PHYSICS

For JEE MAIN + JEE ADVANCED

SOLUTIONS BOOKLET

1. WAVE OPTICS
2. MODERN PHYSICS
3. NUCLEAR PHYSICS

JEE-SERIES

JEE-MAIN+ADV.

TOPIC

WAVE OPTICS

SOLUTIONS

WAVE OPTICS

Exercise-I

1. **B**

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

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

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 = $f_2 - f_1$

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

$Dx = \frac{\lambda}{2\pi} \times Df$

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

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**

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

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

$y_2 = A_2 \sin\left(\frac{\pi}{2} + 3\omega t + \frac{\pi}{6}\right)$, $\quad f_2 = \frac{\pi}{2} + \frac{\pi}{6}$
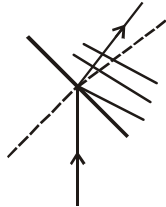
D f = $f_2 - f_1$

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

10. **B**

Given $\quad I_1 : I_2 = 100 : 1$

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

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

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

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

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**

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

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

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**

$$\Delta x = n\lambda \ (maxima)$$

20. **B**

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

21. **A**

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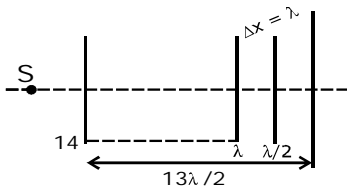
$$\lambda = \frac{xd}{L}$$

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**

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

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

$$\Rightarrow \quad n = 2.$$

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**

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

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

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**

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

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

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

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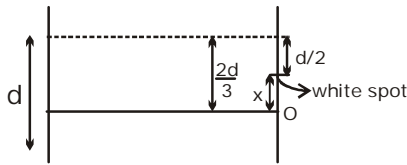
35. **C**

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

$$\Rightarrow \quad n = 300$$

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

36. **D**

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

37. **A**

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

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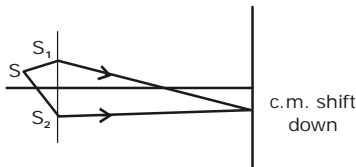
38. **D**

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

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**

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

41. **C**

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

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

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

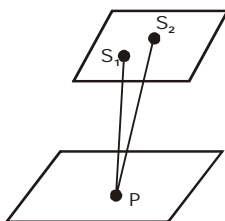$$\Rightarrow \quad \frac{2\pi}{\lambda} \times \frac{\left(\frac{3}{2}-1\right)t}{2} = \frac{\pi}{4}$$

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

42. **B**

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

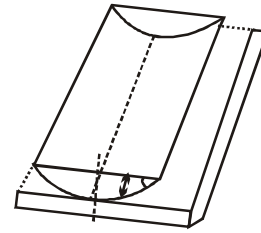$$t = \frac{d.y}{D} \Rightarrow y = \frac{t D}{d}$$

43. **B**

$S_2P - S_1P = n\lambda = \text{const.}$
$\Rightarrow$ 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**

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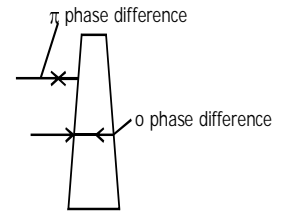

at top
$t \to 0$
$\Delta\phi = \pi$
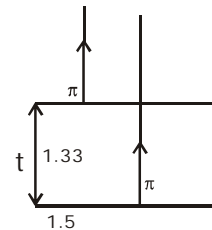Minima for all the wave length.
Top position will appear dark.
$\Rightarrow$ As we move down violet Maxima will appear first.
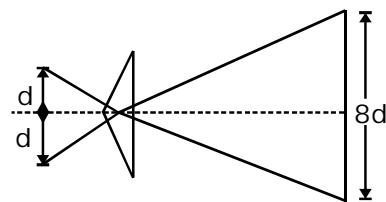first colour will be violet.

46. **A**

$$2 \times \frac{4}{3} t = 600$$
$t = 225$ nm.

