PHYSICS

For JEE MAIN + JEE ADVANCED

SOLUTIONS BOOKLET

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TOPIC

WAVE OPTICS

SOLUTIONS

WAVE OPTICS

Exercise-I

1. **B**

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

$$\Delta\phi = \frac{2\pi}{5460\times10^{-10}}\,\frac{1\times10^{-6}}{10} = 7.692\,\pi$$

2. **A**

In monochromatic light, only one wave length is present.

3. **B**

Given $y_1 = A_1 \sin wt$, $f_1 = 0$

$y_2 = A_2 \cos(wt + f) = A_2 \sin\left(\frac{\pi}{2} + \omega t + \phi\right)$

$f_2 = \frac{\pi}{2} + f$

D f = $f_2 - f_1$

$\Delta\phi = \frac{\pi}{2} + \phi$ Þ $\Delta\phi = \Delta\phi\left(\frac{\lambda}{2\pi}\right)$

Dx = $\frac{\lambda}{2\pi}$ × Df

Dx = $\frac{\lambda}{2\pi}\left(\frac{\pi}{2} + \phi\right)$

4. **C**

Amplitude depends upon intensity and phase difference.

5. **D**

In interferene there should be two coherent sources and propagation of waves should be simultaneously and in same direction.

6. **C**

In transverse and longitudinal waves.

7. **B**

Wave nature

8. **B**

Principle of Superposition.

9. **B**

$y_1 = A_1 \sin 3\omega t$, $f_1 = 0$

$y_2 = A_2 \cos\left(3\omega t + \frac{\pi}{6}\right)$

$y_2 = A_2 \sin\left(\frac{\pi}{2} + 3\omega t + \frac{\pi}{6}\right)$, $f_2 = \frac{\pi}{2} + \frac{\pi}{6}$

D f = $f_2 - f_1$

$$\Delta\phi = \frac{\pi}{2} + \frac{\pi}{6} = \frac{3\pi + \pi}{6} = \frac{4\pi}{6} = \frac{2\pi}{3}$$

10. **B**

Given $I_1 : I_2 = 100 : 1$

$\frac{\sqrt{I_1}}{\sqrt{I_2}} = 10 : 1$

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (10 + 1)^2 = 121$

$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = (10 - 1)^2 = 81$

$\frac{I_{max}}{I_{min}} = 121 : 81$

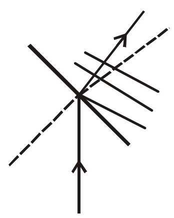
11. **D**

In coherent sources initial phase remains constant.

12. **B**

Phase difference changes with time.

13. **A**



Wave front.

14. **C**

Given $I_1 = I$ & $I_2 = 4I$

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

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

15. **C**

Frequency remains constant wave length decreases.

16. **B**

$62 = \frac{y}{\frac{\lambda_1 D}{d}} \quad \Rightarrow y = \frac{62\lambda_1 D}{d}$

$\frac{x\lambda_2 D}{d} = \frac{62\lambda_1 D}{d} \Rightarrow 4 = \frac{62 \times 5893}{5461} = 67$

17. **C**

$\Delta x = (24-1)\frac{\lambda}{2} = \frac{dy}{D}$

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

18. **C**

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

$\lambda \downarrow \beta \downarrow$

19. **B**

$\Delta x = n\lambda \ (\text{maxima})$

20. **B**

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

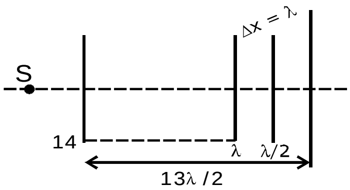
21. **A**

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

$\lambda = \frac{xd}{L}$

22. **A**

$\frac{13\lambda}{2} = 0.13$



$\Rightarrow \lambda = \frac{2}{100}$ m

$\because \quad f = \frac{v}{\lambda}$

$\Rightarrow \quad f = \frac{3 \times 10^8 \times 100}{2} = 1.5 \times 10^{10}$ Hz

23. **B**

$2\left[\frac{d}{\lambda}\right] + 1 = 7$

24. **D**

D = By using white light instead of single wavelength light.

25. **B**

$\frac{n\lambda_R D}{d} = (n+1)\frac{\lambda_B D}{d}$

$\Rightarrow$ n. 7800 = (n + 1) 5200

$\Rightarrow$ n = 2.

26. **C**

C $\rightarrow$ the fringe next to the central will be red.

27. **D**

$\Delta x = (2n+1)\frac{\lambda}{2}$

$\Delta x = (\ell_1 + \ell_3) - (\ell_2 + \ell_4) = (2n+1)\frac{\lambda}{2}$

28. **C**

$4I_0 = I$

$I_0 = I/4$

29. **C**

$I' = 4I\cos^2\frac{\Delta\phi}{2}$

$\Rightarrow \cos^2\frac{\Delta\phi}{2} = \frac{1}{4} \qquad \Rightarrow \cos\frac{\Delta\phi}{2} = \pm\frac{1}{2}$

$\Rightarrow \Delta\phi = \frac{2x}{\lambda}\frac{dy}{D} \qquad \Rightarrow \cos\frac{\pi.dy}{\lambda D} = +\frac{1}{2}$

$\Rightarrow \frac{\pi.dy}{\lambda D} = \frac{\pi}{3} \qquad \Rightarrow \quad y = \frac{\lambda D}{3d}$

30. **D**

$4 \times 6300 = (4.5)\lambda$

$\lambda = \frac{4 \times 6300}{9} \times 2 = 5600$ Å

31. **A**

$\Delta\phi = \frac{d.y}{D} \times \frac{2\pi}{\lambda}$

$\because \quad y = \frac{\lambda D}{d} \times \frac{1}{4}$

$\therefore \quad \Delta\phi = \frac{\pi}{2}$

$\Rightarrow \quad I' = 4I\cos^2\frac{\Delta\phi}{2} = 2I$

32. **C**

As the D$\uparrow$ position of first maxima

i.e., $y\uparrow \left(\frac{\lambda D}{d}\right)$

$\Rightarrow$ First decrease then increase.

