Wave Optics

JEE Main Exercise

1. (A)

If λ is the wavelength in vacuum, then $\lambda_1 = \dfrac{\lambda}{\mu_g}$ and $\lambda_2 = \dfrac{\lambda}{\mu_w}$ are the wavelength in glass and water respectively.

Then, $\dfrac{4}{\lambda_1} = \dfrac{5}{\lambda_2} \qquad \Rightarrow \dfrac{4\lambda}{\mu_w} = \dfrac{5\lambda}{\mu_g}$

$\therefore\ \mu_g = \dfrac{5}{4}\mu_w = \dfrac{5}{4}\times\dfrac{4}{3} = \dfrac{5}{3}$

2. (A)

In the liquid, the frequency v remains same and wavelength λ' becomes $\lambda' = \dfrac{\lambda}{\mu} = \dfrac{\lambda}{3/2} = \dfrac{2}{3}\lambda$

3. (A)

Here, $\dfrac{I_1}{I_2} = 9$

$$\frac{I_{\max}}{I_{\min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{\frac{I_1}{I_2}}-1\right)^2} = \left(\frac{3+1}{3-1}\right)^2 = 4$$

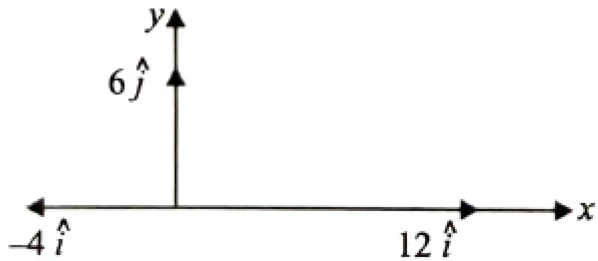
4. (B)

$\dfrac{I_1}{I_2} = \beta$

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

$$= \frac{4\sqrt{I_1 I_2}}{2\left(I_1+I_2\right)} = \frac{2\sqrt{I_1/I_2}}{1+I_1/I_2} = \frac{2\sqrt{\beta}}{1+\beta}$$

5. (B)



As the three waves are coherent with successive phase difference of $\frac{\pi}{2}$, their amplitude in vector form can be written as

$12\hat{i}$ mm, $6\hat{i}$ mm and $-4\hat{i}$ mm

Their vector sum is $\vec{A} = 12\hat{i} + 6\hat{j} + (-4\hat{i}) = (8\hat{i} + 6\hat{j})$mm

Its magnitude is $\sqrt{8^2 + 6^2} = 10$ mm

6. (D)

As the lights emergent from the two filters have difference wavelengths, the interference pattern will not be formed.

7. (D)

The distance of second dark fringe from central fringe is

$$\frac{3}{2}\frac{\lambda D}{d} = 1\text{ mm}$$

$$\Rightarrow \quad \frac{3}{2} \times \frac{\lambda \times 1}{0.9 \times 10^{-3}} = 10^{-3}$$

$$\therefore \quad \lambda = 0.6 \times 10^{-6}\text{ m} = 6 \times 10^{-5}\text{ cm}$$

8. (C)

$$\omega = \frac{\lambda D}{d} \qquad \Rightarrow \quad \frac{\omega_2}{\omega_1} = \frac{\lambda_2}{\lambda_1}$$

$$\Rightarrow \quad \omega_2 = \frac{\lambda_2}{\lambda_1}\omega_1 = \frac{6000}{5000} \times 1 = 1.2\text{ mm}$$

9. (A)

For a maxima at distance *x* from central maxima, we have

$$x = \frac{n\lambda D}{d} \quad \text{or} \quad \lambda = \frac{xd}{nD}$$

$$\Rightarrow \quad \lambda = \frac{10^{-3} \times 2 \times 10^{-3}}{2 \times 2.5} = \frac{0.8}{n} \times 10^{-6}\text{ m} = \frac{8000}{b}\text{ Å}$$

In the visible region, $\lambda = \frac{8000}{2} = 4000$ Å

10. (B)

$\lambda = 600\text{ nm}$ and $d = 2100\text{ nm}$

The maximum possible path difference is at infinity equal to *d*.