47. **B**

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

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

$$= \frac{16d^2}{\lambda D} = \frac{16[(\mu - 1)A.1]^2}{6000 \times 10^{-10} \times 5}$$
$$= 5.33$$

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.
$n = a + b/\lambda^2 + \ldots\ldots\ldots$
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
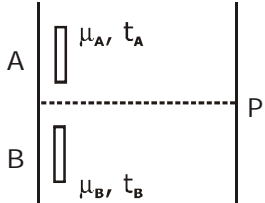And the reason of 1 is larger λ

50. **C**
Maxima occurs where phase difference is zero.
E.M. field is varying but the variation of both the slits wave is same
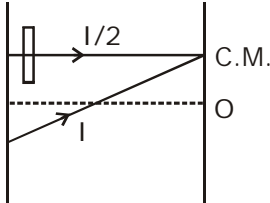
Exercise-I

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**
Red $\longrightarrow$ Blue
$\overrightarrow{\quad\lambda\downarrow\quad}$

$\beta = \dfrac{\lambda D}{d}\downarrow$

4. **B**
$\beta = \dfrac{\lambda D}{d}$
as (a) $d\downarrow$, $\beta\uparrow$

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

5. **AC**
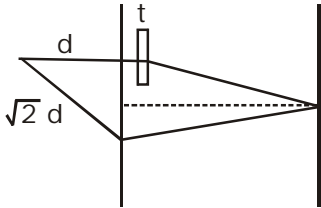Shift $\dfrac{d.y}{D} = (\mu - 1)t$
for C.M.

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

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.

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

$\beta = \dfrac{\lambda D}{d}$ (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**
$\beta = \dfrac{\lambda D}{d}$ $\lambda\uparrow\beta\uparrow$

$\overrightarrow{\dfrac{VIBGYOR}{\lambda\uparrow}}$

11. **ABD**
Angular fringe width $= \dfrac{\beta}{D} = \dfrac{\lambda}{d}$

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

12. **BD**
C is not correct
C.M.; does not change.

13. **AC**

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

$I(\theta) = I_0 \cos^2 \left[\dfrac{150 \times 10^6}{3 \times 10^8} \times \pi \times \sin\theta \right]$

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

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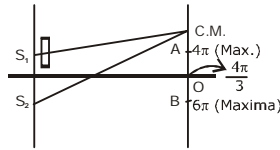
$I(\theta) = I_0 \cos^2 0 = I_0.$

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

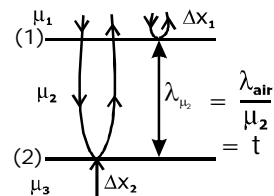$1.05 \ \mu m = 9000 \ \text{Å} + y_1 \times 10^{-3}$

$\boxed{y_1 = .15mm}$

At B.

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

$10500 \ \text{Å} + \dfrac{1 \times 10^{-3} \times y_2}{1} = 3 \times 4500 \ \text{Å}$

$\boxed{y_2 = 0.3mm}$

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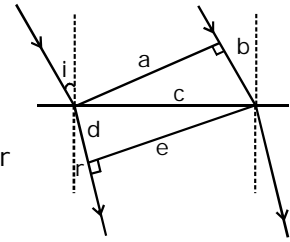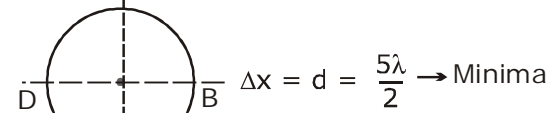
$\sin r = \dfrac{d}{c}$

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

$\Rightarrow \quad i\sin i = u \sin r$
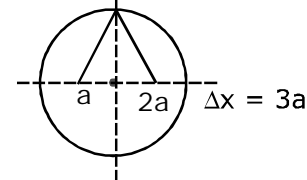
$\Rightarrow \quad \mu = \dfrac{b}{d}$

