UNIT # 11 (PART - II)

WAVE OPTICS (Nature of Light & Interference)

EXERCISE –I

8. $I_1 \propto a_1^2$, $I_2 \propto a_2^2$

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

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$, When $\cos\phi = 1$, $\phi = 0, 2\pi, ...$

9. $y_1 = a \sin\omega t = a\cos(\omega t - \pi/2)$,

$y_2 = a\cos\omega t$

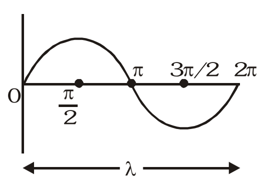
10. $y_1 = a\sin\left(\omega t + \frac{\pi}{3}\right)$ and $y_2 = a\sin\omega t$

$$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi} \quad \text{where} \quad \phi = \frac{\pi}{3}$$

$$= \sqrt{a^2 + a^2 + 2aa\cos\frac{\pi}{3}} = \sqrt{3}a$$

11. In interference pattern we can see that resultant amplitude of super imposed wave depends on the phase difference of waves so it varies from maximum to minimum amplitude by redistributing of energy but total energy remains conserved.

12.



When path difference is λ then phase difference is 2π

When path difference is 1 then phase difference is $\frac{2\pi}{\lambda}$

When path difference is x then phase difference is $\frac{2\pi}{\lambda}x$

13. Resultant amplitude $A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$

ϕ – Angle between two waves or phase difference. So A depends on both amplitude & phase difference.

15. From the definition of coherent source.

16. Sustained interference means a interference pattern (arrangement of fringes) can not be change with time. It is only possible when the phase difference between waves at a point does not change with time.

17. Given $\frac{I_1}{I_2} = 4 \therefore I_1 = 4I$ (let the $I_2 = I$)

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

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

$$\therefore \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{9I - I}{9I + I} = \frac{8I}{101} = \frac{4}{5}$$

19. For minima $y_n = (2n-1)\frac{\lambda D}{2d}$ where n is the no. of minimum. For maxima $y_n = \frac{n\lambda D}{d}$

$$y_{5^{th}\,dark} = \frac{9\lambda D}{2d}; \quad y_{1^{st}\,maxima} = \frac{\lambda D}{d}$$

By Equation $y_{5^{th}\,min} - y_{1^{st}\,max} = 7 \quad 10^{-3}$

$$\frac{9\lambda D}{2d} - \frac{\lambda D}{d} = 7\times10^{-3} \Rightarrow \lambda = \frac{7\times10^{-3}\times15\times10^{-5}\times2}{7\times50\times10^{-2}}$$

$\therefore \lambda = 600$ nm

20. Fringe width $\beta = \frac{\lambda D}{d}$;

$$\beta' = \frac{\lambda' D'}{d'} = \frac{\lambda\times2D}{d/2}, \quad \beta' = 4\frac{\lambda D}{d} = 4\beta$$

21. On a given screen width $n\beta$= car tan, Here n is number of fringes and $\beta = \frac{\lambda d}{D}$ is the fringe width

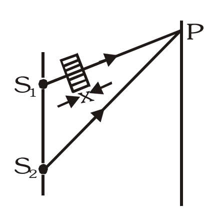
$n_1\beta_1 = n_2\beta_2 \Rightarrow n_2\lambda_1 = n_2\lambda_2$

$$\Rightarrow n_2 = \frac{n_1\lambda_1}{\lambda_2} = \frac{92\times5898}{5461} \cong 99.360$$

Number of fringes are integers so $n_2 = 99$

23. Mica sheet of thickness 't'

Refractive index 'μ'



$\Delta X_P = S_2P - [(S_1P - t)_{air} + t_{sheet}]$

$= (S_2P - S_1P) - (\mu t - t)$

$= d\sin\theta - (\mu-1)t$

Additional path difference

Position of n^{th} maxima

$$n\lambda = \frac{dy_n}{D} - (\mu-1)t \Rightarrow y_n = \frac{nD\lambda}{d} + \frac{D}{d}(\mu-1)t$$

Shift of interference pattern $= \frac{D}{d}(\mu-1)t$

24. Central fringe is that fringe where the path difference $\Delta x = 0$, for all wavelengths. So the central fringe is white followed by the some coloured fringes and after that there is very much overlapping in fringes so equal illumination exists.

25. Central maxima i.e.

$$I_0 = (\sqrt{I_1} + \sqrt{I_2})^2 \Rightarrow I_0 = (2\sqrt{I})^2 = 4I$$

$$\therefore I = \frac{I_0}{4}$$

[Intensity due to single slit]

26. For maxima, $I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

When $I_1 = I_2$ then $I_{max} = 4I$

For minima $I_{min} = \left(\sqrt{I_1} \sim \sqrt{I_2}\right)^2$ $I_{min} = 0$

$$I_2 = \frac{I_1}{2}, \text{ then } I'_{max} = \left(\sqrt{\frac{I_1}{2}} + \sqrt{I_1}\right)^2 < 4I_1$$

$$I'_{min} = \left(\sqrt{\frac{I_1}{2}} \sim I_1\right)^2 > I_{min}$$

27. $\lambda = 200nm$, $d = 700$ nm

No. of maxima $= \frac{2d}{\lambda} = \frac{2 \times 700nm}{200nm} = 7$

28. Fringe width remains unchanged $\beta = \frac{\lambda d}{D}$

But central bright fringe (zero path difference)

Shift downwards therefore whole fringe pattern shifts downwards.

29. When $\mu=1$ i.e. no change in path difference due to optical path difference so the mid point of the screen is again the central bright fringe.

But when $\mu > 1$ the central bright fringe will shift according to $\frac{D}{d}(\mu-1)t$

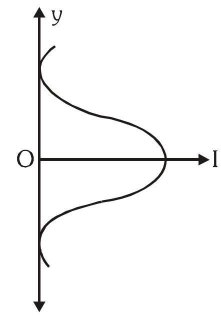
As μ increases, CBF will shift upwards from midpoint i.e. at mid point. Less bright fringe appears and when the shift is equal to value of fringe width, the dark fringe (zero intensity) will appear.

OR

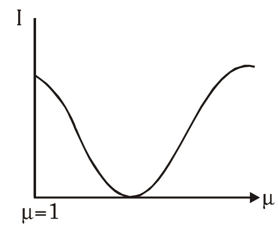
- Intensity variation

  $O \equiv$ central bright fringe

  $y \equiv$ distance from 'O' screen

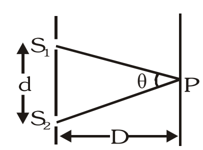


- When μ increases, the fringe patterns shift towards the slit when sheet introduced shift $\frac{D(\mu-1)}{t}$ from the above two fact variation in I with μ is



31. There is a phase change of π when the ray enters from rarer medium into denser medium, the boundary is called rigid boundary and also no change in phase when it enters into rarer medium.

32. As distance between S_1 & S_2 is very much less and equal to 'd' so the angle made at 'P' is very much small



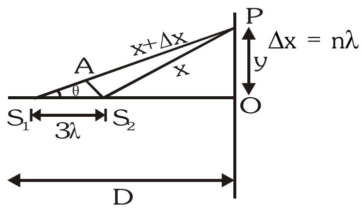
$$\therefore \text{Angle} = \frac{Arc}{D} \Rightarrow \theta = \frac{d}{D}$$

$$\therefore \text{Fringe width} = \frac{\lambda D}{d} = \frac{\lambda}{\theta} \quad \left(\because \frac{d}{D} = \theta\right)$$

34. Path difference for points A & C is O so constructive interference take place.

Path difference for B & D = $5\mu m = \frac{5\lambda}{2}$

So distructive interference take place.