So, $\Delta p < 2100\text{ nm} = 3.5\lambda$

Maximas are obtained when $\Delta p = n\lambda$ corresponding to $n = -3, -2, -1, 0, 1, 2, 3$

Hence, 7 maximas can be obtained.

11. (B)

P is the 11th bright fringe from Q and 10th bright fringe from O.

So, $S_1P - S_2P = 10\,\mu = 10 \times 6000\,\text{Å} = 6\,\mu\text{m}$

12. (A)

The phase difference corresponding to a path difference of $\frac{\lambda}{6}$ is $\phi = \frac{\lambda}{6} \times \frac{2\pi}{\lambda} = \frac{\pi}{3}$

$$\Rightarrow \quad I = I_0 \cos^2 \frac{\phi}{2} = I_0 \cos^2 \frac{\pi}{6}$$

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

13. (A)

When $\Delta p = \lambda, \phi_1 = 2\pi$ and when $\Delta p = \frac{\lambda}{3}, \phi_2 = \frac{2\pi}{3}$

$$\Rightarrow \quad I = I_{\max} \cos^2\left(\frac{\phi_1}{2}\right) = I_{\max} \text{ and } I' = I_{\max} \cos^2\left(\frac{\phi_2}{2}\right) = \frac{I_{\max}}{4}$$

$$\therefore \quad I' = \frac{I}{4}$$

14. (C)

The intensity at the centre is zero, if the fringe shift,

$FS = (2n+1)\frac{\omega}{2}$ or the optical path difference at centre is

$$\Delta p = (2n+1)\frac{\lambda}{2} \text{ or } t(\mu - 1) = (2n+1)\frac{\lambda}{2}$$

$$\therefore \quad t_{\min} = \frac{\lambda}{2(\mu-1)}$$

15. (B)

For the total path difference to be zero,

$$t(2\mu - 1) = 2t(\mu - 1) + \frac{dy}{D} \qquad \Rightarrow \frac{dy}{D} = t \qquad \therefore\ y = \frac{tD}{d}$$

16. (A)

As the lower ray is geometrically longer, mica sheet must be placed in front of S_1 so that

$$t(\mu - 1) = \Delta p = \sqrt{2}d - d$$

$$\therefore \quad t = \frac{d(\sqrt{2}-1)}{1.5-1} = 2(\sqrt{2}-1)d$$

17. (B)
Diffraction and interference observed in light indicates wave nature of light.

18. (C)
Second maximum lies between 2nd minimum ($\Delta p = 2\lambda$) and 3rd minimum ($\Delta p = 3\lambda$)
For second maximum, $\Delta p = 2.5\lambda$

$$\therefore \quad a \sin\theta = \frac{5}{2}\lambda$$

19. (A)
The angular width of central maximum is

$$\frac{2\lambda D/a}{D} = \frac{2\lambda}{a} = \frac{2\times 6328\times 10^{-10}}{0.2\times 10^{-3}} = 6.328\times 10^{-3} \text{ rad}$$

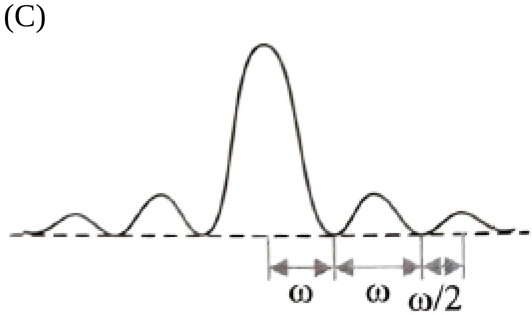
$$= 6.328\times 10^{-3} \times \frac{180}{\pi} = 0.36^\circ$$