33. **C**

$I_0 = 4I$

Intensity due to one

$\Delta\phi = \frac{d.y}{D} \times \frac{2\pi}{\lambda}$

$= \frac{0.25 \times 10^{-2} \times 4 \times 10^{-5}}{100 \times 10^{-2}} \times \frac{2\pi}{6000 \times 10^{-10}}$

$\Delta\phi = \pi/3$

$I' = I_0\cos^2\frac{\frac{\pi}{3}}{2} = \frac{3I_0}{4}$

34. **C**

$\frac{dy}{D} \times \frac{2\pi}{\lambda} = \Delta\phi$

$\Rightarrow \quad 2I = 4I\cos^2\frac{\Delta\phi}{2} \quad \Rightarrow \cos\frac{\Delta\phi}{2} = \frac{1}{\sqrt{2}}$

$\Rightarrow \quad \frac{\Delta\phi}{2} = \frac{\pi}{4} \qquad \Rightarrow \frac{d.y}{D}.\frac{2\pi}{\lambda} = \frac{\pi}{2}$

$\Rightarrow \frac{1 \times 10^{-3} \times y}{1 \times 500 \times 10^{-1}} = \frac{1}{4} \Rightarrow y = 1.25 \times 10^{-4}$ m

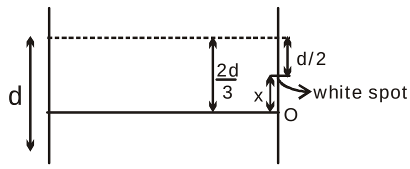
35. **C**

$0.3 \times 10^{-3} \times \sin 30^\circ = n \times 500 \times 10^{-9}$

$\Rightarrow \quad n = 300$

$\therefore \quad 299 + 299 + 1 = 599$

36. **D**



$x = \frac{d}{2} - \frac{2d}{3} = d/6$

37. **A**

$\frac{d.d}{6D} = n\lambda$

$\Rightarrow \quad \lambda = \frac{d^2}{6nD}$ $\quad$ [n = 1, 2, 3.....]

38. **D**

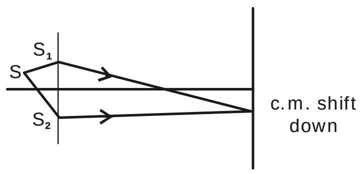
$\beta = \frac{\lambda D}{d}$

In water $\lambda\downarrow$ so $\beta\downarrow$

39. **A**

$\Delta\phi = \frac{2\pi}{\lambda/\mu}.x = \frac{2\pi\mu x}{\lambda}$

40. **D**



$\beta = \frac{\lambda D}{d}$ = remain same.

41. **C**

$2I = 4I\cos^2\frac{\Delta\phi}{2}$

$\Rightarrow \quad \cos\frac{\Delta\phi}{2} = \frac{1}{\sqrt{2}}$

$\Rightarrow \quad \frac{\Delta\phi}{2} = \frac{\pi}{4}$

$\Rightarrow \quad \frac{2\pi}{\lambda} \times \frac{\left(\frac{3}{2}-1\right)t}{2} = \frac{\pi}{4}$

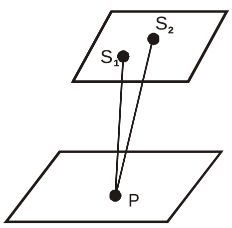
$\Rightarrow \quad t = \lambda/2$

42. **B**

$\left|(2\mu - 1)\,t - (\mu - 1).2t\right| = \frac{d.y}{D}$

$t = \frac{d.y}{D} \Rightarrow y = \frac{tD}{d}$

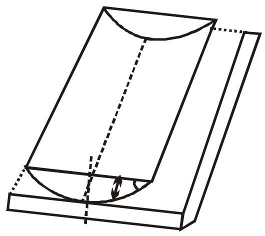
43. **B**



$S_2P - S_1P = n\lambda$ = const.

$\Rightarrow$ equation of hyperbola

44. **C**

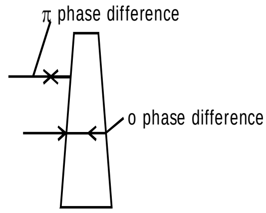


t changes more rapidly when we go outwards.

$\Rightarrow$ path diff. changes more rapidly

$\Rightarrow$ fringe width $\downarrow$

45. **C**



$\Delta\phi = \pi + (2\mu t).\frac{2\pi}{\lambda}$

at top

$t \to 0$

$\Delta\phi = \pi$

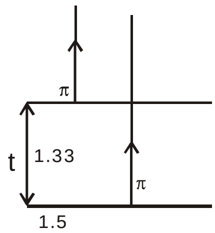
Minima for all the wave length.

Top position will appear dark.

$\Rightarrow$ As we move down violet Maxima will appear first.

first colour will be violet.

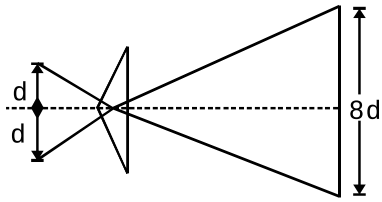
46. **A**



$2 \times \frac{4}{3}t = 600$

t = 225 nm.

47. **B**



$d = (\mu - 1)\,A \times 1$

no. of fringes $= \frac{8d^2.2}{\lambda D}$

$= \frac{16d^2}{\lambda D} = \frac{16[(\mu-1)A.1]^2}{6000\times10^{-10}\times5}$

= 5.33

48. **D**

If liquid is filled then λ will change but central maxima is independent of λ

so it will not shift any where

So statement 1 is false

change in path difference will cause the change in central bright fringe.

statement 2 is true.

49. **A**

According to cauchy's formula.

$n = a + b/\lambda^2 + \ldots\ldots\ldots\ldots\ldots$

In VIBGYOR λ will increase so n will decrease

$v = \frac{c}{n}$

$n_R < n_B$

So, $v_R > v_B$

statement 1 is True

And the reason of 1 is larger λ

50. **C**

Maxima occurs where phase difference is zero.

E.M. field is varying but the variation of both the slits wave is same

Exercise-I

1. **BD**

For coherent source

$\Rightarrow$ frequency same

$\Rightarrow$ constant phase difference

2. **BCD**

The fringes next to central will be violet and there will not be a complete dark fringe.

3. **BC**

$\xrightarrow{\text{Red} \longrightarrow \text{Blue}}$

$\lambda \downarrow$

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

4. **B**

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

as (a) $d\downarrow, \beta\uparrow$

(b) $\frac{\text{VIBGYOR}}{\lambda\uparrow n\downarrow}$

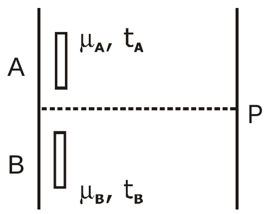
5. **AC**

Shift $\frac{d.y}{D} = (\mu - 1)t$

for C.M.

$y = (\mu - 1).\ t.\ \frac{\beta}{\lambda}$

6. **D**



At point P we assume t_A provide greater path difff.