35. 

in this case path difference is d cos θ.

So $n\lambda = \lambda = 3\lambda\cos\theta \Rightarrow \cos\theta = \frac{1}{3}$

$\Rightarrow \frac{D}{\sqrt{D^2+y^2}} = \frac{1}{3} \Rightarrow 3D = \sqrt{D^2+y^2}$

$\Rightarrow y = \sqrt{8}D = 2\sqrt{2}D$

36. Let t be the thickness so corresponding

$\Delta x = \mu t = \frac{3}{2}t$. Also $I_{max} = 4I$ so $I' = 2I$

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

$\Rightarrow 2I = I + I + 2\sqrt{I^2}\cos\left(\frac{3\pi t}{\lambda}\right) \Rightarrow \cos\left(\frac{3\pi t}{\lambda}\right) = 0$

$\Rightarrow \cos\left(\frac{3\pi t}{\lambda}\right) = \cos\frac{\pi}{2}$ or $\cos\frac{3\pi}{2}$ or $\frac{5\pi}{2}$

$\Rightarrow \frac{3\pi t}{\lambda} = \frac{\pi}{2} \Rightarrow t = \frac{\lambda}{6}$; $\frac{3\pi t}{\lambda} = \frac{3\pi}{2} \Rightarrow t = \frac{\lambda}{2}$

and $\frac{3\pi t}{\lambda} = \frac{5\pi}{2} \Rightarrow t = \frac{5\lambda}{6}$

37. At the central Maxima Δx=0

But upward shift $= \frac{(2\mu-1)tD}{d}$ and

Downward shift $= \frac{(\mu-1)2tD}{d}$

So net shift $y = \frac{tD}{d}[2\mu - 1 - 2\mu + 2] \Rightarrow y = \frac{tD}{d}$

38. $I' = \frac{3}{4}(4I) = 3I$.

So $4I = I + I + 2I\cos\phi \Rightarrow \cos\phi = \frac{1}{2} \Rightarrow \phi = \frac{\pi}{3}$

But value should lie between 3π & 6π.

So it cannot be $\frac{\pi}{3}$

For second minima $\phi = 3\pi$

For third maxima $\phi = 6\pi$

EXERCISE –II

1. Path differences

$\Delta x_1 = \frac{\lambda}{2}, \Delta x_2 = \lambda, \Delta x_3 = \frac{\lambda}{4}, \Delta x_4 = \frac{3\lambda}{4}$

Therefore $I_2 > I_3 = I_4 > I_1$

2. Path difference $= \frac{\lambda}{6}$

$\therefore$ Phase difference $= \frac{2\pi}{6} = \frac{\pi}{3}$

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

If $I_1 = I_2 = I$ then intensity at central

$I_0 = I + I + 2\sqrt{I}\sqrt{I}\cos 0 = 4I$

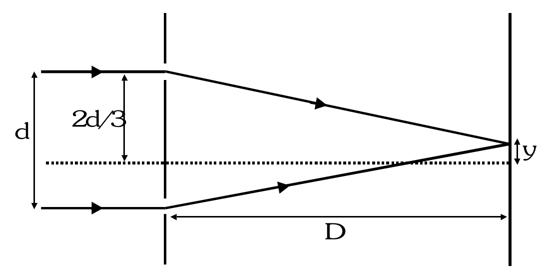
and intensity at a point 'P'

$I' = I + I + 2\sqrt{I}\times\sqrt{I}\times\cos\frac{\pi}{3}$

$= 3I = \frac{3}{4}\times 4I = \frac{3}{4}\times I_0 = 0.75\ I_0$

3. Phase difference $= \frac{2\pi}{\lambda}\times$ Path difference

4. Let the distance 'y'from 'O' where nearest white spot occurs. Then the path difference = 0



$\Rightarrow \sqrt{D^2 + \left(\frac{2d}{3} - y\right)^2} - \sqrt{D^2 + \left(\frac{d}{3} + y\right)^2} = 0$

$\therefore y = \frac{d}{6}$

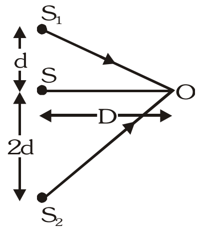
5. Path difference occurs due to the medium of variable refractive index = (μ–1)t

$\therefore \int_0^{\ell}\{(1+ax)-1\}dx = \frac{a\ell^2}{2}$

For minima at '0' the path difference should be $\frac{\lambda}{2}$ (for minimum value of)

$\therefore \frac{a\ell^2}{2} = \frac{\lambda}{2}, \therefore a = \frac{\lambda}{\ell^2}$

6. For reflected light waves the two virtual source (images of source in mirrors) at a distance '3d'
Path difference at O = $S_2O - S_1O$

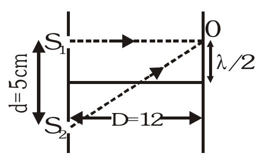


$$\sqrt{D^2+(2d)^2}-\sqrt{D^2+d^2}=\lambda$$

$$\Rightarrow D^2 + 4d^2 = D^2 + d^2 + \lambda^2 + 2\sqrt{D^2+d^2}\,\lambda$$

$$\Rightarrow 3d^2 = 2D\lambda \Rightarrow \lambda=\frac{3d^2}{2D}$$

7. By Geometry, path difference at '0' for minima should be $(2n-1)\frac{\lambda}{2}$



$\therefore S_2O - S_1O = (2n-1)\frac{\lambda}{2}$

$$\Rightarrow \sqrt{D^2+d^2}-D=(2n-1)\frac{\lambda}{2}$$

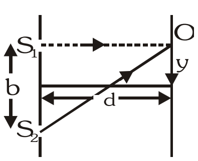
$$\Rightarrow (13-12)\text{cm} = (2n-1)\frac{\lambda}{2}$$

For n=1, 2,3 $\Rightarrow \lambda$ = 2cm, $\frac{2}{3}$ cm,

8. As path difference $d\sin\theta = n\lambda \Rightarrow d=\frac{n\lambda}{\sin\theta}$
As $\sin\theta < 1$ so $d > n\lambda$, where n is an integer
Therefore $d \neq \lambda$ and $d \neq \frac{\lambda}{2}$

10. Seperation between slits =b, screen distance d (>>b)
Path difference at 'O' must be odd multiple of $\frac{\lambda}{2}$

for missing wavelengths $S_2O - S_1O = \frac{n\lambda}{2}$



$$\Rightarrow \sqrt{d^2+b^2}-d=\frac{n\lambda}{2}$$

$$\Rightarrow d^2 + b^2 = d^2+\frac{n^2\lambda^2}{4}+2\times\frac{n\lambda}{2}\times d$$

$$\Rightarrow \lambda=\frac{b^2}{nd}\ (n=1,3,5)$$

11. The intensity of light is $I(\theta) = I_0\cos^2\left(\frac{\delta}{2}\right)$

where $\delta=\frac{2\pi}{\lambda}(\Delta x)=\left(\frac{2\pi}{\lambda}\right)(d\sin\theta)$