20. (B)
Angular width of central maximum is

$$\omega = \frac{2\lambda}{a} \qquad \Rightarrow \quad \frac{\lambda_2}{\lambda_1} = \frac{\omega_2}{\omega_1} = 0.7$$

$$\therefore \quad \lambda_2 = 0.7 \times 6000 = 4200 \text{ Å}$$

21. (C)



The distance of second maximum from central maximum is

$$\omega + \omega + \frac{\omega}{2} = \frac{5}{2}\frac{\lambda D}{2} = 12 \text{ mm}$$

$$\therefore \quad a = \frac{5\times 6000\times 10^{-10}\times 4}{2\times 12\times 10^{-3}} = 5\times 10^{-4} \text{ m} = 0.5 \text{ mm}$$

22. (A)

$$I = I_0\left(\frac{\sin\beta}{\beta}\right)^2 \text{ where, } \beta = \frac{\pi a \sin\theta}{\lambda}$$

For the principal maxima,

$$\theta = 0 \quad \Rightarrow \beta = 0 \qquad \therefore I = I_0.$$

Increasing the width of the slit will make central peak narrower but there will be no change in intensity at the centre.

23. (A)

If r is the distance of the poles from the person, then

$$\alpha_{\min} = \frac{10}{r} \text{ where, } \alpha_{\min} = \frac{1}{60} \times \frac{\pi}{180} \text{rad}$$

$$\therefore \quad r = \frac{10 \times 60 \times 180}{\pi} = 3.4 \times 10^4 \text{ m} \approx 34 \text{ km}$$

24. (C)

If a = 3 mm is the pupil diameter and D is the maximum distance at which the dots at distance x can be resolved by the eye, then the limit of resolution is $\frac{x}{D} = \frac{1.22\lambda}{a}$

$$\therefore \quad D = \frac{ax}{1.22\lambda} = \frac{3 \times 10^{-3} \times 10^{-3}}{1.22 \times 500 \times 10^{-9}} = 4.9 \text{ m} \approx 5 \text{ m}.$$

25. (D)

In one rotation of polaroid, the transmission axis of the polaroid will be twice in line and twice perpendicular to the plane of polarisation of the incident light.

26. (C)

As the intensity of emergent light is reduced to half, the light which does not get transmitted is $\frac{I_0}{2}$.

27. (A)

If the intensity of unpolarised light is I_0, then the intensity of light transmitted through analyser is

$$\frac{I_0}{2} \cos^2 45° = \frac{I_0}{4}$$

As $I \propto A^2$, the amplitude of transmitted light is $\frac{A}{2}$.

28. (B)

The intensity of light transmitted through the combination is

$$\frac{I}{2} \times \cos^2 \frac{\pi}{3} \times \cos^2 \frac{\pi}{3} \times \cos^2 \frac{\pi}{3} = \frac{I}{128}$$

29. (C)

30. (7)

As the central bright fringe shifts to the position of 5th bright fringe, the optical path difference due to the glass plate is

$$t(\mu - 1) = 5\lambda$$

$$\therefore \quad t = \frac{5\lambda}{\mu - 1} = \frac{5 \times 7 \times 10^{-7}}{1.5 - 1} = 7 \,\mu\text{m}$$

31. (7)

$\lambda = 5000\,\text{Å}, t = 14\,\mu\text{m}, \mu = 1.25$

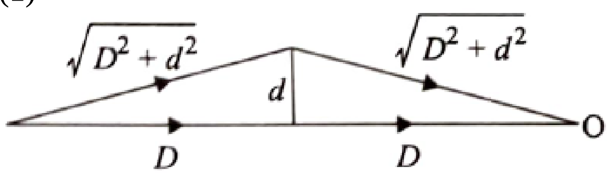
The optical path difference due to the sheet is

$\Delta p = t(\mu - 1) = 14\times10^{-6}(1.25-1) = 3.5\times10^{-6}\text{ m}$

$= 35000\,\text{Å} = 7\lambda$

So, the number of fringes shifted is 7.