$\Rightarrow$ $(\mu_A - 1)\ t_A - (\mu_B - 1)\ t_B$

$\Rightarrow$ $t_B - t_A = \Delta x$

if $t_B > t_A$ $\Delta x = +ve$ (shift towards A)

if $t_B < t_A$ $\Delta x = -ve$ (shift towards B)

7. **B**

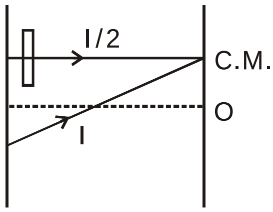
As width $\uparrow \Rightarrow I \uparrow$

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

$\Rightarrow$ $I_1 \neq I_2$

$I_{min} \neq 0$

8. **ACD**

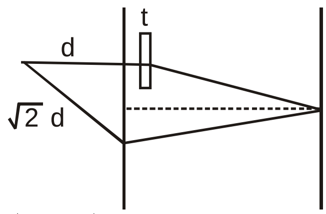


A $\rightarrow$ The fringe pattern will get shifted towards covered slit.

$$\left.\begin{aligned} I_{max.} &= \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 \\ I_{min.} &= \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 \end{aligned}\right\} \begin{aligned} &I_1 \neq I_2 \text{ then} \\ &I_{min.}\uparrow I_{max.}\downarrow \end{aligned}$$

$\beta = \frac{\lambda D}{d}$ (doesn't change)

9. **A**



$\left(\sqrt{2} - 1\right)$ d = (1.5 – 1) t

$t = 2\left(\sqrt{2} - 1\right)$ d

10. **ACD**

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

$\xrightarrow{\text{VIBGYOR}}$

$\lambda\uparrow$

11. **ABD**

Angular fringe width = $\frac{\beta}{D} = \frac{\lambda}{d}$

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

12. **BD**

C is not correct

C.M.; does not change.

13. **AC**

$I(\theta) = I_0 \cos^2 \frac{\phi}{2}$ $\qquad \left\{\Delta\phi = d\sin\theta\frac{2\pi}{\lambda}\right.$

$I(\theta) = I_0 \cos^2\left[\dfrac{150\times10^6}{3\times10^8}\times\pi\times\sin\theta\right]$

$I(\theta) = I_0 \cos^2 (\sin\theta \,.\, \pi/2)$

at $\theta = 30° \Rightarrow I(\theta) = I_0 \cos^2\left(\dfrac{\pi}{4}\right) = \dfrac{I_0}{2}$

at $\theta = 90° \Rightarrow I_0 \cos^2 \pi/2 = 0$

at $\theta = 0$

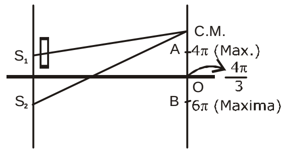
$I(\theta) = I_0 \cos^2 0 = I_0$.

14. **CD**

Path difference at 0

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

$= \dfrac{7\lambda}{3}$



$\Delta\phi = \dfrac{2\pi}{\lambda}\times\dfrac{7\pi}{3}$

$= \dfrac{14\pi}{3}$

At A . $\Delta x = (\mu - 1)\, t - \dfrac{dy_1}{D} = 2\lambda$

$1.05\ \mu m = 9000\ Å + y_1 \times 10^{-3}$

$\boxed{y_1 = .15mm}$

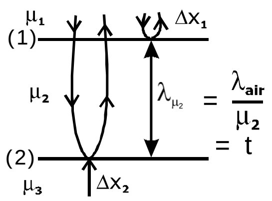
At B.

$\Delta x = (\mu - 1)t + \dfrac{dy_2}{D} = 3\lambda$

$10500\ Å + \dfrac{1\times10^{-3}\times y_2}{1} = 3 \times 4500\ Å$

$\boxed{y_2 = 0.3mm}$

15. **AD**



$\Delta x = \mu_2 \dfrac{2\lambda_{air}}{\mu_2} + \Delta x_1 - \Delta x_2$

$\Delta x = 2\lambda_{air} + \Delta x_1 - \Delta x_2$

$\mu_3 > \mu_2 > \mu_1$

$\Rightarrow \quad \Delta x_1 = \Delta x_2 = \dfrac{\lambda_{air}}{2}$

$\Delta x = 2\lambda_{air} = n\lambda_{air}$

Maxima at Interface (1)

$\Rightarrow \quad \mu_1 < \mu_2 > \mu_3$

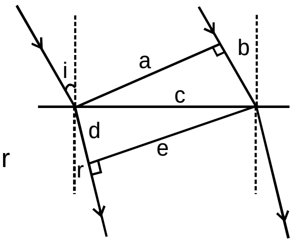
$\Delta x_1 = \dfrac{\lambda}{2},\ \Delta x_2 = 0$

$\Delta x = 2\lambda_{air} + \dfrac{\lambda_{air}}{2} = (2n+1)\dfrac{\lambda}{2}$