(i) For θ = 30

$$\lambda=\frac{c}{\nu}=\frac{3\times10^8}{10^6}=300\text{ m and } d = 150 \text{ m}$$

$$\delta=\left(\frac{2\pi}{300}\right)(150)\left(\frac{1}{2}\right)=\frac{\pi}{2}\quad\therefore\ \frac{\delta}{2}=\frac{\pi}{4}$$

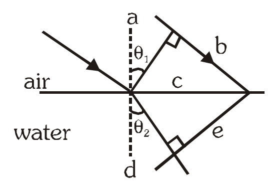
$$\therefore I(\theta)=I_0\cos^2\left(\frac{\pi}{4}\right)=\frac{I_0}{2}$$

(ii) For θ = 90

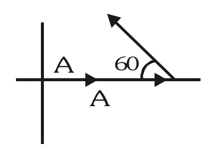
$$\delta=\left(\frac{2\pi}{300}\right)(150)(1)=\pi \Rightarrow \frac{\delta}{2}=\frac{\pi}{2} \text{ and } I(\theta)=0$$

(iii) For θ = 0 : $\delta = 0 \Rightarrow \frac{\delta}{2}=0 \quad \therefore I(\theta) = I_0$

12. From the snells law
1 $\sin(90-\theta_1) = \mu\sin\theta_2$
$1\ \frac{b}{c}=\mu\times\frac{d}{c}\ \therefore\ \mu=\frac{b}{d}$



13. $d_{12}=\frac{2\pi}{\lambda}\times\frac{\lambda}{6}\times2=\frac{2\pi}{3}$



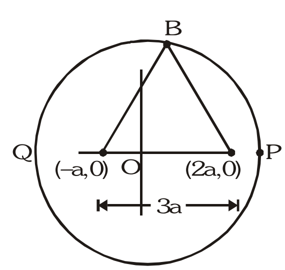
$$d_{23}=\frac{2\pi}{\lambda}\times\frac{\lambda}{2}\times2=2\pi$$

$$A'=\sqrt{\left(\frac{\sqrt{3}A}{2}\right)^2+\left(\frac{3A}{2}\right)^2}=\sqrt{3}A$$

$\Rightarrow I \propto A^2 \Rightarrow A_R^2 = 3A^2 \Rightarrow I_R = 3I$

14. fringes to be more closed when fringe width becomes reduced fringe width $\beta=\frac{\lambda D}{d}$
As λ decrease β also decreases ($\lambda_{Blue} < \lambda_{green}$)

15. $\lambda = \frac{a}{5}$



For point P, $\Delta x = 3a = 15\lambda$ and at point Q it is also 15λ somewhere at point B, it is zero thus in half part of the circle available maxima
15 2 = 30
Thus total maxima = 2 30 = 60

16. The maxima at P becomes minima & then maxima alternately. But central bright fringe is always remain at O.

17. Here the shift produced by mica sheet of thickness t is $(\mu t - t) = t(\mu - 1)$. It should be equal to extra path traveled by the ray SS_2O i.e. $\Delta = SS_2 - d = \sqrt{2}d - d$

$\Rightarrow \frac{t}{2} = d(\sqrt{2}-1) \Rightarrow t = 2d(\sqrt{2}-1)$ infront of S_1

21. $\beta = \dfrac{(a+b)\lambda}{2a(\mu-1)\alpha} = \dfrac{\left(1+\frac{b}{a}\right)\lambda}{2(\mu-1)\alpha}$

For parallel beam, $a \simeq \infty$. So $\beta = \dfrac{\lambda}{2(\mu-1)\alpha}$

EXERCISE – III

True/False

2. For interference pattern, sources must be cohrent and two independent light sources are never be coherent.

3. Central bright fringe (Path difference at this point is zero so this fringe is white then following fringes are coloured.)

Match the Column

1. Additional path difference by introducing the thin sheet is given by $(\mu-1)t$

Resultant path difference at P = Geometrical path difference + Optical path difference

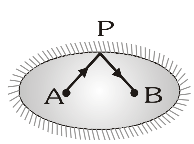
Comprehension–1

1. Optical path length

$$= \int \mu dx = \int_0^1 \left(1+x^2\right) dx = \left(x + \frac{x^3}{3}\right)_0^1 = \frac{4}{3} m$$

2. Optical path length must be optimum i.e. minimum.

3.



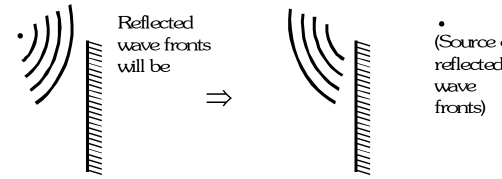
For any point AP + PB = constant
= 2 (semi–major axis of ellipse)

Comprehension–3

1. Wave front of point source is spherical. The point source is at origin and distance travelled by wave in 't' time with a speed of light 'c' is 'ct'. Hence radius of wave front is 'ct'.

$\therefore$ Equation of sphere is $x^2 + y^2 + z^2 = (ct)^2$

2.



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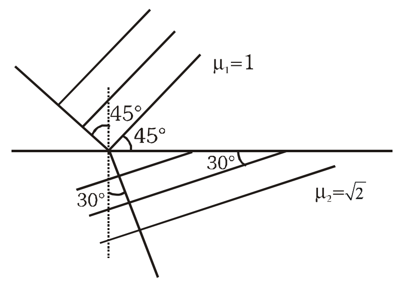
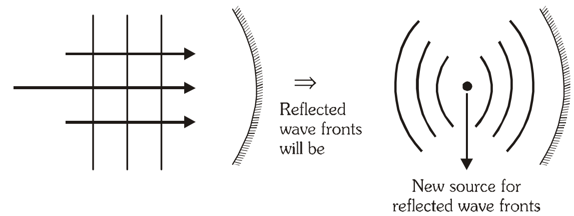


$\mu_1 \sin 45 = m_2 \sin\theta \Rightarrow \theta = 30$

4.



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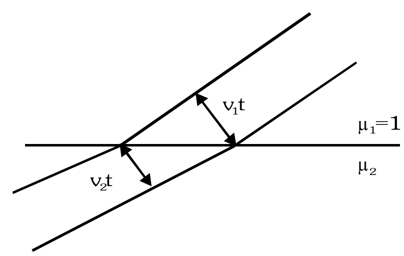


$\frac{v_1 t}{v_2 t} = \frac{\mu_2}{\mu_1} \Rightarrow \frac{2}{1} = \frac{\mu_2}{1} \Rightarrow \mu_2 = 2$

6. Angle made by the direction of light with the y–axis is $\cos\beta = \dfrac{2}{\sqrt{1^2+2^2+3^2}} = \dfrac{2}{\sqrt{14}}$

Comprehension–4

1. Third order bright fringe is the 3rd bright fringe from the central bright fringe having 3λ path difference.

2. At central bright fringe the waves from slits are in phase and following bright fringes having a difference of 2π. $4\pi = 2 \quad 2\pi \Rightarrow$ 2nd order bright fringe

3. CBF $\Rightarrow$ Path difference = 0

$\Delta X_A \rightarrow$ At 1,

dark fringe having path difference $= \frac{\lambda}{2}$

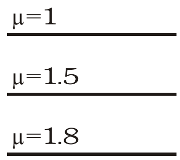
$\Delta X_c \rightarrow$ At 3,
bright fringe having path difference= λ

$$\therefore (|\Delta X_c| - |\Delta X_A|) = \left(\lambda - \frac{\lambda}{2}\right) = \frac{\lambda}{2} = \frac{600}{2}\text{nm} = 300\text{nm}$$