17. D

$\Delta x = 0 \Rightarrow$ Maxima

$\Delta x = d = \dfrac{5\lambda}{2} \rightarrow$ Minima

$\Rightarrow$ A, C Bright

$\Rightarrow$ B, D Dark

18. A

$\Delta x = 0 \ [\because R >> 2a]$

$\Delta x = 3a$

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

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

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

19. D
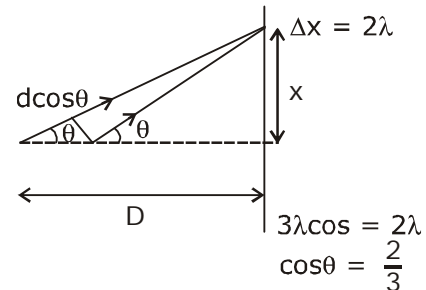
$3\lambda\cos = 2\lambda$

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

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

20. B

Intensity in first case $= 4I_0$

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

$\therefore \quad$ Average $= 2I_0$

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

21. A

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

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

$\Rightarrow \quad n_1 = 4$

$\quad n_2 = 5$

$\therefore \quad y = \dfrac{4 \times 6500 \times 10^{-10} \times 120 \times 10^{-2}}{2 \times 10^{-3}}$

$$y = 0.156 \text{ cm}$$

22. **A**

$$S_1P - S_2P = \lambda/6$$

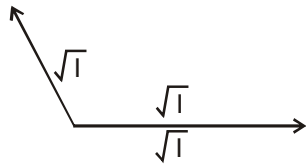$$\therefore \quad SS_1P - SS_2P = \lambda/3 \quad\quad\quad .....(1)$$

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

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

$$(2) - (1)$$

$$SS_2P - SS_3P = \lambda$$

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

Take base SS_3P

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

$$I_{net} = 3I$$

23. **A**

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

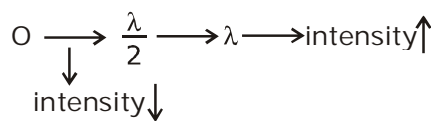$$\therefore \quad \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

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

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

24. **C**

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

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

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

25. **A**

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

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

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

$$\Delta\phi = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \frac{13\pi}{3}, \frac{17\pi}{3}......$$
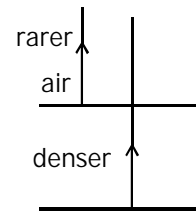
for third Maxima $\Rightarrow \Delta\phi = 6\pi$

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

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

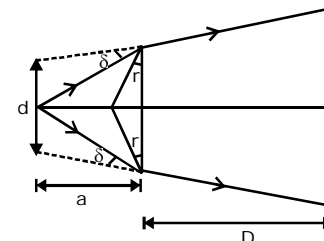$$\Rightarrow \Delta\phi = \frac{11\pi}{3}, \frac{13\pi}{3}, \frac{17\pi}{3}$$

$\frac{\pi}{3}$ 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. $\beta = \dfrac{\lambda.D}{d} = \dfrac{600 \times 10^{-9} \times 1}{4/3 \times 0.2 \times 10^{-2}}$
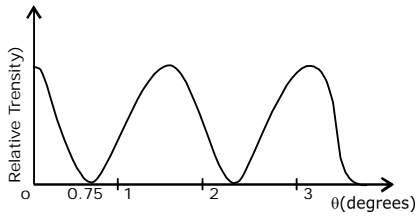
$$\Rightarrow \beta = 0.225 \text{ mm}$$

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

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

3. $\Delta x = nl$

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

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

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

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

5.

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

$$d.0.75 \times \frac{\pi}{180} = \frac{520 \times 10^{-3}}{2}$$

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

6.

$$\frac{9\lambda D}{\alpha} - \frac{3\lambda D}{2d} = 7.5 \times 10^{-3}$$

$$\Rightarrow \frac{15\lambda D}{2d} = 7.5 \times 10^{-3} \Rightarrow \lambda = 5000 Å$$

7.