32. (1)



For a dark fringe at O, the path difference of the two rays reaching O from two slits is $\frac{\lambda}{2}$

$\Rightarrow\quad 2\left[\sqrt{D^2+d^2} - D\right] = \frac{\lambda}{2}$

$\Rightarrow\quad 2\left[D\left(1+\frac{d^2}{D^2}\right)^{1/2} - D\right] = \frac{\lambda}{2}$

$\Rightarrow\quad 2\left[D\left(1+\frac{d^2}{2D^2}\right) - D\right] = \frac{\lambda}{2}$

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

$\therefore\quad d = \sqrt{\frac{\lambda D}{2}} = \sqrt{\frac{4000\times10^{-10}\times5}{2}} = 10^{-3}\text{ m} = 1\text{mm}$

33. (0)

λ = 5000 Å, d = 0.5 mm, D = 1 m, t = 1.5 μm

At the centre of screen, the path difference is only optical

$\Rightarrow\quad \Delta p = t(\mu-1) = 1.5\times10^{-6}(1.5-1) = 7.5\times10^{-7}\text{ m}$

$= 7500\,\text{Å} = \frac{3\lambda}{2}$

So, there will be a destructive interference at the centre

$\therefore\quad n = 0$

34. (9)

At upper surface of layer, reflected is at rarer to denser medium while on the lower surface, the reflection is at denser to rarer medium. So, the two rays differ in phase by π. For the two rays to interfere constructively,

$\Delta p = 2\mu t = (2n+1)\frac{\lambda}{2}$

$\Rightarrow\quad t_{\min} = \frac{\lambda}{4\mu} = \frac{648\text{ nm}}{4\times1.8} = 90\text{ nm} = (10\times9)\text{nm}$

$\therefore\quad P = 9$

35. (6)

D = 80 cm, d = 2 mm, $t_1 = 25\,\mu\text{m}$, $t_2 = 12.5\,\mu\text{m}$, $\mu_w = 4/3$, $\mu = 1.4$, $\lambda = 5000\,\text{Å}$

The wavelength in water is $\lambda_w = \dfrac{\lambda}{\mu_w} = \dfrac{5000\,\text{Å}}{4/3} = 3750\,\text{Å}$

Taking the water as reference medium, the optical path difference at the centre of screen is

$$\Delta p = t_1\left(\frac{\mu}{\mu_w}-1\right) - t_2\left(\frac{\mu}{\mu_w}-1\right) = (t_1 - t_2)\left(\frac{\mu}{\mu_w}-1\right)$$

$$= (25-12.5)\times 10^{-6}\times\left(\frac{1.4}{4/3}-1\right) = 12.5\times 10^{-6}\times 0.05\,\text{m}$$

$$= 6250\ \text{Å}$$

$$\phi = \frac{\Delta p}{\lambda_w}\times 2\pi = \frac{6250}{3750}\times 2\pi = \frac{10\pi}{3}$$

If the intensity of individual slit at the centre of screen is I_0, then the resultant intensity of light from the two slits is

$\Rightarrow \quad I_R = 4I_0\cos^2\dfrac{\phi}{2} = 4I_0\cos^2\dfrac{5\pi}{3} = I_0$

$\Rightarrow \quad \dfrac{I_R}{I_0} = 1 = \dfrac{6}{6}$

$\therefore \quad n = 6$

36. (4)

$\lambda = 450\,\text{nm},\ \mu = 1.5,\ \theta = (1/20)^\circ,\ x = 43n\times 10^{-6}\ \text{m}$

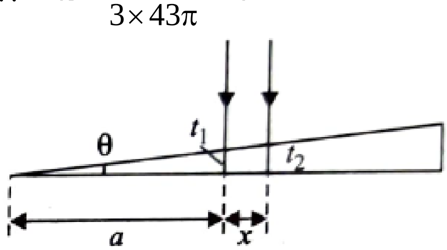
$2\mu t_1 = k\lambda$ and $2\mu t_2 = (k+1)\lambda$