Comprehension–6

1. For strongly reflect light path difference

$(2\mu t + \frac{\lambda}{2}) - \frac{\lambda}{2} = \lambda$ (for minimum thickness)



$2\mu t = \lambda \quad \therefore\ t = \frac{600\text{nm}}{2\times 1.5} = 200\text{nm}$

2. Again as previous question path difference for n,t reflect light must be the odd multiple of $\frac{\lambda}{2}$

$\therefore\ 2\mu t = \frac{n\lambda}{2}$

$\therefore\ t = \frac{n\times 640}{2\times 2\times 1.33}\text{nm} = n \quad 120$ (n=1,3,5)

Hence = 3   120 = 360 nm

3. Path difference $\Rightarrow 2\mu t - \frac{\lambda}{2} = 0$

$2\mu t = \frac{\lambda}{2} \Rightarrow t = \frac{\lambda}{2\times 2\times \mu} = \frac{\lambda}{4\mu}$

4. t = 350nm, n = 1.35

$2nt - \frac{\lambda}{2} = \frac{m\lambda}{2}$ (m =1,3,5,...)

$$t = \frac{(m+1)\frac{\lambda}{2}}{2\times 1.35} = 350\text{nm}$$

$$\lambda = \frac{350\times 2.7\times 2}{(m+1)} = \frac{945\times 2}{m+1}$$

For m = 1,3,5, λ = 945, 473...

5. t = 1 μm, n = 1.35, λ = 600 nm

Path difference = $\left|2\times 1.35\times 10^{-6} - \frac{\lambda}{2}\right|$

$2.7 \quad 10^{-6} - 300 \quad 10^{-9} = 2.4\ \mu m$

EXERCISE –IV(A)

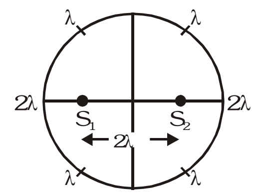
1. (i) $I_{result} = I + 4I + 2\sqrt{I}\times\sqrt{4I}\cos\frac{\pi}{4}$

$= 5I + 2\sqrt{2}I = 7.8I$

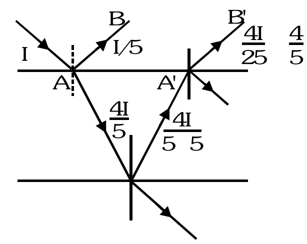
(ii) $I_{result} = I + 4I + 2\sqrt{I}\times\sqrt{4I}\times\cos\pi = 5I - 4I = I$

(iii) $I_{result} = I + 4I + 2\sqrt{I}\ \sqrt{4I}\ \cos 4\pi = 5I + 4I = 9I$

2. The position of maxima where the path difference between two ways is integral multiple of λ.
And positions of minima where the path difference between two ways is odd multipleof $\lambda/2$.



3. As given reflection cofficient = 20% $\therefore$ AB = $\frac{I}{5}$



$A'B' = \frac{16I}{125}$

If AB and A'B' interference than

$$I_{max} = \left(\sqrt{\frac{I}{5}} + \sqrt{\frac{16I}{125}}\right)^2 = \frac{I}{5}\times\frac{81}{25}$$

$$I_{min} = \left(\sqrt{\frac{I}{5}} - \sqrt{\frac{16I}{125}}\right)^2 = \frac{I}{5}\times\frac{1}{25}$$

$\therefore\ I_{max}/I_{min} = 81 : 1$

4. d = 0.2 cm, λ = 5896 Å, D =1m

Fringe width $\beta = \frac{\lambda D}{d} = \frac{5896\times 10^{-10}\times 1}{0.2\times 10^{-2}} = 0.3$ mm

If system is immersed in water (μ=1.33), then the fringe width becomes

$$\beta' = \frac{\beta}{\mu} = \frac{0.3}{1.3}\text{mm} = 0.225\ \text{mm}$$

5. Shifting of fringe pattern due to plate is given by
$\frac{D}{d}(\mu-1)t$ [Towards the side of plate]
Due to two plates introducing infront of slits then shifting is resultant of both

$$\frac{D}{d}[(1.7 - 1)2t - (1.4-1)t] = \frac{5\lambda D}{d}$$

(Position of 5th bright fringe)
(t – thickness of one plate)
t = 5λ = 5   4800 Å = 2.4 μm
∴ Thickness of second = 2t = 4.8 μm

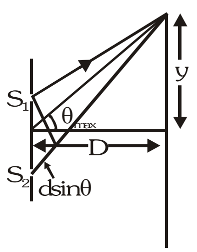
6. Fringe width $\beta = \frac{\lambda D}{d}$; $\beta' = \frac{\lambda(D - 5\times10^{-2})}{d}$

Given $|\beta' - \beta| = \left|\frac{\lambda(D - 5\times10^{-2})}{d} - \frac{\lambda D}{d}\right|$

$\therefore 3 \quad 10^{-5} = \frac{\lambda \times 5\times10^{-2}}{d}$

$\therefore \lambda = \frac{3\times10^{-5}\times10^{-3}}{5\times10^{-2}} = 6000$ Å

7. The length of the screen for the fringe pattern = 2y



$\because$ d sin θ_{max} = $\frac{y}{D}$ =1; y = D

∴ No. of maxima

$$= \frac{2\times D}{\text{fringe width}} = \frac{2D}{\lambda D/d}$$

$$= \frac{2d}{\lambda} = \frac{2\times5\text{cm}}{3\text{cm}} = 3.3 \text{ (say 3)}$$

8. Due to the introduction of sheet in front of one slit (thickness t and refrective index μ) the shift = $\frac{D}{d}(\mu-1)t$ i.e. the path difference becomes (μ–1)t instead of zero at centre of screen (Δx ≠ 0)

∴ Phase difference = $\frac{2\pi}{\lambda}\times(\mu-1)t$

∴ Resultant intensity

$$I_0 = \frac{I}{4} + \frac{I}{4} + 2\sqrt{\frac{I}{4}}\sqrt{\frac{I}{4}}\cos\left[\frac{2\pi}{\lambda}(\mu-1)t\right]$$

Intensity at centre I = 4I' ⇒ I' = $\frac{I}{4}$

[I' – Intensity due to one slit]

$$I_0 = \frac{2I}{4}\left[1 + \cos\left[\frac{2\pi}{\lambda}(\mu-1)t\right]\right]$$

$$I_0 = I\cos^2\left[\frac{2\pi}{\lambda}\frac{(\mu-1t)}{2}\right] = I\cos^2\left(\frac{\pi(\mu-1)t}{\lambda}\right)$$

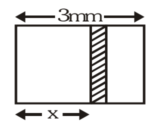
EXERCISE –4(B)

1. I = 10^{-15} W/m², λ = $4000\sqrt{3}$ Å, t = 3mm.

The path difference due to glass plate 3mm

Path difference= $\int ds = \int_0^{3mm}(n-1)dx$

$$\int_0^3 (1+\sqrt{x}-1)dx = \frac{2}{3}x^{3/2} = 2\sqrt{3}\text{mm}$$



∴Phase difference

$$= \frac{2\pi}{4000\sqrt{3}\times10^{-10}}\times2\sqrt{3}\times10^{-3} = \pi \quad 10^{7-3}$$

