{aligned}\Delta\phi &= \frac{2\pi}{\lambda}\Delta x \\ \Delta\phi &= Kx\end{aligned}}$$

Relation between $\Delta\phi$ & Δx :-

λ Length $\longrightarrow$ 2π rad.

1 Length $= \frac{2\pi}{\lambda}$ rad.

Δx Length $= \frac{2\pi}{\lambda} \cdot \Delta x$

Relation between $\Delta\phi$ & Δx.

$$\boxed{\Delta\phi = \frac{2\pi}{\lambda}\cdot\Delta x}$$

(i) path diff $= \frac{\lambda}{2}$ Phase diff $= \frac{2\pi}{\lambda}\cdot\frac{\lambda}{2} = \pi$ (dest)

path diff $= \lambda$ Phase diff $= \frac{2\pi}{\lambda}\cdot\lambda = 2\pi$ (const)

path diff $= \frac{3\lambda}{2}$ Phase diff $= \frac{2\pi}{\lambda}\cdot\frac{3\lambda}{2} = 3\pi$ (dest).

Path difference between two waves

Constructive Int.

$$\boxed{\Delta x = 0, \lambda, 2\lambda, 3\lambda - - - N\lambda}$$

$N=0, N=1, N=2 - - - -$

$$\boxed{\Delta\phi = \frac{2\pi}{\lambda} \cdot N\lambda = 2N\pi}$$

Destructive Interf.

$$\boxed{\Delta x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2} - - - (2N-1)\frac{\lambda}{2}}$$

$N=1, N=2, N=3 - - - -$

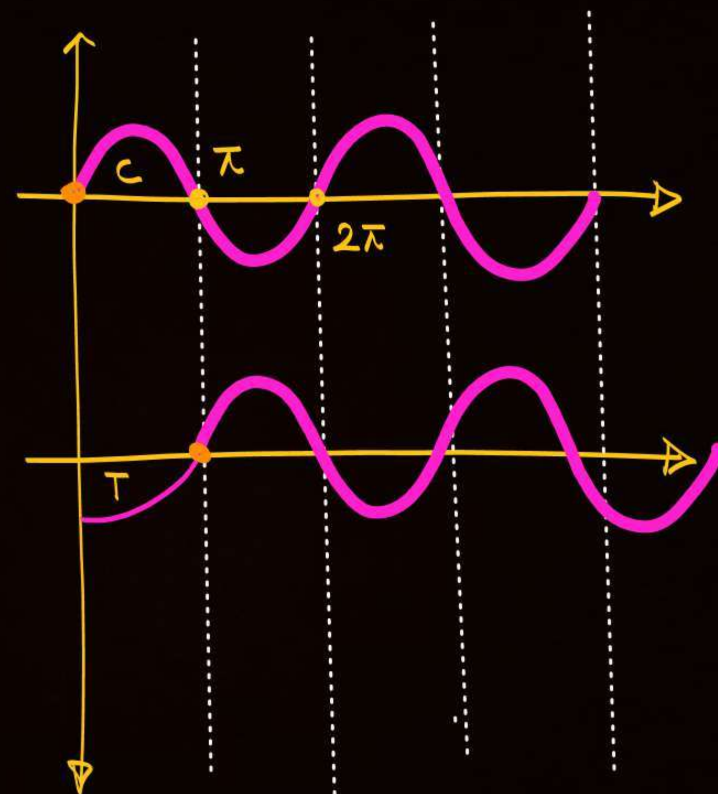
$$\boxed{\Delta\phi = \frac{2\pi}{\lambda}(2N-1)\frac{\lambda}{2} = (2N-1)\pi}$$

⊙ $y_1 = A\sin\omega t$

⊙ $y_2 = A\sin(\omega t - \overset{\phi}{\pi})$

+ve dir
Shift

$$\boxed{y_2 = -A\sin\omega t}$$



Destructive.

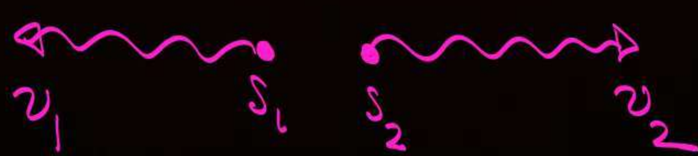
Interference

Conditions for observing sustained interference with good contrast:

- The initial phase difference between interfering wave should be either zero or constant, then only interference can be sustained.
- The frequencies and wavelength of two waves waves should be equal (coherent), if not the phase
- The source must be close to each other(if not the interference pattern will be very close to each other that we will not be able to resolve.

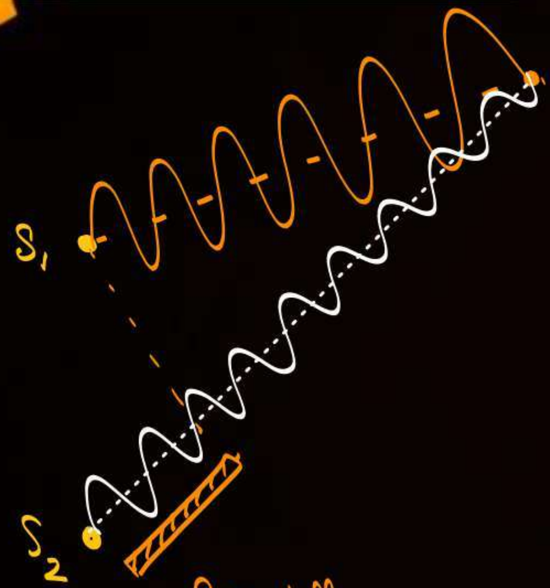
$\boxed{\nu_1 = \nu_2 = \text{Coherent}}$

$\nu_1 \neq \nu_2 = \text{Non-Coherent.}$



Interference

Coherent



Path diff $= x$

Phase diff $= \phi = \frac{2\pi}{\lambda} \cdot x$

$$y_1 = A_1 \sin(\omega t)$$

$$y_2 = A_2 \sin(\omega t + \phi) \quad \pi$$

$$y_R = y_1 + y_2$$

$$= A_1 \sin \omega t + A_2 \sin(\omega t + \phi)$$

$$= A_1 \sin \omega t + A_2 \sin \omega t \cos\phi + A_2 \cos \omega t \sin \phi$$

$$= \underbrace{(A_1 + A_2 \cos\phi)}_{R\cos\theta} \sin \omega t + \underbrace{(A_2 \sin\phi)}_{R\sin\theta} \cos \omega t$$

$$= R\cos\theta \sin \omega t + R \sin\theta \cos \omega t$$

$$= R \sin(\omega t + \theta)$$

R = Resultant Amp of wave

$$R\cos\theta = A_1 + A_2\cos\phi$$

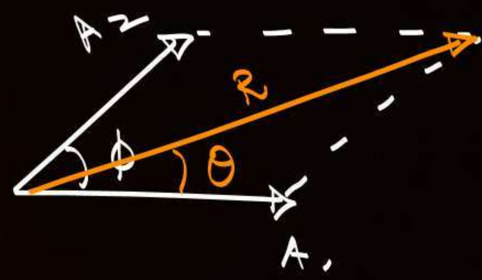
$$R\sin\theta = A_2\sin\phi$$

Sq & Adding

$$\boxed{R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}}$$

$$\boxed{\tan\theta = \frac{A_2\sin\phi}{A_1 + A_2\cos\phi}}$$

If we have two add two Sinosidal fn of Same freq.



Angle between them = ϕ

(Vector analysis)

Amplitude in Constructive and Destructive Interference

$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$

Interference

Constructive

$\Delta x = 0, \lambda, 2\lambda \cdots N\lambda$

$\Delta\phi = 2N\pi$

$N = 0, 1, 2 \cdots$

$N = 0 \quad \phi = 0$

$R = A_1 + A_2$

If $A_1 = A_2$

$R = 2A$.

Destructive

$\Delta x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2} \cdots (2N-1)\frac{\lambda}{2}$

$\Delta\phi = (2N-1)\pi$

$N = 1, 2, 3 \cdots$

$N = 1 \quad \phi = \pi$

$R = A_1 - A_2$

If $A_1 = A_2 \quad R = 0$

Intensity In Interference

If v is Constant

$$\boxed{I = KA^2}$$

$$R^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$$

$$KR^2 = KA_1^2 + KA_2^2 + 2\sqrt{K}A_1\sqrt{K}A_2\cos\phi$$

$$\boxed{I_R = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi}$$

$I_1 = KA_1^2$

$\sqrt{I_1} = \sqrt{K}A_1$

$I_2 = KA_2^2$

$\sqrt{I_2} = \sqrt{K}A_2$

Const

$\phi = 2N\pi$

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

If $I_1 = I_2$

$I_R = 4I$ (Bright)

Dest

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

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

If $I_1 = I_2$ $I_{min} = 0$. (Dark)

Question 2

The intensity ratio of the maxima and minima in an interference pattern produced by two coherent sources of light is 9: 1. The intensities of the used light sources are in ratio :

1. 3 : 1
2. 4 : 1 Ans
3. 9 : 1
4. 10 : 1

$$\frac{I_{max}}{I_{min}} = \frac{9}{1} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2}$$

$$\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}} = 3$$

$$\sqrt{I_1}+\sqrt{I_2} = 3\sqrt{I_1} - 3\sqrt{I_2}$$

$$\cancel{4}^{2}\sqrt{I_2} = \cancel{2}\sqrt{I_1}$$

$$2\sqrt{I_2} = \sqrt{I_1}$$

$$4 = \frac{I_1}{I_2}$$

Question 3

The interference pattern is obtained with two coherent light sources of intensity ratio n. In the interference pattern, the ratio $\frac{I_{max} - I_{min}}{I_{max} + I_{min}}$ will be

fringe visibility

1. $\frac{\sqrt{n}}{n+1}$
2. $\frac{2\sqrt{n}}{n+1}$ Ans
3. $\frac{\sqrt{n}}{(n+1)^2}$
4. $\frac{2\sqrt{n}}{(n+1)^2}$

$\frac{I_1}{I_2} = n \quad I_1 = nI_2$

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

$I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2}$

$I_{max} + I_{min} = 2(I_1 + I_2)$

$I_{max} - I_{min} = 4\sqrt{I_1 I_2}$

$$\text{Ratio} = \frac{4\sqrt{I_1 I_2}}{2(I_1 + I_2)}$$

$$= \frac{2\sqrt{n}\,\cancel{I_2}}{(n+1)\cancel{I_2}}$$

Question 4

Two coherent monochromatic light beams of intensities I and 4I are superposed. The maximum and minimum possible intensities in the resulting beam are :

1. 5I and I
2. 5I and 3I
3. 9I and I Ans.
4. 9I and 3I

$I, 4I$

$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$$
$$= (3\sqrt{I})^2 = 9I$$

$$I_{min} = (\sqrt{4I} - \sqrt{I})^2$$
$$= (2\sqrt{I} - \sqrt{I})^2$$
$$= I$$

Question 5

If an interference pattern has maximum and minimum intensities in 36 :1 ratio then what will be the ratio of amplitudes?

1. 5 : 7
2. 7 : 4
3. 4 : 7
4. 7 : 5

Ans.

$$\frac{I_{max}}{I_{min}} = \frac{36}{1} = \frac{KR_{max}^2}{KR_{min}^2} = \frac{(A_1+A_2)^2}{(A_1-A_2)^2}$$

$$6 = \frac{A_1+A_2}{A_1-A_2}$$

$$6A_1 - 6A_2 = A_1 + A_2$$

$$5A_1 = 7A_2 \qquad \frac{A_1}{A_2} = \frac{7}{5}$$

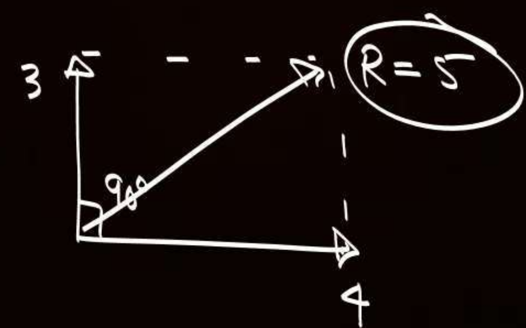
Question 6

The displacements of two interfering light waves are $y_1 = 4\sin(\omega t)$ and $y_2 = 3\cos(\omega t)$. The amplitude of the resultant wave is (y_1 and y_2 are in CGS system)

1. 5 cm. Ans
2. 7 cm
3. 1 cm
4. Zero

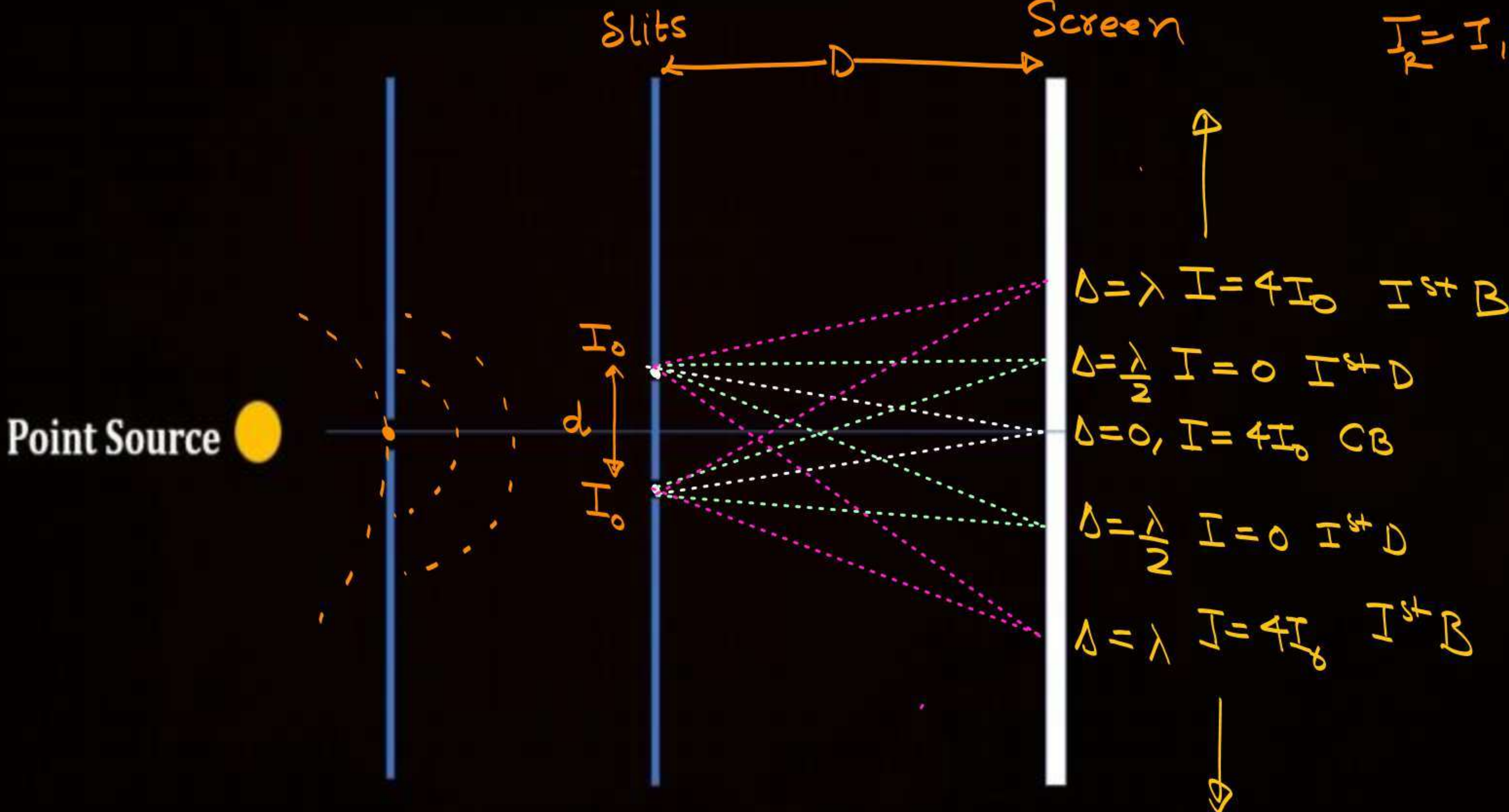
$y_1 = \underline{\underline{4}} \sin \omega t$