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

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

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

$$y = \frac{D}{d}.\frac{\lambda}{6}, \frac{D}{d}\underbrace{\frac{5\lambda}{6}, \frac{D}{d}}_{min.Dis\tan ce}.\frac{7\lambda}{6}$$

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

$$= \frac{1.\times 600\times10^{-9}}{3\times10^{-3}} = 2\times10^{-4}m$$

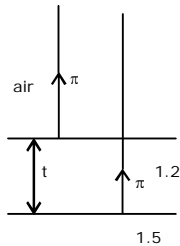**8.** $\Delta x = d\sin\theta = \lambda$

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

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

9.

$$2\mu t = \frac{\lambda}{2} \to minimum$$

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

10. Loyd's mirror

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

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

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

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

$$(2) - (1)$$

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

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

12.

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

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

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

$$(1) - (2)$$

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

$$\lambda = 6000\ Å$$

13. Path diff at centre

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

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

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

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

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

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

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

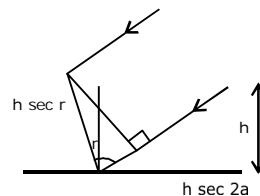$$\Rightarrow \frac{6300\times1.33\times100}{1.33\times2\times0.20} = 1.575\mu m$$

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

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

Now for central maxima :

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

$$y = 0.085D$$

16.

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

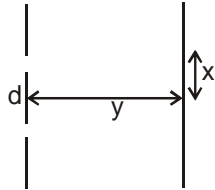$$\Rightarrow 2h\cos\alpha = \lambda/2 \Rightarrow h = \frac{\lambda}{\Delta\cos\alpha}$$

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

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

$\lambda_2 = 5400\text{Å}$

Exercise-III   Level-II
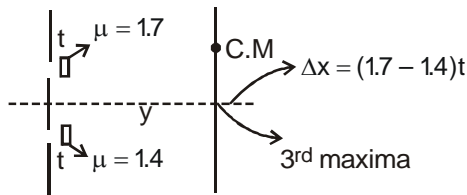
1 $\beta = \dfrac{\lambda y}{d}$

No. of fringe in x

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

∴ Rate of apperaance of no. of fringes

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

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

$\Delta\phi = (\mu - 1)t\,\dfrac{2\pi}{\lambda}$
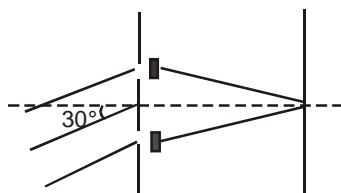
$I = I_0 \cos^2\left(\dfrac{\Delta\phi}{2}\right)$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$\dfrac{2\pi}{\lambda}\cdot\dfrac{dy}{D} = \pi - \dfrac{2\pi}{3} = \dfrac{\pi}{3}$

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

(d) 5 cm above O

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

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

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

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

5cm below O

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

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

I case

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

II case

$\dfrac{\lambda(100cm)}{(d + 1.2mm)} = \dfrac{2}{3}(0.25mm) \qquad ...(2)$

(1) ÷ (2)

$\dfrac{d + 1.2mm}{d} = \dfrac{3}{2} \Rightarrow d = 2.4\,mm$

Putting in (1)

we get $\lambda = 600$ nm

when the slabe is placed, C.M. shift to 20th maxima

$\therefore (\mu - 1) t = 20 \lambda \Rightarrow (1.5 - 1) t = 20 (600 \times 10^{-9})$ m

$\qquad t = 24 \, \mu m$

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

$= \left(\dfrac{27}{20} - 1\right)(2.5 - 1.25)$

$$\Delta x = \dfrac{7}{16} \mu m$$

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

$(\lambda_{air} = 5000 \, \text{Å})$

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

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

$\qquad = \dfrac{7\pi}{3}$

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

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

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

Q.6 $\lambda = 7 \times 10^7$ m

$\therefore \Delta x = (\mu - 1) t = 5 \lambda \qquad \ldots(i)$
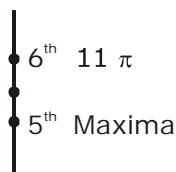
$t = 7 \, \mu m$