Minima at (1) interface

16. **C**

$\sin r = \dfrac{d}{c}$

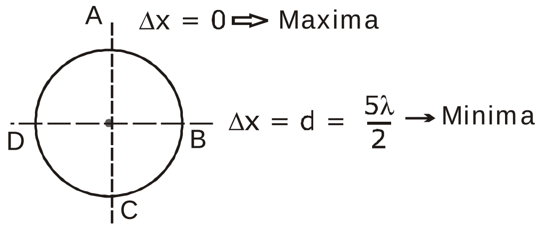


$\sin i = \dfrac{b}{c}$

$\Rightarrow \quad i\sin i = u \sin r$

$\Rightarrow \quad \mu = \dfrac{b}{d}$

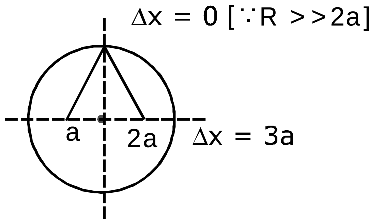
17. **D**



$\Rightarrow$ A, C Bright

$\Rightarrow$ B, D Dark

18. **A**

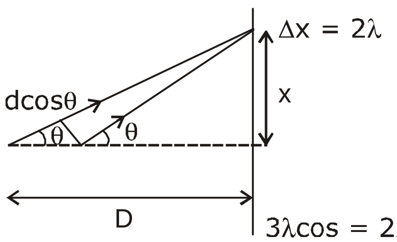


$\Rightarrow \quad 3a = n\lambda \qquad \Rightarrow \qquad n = 15$

$\Delta x = 15\lambda \rightarrow$ Maxima

$\Rightarrow \quad 14 + 14 + 14 + 14 + 4 = 60$

19. **D**



$3\lambda\cos = 2\lambda$

$\cos\theta = \dfrac{2}{3}$

$\tan\theta = \dfrac{x}{D} = \dfrac{\sqrt{5}}{2}$

20. **B**

Intensity in first case $= 4I_0$

In second case $= 4I_0 \cos^2 \dfrac{\Delta\phi}{2}$

$\therefore$ Average $= 2I_0$

$\Rightarrow \quad \dfrac{I_1}{I_2} = \dfrac{4I_0}{2I_0} = 2 : 1$

21. **A**

$\dfrac{n_1.\lambda D}{d} = \dfrac{n_2\lambda_2.D}{d}$

$\Rightarrow \quad n_1 \times 6500 = n_2 \times 5200$

$\Rightarrow \quad n_1 = 4$

$n_2 = 5$

$\therefore \quad y = \dfrac{4\times6500\times10^{-10}\times120\times10^{-2}}{2\times10^{-3}}$

$y = 0.156$ cm

22. **A**

$S_1P - S_2P = \lambda/6$

$\therefore \quad SS_1P - SS_2P = \lambda/3 \qquad .....(1)$

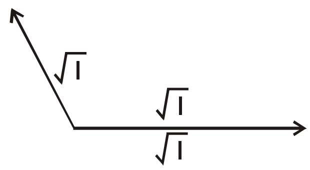
$SS_1P - SS_3P = 4\lambda/3 \qquad .....(2)$

$\Rightarrow \quad \Delta\phi = \frac{2\pi}{\lambda} \times \frac{4\lambda}{3}$

(2) – (1)

$SS_2P - SS_3P = \lambda$

$\Rightarrow \quad \Delta\phi = \frac{2\pi}{\lambda} \times \lambda = 2\pi$



Take base SS_3P

$I_{net} = \left(2\sqrt{I}\right)^2 + \left(\sqrt{I}\right) + 2.2\sqrt{I}\sqrt{I}\cos 120^o$

$I_{net} = 3I$

23. **A**

$\left(\frac{n_3}{n_2} - 1\right) t \times \frac{2\pi}{\lambda_2}$

$\therefore \quad \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$

$\Rightarrow \quad \left(\frac{n_3}{n_2} - 1\right) t \times \frac{2\pi n_2}{\lambda_1 n_1}$

$= \frac{2\pi}{\lambda_1 n_1}(n_3 - n_2)\ t$

24. **C**

Path diff. $= t(\mu - 1)$

as $\mu \uparrow$ Path diff. $\uparrow$

$O \longrightarrow \frac{\lambda}{2} \longrightarrow \lambda \longrightarrow$ intensity$\uparrow$

$\downarrow$

intensity$\downarrow$

25. **A**

$0.75 \times 4I = 4I\cos^2\left(\frac{\Delta\phi}{2}\right)$

$\cos\frac{\Delta\phi}{2} = \pm\frac{\sqrt{3}}{2}$

$\frac{\Delta\phi}{2} = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}, \frac{13\pi}{6}, \frac{17\pi}{6}......$

$\Delta\phi = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \frac{13\pi}{3}, \frac{17\pi}{3}......$

for third Maxima $\Rightarrow \Delta\phi = 6\pi$

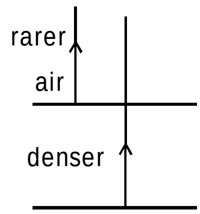
for second Minima $\Rightarrow \Delta\phi = 3\pi$

$\Delta\phi$ must lie between 3π and 6π

$\Rightarrow \Delta\phi = \frac{11\pi}{3}, \frac{13\pi}{3}, \frac{17\pi}{3}$

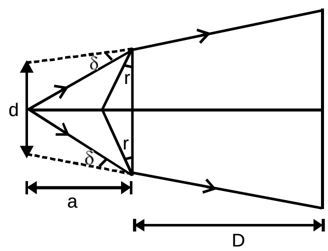
$\frac{\pi}{3}$ is not lying in the Range.

26. **A**



$2ut = \frac{\lambda}{2} \Rightarrow t = \frac{\lambda}{4}$

27. **A**



$d = 2a\delta$

$= 2a(\mu - 1)d$

$\beta = \frac{\lambda(a+D)}{2a(\mu-1)\alpha}\left(1 + \frac{D}{a}\right)$

$a \to \infty$

$\Rightarrow \quad \beta = \frac{\lambda}{2\alpha(\mu - 1)}$

Exercise-III — Level-I

1. $\beta = \frac{\lambda.D}{d} = \frac{600 \times 10^{-9} \times 1}{4/3 \times 0.2 \times 10^{-2}}$

$\Rightarrow \beta = 0.225$ mm

2. $\frac{x}{\beta} = 12 \Rightarrow \beta_1 = \frac{600 \times D}{d}$

$\frac{x}{\beta_2} = 18 \Rightarrow \beta_2 = \frac{400 \times D}{d}$

3. $\Delta x = nl$

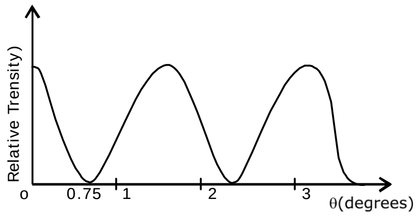
$(1.7 - 1).t - (1.4 - 1)t = 5\lambda$

$\Rightarrow t = \frac{5 \times 4800 \times 10^{-10}}{0.3}$

$= 8 \times 10^{-6}$ m

4. $\frac{I_{max}}{I_{min}} = \left[\frac{\sqrt{0.2I} + 0.8\sqrt{0.27}}{\sqrt{0.2I} - 0.8\sqrt{0.2I}}\right]^2 = \left(\frac{1.8}{0.2}\right)^2 = 9^2 = 81$

5.