$y_2 = 3\cos \omega t = \underline{\underline{3}} \sin\left(\omega t + \underline{\underline{\frac{\pi}{2}}}\right)$



Setup of Young Double slit experiment:

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

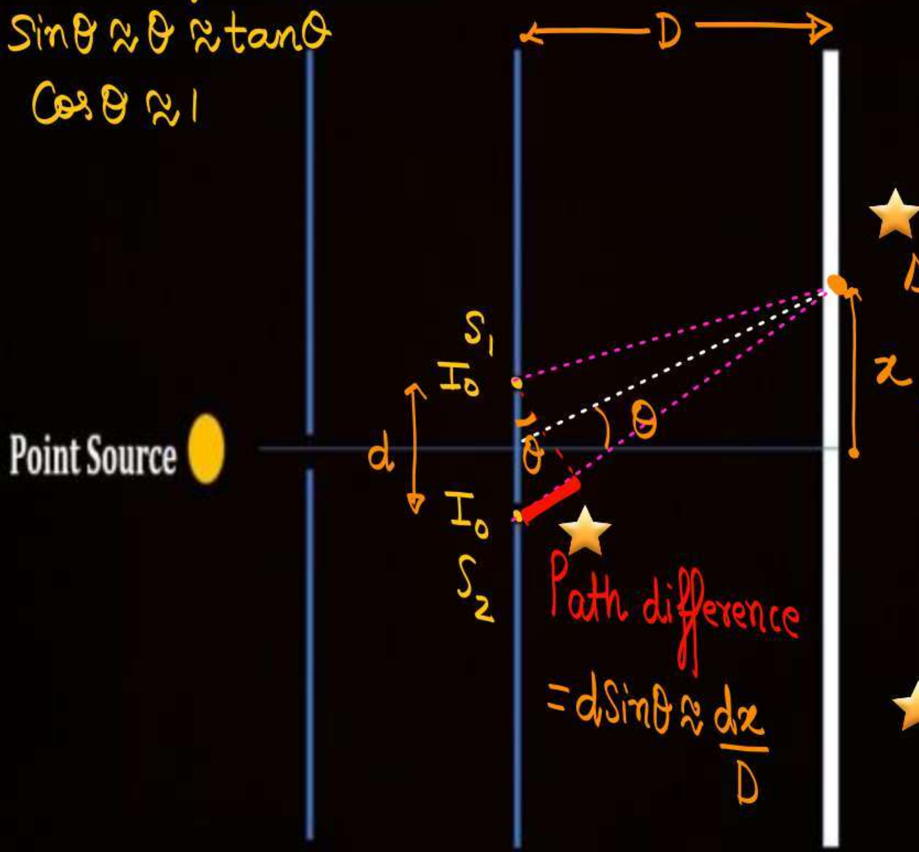


Path difference and phase difference at any point on screen

Small Angle Approx

$\sin\theta \approx \theta \approx \tan\theta$

$\cos\theta \approx 1$



Path difference $= d\sin\theta \approx \dfrac{dx}{D}$

$\Delta\phi = \dfrac{2\pi}{\lambda}\left(\dfrac{dx}{D}\right)$

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

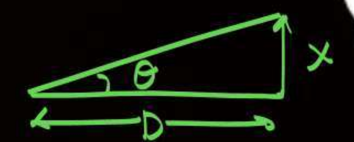
$= 2I_0 + 2I_0\cos\phi$

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

$$\boxed{I = 4I_0\cos^2(\phi/2)}$$

Path diff $= d\sin\theta$

for Small angle.



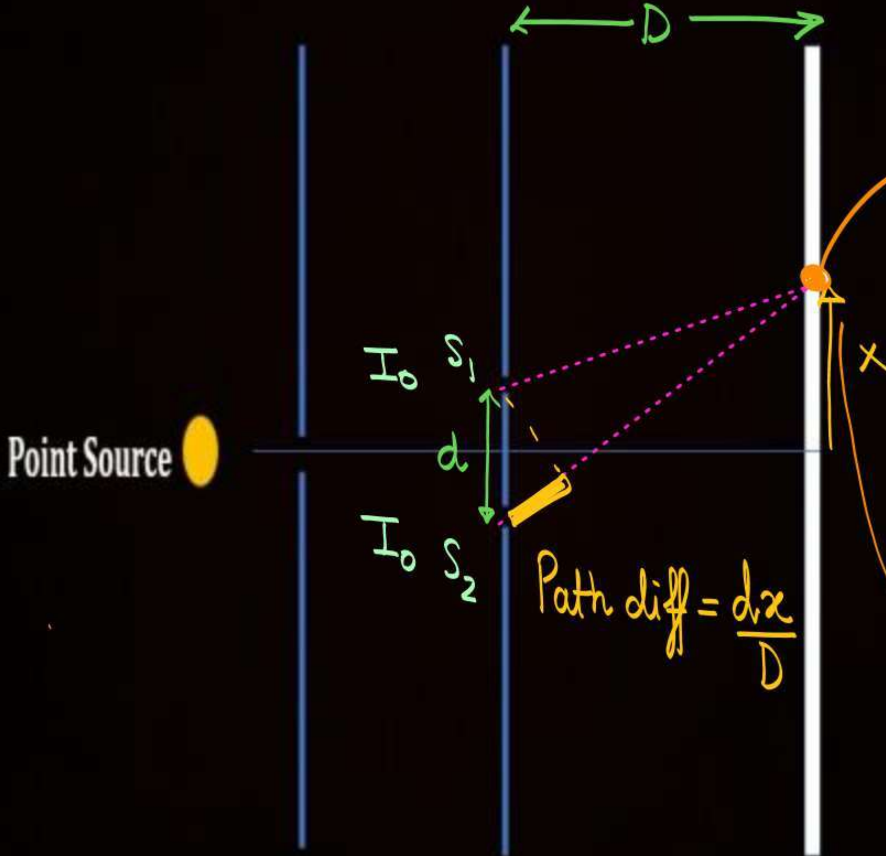
$d \ll D$

$$\boxed{\Delta x = d\sin\theta}$$

$\approx d\theta$

$$\boxed{\Delta x \approx \frac{dx}{D}}$$

Positions of Bright and Dark fringe



Bright fringe.

$$\frac{dx}{D} = N\lambda$$

$$\boxed{x_{Bright} = \frac{N\lambda D}{d}}$$

$N = 1, 2, 3 \ldots$

Dark fringe

$$\frac{dx}{D} = \frac{(2N-1)\lambda}{2}$$

$$\boxed{x_{Dark} = \frac{(2N-1)\lambda D}{2d}}$$

$N = 1, 2, 3 \ldots$

Bright → Const

$\Delta x = N\lambda$

Dark → Dest

$\Delta x = (2N-1)\frac{\lambda}{2}$

If we have to find fringe width (β)

Position of Bright fringe $= x_1 = \frac{\lambda D}{d}$ $\quad x_2 = \frac{2\lambda D}{d}$ $\quad x_3 = \frac{3\lambda D}{d}$ $\quad x_4 = \frac{4\lambda D}{d}$

$$\boxed{\Delta x = \text{fringe width of Dark} = \frac{\lambda D}{d} = \beta}$$

Positions of Dark fringe $x_{Dark} = \frac{(2N-1)\lambda D}{2d}$ $\quad x_{1D} = \frac{\lambda D}{2d}$ $\quad x_{2D} = \frac{3\lambda D}{2d}$ $\quad x_{3D} = \frac{5\lambda D}{2d}$

$$\boxed{\beta_{bright} = \beta_{dark}}$$

$$\boxed{\text{diff of position} = \beta_{Bright} = \frac{\lambda D}{d}}$$

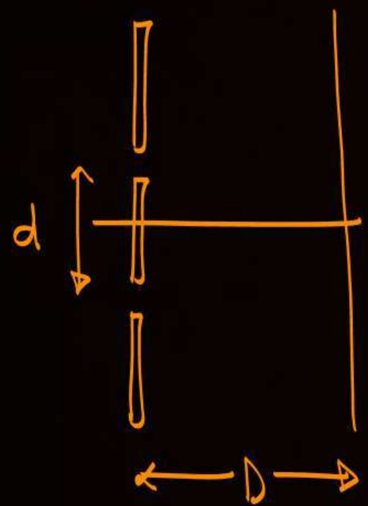
YDSE dipped in Liq

$\mu = \frac{c}{v} = \frac{\nu \times \lambda_0}{\nu \times \lambda_m}$

$\mu = \frac{\lambda_0}{\lambda_m}$

$\boxed{\lambda_m = \frac{\lambda_0}{\mu}}$

$\lambda_{medium} = \frac{\lambda_i}{\mu}$, $\boxed{\beta = \frac{\lambda D}{d}}$

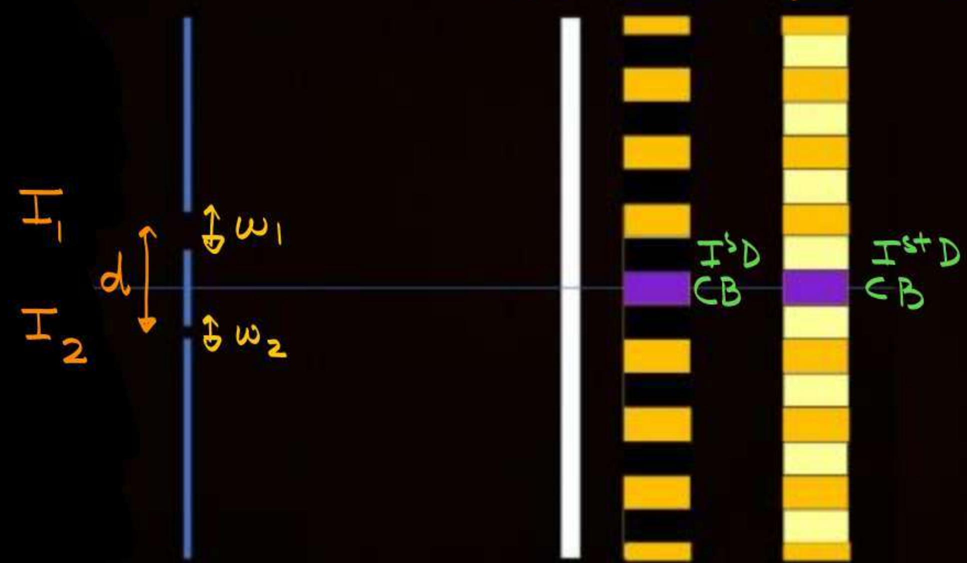


- Positions of Bright & Dark Change.
- Fringe width $\boxed{\beta_{new} = \frac{\beta_{old}}{\mu}}$
- Intensity of Max & Min = Same.

$I_{max} = 4I_0$

$I_{min} = 0.$

YDSE with Different Slit Width



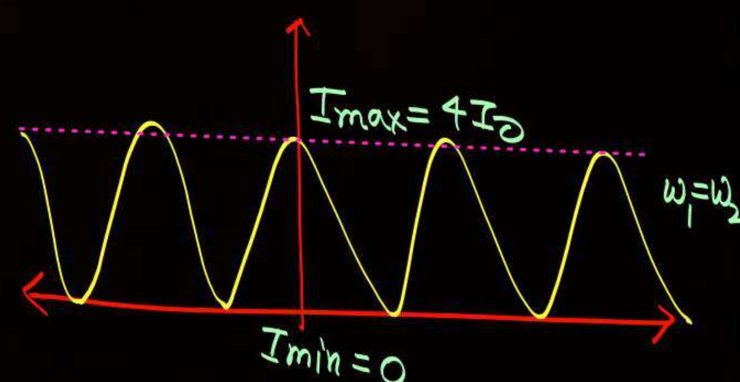
Intensity from both Slits will be diff.