for Green light

$t (\mu_g - 1) = \Delta x = 6\lambda_r \quad \Rightarrow \mu_g - 1$

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

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

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

$\Delta\phi$ should be in between $10 \pi \to \qquad 11 \pi$

$6^{th} \quad 11 \pi$

$5^{th} \quad$ Maxima

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

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

$\therefore (1.7 - 1) t - (1.4 - 1) t = \dfrac{31\lambda}{6} \Rightarrow t = 9.3 \, \mu m$
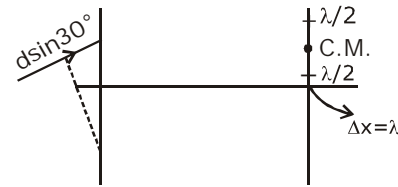
Q.8. Maxima $\Delta x = d = 2 \lambda$

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

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

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

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

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

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

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

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

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

$\qquad\qquad \dfrac{\pi}{180} \to 60$ min

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

$\left[\begin{array}{l} \text{5th dark fringe} \\ \Delta x = 4.5 \lambda \\ y = 1.5 \times \dfrac{\pi}{3.6} = \dfrac{\pi}{2.4} mm \end{array} \right.$
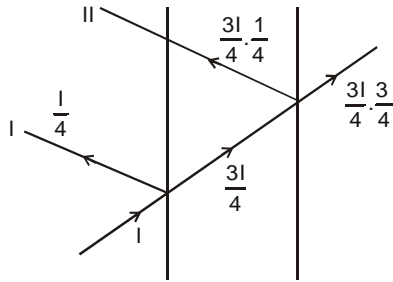
$$d = \frac{6.48}{\pi}$$

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

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

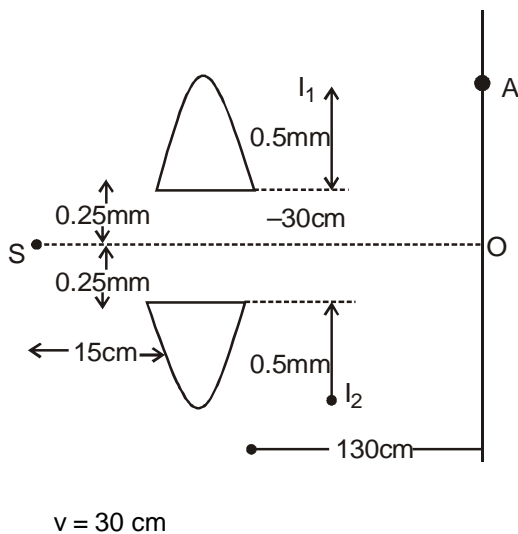**Q.10** I & II light wave interfere to produce interference Pattern

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

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

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

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

v = 30 cm

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

$h_i = 2h_0 = 2(0.25) = 0.5$ mm
∴ d = (0.5 + 0.5 + 0.5) = 1.5 mm
D = (130 − 30) = 100 cm
$\lambda = 500$ nm

$$OA = \frac{3\lambda D}{d} = \frac{3(500 \times 10^{-9})(100 \times 10^{-2})}{(1.5) \times 10^{-3}}$$

OA = 1mm

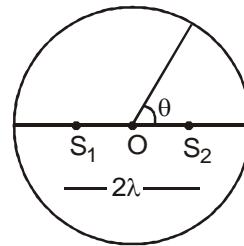(ii) If 0.5 mm is reduced, then resultant d will

reduce hence $OA = \dfrac{3\lambda D}{d}$ will ↑

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

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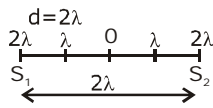
= 0.3 cm

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

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

Exercise-IV   Level-I

1. Coherent sources.

2.

$$d=2\lambda$$

$$2\lambda \quad \lambda \quad O \quad \lambda \quad 2\lambda$$

$$S_1 \xleftrightarrow{\quad 2\lambda \quad} S_2$$

Maxima 5

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

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

4. **C**

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

For principal maximum $\quad y = 0$
$\quad\quad\quad\quad\quad\quad\quad\quad\quad \theta = 0$
Hence, intensity will remain same.