$\Delta x = d\sin\theta = d.\theta = \dfrac{\lambda}{2}$

$d.0.75 \times \dfrac{\pi}{180} = \dfrac{520\times10^{-3}}{2}$

$d = 1.98 \times 10^{-2}$

6. $\dfrac{9\lambda D}{\alpha} - \dfrac{3\lambda D}{2d} = 7.5\times10^{-3}$

$\Rightarrow \dfrac{15\lambda D}{2d} = 7.5\times10^{-3} \quad \Rightarrow \lambda = 5000\text{Å}$

7. $3I = 4I\cos^2\dfrac{D\phi}{2}, \qquad \cos\dfrac{\Delta\phi}{2} = \pm\dfrac{\sqrt{3}}{2}$

$\dfrac{\Delta\phi}{2} = \dfrac{\pi}{6}, \dfrac{5\pi}{6}, \dfrac{7\pi}{6}$

$\dfrac{dy}{D}\times\dfrac{2\pi}{\lambda} = \Delta\phi = \dfrac{\pi}{3}, \dfrac{5\pi}{3}, \dfrac{7\pi}{6}$

$y = \dfrac{D}{d}.\dfrac{\lambda}{6}, \underbrace{\dfrac{D}{d}\dfrac{5\lambda}{6}, \dfrac{D}{d}}_{\text{min.Distance}}.\dfrac{7\lambda}{6}$

Minimum Distance $= \dfrac{7\lambda}{6}\dfrac{D}{d} - \dfrac{5\lambda}{6}\dfrac{D}{d} = \dfrac{\lambda}{3}\dfrac{D}{6}$

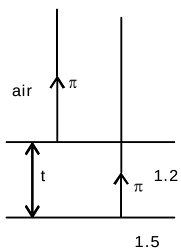
$= \dfrac{1.\times600\times10^{-9}}{3\times10^{-3}} = 2\times10^{-4}\text{m}$

8. $\Delta x = d\sin\theta = \lambda$

$\Rightarrow d\times\dfrac{y}{\sqrt{D^2+y^2}} = \lambda \quad \Rightarrow d^2y^2 = \lambda^2(D^2 + y^2)$

$\Rightarrow y^2(d^2 - l^2) = \lambda^2D^2 = y = \dfrac{10^{-3}\times1}{\sqrt{(3^2-1)10^{-6}}} = 0.35\text{m}$

9.



$2\mu t = \dfrac{\lambda}{2} \rightarrow \text{minimum}$

$t = \dfrac{\lambda}{4\mu} = 10^{-7}\text{m}$

10. Loyd's mirror

$\Rightarrow \dfrac{\lambda D}{2d} = \dfrac{600\times10^{-9}\times1}{2\times2\times1\times10^{-3}}$ {d=2mm} = 0.15 mm

11. $2\mu t = n\lambda$

$2\times\dfrac{\mu\times x}{2500} = n\lambda \qquad ....(1)$

$2\times\dfrac{\mu\times x'}{2500} = (n+1)\lambda \qquad ....(2)$

(2) – (1)

$\Rightarrow \dfrac{2\times\mu}{2500}\underbrace{[x' - x]}_{\text{fringwidth}} = \lambda \quad \therefore x' - x = 0.85\text{ mm}$

no. of fringes $= \dfrac{120}{x'x} = 141$

12. $\beta_1 = \dfrac{\lambda D}{10^{-3}} \qquad ...(1)$

$\beta_b = \dfrac{\lambda.(D - 5\times10^{-2})}{10^{-3}} \qquad ...(2)$

$\beta_1 - \beta_2 = 3\times10^{-5} \qquad ....(3)$

(1) – (2)

$10^{-3}(\beta_1 - \beta_2) = \lambda\times5\times10^{-2}$

$\lambda = 6000$ Å

13. Path diff at centre

$\Delta x = 7.5\times10^{-7} \Rightarrow \Delta\phi = \dfrac{(\mu-1)t2\pi}{\lambda} = 3\pi$

$I = I_0\cos^2\dfrac{\Delta\phi}{2} = 0, \quad \Delta x = \dfrac{yd}{D} \Rightarrow y = 1.5\text{m}$

14. (a) $\dfrac{\lambda_1}{\lambda_2} = \dfrac{n_2}{n_1}$

$\dfrac{6900}{\lambda_2} = \dfrac{1.33}{1}$

$\lambda_2 = \dfrac{6300}{1.33}$

$\beta = \dfrac{63\times1.33}{1.33\times1\times10^{-3}} \Rightarrow \beta = 0.63\text{mm}$

(b) $\left(\dfrac{1.58}{1.33} - 1\right)t = \dfrac{\lambda}{2}$

$\Rightarrow \dfrac{6300\times1.33\times100}{1.33\times2\times0.20} = 1.575\mu\text{m}$

15. $\Delta x = (\mu - 1)t$

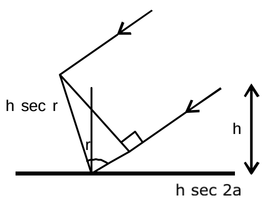
$= (1.17 - 1)(1.5\times10^{-7}) = 0.255\times10^{-7}$

Now for central maxima :

$\Delta x = \dfrac{dy}{D} \Rightarrow 0.255\times10^{-7} = = \dfrac{3\times10^{-7}}{D}\times y$

$y = 0.085D$

16.



$\Delta x = h\sec\alpha(1 + \cos2a) = \lambda/2$

$\Rightarrow 2h\cos\alpha = \lambda/2 \quad \Rightarrow h = \dfrac{\lambda}{\Delta\cos\alpha}$

17. $\lambda_2 = \frac{\beta_1}{\beta_1}\lambda_1$, $\beta_2 = \frac{\lambda_2 D}{d}$, $\lambda_2 = \frac{\beta_2}{\beta_1}\lambda_1$

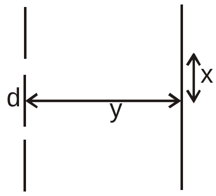
$= \frac{2.7 \times 20}{30 \times 2} \times 6000$

$\lambda_2 = 5400$Å

Exercise-III Level-II

1 $\beta = \frac{\lambda y}{d}$

No. of fringe in x



$= \frac{x}{\frac{\lambda y}{d}} = \frac{dx}{\lambda y}$

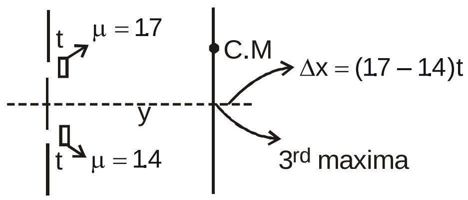
$\therefore$ Rate of apperaance of no. of fringes

$= \frac{d}{dt}\left(\frac{dx}{\lambda y}\right) = \frac{d}{dt}(d)\frac{x}{\lambda y} = \frac{xv}{\lambda y}$

2 (i) $x = (\mu - 1)t$

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

$I = I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$



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

For 3^{rd} maxima

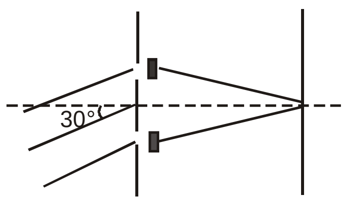
$\Delta x = (1.7 - 1.4)\,t = 3\lambda$

$t = \frac{3 \times 4000 \times 10^{-10}}{0.3} = 4\ \mu m$

3 $\Delta x = d \sin 30° + (\mu_1 - 1)\,t_1 - (\mu_2 - 1)\,t_2$

$= \frac{0.1}{2} + (1.5–1)\,20.4 \times 10^{-3} - (1.5 - 1)\,t_2 = 0.0602 - 0.5\,t_2$

$3I = I + 4I + 2\sqrt{4I^2}(\cos\Delta\phi)$



$\cos\Delta\phi = \frac{-1}{2}$

$\Delta\phi = \frac{2\pi}{3}$, ...