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

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

⊙ Positions of fringes → Same

If $\omega_1 = \omega_2$

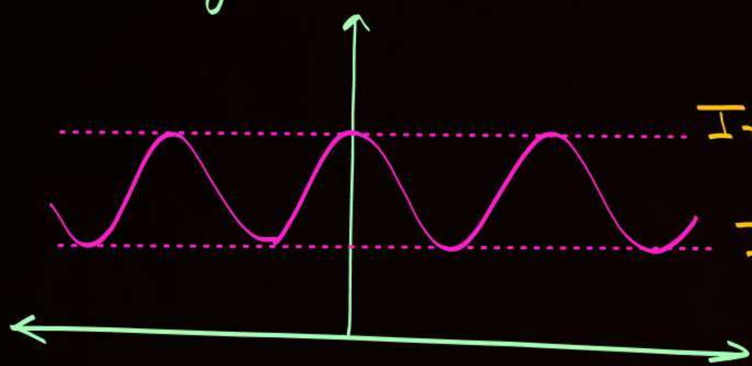


$\boxed{\text{Amplitude of light} \propto \text{width of slit}}$

width ↑ Intensity ↑

width ↓ Intensity ↓

If $\omega_1 \neq \omega_2$



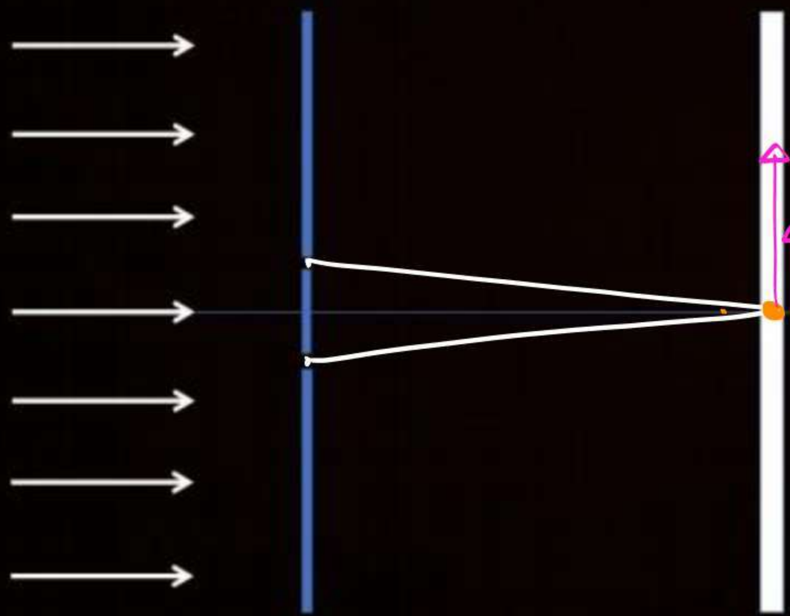
$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

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

YDSE with White Light

White Light → V I B G Y O R

$\lambda_V \approx 4000 Å$ $\lambda_R \approx 8000 Å$



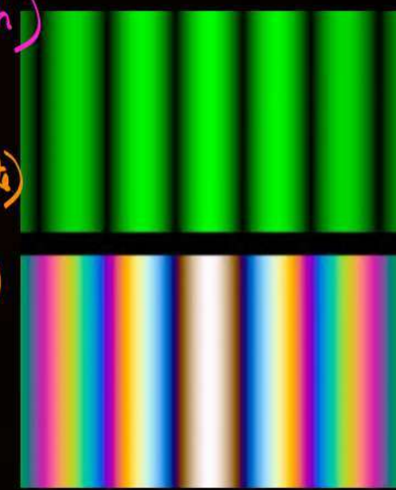
$\Delta = 4000$ (Voilet Const, Red dest)

$\Delta = 2000$ (Voilet dest) (Red dominate)

Const for all colors (White spot)

$(\Delta = 0)$

(Bluish)



Red $\lambda = 8000$

dest = 4000, 12,000 - - -

Const = 8000, 16,000 - - -

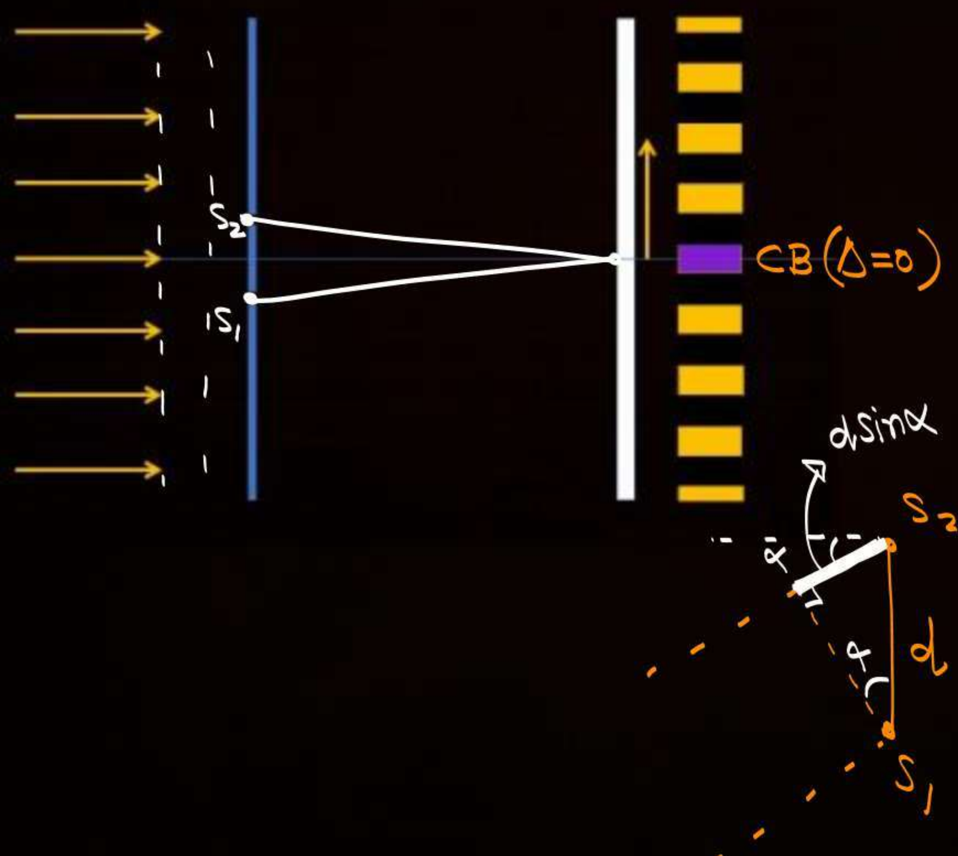
Voilet $\lambda = 4000$

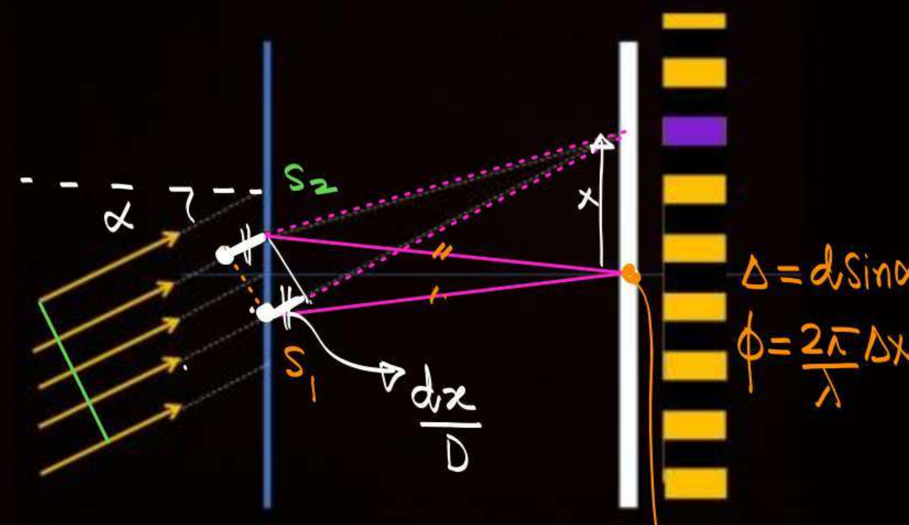
Dest = 2000, 6000, 10000

Const = 4000, 8000, 12,000

YDSE with tilted light

Case 1:





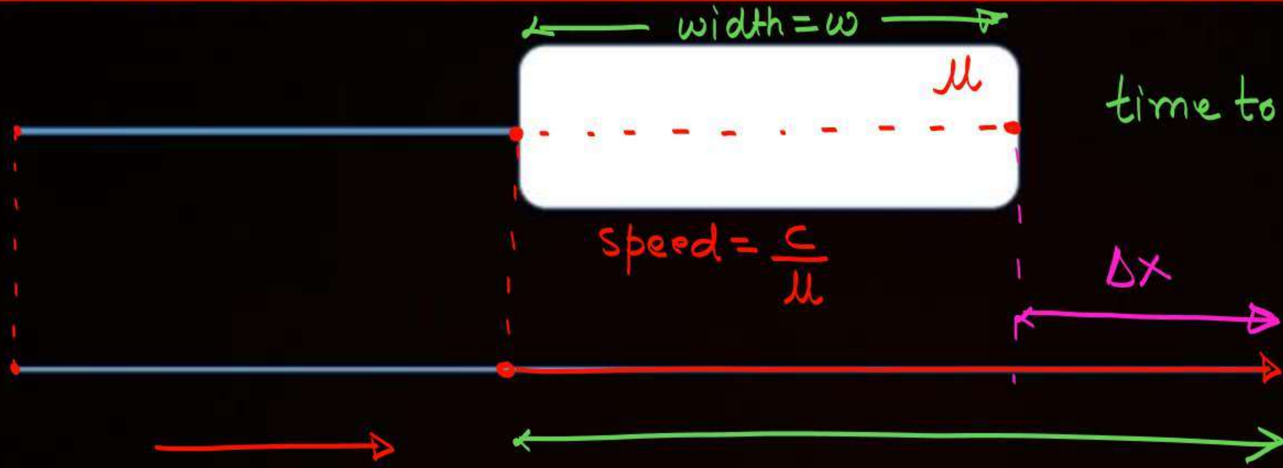
Shift of CB.

$$d\sin\alpha = \frac{dx}{D}$$

$$\boxed{x = D\sin\alpha}$$

$$I = 4I_0\cos^2(\phi/2)$$

Path difference between two parallel waves due to denser medium



Speed = c

time to Cross = $\frac{\omega \mu}{c}$

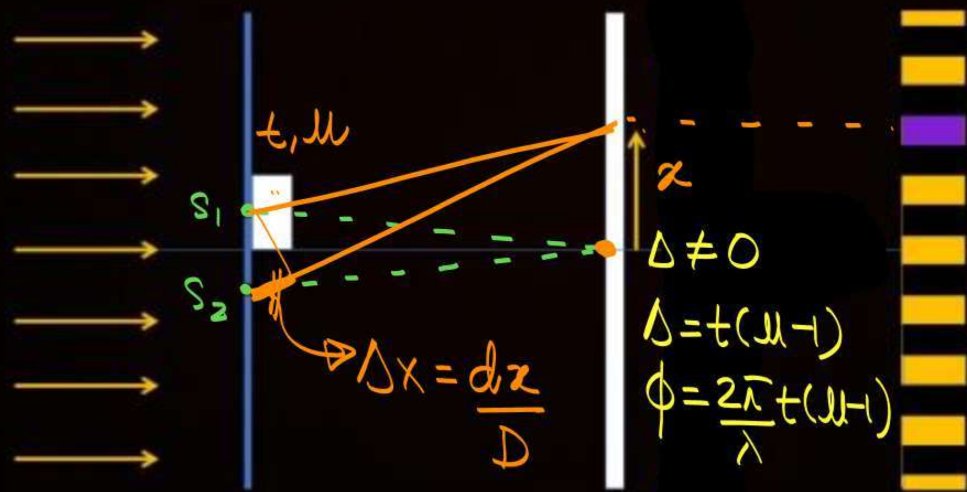
Distance travelled = Speed × time = $c \times \left(\frac{\mu \omega}{c}\right)$

$= \mu \omega$

$$\boxed{\text{Path diff} = \Delta x = \mu\omega - \omega = (\mu - 1)\,\omega}$$

→ thickness.

YDSE with Transparent Film



$\Delta \neq 0$

$\Delta = t(\mu-1)$

$\phi = \frac{2\pi}{\lambda} t(\mu-1)$

$I = 4I_0 \cos^2(\phi/2)$

CB will Shift

$\Delta x = 0$

$$\frac{dx}{D} = t(\mu-1)$$

$$\boxed{x = \frac{tD(\mu-1)}{d}}$$

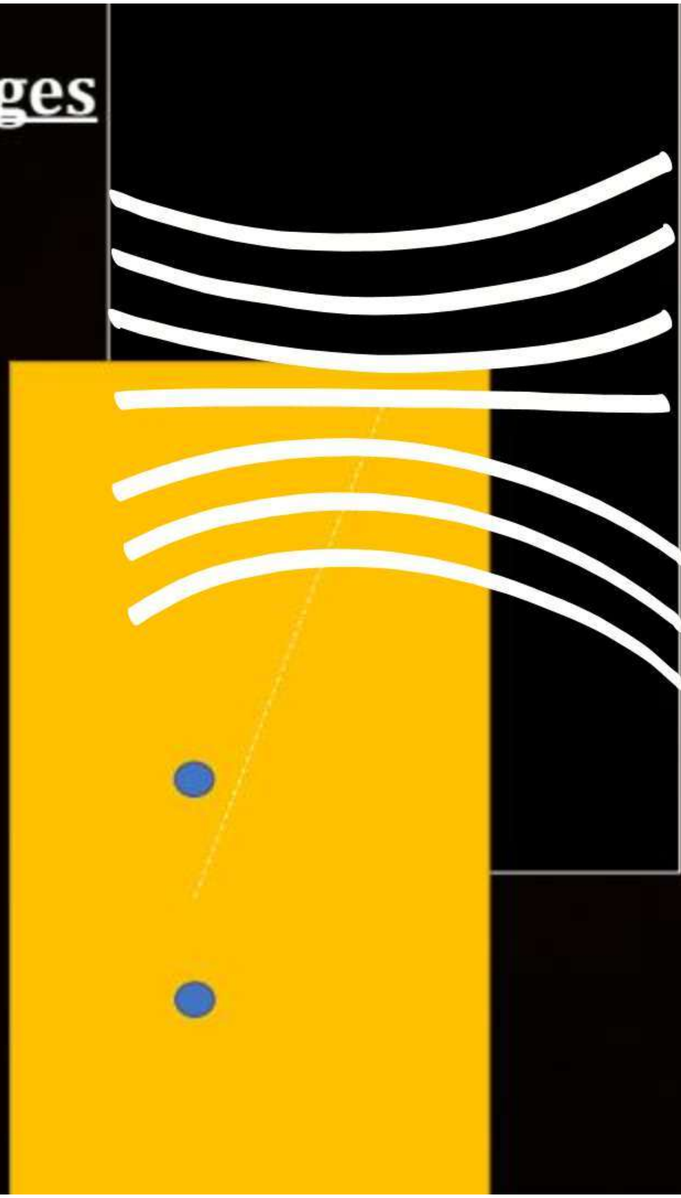
Shift of CB.