∴ 2πn = 10^4 π

At point I there is point of maxima n = 5 10^3

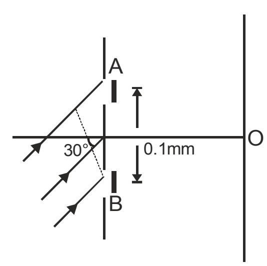
∴ Intensity = I + I + $2\sqrt{I}\times\sqrt{I}$ cos 10^4 π

= 4I = 4 10^{-15} W/m²

2. Fringe pattern forms on a screen the distance of the nth maxima in x–direction i.e. x cordinates is nλD' and y–position is decided by the SHM of spring.

$$D' = D + \frac{Mg}{k}(1-\cos\omega t)$$

3. Path difference = d cos 60



As given at 0 the Intensity = 3I

3I = I + 4I+$2\sqrt{I}\sqrt{4I}$ cosϕ

$$\phi = \frac{2\pi}{3}$$

$$\frac{2\pi}{\lambda}\left[\frac{d}{2} + (1.5-1)\times20.4\times10^{-6} - \frac{1}{2}t\times10^{-6}\right] = \frac{2\pi}{3}$$

⇒ 0.1 10^{-3} + (20.4 – t)10^{-6}

= 2/3   6000 10^{-10} = 4 10^{-7}

⇒ t = 20.4 – 0.4 + 100 = 120 μm

4. Fringe width

$$\beta = \frac{\lambda D}{d} = \frac{(5000\times10^{-10})(80\times10^{-2})}{\frac{4}{3}\times2\times10^{-3}} m = 150\ \mu m$$

Net upward shift

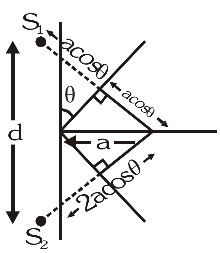
$$= \frac{D}{d}\left({}_{w}\mu_{g} - 1\right)t_1 - \frac{D}{d}\left({}_{w}\mu_{y} - 1\right)t_2 = 25\mu m$$

Phase difference at point C

$$\Delta\phi = 2\pi\left(\frac{25\mu m}{150\mu m}\right) = \frac{\pi}{3}$$

$$I_C = I_{max}\cos^2\frac{\Delta\phi}{2} = I_{max}\left(\frac{3}{4}\right) \Rightarrow \frac{I_C}{I_{max}} = \frac{3}{4}$$

5. Distance between two sources S_1 and S_2
$d = 2\ \ 2a\cos\theta\sin\theta = 2a\sin2\theta$



Screen distance $D = b + 2a\cos^2\theta$

$$\beta = \frac{\lambda D}{d} = \frac{\lambda(b+2a\cos^2\theta)}{2a\sin2\theta} = \frac{\lambda(b+2a)}{4a\theta}$$

(if θ is very much small)

6. (i) For the lens, u = –0.15 m; f = +0.10 m

Therefore, using $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ we have

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{(-0.15)} + \frac{1}{(0.10)} \quad \text{or} \quad v = 0.3\ m$$

Linear magnification , $m = \frac{v}{u} = \frac{0.3}{-0.15} = -2$

Hence, two images S_1 and S_2 of S will be formed at 0.3 m from the lens as shown in figure. Image S_1 due to part 1 will be formed at 0.5 mm above its optic axis (m=–2). Similarly, S_2 due to part 2 is formed 0.5 mm below the optic axis of this part as shown.

Hence, d = distance between S_1 and S_2 = 1.5 mm

Δ = 1.30 – 0.30 = 1.0 m = 10^3 mm

λ = 500 nm = 5 10^{-4} mm

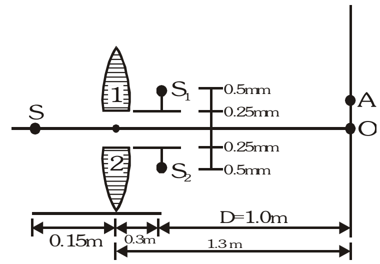
Therefore, fringe width,

$$\omega = \frac{\lambda D}{d} = \frac{(5\times10^{-4})(10^3)}{(1.5)} mm = \frac{1}{3} mm$$

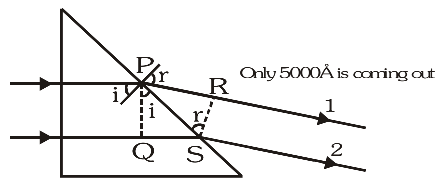
Now, as the point A is at the third maxima

OA = 3ω = 3(1/3) mm or OA = 1mm

(ii) If the gap between L_1 and L_2 is reduced, d will decrease. Hence, the fringe width ω will increase or the distance OA will increase.



7. Path difference between rays 1 and 2 :



$\Delta x = \mu(QS) - PR$ ...(i)

Further $\frac{QS}{PS} = \sin i$; $\frac{PR}{PS} = \sin r$

$\therefore \frac{PR/PS}{QS/PS} = \frac{\sin r}{\sin i} = \mu \ \therefore\ \mu(QS) = PR$

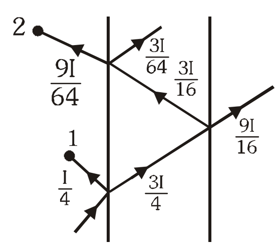
Substituting in equation (i), we get $\Delta x = 0$

∴ Phase difference between rays 1 and 2 will be 0 or these two rays will interfere constructively.

So maximum intensity will be obtained from their interference or

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{4I} + \sqrt{I}\right)^2 = 9I$$

8. Each plate reflects 25% and transmits 75 . Incident beam has an intensity I. This beam undergoes multiple reflections and refractions. The corresponding intensity after each reflection and refraction (transmission) are shown in figure.



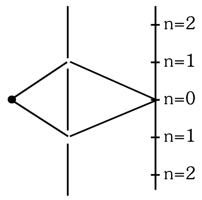
Interference pattern is to take place between rays 1 and 2. $I_1 = I/4$ and $I_2 = 9I/64$

$$\therefore \frac{I_{min}}{I_{max}} = \left(\frac{\sqrt{I_1} - \sqrt{I_2}}{\sqrt{I_1} + \sqrt{I_2}}\right)^2 = \frac{1}{49}$$

EXERCISE – V-A

1. To demonstrate the phenomenon of interference we require coherent sources, i.e., sources with same frequency and a fixed phase relationship.

2. $d\sin\theta = n\lambda \Rightarrow n=\frac{d\sin\theta}{\lambda}=\frac{2\lambda\sin\theta}{\lambda}=2\sin\theta$



$\Rightarrow$ $n_{max} = 2$

$\Rightarrow$ Maximum number of possible interference maxima = $(2n_{max} + 1) = 5$

3. The shape of interference fringes on the screen is hyperbola.

4. The intensity at a general point with respect to maximum intensity is $I = I_0\cos^2\left(\frac{\phi}{2}\right)$

Phase difference, $\phi=\left(\frac{2\pi}{\lambda}\right)$ (Path difference)

$\Rightarrow \phi=\frac{2\pi}{\lambda}\frac{\lambda}{6}=\frac{\pi}{3}$

Hence, $\frac{I}{I_0}=\left[\cos\left(\frac{60}{2}\right)\right]^2=\left(\frac{\sqrt{3}}{2}\right)^2=\frac{3}{4}$

5. Third bright of known light

$X_3 = \frac{3\lambda_1 D}{d}$ ..... (1)

4^{th} bright of unknown light

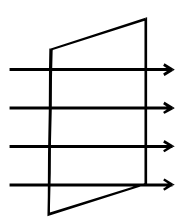
$X_4 = \frac{4\lambda_2 D}{d}$ ..... (2)

Given $X_3 = X_4$

$3\lambda_1 = 4\lambda_2$

$\lambda_2 = \frac{3}{4}\lambda_1 = \frac{3}{4}$ 590 = 442.5 nm

6. Parallel cylindrical beam gives planar wavefront

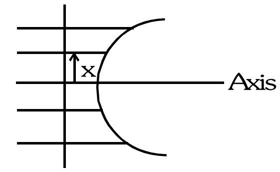


7. $\mu = \frac{c}{v} \Rightarrow v = \frac{c}{\mu}$

Since I is decreasing so μ also decreases and hence v increases

So v is minimum on the axis of the beam.