For t_2 to be max. $\Delta\phi = \frac{2\pi}{3}$

$\frac{2\pi}{\lambda}(0.0602 - 0.5t_2) = \frac{2\pi}{3} \Rightarrow t_2 = 120\ \mu m$

$\beta = \frac{\lambda D}{d} = \frac{6000 \times 10^{-10} \times 1}{0.1 \times 10^{-3}} = 6$ mm

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

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

(c) At O, we have already found out that $\Delta\phi = \frac{2\pi}{3}$ for nearest minima, $\Delta\phi$ should be equal to π.

$\frac{2\pi}{\lambda}.\frac{dy}{D} = \pi - \frac{2\pi}{3} = \frac{\pi}{3}$

$y = \frac{\lambda D}{6d} = \frac{\beta}{6}$

(d) 5 cm above O

$\Delta\phi = \frac{2\pi}{\lambda}.\frac{dy}{D} + \frac{2\pi}{3} = \frac{2\pi}{6000 \times 10^{-10}} \times \frac{5 \times 10^{-2} \times .1 \times 10^{-3}}{1 \times 10}$

$\Delta\phi = \frac{50\pi}{3} + \frac{2\pi}{3} = \frac{52\pi}{3} = 14\pi$

$I' = I + 4I + 2\sqrt{4I^2}\cos(\Delta\phi)$

$= 5I + 4\,I\cos(14\pi) = 9\,I$

5cm below O

$\Delta\phi = \frac{50\pi}{3} - \frac{2\pi}{3} = \frac{48\pi}{3} = 16\pi$

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

I case

$\frac{\lambda(100cm)}{d} = 0.25mm$ ...(1)

II case

$\frac{\lambda(100cm)}{(d + 12mm)} = \frac{2}{3}(0.25mm)$ ...(2)

$(1) \div (2)$

$\frac{d + 12mm}{d} = \frac{3}{2} \Rightarrow d = 2.4$ mm

Putting in (1)
we get $\lambda = 600$ nm
when the slabe is placed, C.M. shift to 20^{th} maxima
$\therefore (\mu - 1)\,t = 20\,\lambda \Rightarrow (1.5 - 1)\,t = 20\,(600 \times 10^{-9})$ m
$t = 24\ \mu m$

Q.5 Path difference at C = $\left(\frac{\mu}{\mu_w} - 1\right)t_1 - \left(\frac{\mu}{\mu_w} - 1\right)t_2$

$= \left(\frac{27}{20} - 1\right)(2.5 - 125)$

$$\Delta x = \frac{7}{16}\,\mu m$$

$\therefore \quad \Delta\phi = \frac{2\pi}{\lambda_\omega} \times \frac{7}{16} \times 10^{-6}$

$(\lambda_{air} = 5000\ \text{Å})$

$= \frac{2\pi \times 4 \times 7 \times 10^{-6}}{5000 \times 3 \times 10^{-10} \times 16}$

$\left[\frac{\lambda_w}{\lambda_{air}} = \frac{\mu_{air}}{\mu_{water}}\right]$

$= \frac{7\pi}{3}$

$= \lambda_w = \frac{5000(3)}{4}$ A

$I = I_0 \cos^2\left(\frac{\Delta\phi}{2}\right) \Rightarrow I = I_0 \cos^2\left(\frac{7\pi}{6}\right)$

$I = \frac{3I_0}{4} \qquad \therefore \quad \frac{I}{I_0} = \frac{3}{4}$

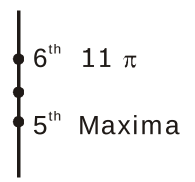
Q.6 $\lambda = 7 \times 10^7$ m
$\therefore \Delta x = (\mu - 1)\,t = 5\,\lambda$ ...(i)
$t = 7\ \mu m$
for Green light
$t\,(\mu_g - 1) = \Delta x = 6\lambda_r \quad \Rightarrow \mu_g - 1$

$= \frac{6 \times 7 \times 10^{-7}}{7 \times 10^{-6}} = \frac{6}{10} = 1.6$

Q.7 $3I = 4I \cos^2 \frac{\Delta\phi}{2}$

$\cos \frac{\Delta\phi}{2} = \pm \frac{\sqrt{3}}{2}$

$\Delta\phi$ should be in between $10\,\pi \rightarrow \quad 11\,\pi$



$\Delta\phi = 10\,\pi + \pi/3 = \frac{31\pi}{3}$

$\Delta\phi = \frac{2\pi}{\lambda} \times 5\,\lambda = 10\,\pi$

$\therefore (1.7 - 1)\,t - (1.4 - 1)\,t = \frac{31\lambda}{6} \Rightarrow t = 9.3\ \mu m$

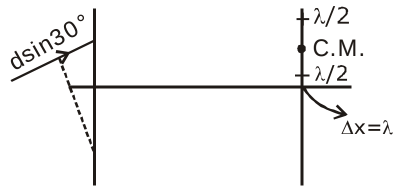
Q.8. Maxima $\Delta x = d = 2\,\lambda$

Miximum correspond $\pm\frac{\lambda}{2}$ & $\pm\frac{3\lambda}{2}$

$d \sin\theta = \frac{\lambda}{2}, \ \sin\theta = \frac{1}{4}$

$\tan\theta = \frac{1}{\sqrt{15}} \qquad \therefore \quad y = \pm\frac{1}{\sqrt{15}}$

$d \sin\theta = \frac{3\lambda}{2} \qquad \sin\theta = \frac{3}{4} \qquad \therefore y = \pm\frac{3}{\sqrt{7}}$



$d \sin 30° - d \sin\theta = \frac{\lambda}{2} \Rightarrow \sin\theta = \frac{1}{4}$