If dipped in liq.

$$\boxed{\lambda_{new} = \frac{\lambda}{\mu}}$$

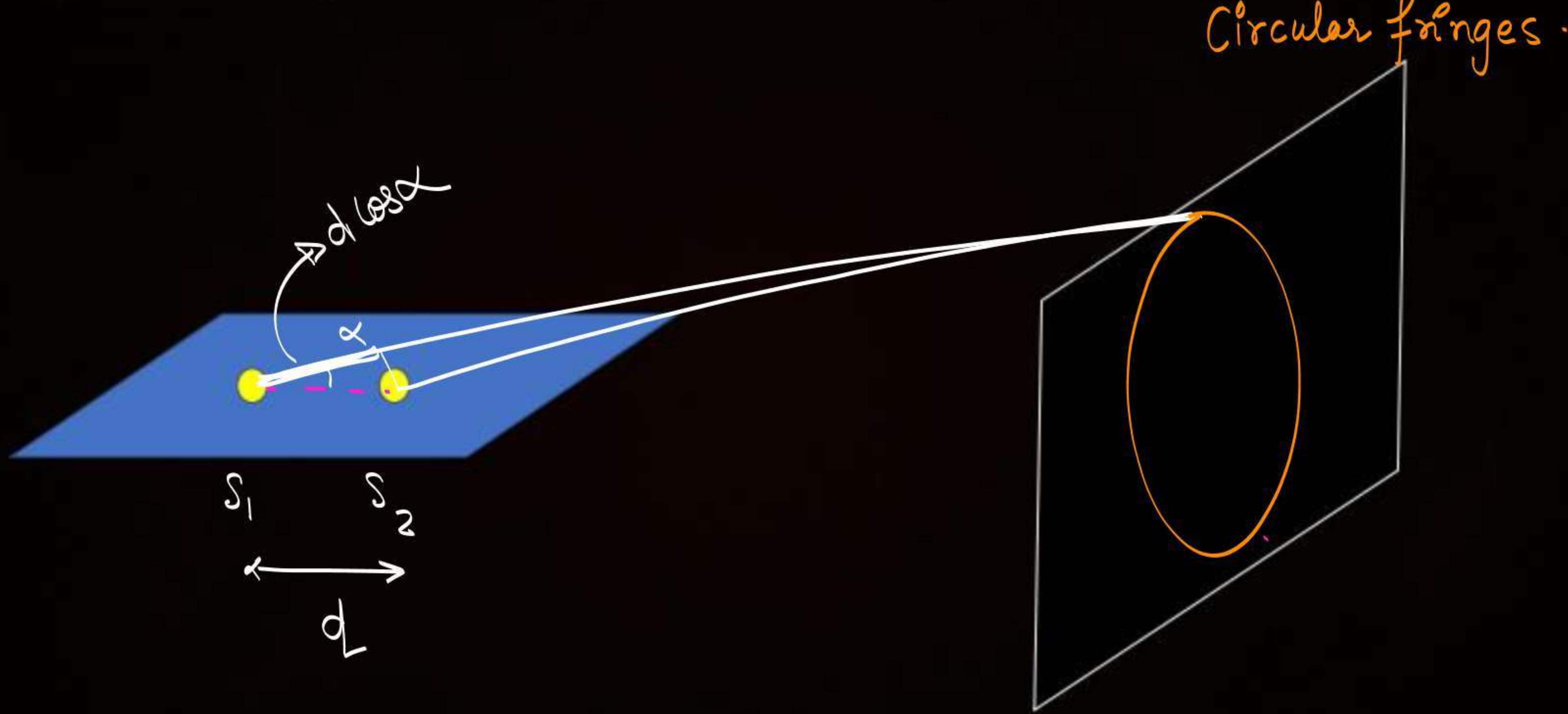
$$\boxed{\underset{(RI)}{\mu} = \mu_{rel}}$$

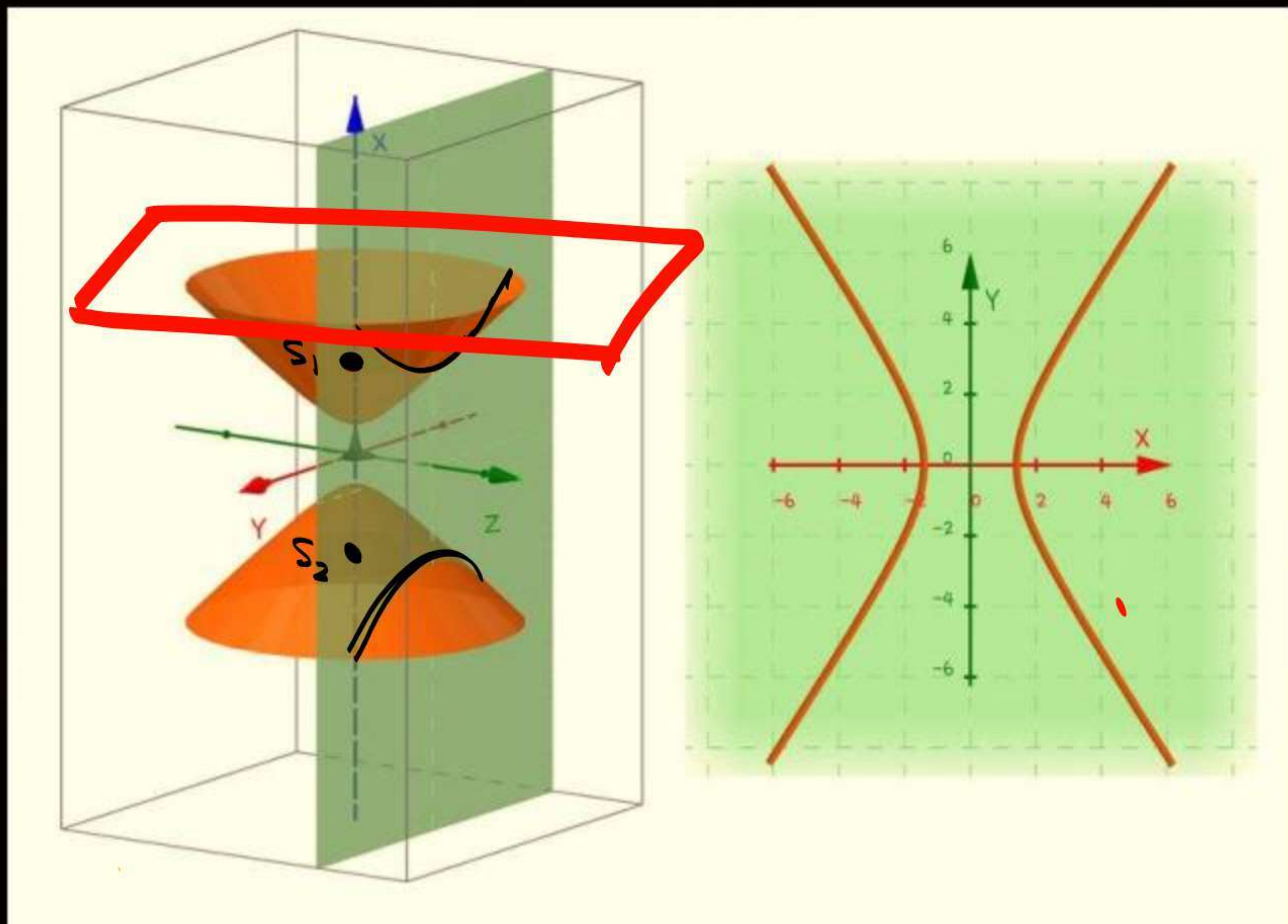
Shape of fringes



Hyperbolic fringes.

Shape of fringes




X
Y
Z
S_1
S_2
6
4
2
0
-2
-4
-6
X
Y
-6
-4
0
2
4
6

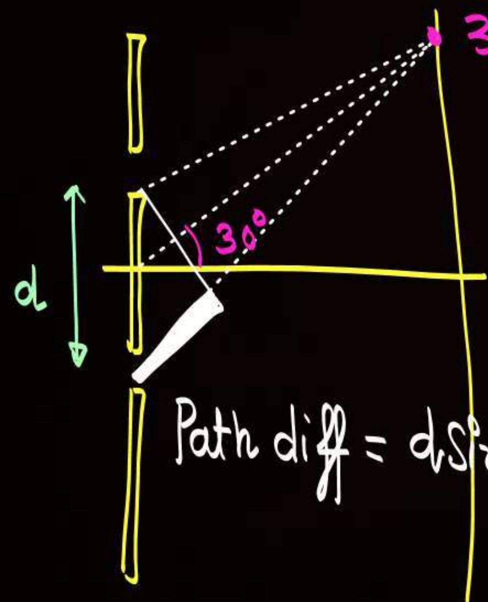
Question 7

IN YDSE setup find the distance between two slits that results in the third minimum for 4200A voilet light at an angle 30^0 . Take d<<D

Minima → Dark

destr.

$\lambda = 4200\,\text{Å}$.



3rd Minima $\Delta x = \frac{5\lambda}{2}$

Path diff = $d\sin 30°$

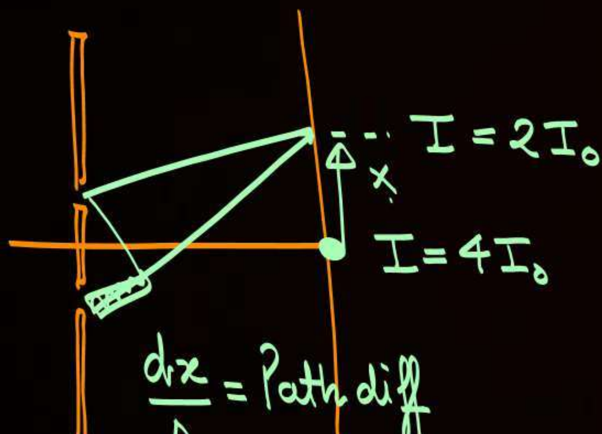
$d \sin 30 = \frac{5\lambda}{2}$

$d = 5\lambda$

$\boxed{d = 5 \times 4200 = \_\_\_\_ .}$

Question 8

In YDSE experiment, find the minimum distance from centre of screen where intensity is half of intensity at centre.



$\frac{dx}{D}$ = Path diff

$$\phi = \frac{2\pi}{\lambda}\cdot\frac{dx}{D}$$

$$I = 4I_0 \cos^2(\phi/2)$$

$$2I_0 = 4I_0 \cos^2(\phi/2)$$

$$\frac{1}{\sqrt{2}} = \cos(\phi/2)$$

$$\cos^{-1}\left(\frac{1}{\sqrt{2}}\right) = \frac{\phi}{2}$$

$$\frac{\phi}{2} = \frac{\pi}{4}$$

$$\frac{\cancel{2}\cancel{\pi}}{\cancel{2}\cdot\lambda}\cdot\frac{dx}{D} = \frac{\cancel{\pi}}{4}$$

$$x = \frac{\lambda D}{4d}$$

Question 9

The width of one of the two slits in a Young's double slit experiment is three times the other slit. If the amplitude of the light coming from a slit is proportional to the slit-width, the ratio of minimum to maximum intensity in the interference pattern is x : 4 where x is ________.

[JEE Main 2019 (Online) 1st September Evening Shift]

Slit width $\propto$ Amp. $\quad I \propto A^2 \propto (\text{Slit width})^2$

$9I_0 \quad 3w_0$

$I_0 \quad w_0$

$$I_{max} = (\sqrt{I_1}+\sqrt{I_2})^2 = (4\sqrt{I_0})^2 = 16 I_0$$

$$I_{min} = (\sqrt{I_1}-\sqrt{I_2})^2 = (2\sqrt{I_0})^2 = 4 I_0$$

$$\frac{4I_0}{16I_0} = \frac{x}{4}$$

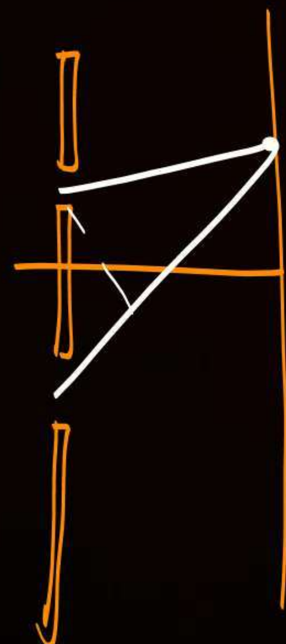
$x = 1$

Question 10

The ratio of intensities at two points P and Q on the screen in a Young's double slit experiment where phase difference between two wave of same amplitude are $\pi/3$ and $\pi/2$, respectively are

[10 April, 2023 Shift-II]

1. $1:3$
2. $3:1$
3. $3:2$
4. $2:3$



Case:1 Amplitude $\Rightarrow$ Same I = Same.

$\Delta\phi = \frac{\pi}{3}$

Case: $\Delta\phi = \frac{\pi}{2}$

$I_R = 4I_0 \cos^2(\phi/2)$

$I_P = 4I_0\cos^2\left(\frac{\pi}{6}\right)$ $\quad I_Q = 4I_0\cos^2\left(\frac{\pi}{4}\right)$

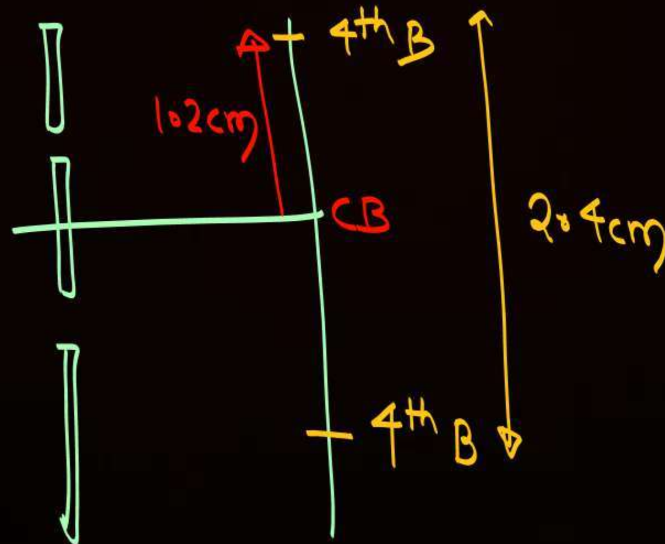
$$\frac{I_P}{I_Q} = \frac{\cos^2 30}{\cos^2 45} = \frac{3}{4} \times 2 = \frac{3}{2}$$

Question 11

In a Young's double slit experiment, the slits are separated by 0.3 mm and the screen is 1.5 m away from the plane of slits. Distance between fourth bright fringes on both sides of central bright is 2.4 cm. The frequency of light used is ________ $\times 10^{14}$ Hz. **[JEE Main 2021 (Online) 31st August Evening Shift]**

$d = 0.3\ mm$

$D = 1.5\ m$



$$x_{Bright} = \frac{N\lambda D}{d}$$

$$1.2 \times 10^{-2} = \frac{4 \times \lambda \times 1.5}{0.3 \times 10^{-3}}$$

$$\text{Speed} = \nu \times \lambda$$

$$\nu = \frac{3 \times 10^{8}}{\lambda}$$

Question 12

The width of fringe is 2 mm on the screen in a double slits experiment for the light of wavelength of 400 nm. The width of the fringe for the light of wavelength 600 nm will be :