8.



converge when it enter in the medium.

When light is moving and as it enters the medium than along the axis velocity is decreasing so as we move away from the centre (that is x in figure) the wave covers less distance and hence shape is convex.

9. At P : $\Delta x = 0$; $\Delta\phi=\frac{2\pi}{\lambda}\times 0=0$

$I_P=\left(\sqrt{I}+\sqrt{I}\right)^2=4I$

At Q : $\Delta x=\frac{\lambda}{4}$

$I_Q=I+I+2\sqrt{II}\cos\frac{\pi}{2}=2I$; $\frac{I_P}{I_Q}=\frac{4I}{2I}=\frac{2}{1}$

10. $I_{coherent}=\left(\sqrt{I}+\sqrt{I}\right)^2=4I$

$I_{noncoherent} = I + I = 2I$

$\frac{I_{coherent}}{I_{noncoherent}}=\frac{4I}{2I}=\frac{2}{1}$

11. $I_{max}=\left(\sqrt{I}+\sqrt{4I}\right)^2=9I=I_m \Rightarrow I=\frac{I_m}{9}$

$I_P = I + 4I + 2\sqrt{(I)(4I)}\cos\phi$

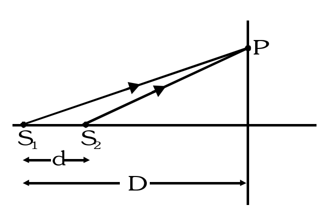
$= 5I + 4I\cos\phi$

$= I + 4I(1 + \cos\phi)$

$= I + 8I\cos^2\frac{\phi}{2}$

$= \frac{I_m}{9}\left(1+8\cos^2\frac{\phi}{2}\right)$

12. For bright fringe $S_1P - S_2P = n\lambda$



So fringes are concentric circles (centre of origin)

EXERCISE –V-B

1. $I_A = I + 4I + 2\sqrt{4I^2}\cos\frac{\pi}{2} = 5I$

$I_B = I + 4I + 2\sqrt{4I^2}\cos\pi = I$

So difference $I_A - I_B = 4I$

2. As path difference due to slab = $(\mu-1)t$

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

for minimum thickness t of plate, n should be minimum i.e. n=1 $\therefore (\mu-1)t = \lambda$

$\Rightarrow t = \frac{\lambda}{\mu-1} \Rightarrow t = \frac{\lambda}{1.5-1} \Rightarrow t = 2\lambda$

3. In ΔOPR ; $\frac{PR}{OP} = \cos\theta \Rightarrow OP = \frac{d}{\cos\theta}$

in ΔCOP $\cos 2\theta = \frac{OC}{OP}$

$\Rightarrow OC = OP\cos 2\theta = \frac{d\cos 2\theta}{\cos\theta}$

So Path difference = CO + OP + $\frac{\lambda}{2}$

$= \frac{d\cos 2\theta}{\cos\theta} + \frac{d}{\cos\theta} + \frac{\lambda}{2}$

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

Now for constructive interference at P between BP and OP, path difference = $n\lambda$

$\Rightarrow 2d\cos\theta + \frac{\lambda}{2} = n\lambda \Rightarrow 2d\cos\theta = \left(n - \frac{1}{2}\right)\lambda$

$\Rightarrow \cos\theta = \left(\frac{2n-1}{4d}\right)\lambda$; For n = 1, $\cos\theta = \frac{\lambda}{4d}$

4. At the area of total darkness, in double slit apparatus, minima will occur for both the wavelength which are incident simultaneously and normally.

$\left(\frac{2n+1}{2}\right)\lambda_1 = \frac{(2m+1)}{2}\lambda_2 \Rightarrow \frac{2n+1}{2m+1} = \frac{\lambda_2}{\lambda_1}$

$\Rightarrow \frac{2n+1}{2m+1} = \frac{560}{400} = \frac{7}{5}$ or $10n = 14m + 2$

By inspection, the two solutions are

(i) If $m_1 = 2$, $n_1 = 3$ (ii) If $m_2 = 7$, $n_2 = 10$

$\therefore$ Distance between are as correspond to these points.

$\therefore$ Distance $\Delta S = \frac{D\lambda_1}{d}\left[\frac{(2n_2+1)-(2n_1+1)}{2}\right]$

Now putting $n_2 = 10$ and $n_1 = 3$

$\Delta S = 4 \quad 7 \quad 10^{-3}$ m $\Rightarrow \Delta S = 28$ mm

5. Given $I_R = \frac{4I}{4} = I$. So $I = I + I + 2I\cos\phi$

$\cos\phi = -\frac{1}{2} \Rightarrow \phi = \frac{2\pi}{3}$

Corresponding path difference $\Delta x = \frac{\lambda}{3}$

So $d\sin\theta = \frac{\lambda}{3} \Rightarrow \theta = \sin^{-1}\left(\frac{\lambda}{3d}\right)$

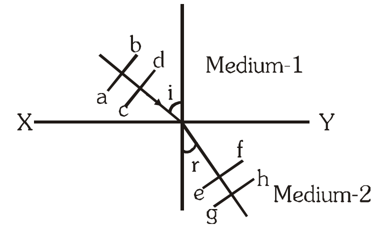
6. $I_{net} = I_0 + I_0 + 2I_0\cos\phi = \frac{I_{max}}{2} = 2I_0 \Rightarrow \cos\phi = 0 \Rightarrow \phi = n\pi + \frac{\pi}{2} = \frac{2\pi}{\lambda}\Delta x \Rightarrow \Delta x = (2n+1)\frac{\lambda}{4}$

MCQ

1. Given d, λ, $I_1 = 4I_2$, $I_1 = 4I$ & $I_2 = I$
if $d=\lambda$, then maximum path difference ($d\sin\theta$) will be less than λ. So there will be only central maxima on the screen, because in the equation $d\sin\theta = n\lambda$, n can take only one value.
If $\lambda < d < 2\lambda$, then the maximum path difference will be less than 2λ. So there will be two more maximum on screen in addition to the central maximum. Intensity of dark fringes becomes zero if intensities at the two slits made are equal.
[So C & D are not correct]

Comprehension based questions

1.



The wave fronts in both the media, are parallel, the light will be a parallel beam.

2. Point c and d are on the same wave fronts, $\phi_C = \phi_d$.
Also $\phi_c = \phi_f$. So clearly $\phi_d - \phi_f = \phi_c - \phi_e$

3. As the ray bends towards the normal so medium (2) is denser.

Match the column

1. **(A)** P_0 central maxima so has highest intensity.