$\frac{y}{\sqrt{D^2 + y^2}} = \frac{1}{4} \Rightarrow y = \frac{1}{\sqrt{15}}$

$d \sin\theta - d \sin 30° = \frac{\lambda}{2} \Rightarrow \sin\theta = \frac{3}{4}$

$\frac{y}{\sqrt{D^2 + y^2}} = \frac{3}{4} \Rightarrow y = \frac{3}{\sqrt{7}}$

Q.9 A.f.w $= \frac{\lambda}{d} \qquad 1° \rightarrow 60$ min

$\frac{\pi}{180} \rightarrow 60$ min

$\Rightarrow \frac{\pi}{180 \times 60} = \frac{6000 \times 10^{-10}}{d}$

5th dark fringe
$\Delta x = 4.5\,\lambda$
$y = 1.5 \times \frac{\pi}{3.6} = \frac{\pi}{2.4}$ mm

$$d = \frac{6.48}{\pi}$$

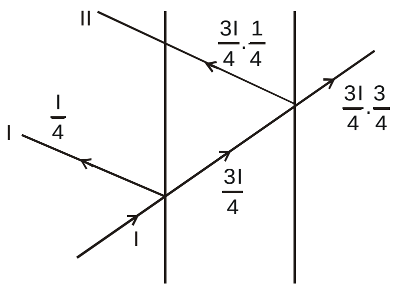
3rd Bright fringe $\Delta x = \frac{yd}{D} = 3\lambda$

$$y = \frac{3 \times 6000 \times 10^{-10}}{1} \times \frac{\pi}{6.48 \times 10^{-3}} = \frac{\pi}{3.6} \text{ mm}$$

Q.10 I & II light wave interfere to produce interference Pattern

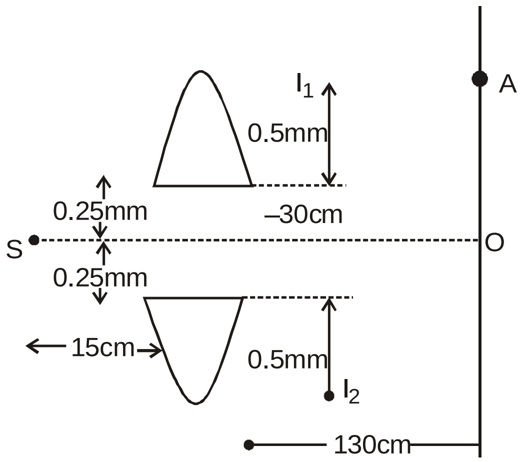
$$I_1 = \frac{I}{4}, \quad I_2 = \frac{3I}{16}$$

$$\frac{I_{min}}{I_{max}} = \frac{(\sqrt{I_1} - \sqrt{I_2})^2}{(\sqrt{I_1} + \sqrt{I_2})^2} = \frac{\frac{I}{4} + \frac{3I}{16} - \frac{2\sqrt{3}}{8}I}{\frac{I}{4} + \frac{3I}{16} + \frac{2\sqrt{3}I}{8}} = \frac{1}{49}$$



Q.11 (i) $\frac{1}{V} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{V} + \frac{1}{15} = \frac{1}{10}$$



v = 30 cm

$$m = \frac{v}{u} = \frac{h_i}{h_0}$$

$h_i = 2h_0 = 2(0.25) = 0.5$ mm

$\therefore$ d = (0.5 + 0.5 + 0.5) = 1.5 mm

D = (130 – 30) = 100 cm

λ = 500 nm

$$OA = \frac{3\lambda D}{d} = \frac{3(500 \times 10^{-9})(100 \times 10^{-2})}{(15) \times 10^{-3}}$$

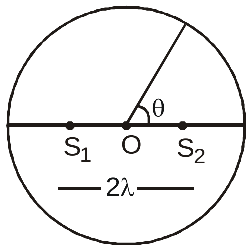
OA = 1mm

(ii) If 0.5 mm is reduced, then resultant d will reduce hence $OA = \frac{3\lambda D}{d}$ will $\uparrow$

Q.12 Δx due to above arrangement = d cos θ

$$\therefore \Delta\phi = \frac{2\pi}{\lambda}(d\cos\theta) = \frac{2\pi}{\lambda}(2\lambda\cos\theta) = 4\pi\cos\theta$$

$$I = I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$$



$$\frac{I_0}{2} = I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$$

$$\frac{\Delta\phi}{2} = 2n\pi \pm \frac{\pi}{4}$$

$$\theta = \cos^{-1}\left(\frac{2n+1}{8}\right) \quad \& \quad \pi \pm \cos^{-}\left(\frac{2n+1}{8}\right)$$

n = 0, 1, 2, 3 ....

Q.13 When convex lens is introduced,

v = 70 cm, u = – 30 cm

$\left|\frac{v}{u}\right| = \left|\frac{h_i}{h_0}\right| \Rightarrow \frac{+7}{3} = \frac{0.7\text{cm}}{h_0} \Rightarrow h_0 = 0.3$ cm i.e. d = 0.3 cm

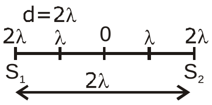
$$\frac{\lambda D}{d} = 0.0195 \text{ cm}$$

$$\frac{\lambda(100\text{cm})}{0.3\text{cm}} = .0195\text{cm} \quad \Rightarrow \lambda = 5850 \text{ Å}$$

Exercise-IV Level-I

1. Coherent sources.

2.



Maxima 5

3. Intersity of polorized light = $\frac{I_0}{2}$

Untransmitted light = $I - \frac{I_0}{2} = \frac{I_0}{2}$

4. **C**

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

For principal maximum $y = 0$

$\theta = 0$

Hence, intensity will remain same.

5. **D**

6. $\Delta\phi = \frac{2\lambda}{\lambda} \times \frac{6}{\lambda} = \frac{\lambda}{3}$

$I = I_0 \cos^2\frac{\Delta\phi}{2} = I0 \cos^2\frac{\lambda}{6}$

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

7. $\frac{3\lambda_1 D}{d} = \frac{4\lambda_2 D}{d} \Rightarrow 3\lambda_1 = 4\lambda_1$

$\lambda_2 = \frac{3}{4}\lambda_1 = \frac{3}{4} \times 590$

$= 442.5$ nm

8. Initiancity of parallel beam is cylindrical therefore the wave front will be planar.

9. **B**

Both statements I and II are correct but statement II does not explain statement I.