[8 April, 2023 Shift-II]

1. 4 mm
2. 1.33 mm
3. 3 mm
4. 2 mm

$\beta = 2\,mm$

$\lambda = 400 \times 10^{-9}\,m$

$\lambda' = 600 \times 10^{-9}\,m$

β'

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

$\frac{\beta'}{\beta} = \frac{\lambda'}{\lambda}$

$$\boxed{\beta' = \frac{\lambda'}{\lambda} \times \beta = \frac{600}{400} \times 2\,mm}$$

$= 3\,mm$

Question 13

In a Young's double slits experiment, the ratio of amplitude of light coming from slits is 2 : 1. The ratio of the maximum to minimum intensity in the interference pattern is :

[13 April, 2023 Shift-II]

1. 9 : 4
2. 9 : 1 Ans
3. 2 : 1
4. 25 : 9

Slit width different

$$\frac{A_1}{A_2} = \frac{2}{1}$$

$$\frac{I_1}{I_2} = \frac{4}{1}$$

$$\boxed{I_1 = 4I_2}$$

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

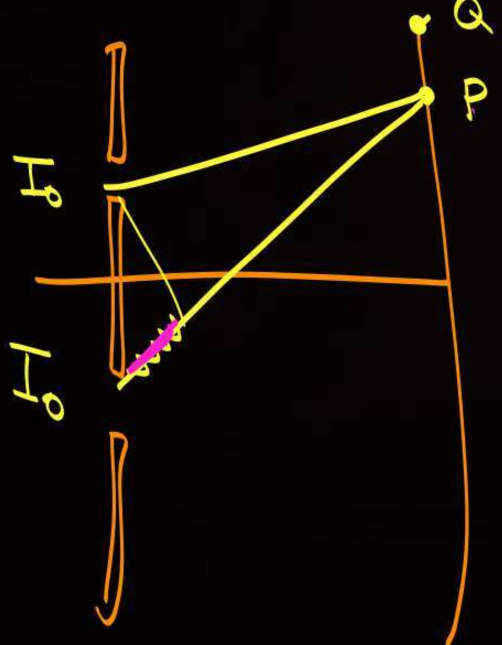
$$= \frac{(2\sqrt{I_2}+\sqrt{I_2})^2}{(2\sqrt{I_2}-\sqrt{I_2})^2} = \frac{9}{1}$$

Question 14

In a Young's double slit experiment, the intensities at two points, for the path difference $\lambda/4$ and $\lambda/3$ (λ being the wavelength of light used) are I_1 and I_2 respectively. If I_0 denotes the intensity produced by each one of the individual slits, then $\frac{I_1 + I_2}{I_0} = \frac{3I_0}{I_0} = 3$.

[30 Jan, 2023 Shift-II]

$\Delta\phi = \frac{2\pi}{\lambda}\cdot\Delta x$



Q $\Delta x = \frac{\lambda}{3}$ $\quad \Delta\phi = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{3} = \frac{2\pi}{3}$ $\quad I_2 = 4I_0\cos^2\left(\frac{\pi}{3}\right) = 4I_0\times\frac{1}{4}$

P $\Delta x = \frac{\lambda}{4}$ $\quad \Delta\phi = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{4} = \frac{\pi}{2}$ $\quad I_1 = 4I_0\cos^2\left(\frac{\pi}{4}\right) = 4I_0\times\frac{1}{2}$

$I_2 = I_0$

$I_1 = 2I_0$

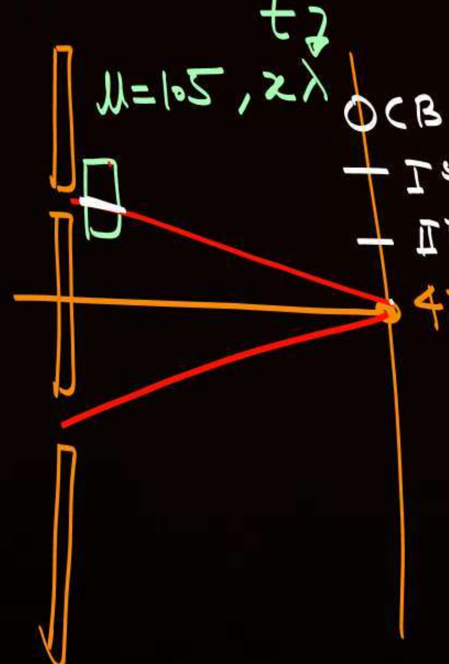
Question 15

In young's double slit experiment performed using a monochromatic light of wavelength λ, when a glass plate ($\mu = 1.5$) of thickness $x\lambda$ is introduced in the path of the one of the interfering beams, the intensity at the position where the central maximum occurred previously remains unchanged. The value of x will be:

→ CB Shift.

[28 June, 2022 Shift-II]

1. 3
2. 2 Ans
3. 1.5
4. 0.5



Path diff in slab $= n\lambda$

$t(\mu - 1) = n\lambda$

$\cancel{x\lambda}\left(\frac{1}{2}\right) = n\cancel{\lambda}$

$\boxed{x = 2n}$ $n = 0, 1, 2, 3 \ldots$

$n = 1$ $x = 2$

Question 16

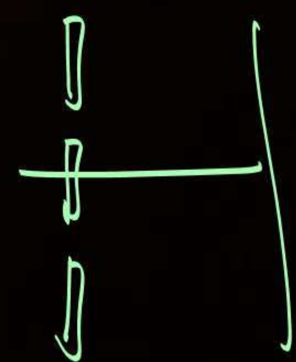
In Young's double slit experiment, if the source of light changes from orange to blue then :

[JEE Main 2021 (Online) 27th July Morning Shift]

1. the central bright fringe will become a dark fringe.
2. the distance between consecutive fringes will decrease. Ans
3. the distance between consecutive fringes will increases.
4. the intensity of the minima will increase.

V I B G Y O R $\longrightarrow \lambda$

λ dec when goes from $O \to B$.

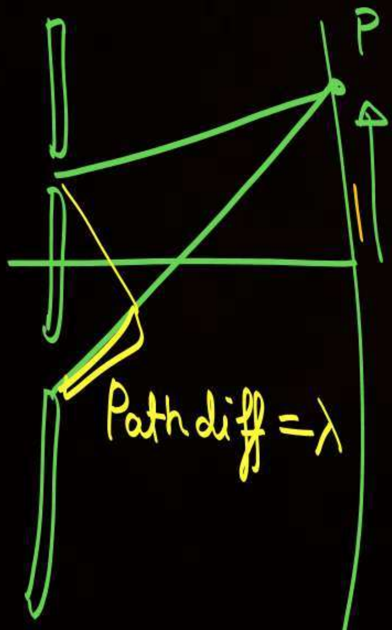


$\beta \downarrow$

Question 17

A Young's double-slit experiment is performed using monochromatic light of wavelength λ. The intensity of light at a point on the screen, where the path difference is λ, is K units. The intensity of light at a point where the path difference is $\frac{\lambda}{6}$ is given by $\frac{nK}{12}$, where n is an integer. The value of n is ________.

[JEE Main 2020 (Online) 6th September Evening Slot]



Const $4I_0 = K$

When $\Delta x = \frac{\lambda}{6}$ $\quad \Delta\phi = \frac{\cancel{2}\pi}{\cancel{\lambda}} \cdot \frac{\cancel{\lambda}}{\cancel{6}\,3} = \frac{\pi}{3}$

$I = 4I_0 \cos^2\left(\frac{\pi}{6}\right)$

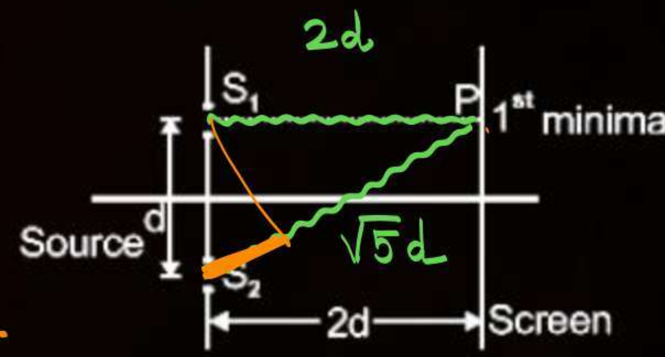
$\frac{nK}{12} = 4I_0 \frac{3}{4}$

$\frac{n(4\cancel{I_0})}{\cancel{12}\,3} = 4\cancel{I_0} \times \frac{3}{\cancel{4}}$

$n = 9$

Question 18

Consider a Young's double slit experiment as shown in figure. What should be the slit separation d in terms of wavelength λ such that the first minima occurs directly in front of the slit (S_1)? [JEE Main 2019 (Online) 10th January Evening Slot]



1. $\dfrac{\lambda}{2(5-\sqrt{2})}$
2. $\dfrac{\lambda}{2(\sqrt{5}-2)}$ Ans
3. $\dfrac{\lambda}{(5-\sqrt{2})}$
4. $\dfrac{\lambda}{(\sqrt{5}-2)}$

Path diff $= \dfrac{\lambda}{2}$

Ist Minima

Path diff $= \sqrt{5}d - 2d = \dfrac{\lambda}{2}$

$d = \dfrac{\lambda}{2(\sqrt{5}-2)}$

Question 19

$[-1, -1]$

In the Young's double slit experiment, the distance between the slits varies in time as $d(t) = d_0 + a_0 \sin \omega t$; where d_0, ω and a_0 are constants. The difference between the largest fringe width and the smallest fringe width obtained over time is given as:

[JEE Main 2021 (Online) 25th July Morning Shift]

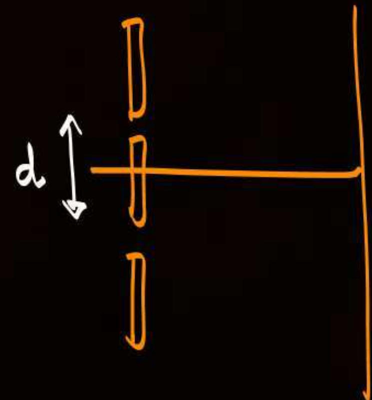
1. $\frac{2\lambda D(d_0)}{(d_0^2 - a_0^2)}$

Ans

2. $\frac{2\lambda D a_0}{(d_0^2 - a_0^2)}$

3. $\frac{\lambda D}{d_0^2} a_0$

4. $\frac{\lambda D}{d_0 + a_0}$



$d = d_0 + a_0 \sin \omega t$.

$d_{min} = d_0 - a_0$

$d_{max} = d_0 + a_0$

Vary

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

Vary

$$\beta_{max} - \beta_{min}$$

$$= \frac{\lambda D}{d_{min}} - \frac{\lambda D}{d_{max}}$$

$$= \frac{\lambda D}{d_0 - a_0} - \frac{\lambda D}{d_0 + a_0}$$

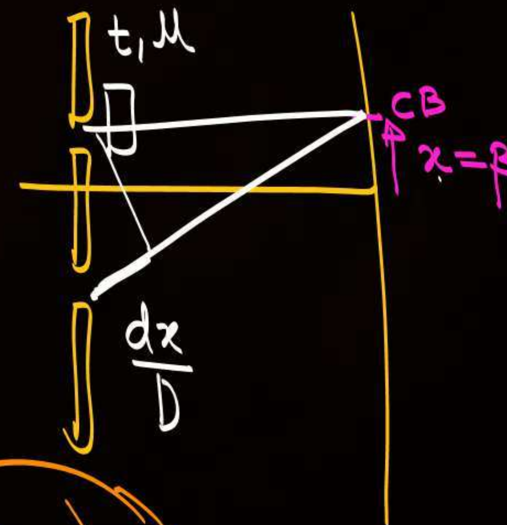
$$= \lambda D \left[\frac{d_0 + a_0 - d_0 + a_0}{d_0^2 - a_0^2} \right]$$

$$= \frac{2 \lambda D a_0}{d_0^2 - a_0^2}.$$

Question 20

In a double slit experiment, when a thin film of thickness t having refractive index μ. is introduced in front of one of the slits, the maximum at the centre of the fringe pattern shifts by one fringe width. The value of t is (λ is the wavelength of the light used) : [JEE Main 2019 (Online) 12th April Morning Slot]

1. $\dfrac{\lambda}{2(\mu-1)}$
2. $\dfrac{\lambda}{(2\mu-1)}$
3. $\dfrac{2\lambda}{(\mu-1)}$
4. $\dfrac{\lambda}{(\mu-1)}$ Ans



$t(\mu-1) = \dfrac{dx}{D}$ as per Ques $x = \dfrac{\lambda D}{d}$

$\dfrac{tD}{d}(\mu-1) = x$ of CB $\dfrac{t\cancel{D}}{\cancel{d}}(\mu-1) = \dfrac{\lambda \cancel{D}}{\cancel{d}}$

$t = \dfrac{\lambda}{\mu-1}$

Break

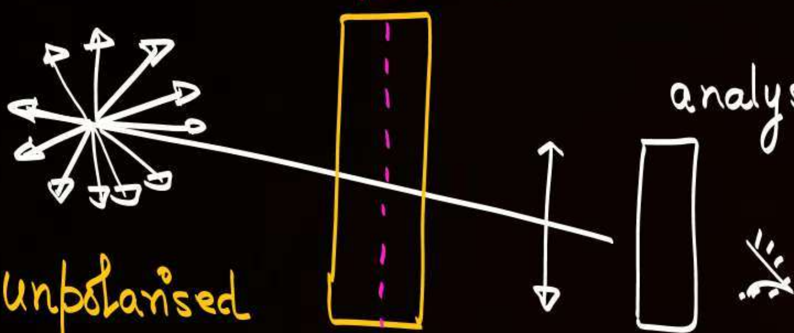
till → 8:50 PM

Polarisation

→ Restricting oscillation of light in one plane.

Polariser

analyser.