(B) $\delta(P_0) = \frac{\lambda}{4}$ $\quad I(P_0) = 2I$

$\delta(P_1) = 0$ $\quad I(P_1) = 4I$

$\delta(P_2) = \frac{\lambda}{4} - \frac{\lambda}{3}$ $\quad I(P_2) = 2I + 2I \frac{\sqrt{3}}{2}$

$= \frac{3\lambda - 4\lambda}{12} = 2I + \sqrt{3}\ I$

$= -\frac{\lambda}{12} = I\ (3.732) = 3.732\ I$

(C) $\delta(P) = \frac{\lambda}{2}$ $\quad I\ (P_0) = 0$

$\delta(P_1) = -\frac{\lambda}{4}$ $\quad I(P_1) = 2I$

$\delta(P_2) = \frac{\lambda}{2} - \frac{\lambda}{3}$ $\quad I(P_2) = 3I$

$= \frac{3\lambda - 2\lambda}{6} = \frac{\lambda}{6}$

(D) $\delta(P_0) = \frac{3\lambda}{4}$ $\quad I(P_0) = 2I$

$\delta(P_1) = \frac{3\lambda}{4} - \frac{\lambda}{4}$ $\quad I(P_1) = 2I - 2I = 0$

$\delta(P_2) = \frac{3\lambda}{4} - \frac{\lambda}{3}$ $\quad I(P_2) = 2I + 2I \frac{\sqrt{3}}{2}$

$= \frac{9\lambda - 4\lambda}{12} = \frac{5\lambda}{12} = 3.732\ I$

Subjective

1. (i) When the incident beam falls normally :

Let path difference = Δx

$\therefore \Delta x = S_2P - S_1P = d \sin \theta$

For minimum intensity

$\Rightarrow d \sin \theta = (2n-1)\frac{\lambda}{2} \Rightarrow \sin \theta = \frac{(2n-1)\lambda}{2d}$

$\Rightarrow \sin \theta = \frac{(2n-1)(0.5)}{2 \times 1} \Rightarrow \sin \theta = \frac{2n-1}{4}$

Since $\sin \theta \leq 1$ $\therefore$ n can be either 1 or 2

When n=1, $\sin \theta_1 = \frac{1}{4}$, $\tan \theta_1 = \frac{1}{\sqrt{15}}$

When n = 2, $\sin \theta_2 = \frac{3}{4}$, $\tan \theta_2 = \frac{3}{\sqrt{7}}$

$\therefore$ y = D tan θ or y = 1 tan θ

For minima, above centre O

$y_1 = \tan \theta_1 = \frac{1}{\sqrt{15}} = 0.26$ m

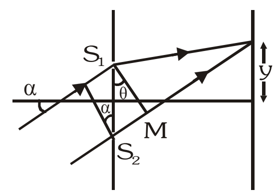
$y_2 = \tan \theta_2 = \frac{3}{\sqrt{7}} = 1.13$ m

For minima, below centre O,

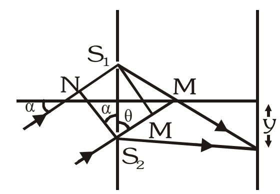
$y_1' = -0.26$ m $\quad y_2' = -1.13$ m

There will be four minima due to interference at positions ± 0.26 m, ± 1.13 m

(ii) When incident beam makes as angle of 30 with x–axis



$\Delta x_1 = d \sin\theta - d \sin\alpha$



$\Delta x_2 = d \sin\alpha + d \sin\theta$

For central maxima, path difference should be zero

$\Delta x_1 = 0$ or $\Delta x_2 = 0$

$d \sin \theta = d \sin \alpha \Rightarrow \alpha = \theta = 30$

$\because$ y = D tan θ $\therefore$ y = 1 tan 30 = 0.58 m

For first minima $d \sin \theta - d \sin \alpha = \frac{\lambda}{2}$

$\Rightarrow d \sin \theta = \frac{\lambda}{2} + d \sin \alpha \Rightarrow \sin \theta = \frac{\lambda}{2d} + \sin \alpha$

$\sin \theta = \frac{0.5}{2 \times 1} + \sin 30 \Rightarrow \sin \theta = 0.75 = \frac{3}{4}$

$\therefore y_2 = D \tan \theta = 1 \quad \frac{3}{\sqrt{7}} = 1.13$ m

For first minima, on either side,

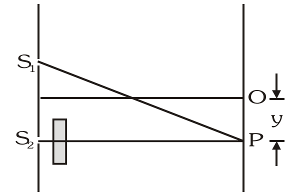
$d \sin \theta = \frac{\lambda}{2} \Rightarrow \sin \theta = \frac{\lambda}{2d} = \frac{0.5}{2 \times 0.1} = \frac{1}{4}$

$\therefore \tan\theta = \frac{1}{\sqrt{15}} = 0.26$ m

$\therefore y_1 = 1 \quad \tan \theta = 0.26$ m

Therefore y coordinates of the first minima on either side of the central maximum are y_1 = 0.26 m and y_2 = 1.13 m

2. (i) Location of central maximum on y–axis. Let the central maximum be obtained at a distance y below point O. It will be below O because glass sheet covers the lower slit.



$\Delta x_1 = S_1P - S_2P = \dfrac{yd}{D}$

Due to glass sheet $\Delta x_2 = \left(\dfrac{\mu_g}{\mu_m} - 1\right)t$

For zero path difference $\Delta x_1 = \Delta x_2$

$\Rightarrow \dfrac{yd}{B} = \left(\dfrac{\mu_g}{\mu_m} - 1\right)t \Rightarrow y = \left(\dfrac{\mu_g}{\mu_m} - 1\right)\dfrac{tD}{d}$

$\Rightarrow y = \left(\dfrac{3/2}{4/3} - 1\right)\left(\dfrac{10.4 \times 10^{-6}}{0.45 \times 10^{-3}}\right)(1.5)$

$y = 4.33 \quad 10^{-3}$m $= 4.33$ mm

(ii) Light intensity at O, $\Delta x_1 = 0$, $\Delta x_2 = \left(\dfrac{\mu_g}{\mu_m} - 1\right)t$

$\therefore$ Net path difference $= \Delta x_2$

$\therefore$ Net phase difference $= \dfrac{2\pi}{\lambda}\Delta x_2$

$\therefore \phi = \dfrac{2\pi}{6 \times 10^{-7}}\left(\dfrac{3/2}{4/3} - 1\right)(10.4 \quad 10^{-6}) = \dfrac{13\pi}{3}$

$\therefore I(\phi) = I_{max}\cos^2\left(\dfrac{\phi}{2}\right)$ or $\dfrac{I(\phi)}{I_{max}} = \dfrac{3}{4} = 0.75$

(iii) Wave length of light that form maxima at O, if 600nm light is replaced by 400 to 700 nm light :

At O, $\Delta x = \left(\dfrac{\mu_g}{\mu_m} - 1\right)t$

For maximum intensity at O, $\Delta x = n\lambda$, where n = 1,2,3.......