10. Constant + source

$I_1 = 4I_0 \cos^2\frac{\phi}{2} = 4I_0$

For incomepent source

$I_2 = I_0 + I_0 = 2I_0$

$\frac{I_1}{I_2} = 2.$

11. $I_1 = 4I_0 \cos^2\frac{\phi}{2}$

$\Delta x = 0$ $\qquad I_1 = 4I_0$

$D x = \frac{\lambda}{y}$ $\qquad \Delta\phi = \frac{2x}{\lambda} \times \frac{\lambda}{y} = \frac{x}{2}$

$I_2 = 4I_0 \cos^2\frac{x}{4} = 2I_0$ Þ $\frac{I_1}{I_2} = \frac{2}{1}$

12. $A_1 = 2A_2$ Þ $I_1 = 4I_2 = 4I_0$

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

$= 9I_0$

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

$= I_2 + 4I_2 + 2\sqrt{I_2 + 4I_2}$ cosf

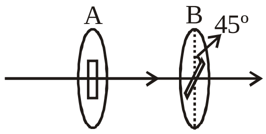
$= 5I_2 + 4I_2 \cos\phi$

$= \frac{I_m}{9}(5 + 4\cos\phi)$

$= \frac{I_m}{9}[1 + 4(\cos\phi)]$

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

13. **A**

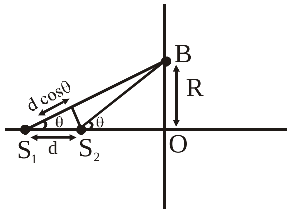


Through A only component parallel to slit will pass so intensity after passing through A will be $\frac{I_0}{2}$.

After passing through B

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

14. **B**



Path differnce on the circle of radius R around O on the wall will be same hence concentric circle.

Exercise-IV Level-II

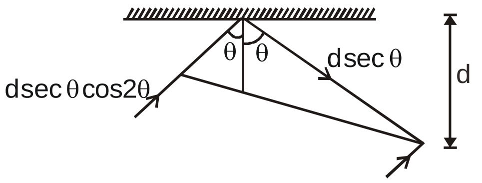
1. **A**

2 **B** Path difference

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

$$= d \sec \theta \, [2 \cos^2 \theta] + \frac{\lambda}{2}$$

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



For constructrive $\Delta x = n\lambda$

$$2d \cos \theta = \frac{\lambda}{2} \Rightarrow \cos \theta = \frac{\lambda}{4d}$$

3. $1. \sin 60^\circ = \sqrt{3} \sin r_1 \Rightarrow r_1 = 30^\circ \Rightarrow r_1 + r_2 = 30$

$\therefore r_2 = 0$

$\therefore$ ray incident $\perp$ on AC, Thin film interference

4. **D**

$(2n_1 - 1)\,\lambda_1 = (2n_2 - 1)\,\lambda_2 \Rightarrow (2n_1 - 1)\,400 = (2n_2 - 1)\,560 \Rightarrow (2n_1 - 1)\,5 = (2n_2 - 1) \times 7$

$n_1 = 4,\ n_2 = 3$

4^{th} dark fringe of 400 nm and 3^{rd} dark of 560 nm coincide.

Again $n_1 = 11,\ n_2 = 7$ coincide $\Rightarrow \Delta x = 7\lambda_1 = 7 \times 400 = 2800$ nm

$$y = \frac{\Delta x D}{d} = 2800 \times 10^{-9} \times 10^4 \quad = 28 \text{ mm}$$

5. $n_1\lambda_1 = n_2\lambda_2$

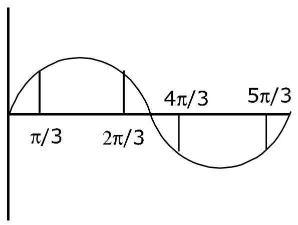
$n_1 \times 500 = n_2 \times 700$

$[n_1 = 7,\ n_2 = 5]$

$\Delta x = 7 \times 500$ nm

$$y = \frac{\Delta x D}{d} = 7 \times 500 \times 10^{-9} \times 10^3 = 3.5 \text{ mm}$$

6. **B** $\cos^2 \dfrac{\Delta\phi}{2} = \dfrac{1}{4} \Rightarrow \qquad \cos \dfrac{\Delta\phi}{2} = \pm \dfrac{1}{2}$



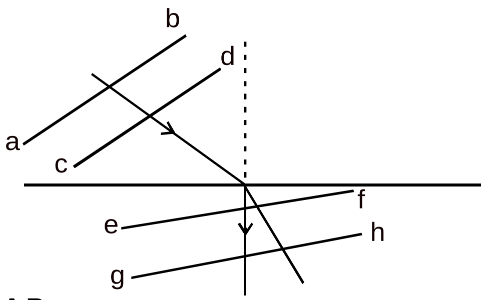
$$\frac{\Delta\phi}{2} = \frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3} \Rightarrow \frac{2\pi.\Delta x}{\lambda} = \Delta\phi$$

$$= \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{8\pi}{3}, \frac{10\pi}{3}$$

$$d \sin \theta . \frac{2\pi}{\lambda} = \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{8\pi}{3}, \frac{10\pi}{3}$$

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

7,8,9. **(A,C,B)**



10. **A,B**

$I_1 = 4I\ I_2 = I \Rightarrow I_{max} = 9I$

$I_{min} = I$

(A) If $d = \lambda \Rightarrow$ only central one maxima

(B) $\lambda < d < 2\lambda \Rightarrow$ one central and one more

(C) I, I

$\Rightarrow I_{max} = 9I$

$I_{min} = 0$

(D) 4I, 4I

$I_{max} = 16\,I$

$I_{min} = 0$

11. **(A) $\rightarrow$ (P,S) ; (B) $\rightarrow$ (Q) ; (C) $\rightarrow$ (T) ; (D) $\rightarrow$ (RST)**

$$S_1P_0 = S_2P_0,\ S_1P_1 - S_2P_1 = \frac{\lambda}{4},$$

$$S_1P_2 - S_2P_2 = \frac{\lambda}{2}$$

(A) $\delta(P_0) = 0$ (P) , $I(P_0) > I(P_1) \rightarrow$ (S)

(B) $\delta(P_1) = 0$ (Q)

(C) $\delta(P_0) = \pi,\ I(P_0) = 0$

$I(P_2) > I(P_1)$

(D) $\delta(P_1) = \pi$, $I(P_2) = 0$ (R) , $I(P_0) > I(P_1)$ (S), $I(P_2) > I(P_1)$ (T)

12. **D**

Fringe width

$$\beta = \frac{\lambda P}{d} \text{ as } (\lambda_R > \lambda_G > \lambda_b) \text{ so } \beta_R > \beta_G > \beta_B$$