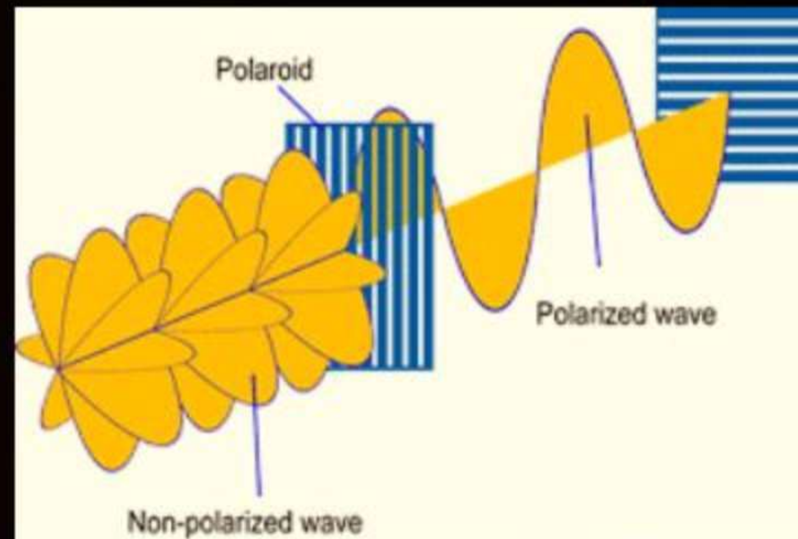
Unpolarised light

T_x

Polarised light

Transmission axis.

(Restricted oscillation in one plane).



Polariser & analyser → Poloroids.

unpolarised light Representation $\updownarrow$

Polarised light Represent $\updownarrow$ Oscillation in Plane of board.

OR

$\bullet$ Oscillation $\perp$ to plane of board.

Polarization By reflection

Brewester's Law:-

$\angle$incidence = Brewester's Angle.

$\theta_B + r = 90^\circ$

Snell's Law

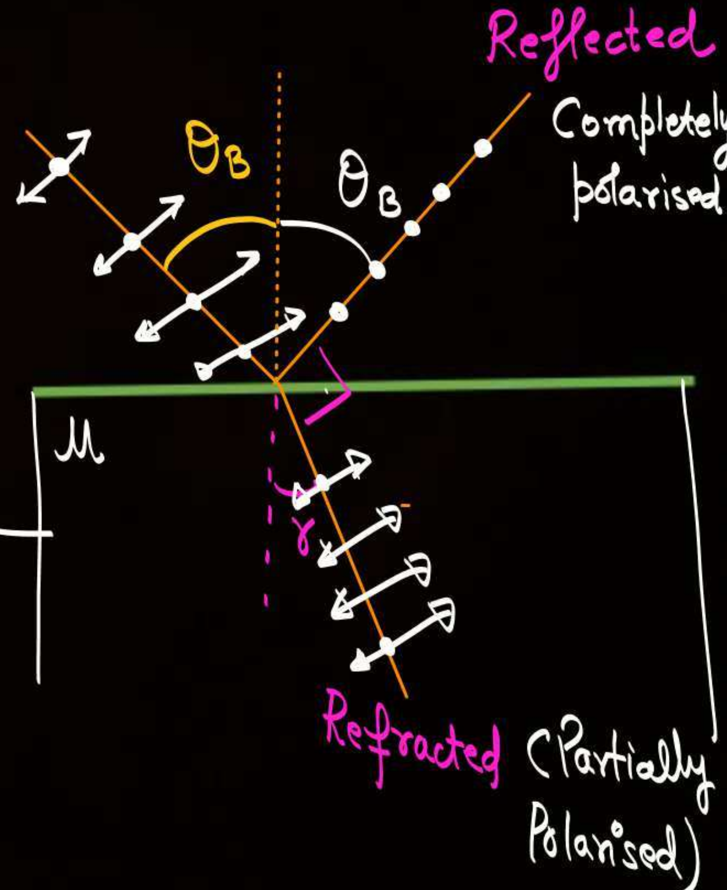
$1 \sin\theta_B = \mu \sin r$

$\sin\theta_B = \mu \sin(90 - \theta_B)$

$\boxed{\tan\theta_B = \mu}$

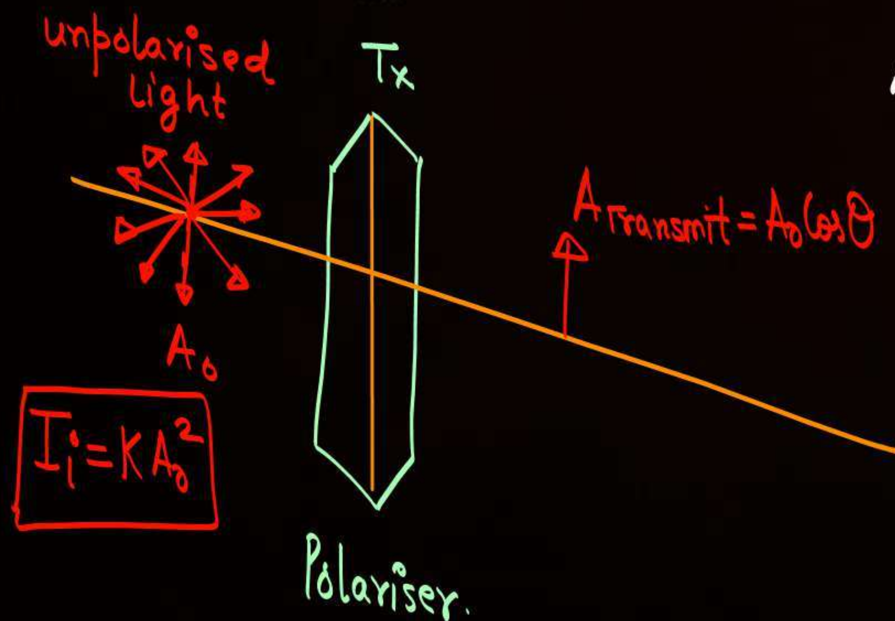
$\boxed{\theta_B = \tan^{-1}(\mu)}$

Calcite,
Quartz,
tormouline.
Silicates



Malus Law

When a plane Polarized light with amplitude A_0 incident on a polaroid.
With the axis of vibration at angle θ to Tx axis then the amplitude of vibration Of transmitted light will be A cosθ



$$A_{Transmit} = A_0 \cos\theta$$

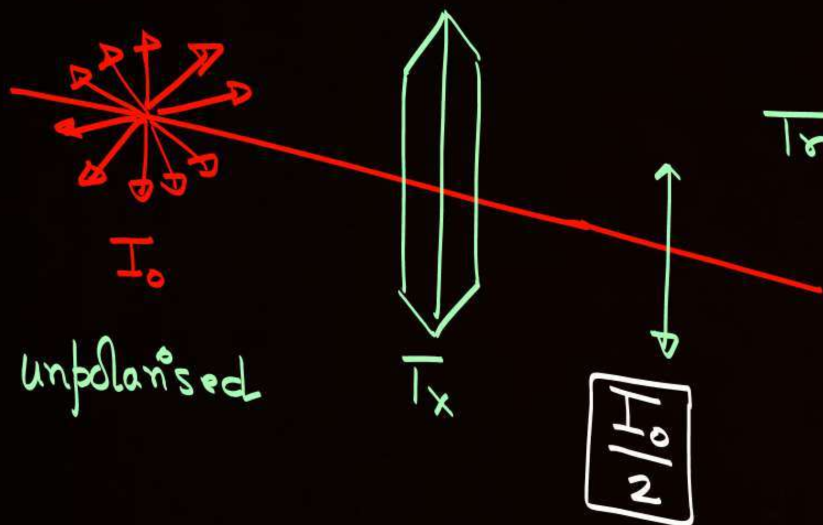
θ is angle with Tx axis.

$$I_{Transmitted} = K A_0^2 \cos^2\theta$$

$$\boxed{I_{Transmit} = I_{incident} \cos^2\theta}$$

Imp point

a)



Polarised light.

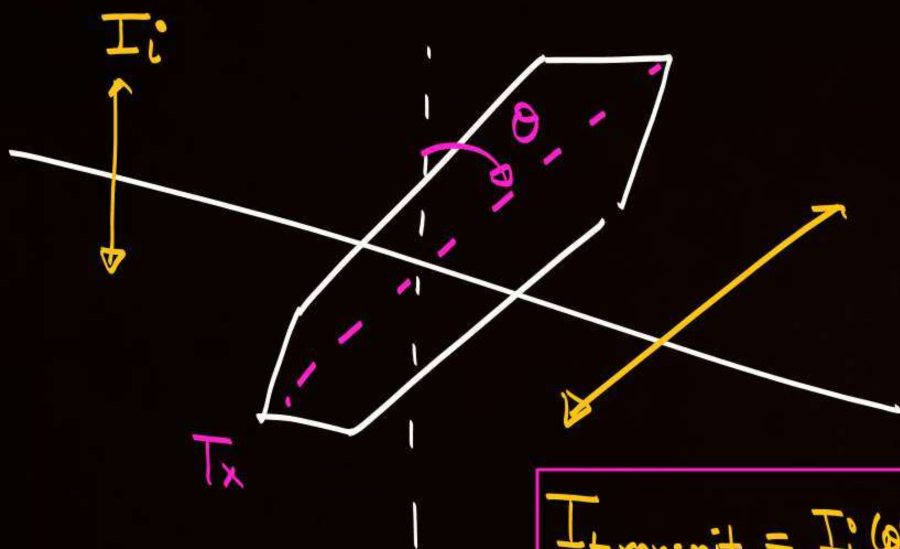
Transmitted $\quad I_{transmit} = I_0 \cos^2\theta.$

$$I_{transmit} = \langle I_0 \cos^2\theta \rangle$$

$$\boxed{I_{tansmit} = \frac{I_0}{2}}$$

Pahli baar jab bhi light polarise hogi $I = \frac{I_0}{2}$ hojayegi.

b) If polarised light Incident on Polariser

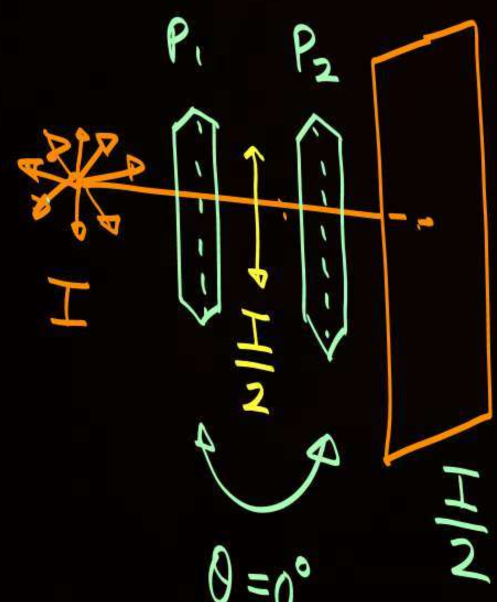


$$\boxed{I_{transmit} = I_i \cos^2\theta}$$

Question 21

A source of light is placed in front of a screen. Intensity of light on the screen is I. Two Polaroids P_1 and P_2 are so placed in between the source of light and screen that the intensity of light on screen is I/2. P_2 should be rotated by an angle of (degrees) so that the intensity of light on the screen becomes $\frac{3I}{8}$.

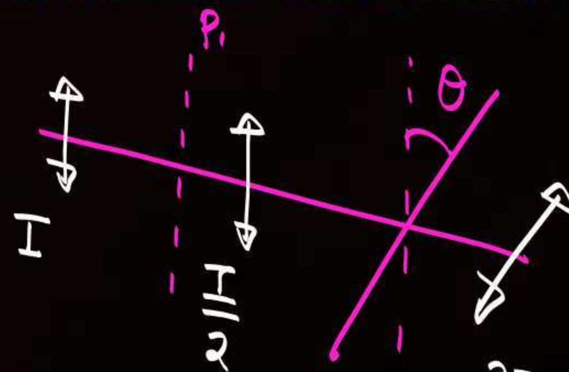
[JEE Main 2021 (Online) 26th August Evening Shift]



$$I_{tran} = I_i \cos^2\theta$$

$$\frac{I}{2} = \frac{I}{2}\cos^2\theta$$

$$\theta = 0°$$



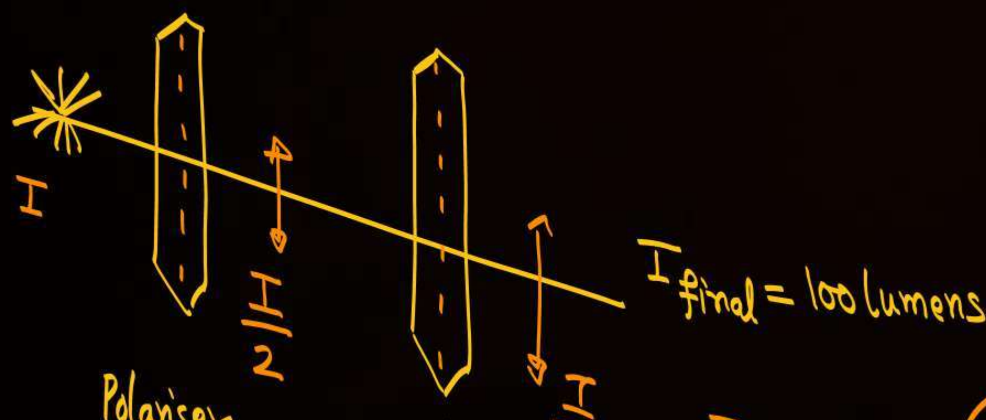
$$\frac{3\cancel{I}}{\cancel{8}_{4}} = \frac{\cancel{I}}{\cancel{2}}\cos^2\theta$$

$$\frac{3I}{8}$$

$$\cos\theta = \frac{\sqrt{3}}{2} \qquad \theta = 30°$$

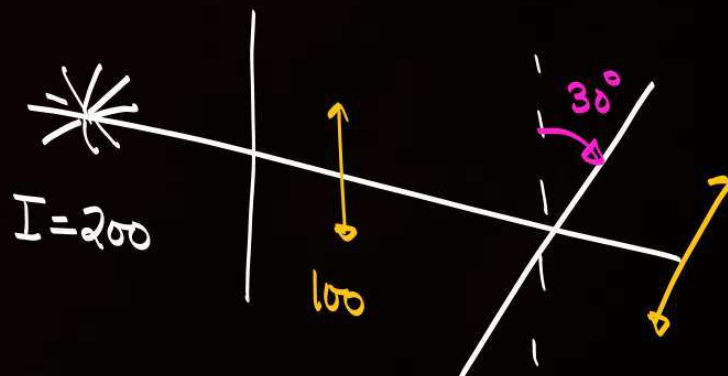
Question 22

An unpolarised light beam is incident on the polarizer of a polarization experiment and the intensity of light beam emerging from the analyzer is measured as 100 Lumens. Now, if the analyzer is rotated around the horizontal axis (direction of light) by 30° in clockwise direction, the intensity of emerging light will be 75 Lumens. **[JEE Main 2021 (Online) 24th February Morning Slot]**