5. **D**

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

$I = I_0 \cos^2\dfrac{\Delta\phi}{2} = 10 \cos^2\dfrac{\lambda}{6}$

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

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

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

$= 442.5$ 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

$I_1 = 4I_0 \cos^2\dfrac{\phi}{2} = 4I_0$
For incomepent source
$I_2 = I_0 + I_0 = 2I_0$
$\dfrac{I_1}{I_2} = 2.$

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

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

$Dx = \dfrac{\lambda}{y} \quad\quad \Delta\phi = \dfrac{2x}{\lambda} \times \dfrac{\lambda}{y} = \dfrac{x}{2}$

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

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

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I_1} + \sqrt{4I_2}\right)^2 = 9I_2$
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad = 9I_0$

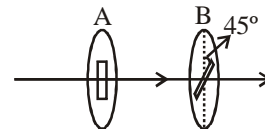$I = I_1 + I_2 \sqrt{I_1 + I_2} \cos\phi$

$= I_2 + 4I_2 + 2\sqrt{I_2 + 4I_2} \cos f$

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

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

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

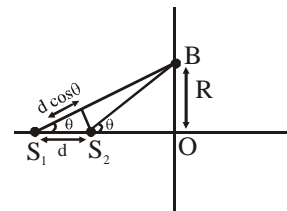$= \dfrac{I_m}{9}\left[\left(1 + 8\cos^2\dfrac{\phi}{2}\right)\right]$

13. **A**

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

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

14. **B**

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

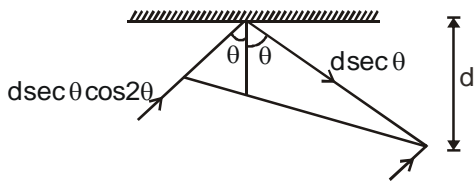## Exercise-IV   Level-II

1.   **A**

2   **B**   Path difference

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

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

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

For constructrive $\Delta x = n\lambda$

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

3.   1. $\sin 60^\circ = \sqrt{3}\ \sin r_1 \Rightarrow r_1 = 30^\circ \Rightarrow r_1 + r_2 = 30$
$\therefore r_2 = 0$
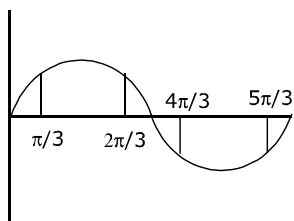$\therefore$ ray incident $\perp$ on AC, Thin film interference

4.   **D**
$(2n_1 - 1)\,\lambda_1 = (2n_2 - 1)\,\lambda_2 \Rightarrow (2n_1 - 1)\,400 = (2n_2 - 1)\,560 \Rightarrow (2n_1 - 1)\,5 = (2n_2 - 1) \times 7$
$n_1 = 4, n_2 = 3$
4th dark fringe of 400 nm and 3rd dark of 560 nm coincide.
Again $n_1 = 11, n_2 = 7$ coincide $\Rightarrow \Delta x = 7\lambda_1 = 7 \times 400 = 2800$ nm

$y = \dfrac{\Delta x D}{d} = 2800 \times 10^{-9} \times 10^4\ = 28$ 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

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

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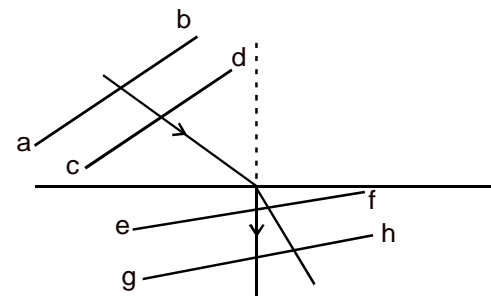

$\dfrac{\Delta\phi}{2} = \dfrac{\pi}{3}, \dfrac{2\pi}{3}, \dfrac{4\pi}{3}, \dfrac{5\pi}{3} \Rightarrow \dfrac{2\pi.\Delta x}{\lambda} = \Delta\phi$

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

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

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

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) → (P,S) ; (B) → (Q) ; (C) → (T) ; (D) → (RST)**

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

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

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

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