$\Rightarrow \quad 2\lambda(t_2 - t_1) = \lambda$

$\Rightarrow \quad \dfrac{\lambda}{2\mu} = t_2 - t_1 = (a+x)\theta - a\theta = x\theta$

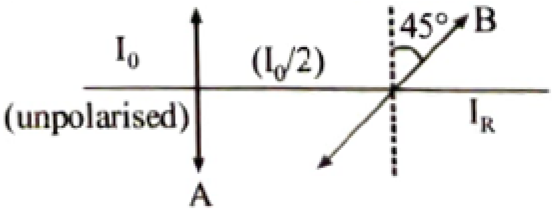
$\Rightarrow \quad \dfrac{450\times 10^{-9}}{2\times 1.5} = 43n\times 10^{-6}\times\dfrac{1}{20}\times\dfrac{\pi}{180}$

$\therefore \quad n = \dfrac{36\times 45}{3\times 43\pi} \approx 4$



1. (D)
It will be concentric circles because locus of all the point having same path difference lies on concentric circle.

2. (C)
Relation between intensities



$$I_r = \left(\frac{I_0}{2}\right)\cos^2(45°) = \frac{I_0}{2}\times\frac{I}{2} = \frac{I_0}{4}$$

3. (A)
Fringe width $B = \frac{D}{d}\lambda$

And number of fringes observed in the field of view is obtained by $\frac{d}{\lambda}$.

4. (C)
Wavelength of radio waves is greater than microwaves hence frequency of radio waves is less than microwaves.
The degree of diffraction is greater whose wavelength is greater.

5. (D)
Intensity $\propto$ (amplitude)^2

$$\frac{I_1}{I_2} = \frac{19}{6} = \frac{a_1^2}{a_2^2}$$

$\Rightarrow a_1 = 4; a_2 = 3$

Therefore the ratio of intensities of bright and dark parts

$$\frac{I_{Bright}}{I_{Dark}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{(4+3)^2}{(4-3)^2} = \frac{49}{1}$$

6. (B)
In a single slit experiment,
For diffraction maxima,

$a\sin\theta = (2n+1)\frac{\lambda}{2}$ and for diffraction minima,

$a\sin\theta = n\lambda$

According to question,

$$(2\times1+1)\frac{\lambda}{2} = 1\times6600 \quad (\because \lambda = 6600\ Å)$$

$$\Rightarrow \lambda = \frac{6600 \times 2}{3} \Rightarrow \lambda = 4400 \text{ Å}$$

7. (C)

Resolving power of microscope,

$$\text{R.P.} = \frac{2n\sin\theta}{\lambda} = \frac{2n\sin 2\beta}{\lambda} \Rightarrow \text{R.P.} \propto n\sin 2\beta$$

$\lambda =$ Wavelength of light used to illuminate the object

n = Refractive index of the medium between object and objective

$\theta =$ Angle of the cone

$\beta =$ Angle made by diameter of objective lens at focus.

8. (C)

$$\beta_{\text{diffrac}} = 2\left(\frac{D\lambda}{a}\right), \text{ a = slit width}$$

$$\beta_{\text{interfer}} = \frac{D\lambda}{d} \qquad \therefore \frac{2D\lambda}{a} = \frac{D\lambda \times n}{d}$$

$$\Rightarrow \frac{2}{a} = \frac{n}{d} \Rightarrow n = \frac{2d}{a} = \frac{2 \times 6.1a}{a} \simeq 12$$

9. (D)