$\frac{I}{2} = 100$

$I = 200$



$I_t = I_i \cos^2 30$

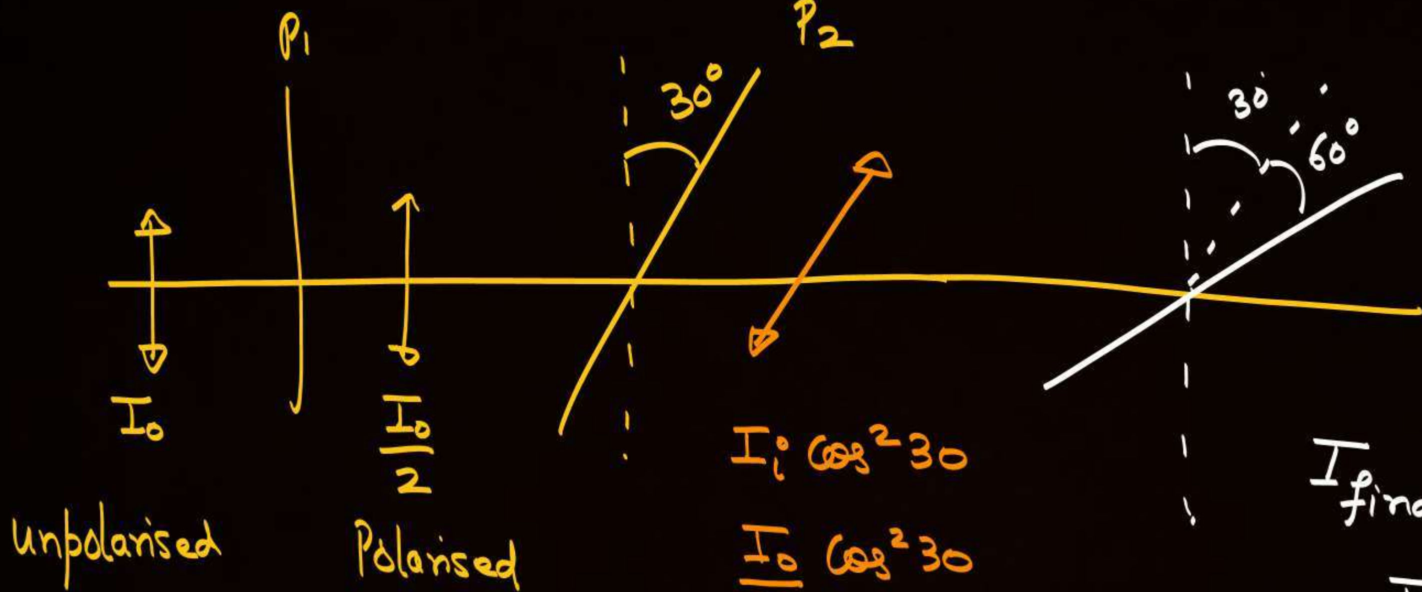
$= 100 \times \frac{3}{4} = 75$

Question 23

A system of three polarizers P_1, P_2, P_3 is set up such that the pass axis of P_3 is crossed with respect to that of P_1. The pass axis of P_2 is inclined at $60°$ to the pass axis of P_3. When a beam of unpolarized light of intensity $I0$ is incident on P_1, the intensity of light transmitted by the three polarizers is I. The ratio $\left(\frac{I_0}{I}\right)$ equals (nearly) :

[JEE Main 2019 (Online) 12th April Evening Slot]

1. 16/3
2. 3/32
3. 32/3
4. 3/16



$$I_i \cos^2 30$$

$$\frac{I_0}{2}\cos^2 30$$

$$= \frac{3I_0}{8}$$

$$I_{final} = I_i \cos^2 60$$

$$I = \frac{3I_0}{8}\,\frac{1}{4}$$

$$I = \frac{3\,I_0}{32}$$

$$\frac{32}{3} = \frac{I_0}{I}$$

Question

HW

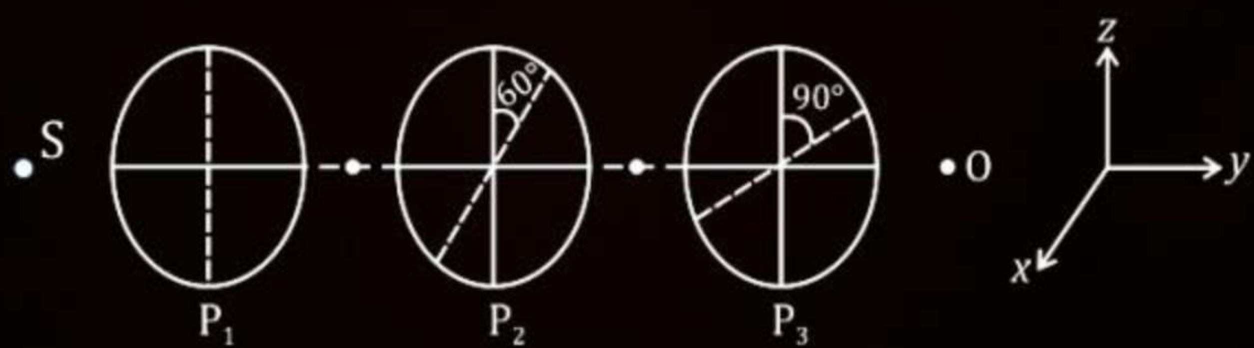
Two polaroide A and B are placed in such a way that the pass-axis of polaroids are perpendicular to each other. Now, another polaroid C is placed between A and B bisecting angle between them. If intensity of unpolarised light is I_0 then intensity of transmitted light after passing through polaroid B will be : [31 Jan, 2023 Shift-I]

1. $I_0/4$
2. $I_0/2$
3. $I_0/8$
4. Zero

Question HW

As shown in figures, three identical polaroids P_1, P_2 and P_3 are placed one after another. The pass axis of P_2 and P_3 are inclined at angle of 60° and 90° with respect to axis of P_1. The source S has an intensity of 256 W/m^2. The intensity of light at point O is ______ W/m^2.

[29 Jan, 2023 Shift-I]



Question 24

The angle of polarisation for any medium is 60°. What will be critical angle for this?

Brewester's Angle $\theta_B = 60^\circ$

1. $\sin^{-1}\sqrt{3}$
2. $\tan^{-1}\sqrt{3}$
3. $\cos^{-1}\sqrt{3}$
4. $\sin^{-1}\frac{1}{\sqrt{3}}$ Ans

$\theta_B = \tan^{-1}\mu$

$\tan 60 = \mu$

$\sqrt{3} = \mu$

$\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$

$\theta_c = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

Question 25

HW

Two polaroids are placed in the path of unpolarized beam of intensity I_0 such that no light is emitted from the second polaroid. If a third polaroid whose polarization axis makes an angle θ with the polarization axis of first polaroid, is placed between these polaroids then the intensity of light emerging from the last polaroid will be:

1. $\left(\frac{I_0}{8}\right)\sin^2 2\theta$
2. $\left(\frac{I_0}{4}\right)\sin^2 2\theta$
3. $\left(\frac{I_0}{2}\right)\cos^4 \theta$
4. $I_0\cos^4 \theta$

Question 26

'n' polarizing sheets are arranged such that each makes an angle $45°$ with the preceding sheet. An unpolarized light of intensity I is incident into this arrangement. The output intensity is found to be $\frac{I}{64}$. The value of n will be :

[1 Feb, 2023 Shift-I]

$\frac{I}{2} \cos^2 45 = \frac{I}{4} = \frac{I}{2^2}$

n^{th} time $= I_{Trans} = \frac{I}{2^n} = \frac{I}{64}$

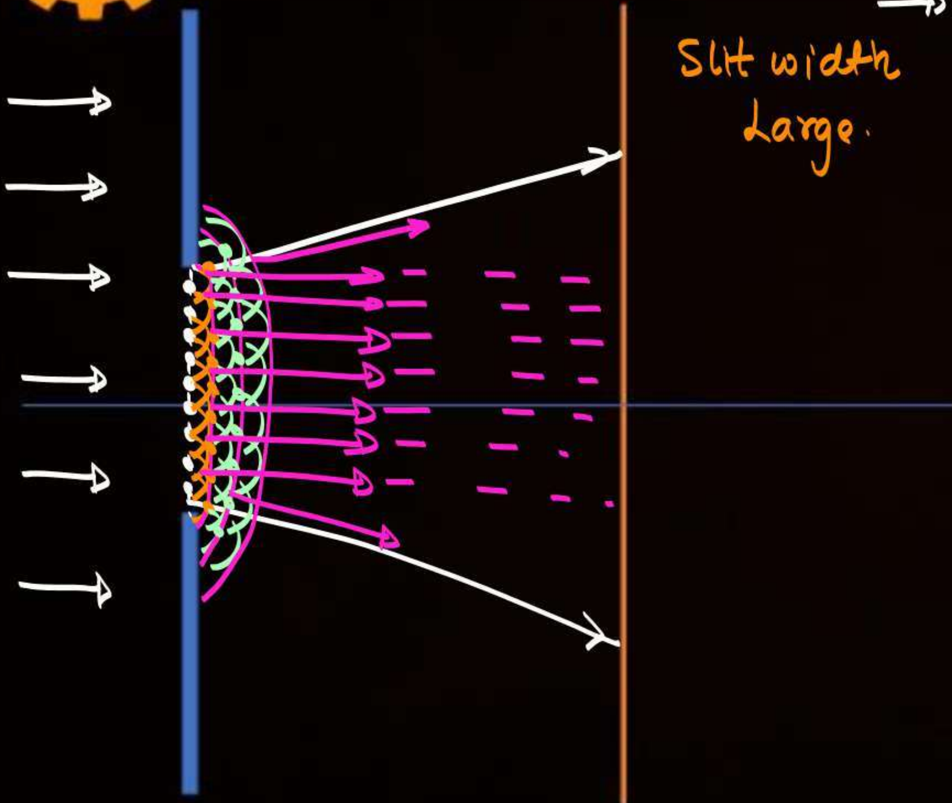
$n =$ ____

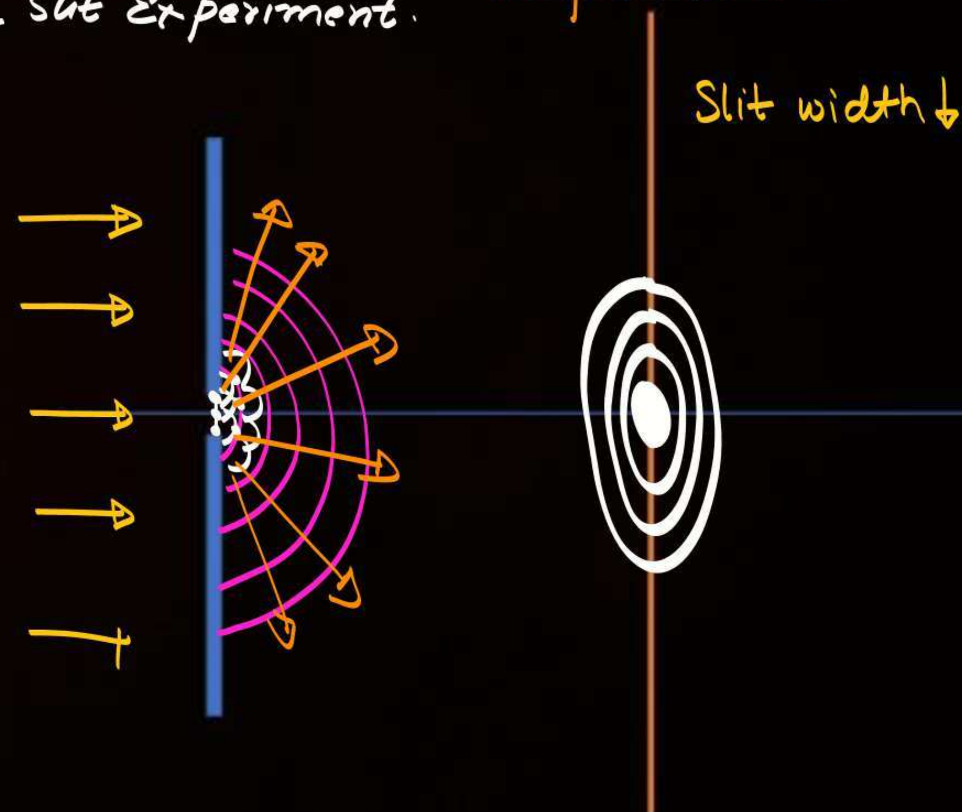
1. 3
2. 6
3. 5
4. 4

Diffraction of Light

→ Bending of light by hitting objects of size Comparable to λ.

→ Single Slit Experiment.