$\therefore \lambda = \dfrac{\Delta x}{1}, \dfrac{\Delta x}{2}, \dfrac{\Delta x}{3}, ...$

$\Delta x = \left(\dfrac{3/2}{4/3} - 1\right)(10.4 \quad 10^{-6}$ m$)$ or $\Delta x = 1300$ nm,

For maximum intensity at O,

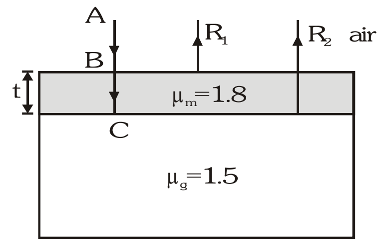
$\lambda = 1300$ nm, $\dfrac{1300}{2}$ nm, $\dfrac{1300}{3}$ nm, $\dfrac{1300}{4}$ nm

$\lambda = 1300$ nm, 650 nm, 433.33 nm,............

or $\lambda = 6.5 \quad 10^{-7}$ m, $4.33 \quad 10^{-7}$ m

3. AB denotes incident ray. It is partly reflected from the upper surface of layer as R_1. R_1 is reflected from a denser medium. It undergoes a phase change of π. Part of AB is reflected from surface of layer as R_2. R_2 is reflected from a rarer medium as ${}^a\mu_m = 1.8$ and ${}^a\mu_g = 1.5$.

There occurs no phase change in R_2.



R_1 and R_2 therefore possess an initial phase difference of π before they undergo interference. Now, for construction interference net phase difference should be $2n\pi$ where n is an integer.

$\Delta\phi = 2n\pi - \pi = (2n-1)\pi \therefore \Delta x = (2n-1)\dfrac{\lambda}{2}$

Since $\Delta x = 2(\mu_m)t = 1.8 \quad 2t = 3.6t$

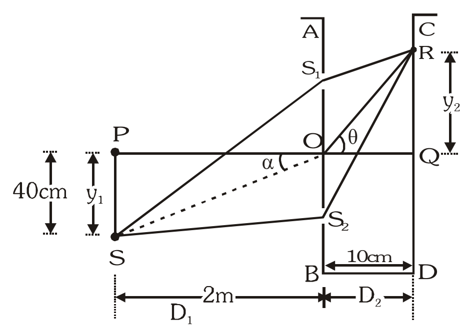
or $3.6\ t = (2n-1)\dfrac{\lambda}{2}$

For least value of t is n=1 $\therefore$ $3.6 \quad t_{min} = \dfrac{\lambda}{2}$

or $t_{min} = \dfrac{648}{3.6 \times 2}$ nm or $t_{min} = 90$nm.

4. (i) O is the middle point of slits S_1 & S_2

Also $S_1S_2 = d = 0.8$ mm in figure $\tan\alpha = \dfrac{y_1}{D_1}$



$\tan\alpha = \dfrac{40}{200} = \dfrac{1}{5} \therefore \sin\alpha = \dfrac{1}{\sqrt{26}} = \dfrac{1}{5.1} \approx \dfrac{1}{5} \approx \tan\alpha$

Path difference $\Delta x_1 = SS_1 - SS_2$

$\Delta x_1 = d\sin\alpha = 0.8\ \dfrac{1}{5}$ or $\Delta x_1 = 0.16$ mm ...(i)

Let R represents the position of CBF i.e.

Net path difference should be 0.

Now $\Delta x_2 = S_2R - S_1R$

or $\Delta x_2 = d\sin\theta \Rightarrow \Delta x_1 = \Delta x_2$ ...(ii)

For central bright fringe

$\Delta x_2 - \Delta x_1 = 0 \Rightarrow d\sin\theta - \Delta x_1 = 0$

$\Rightarrow d\sin\theta = \Delta x_1 = 0.16$ mm

$$\Rightarrow (0.8)\sin\theta = 0.16 \Rightarrow \sin\theta = \frac{0.16}{0.8} = \frac{1}{5}$$

$$\therefore\ \tan\theta = \frac{1}{\sqrt{24}} = \frac{1}{4.9} \simeq \frac{1}{5} = \sin\theta$$

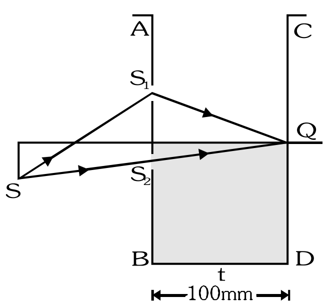
So $\tan\theta = \dfrac{y_2}{D_2} = \dfrac{1}{5} \Rightarrow y_2 = 2$ cm

Thus CBF will be 2cm above point Q.

(ii) When liquid of refractive index μ is poured.

Then for CBF at Q, net path difference = 0

$(\mu-1)t = \Delta x_1 \Rightarrow (\mu-1)100 = 0.16 \Rightarrow \mu-1 = 0.0016$



5. (i) S is a point source, fringes formed will be circular.

(ii) Ratio of minimum and maximum intensities :

Intensity of light direct from source= $I_1 = I_0$ (say)

Intensity after reflection $I_2 = 0.36\ I_0$

$$\therefore\ \frac{I_{min}}{I_{max}} = \left(\frac{\sqrt{I_1} - \sqrt{I_2}}{\sqrt{I_1} + \sqrt{I_2}}\right)^2 = \left(\frac{0.4}{1.6}\right)^2 = \frac{1}{16}$$

(iii) Shift of AB for same intensity

If intensity at P corresponds to maximum it means that constructive interference occurs at P.

$\therefore$ Path difference between direct waves from S and reflected waves, from reflector AB, is $n\lambda$

Let AB is shifted by x (towards P or away from P)

$\therefore$ additional path difference introduced = 2x

For minimum value of x_1 ; n=1.

$\therefore$ Path difference = 1 λ = 600 nm

$\therefore$ 2x = 600 nm $\Rightarrow$ x = 300 nm

6. Let the n_1^{th} maxima of λ_1 coincide with n_2^{th} maxima of λ_2.

$$n_1\frac{\lambda_1 D}{d} = n_2\frac{\lambda_2 D}{d} \Rightarrow \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1}$$

$$\Rightarrow \frac{n_1}{n_2} = \frac{700}{500} \Rightarrow \frac{n_1}{n_2} = \frac{7}{5}$$

Minimum integral value permitted for n_1 is 7.

$\therefore$ Minimum distance = $n_1\dfrac{\lambda_1 D}{d}$ where $\dfrac{D}{d} = 10^3$

$$= \frac{7\left(500\times10^{-9}\right)\times10^3}{1} = 3.5 \text{ mm}$$

DIFFRACTION & POLARISATION

Exercise II : Previous years questions

2. Intensity of the polarized light coming out of polarizing sheet will be $I = \int_0^{2\pi} I_0\cos^2\theta d\theta$

On solving, we get $I = \dfrac{I_0}{2}$

3. $I = I_0\left(\dfrac{\sin\theta}{\theta}\right)^2$ and $\theta = \dfrac{\pi}{\lambda}\left(\dfrac{ay}{D}\right)$

For principal maximum y=0, θ=0

hence, intensity will remain same, i.e., $I=I_0$

4. In polarisation intensity changes as the crystal is rotated. In scattering for Rayleigh's law $I \propto \dfrac{1}{\lambda^4}$

λ is minimum for Blue; so I is larget

Both statements are correct and reason is also correct

5. Since the incident regnt is unporaizes,after light passis through polaroid A= $\dfrac{I_0}{2}$

After this light passes through B,

$I_{energent} = I\ I_{in}\cos^2\phi = \left(\dfrac{I_0}{2}\right)\cos^2 45 = \dfrac{I_0}{4}$