According to malus law, intensity of emerging beam is given by,

$$I = I_0 \cos^2\theta$$

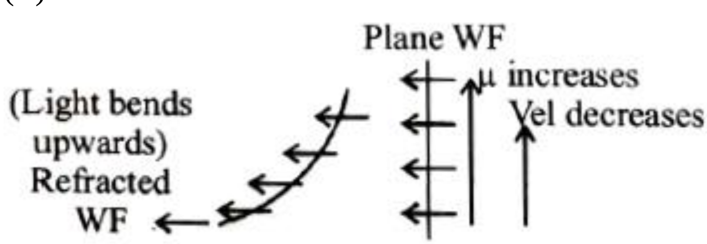
Now, $I_{A'} = I_A \cos^2 30°$

$I_{B'} = I_B \cos^2 60°$

As $I_{A'} = I_{B'}$

$$\Rightarrow I_A \times \frac{3}{4} = I_B \times \frac{1}{4};\ \frac{I_A}{I_B} = \frac{1}{3}$$

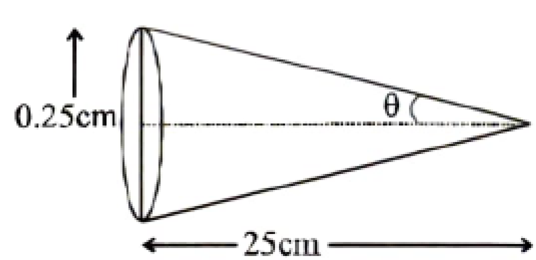
10. (B)



11. (D)

$$\sin\theta = \frac{0.25}{25} = \frac{1}{100}$$

$$\text{Resolving power} = \frac{1.22\lambda}{2\mu\sin\theta} = 30\ \mu\text{m}.$$



12. (C)

$2I_0 = 4I_0\cos^2\left(\frac{\Delta\phi}{2}\right)$ here, $\Delta\phi = \frac{\pi}{2}$

But, $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ So, $\Delta x = \frac{\lambda}{4}$

So, $Y = \frac{\Delta x D}{d} = \frac{\lambda}{4}\cdot\frac{D}{d} = \frac{\beta}{4}$

13. (A)

We know that $\Delta\theta = \frac{0.61\lambda}{4} = \frac{l}{R}$

The minimum distance between them

$l = \frac{R}{9}0.61\times\lambda = \frac{9.46\times10^{15}\times10\times0.61\times600\times10^{-9}}{0.3}$

$= 1.15\times10^{11}\text{m} \Rightarrow 1.115\times10^{8}\text{ km}.$

14. (A)

Given geometrical spread = a

Diffraction spread $= \frac{\lambda}{a}\times L = \frac{\lambda L}{a}$

The sum $b = a + \frac{\lambda L}{a}$

For b to be minimum

$\frac{db}{da} = 0,$ $\therefore \frac{d}{da}\left(a + \frac{\lambda L}{a}\right) = 0 \Rightarrow a = \sqrt{\lambda L}$

$b\min = \sqrt{\lambda L} + \sqrt{\lambda L} = 2\sqrt{\lambda L} = \sqrt{4\lambda L}$

15. (D)

For common maxima, $n_1\lambda_1 = n_2\lambda_2$

$\Rightarrow \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{520\times10^{-9}}{650\times10^{-9}} = \frac{4}{5}$

For λ_1

$y = \frac{n_1\lambda_1 D}{d}$, $\lambda_1 = 650\text{ nm}$

$y = \frac{4\times650\times10^{-9}\times1.5}{0.5\times10^{-3}}$ or y = 7.8 mm

16. (B)

For secondary minima,

$b\sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n\lambda}{b}$

Distance of n^{th} secondary minima $x = D\sin\theta$

or $\sin\theta_1 = \frac{x_1}{D} \Rightarrow \sin\theta_1 = \frac{2\lambda}{b}$

n = 4

$\sin\theta_2 = \frac{4\lambda}{b} = \frac{x_2}{D}$

$x_2 - x_1 = \frac{4\lambda}{b} - \frac{2\lambda}{2} = \frac{2\lambda}{b}$

$3 = \frac{2\lambda}{b} \Rightarrow b = \frac{2\lambda}{3}$ .....(i)