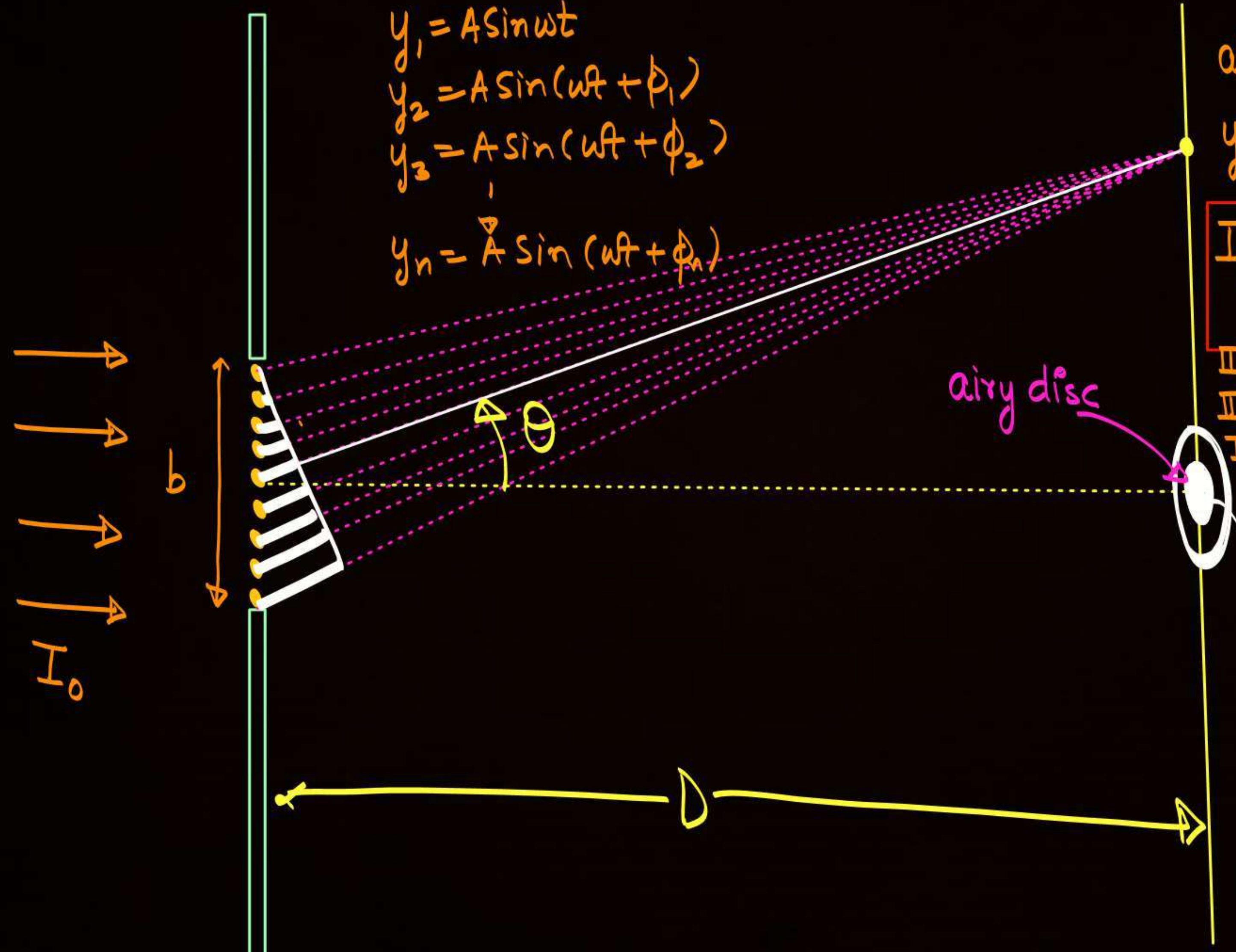
$y_1 = A\sin\omega t$

$y_2 = A\sin(\omega t + \phi_1)$

$y_3 = A\sin(\omega t + \phi_2)$

$\vdots$

$y_n = A\sin(\omega t + \phi_n)$



at any θ

$y_R = y_1 + y_2 + y_3 + y_4 + \cdots N$

learn

$$\boxed{I_{Resultant} = \frac{I_0 \sin^2\beta}{\beta^2}}$$

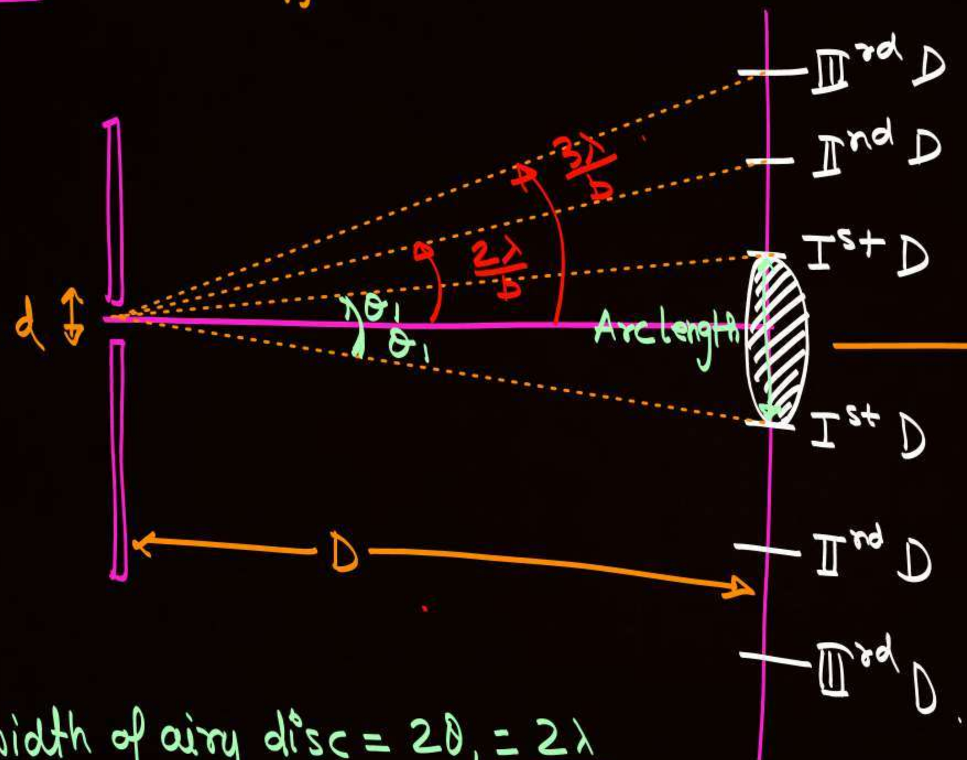
$$\boxed{\beta = \frac{\pi b \sin\theta}{\lambda}}$$

$\theta \to 0 \quad \beta \to 0$

$$I = I_0 \lim_{\beta \to 0} \left(\frac{\sin\beta}{\beta}\right)^2$$

$$I_{centre} = I_0 \quad \#$$

Diffraction (Franhoffer's). $(d << D)$



→ C.B $m = 0$

Dark $I = 0$

$$\frac{I_0 \sin^2\beta}{\beta^2} = 0$$

$$\beta = m\cancel{\pi} = \frac{\cancel{\pi}\, b \sin\theta}{\lambda}$$

$$\boxed{\sin\theta = \frac{m\lambda}{b}}$$

I st Dark $\theta_1 = \sin^{-1}\left(\frac{\lambda}{b}\right) \approx \frac{\lambda}{b}$

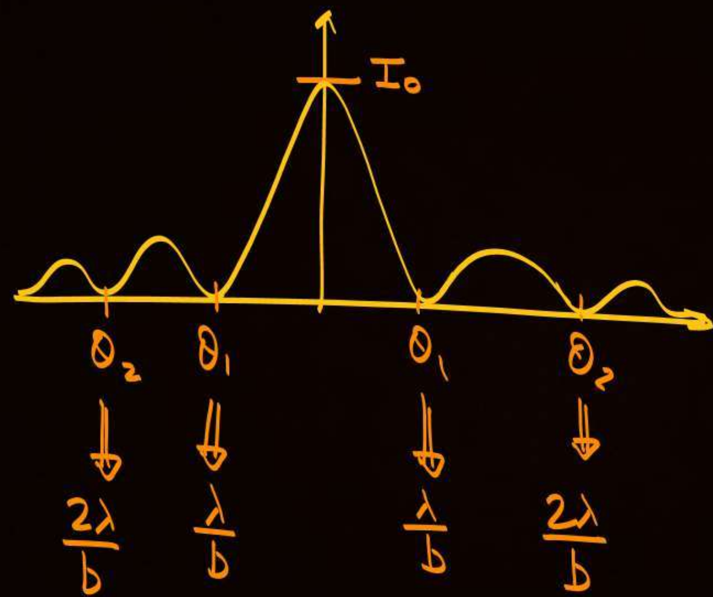
II nd Dark $\theta_2 = \sin^{-1}\left(\frac{2\lambda}{b}\right) \approx \frac{2\lambda}{b}$

III rd Dark $\theta_3 = \sin^{-1}\left(\frac{3\lambda}{b}\right) \approx \frac{3\lambda}{b}$

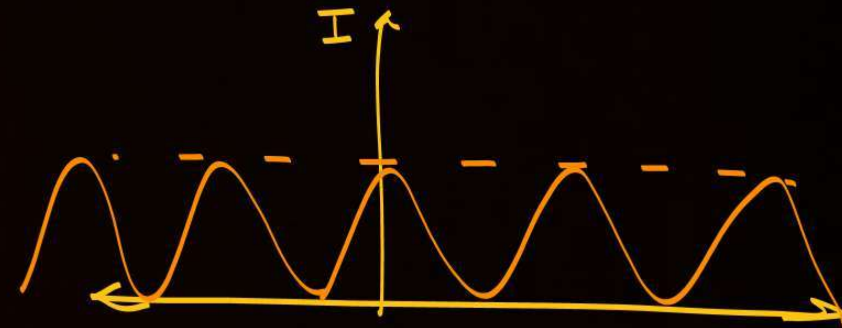
Angular width of airy disc $= 2\theta_1 = \frac{2\lambda}{b}$

diameter of airy disc. = Arclength = Radius × angle $= D(2\theta_1)$.

Diffraction $\longrightarrow$ Central $\rightarrow I_0$ / YDSE Central $= 4I_0$



width $\rightarrow$ Vary

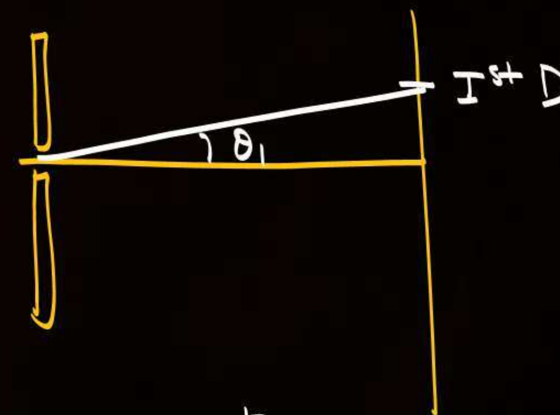


width $\rightarrow$ Constant.

Question 27

A parallel beam of monochromatic light of wavelength 5000 Å is incident normally on a single narrow slit of width 0.001 mm. The light is focused by a convex lens in a screen placed in focal plane. The first minimum will be formed for the angle of diffraction equal to:

1. 0°
2. 15°
3. 30° Ans
4. 50°



$b = 0.001\ mm$

$\lambda = 5000$ Å

$$\sin\theta_1 = \frac{\lambda}{b} = \frac{5000\times10^{-10}}{10^{-3}\times10^{-3}} = 0.5 = \frac{1}{2}$$

$$\theta_1 = 30°$$

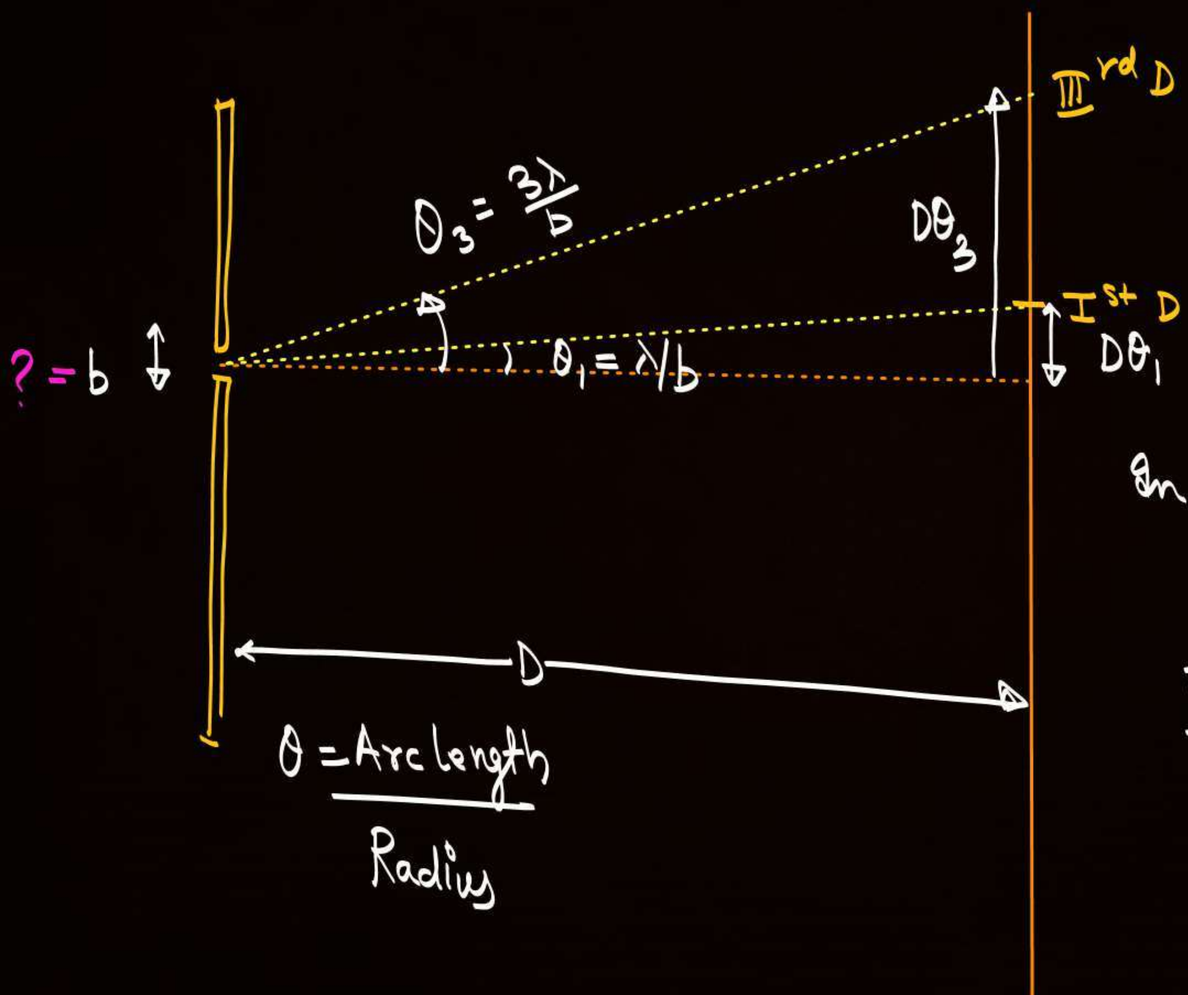
Question 28

A screen is placed 50 cm from a single slit which illuminated with light of wavelength 6000 Å. If the distance between the first and third minima in the diffraction pattern is 3.0 mm The width of the slit is:

1. 1×10^{-4} m
2. 2×10^{-4} m
3. 0.5×10^{-4} m
4. 4×10^{-4} m

$D = 50\,cm$

$\lambda = 6000\,Å$.



$x = 3\,mm$

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

In Ques

$$D\theta_3 - D\theta_1 = 3\times10^{-3} \qquad 50\times10^{-2}$$

$$\frac{3D\lambda}{b} - \frac{D\lambda}{b} = 3\times10^{-3} \qquad 6000\times10^{-10}$$

$$\frac{2D\lambda}{b} = 3\times10^{-3} \qquad b = \frac{2D\lambda}{3\times10^{-3}}$$

Question 29

H/W

In a single slit diffraction, how does the angular width of central maxima changes when the distance between the slit & the screen is increased 3 time ?

1. Angular width increases 3 times
2. Angular width decreases 3 times
3. Angular width increases 6 times
4. There is no change in angular width

Homework

- ALL PYQ of Wave Optics