Width of central maxima $= \frac{2\lambda}{b} = \frac{2\lambda}{2\lambda} = 3\text{ cm}$ … from eq. (i)

17. (B)

$a = 0.1\text{ mm} = 10^{-4}\text{cm}$,

$l = 6000 \times 10^{-10}\text{ cm} = 6 \times 10^{-7}\text{cm}, D = 0.5\text{ m}$

for 3rd dark band, $a\sin\theta = 3\lambda$

or $\sin\theta = \frac{3\lambda}{a} = \frac{x}{D}$

$x = \frac{3\lambda D}{a} = \frac{3 \times 6 \times 10^{-7} \times 0.5}{10^{-4}} = 9\text{ mm}$

18. (A)

Angular width of central maxima $= \frac{2\lambda}{d}$

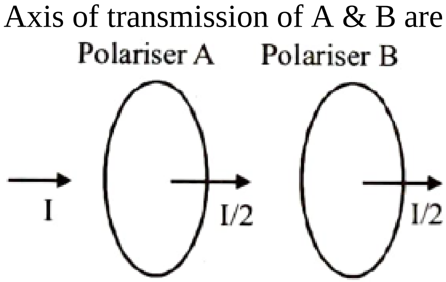
or, $\lambda = \frac{d}{2}$; Fringe width, $\beta = \frac{\lambda \times D}{d'}$

$10^{-2} = \frac{d}{2} \times \frac{50 \times 10^{-2}}{d'} = \frac{10^{-6} \times 50 \times 10^{-2}}{2 \times d'}$

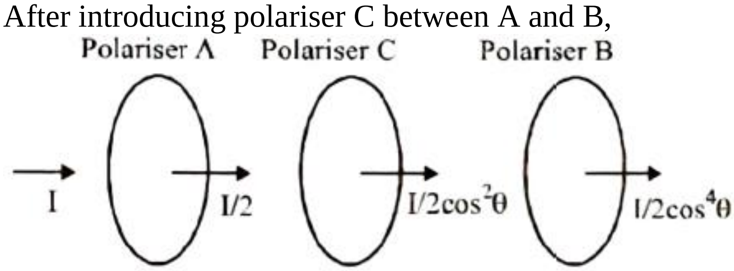
Therefore, slit separation distance, $d' = 25\ \mu\text{m}$

19. (C)

Axis of transmission of A & B are parallel.



After introducing polariser C between A and B,



$\frac{I}{2}\cos^4\theta = \frac{I}{8} \Rightarrow \cos^4\theta = \frac{1}{4} \Rightarrow \cos\theta = \frac{1}{\sqrt{2}}$ or, $\theta = 45°$

20. (A)

Polariser A and B have same alignment of transmission axis.

Lets assume polariser C is introduced at θ angle

$$\frac{1}{2}\cos^2\theta\times\cos^2\theta=\frac{1}{3}\Rightarrow\cos^4\theta=\frac{2}{3}\Rightarrow\cos\theta=\left(\frac{2}{3}\right)^{1/4}$$

21. (C)

Given amplitude ratio of waves is $\frac{a_2}{a_1}=\frac{3}{1}$

$$\therefore\ \frac{I_{max}}{I_{min}}=\left(\frac{a_2+a_1}{a_2-a_1}\right)^2$$

$$=\left(\frac{\frac{a_2}{a_1}+1}{\frac{a_2}{a_1}-1}\right)^2=\left(\frac{3+1}{3-1}\right)^2=\left(\frac{4}{2}\right)^2=\frac{4}{1}=4$$

22. (B)

As we know, $\frac{I_{max}}{I_{min}}=\left(\frac{A_1+A_2}{A_1-A_2}\right)^2$ and $\sqrt{\frac{I_1}{I_2}}=\frac{A_1}{A_2}$

$$\frac{I_{max}}{I_{min}}=16\Rightarrow\frac{A_{max}}{A_{min}}=4\Rightarrow\frac{A_1+A_2}{A_1-A_2}=\frac{4}{1}$$

Using componendo and dividendo.

$$\frac{A_1}{A_2}=\frac{5}{3}\Rightarrow\frac{I_1}{I_2}=\left(\frac{5}{3}\right)^2=\frac{25}{9}$$

23. (A)

Path difference $=d\sin\theta\approx d\theta$

$$0.1\times\frac{1}{40}\text{ mm}=2500\text{ nm}$$

For bright fringe, path difference must be integral multiple of λ.

$\therefore\ 2500=n\lambda_1=m\lambda_2$

$\therefore\ \lambda_1=625$ (for n = 4), $\lambda_2=500$ (for m = 5)

24. (A)

Here, $x_1=2d$ and $x_2=\sqrt{5}d$

For, first minima, $\Delta x=\frac{\lambda}{2}$

$$\therefore\Delta x=x_2-x_1=\sqrt{5}d-2d=\frac{\lambda}{2}\Rightarrow d=\frac{\lambda}{2\left(\sqrt{5}-2\right)}$$

25. (D)

For ‘n’ number of maximas

$$d\sin\theta = n\lambda$$

$$0.32\times10^{-3}\sin 30^\circ = n\times500\times10^{-9}$$

$$\therefore\; n = \frac{0.32\times10^{-3}}{500\times10^{-9}}\times\frac{1}{2} = 320$$

Hence total no. of maximas observed in angular range $-30^\circ \le \theta \le 30^\circ$

= 320 + 1 + 320 = 641

26. (A)

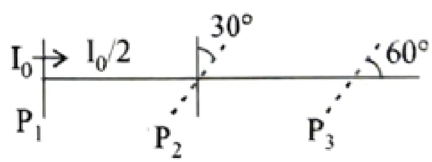
$$x = \frac{1.22\lambda}{2\mu\sin\theta} = \frac{1.22\times5000}{2\times1.25} = 0.24\,\mu m$$

27. (C)

$$I = \left(\frac{I_0}{2}\right)\cos^2 30^\circ\cos^2 60^\circ$$

$$= \frac{I_0}{2}\times\frac{3}{4}\times\frac{1}{4}$$

$$\therefore\; \frac{I_0}{I} = \frac{32}{3} = 10.67$$



28. (C)

$$\theta = \frac{1.22\lambda}{d} = \frac{1.22\times600\times10^{-9}}{250\times10^{-2}} = 3.0\times10^{-7}\text{ rad}$$

29. (A)

$$\theta = \frac{1.22\lambda}{d} = \frac{1.22\times500\times10^{-9}}{2} = 305\times10^{-9}\text{ rad}$$

30. (B)

Angular width between first and second diffraction minima $\theta \simeq \frac{\lambda}{a}$ and angular width of fringe due to double slit is $\theta' = \frac{\lambda}{d}$.

So, number of fringes $= \frac{\theta}{\theta'} = \left(\frac{\frac{\lambda}{a}}{\frac{\lambda}{d}}\right) = \left(\frac{d}{a}\right) = \frac{19.44}{4.05} = 4.81 \simeq 5$

31. (B)

According to Brewster’s law, refractive index of material (μ) is equal to tangent of polarising angle

$$\because\quad \tan i_b = \mu = \frac{1.5}{\mu}$$

$$\frac{1}{\mu} < \frac{1.5}{\sqrt{\mu^2+(1.5)^2}}\;(\because \sin i_c < \sin i_b)\qquad \therefore \sin i_b = \frac{1.5}{\sqrt{\mu^2+(1.5)^2}}$$

$\Rightarrow \sqrt{\mu^2 + (1.5)^2} < 1.5 \times \mu \Rightarrow \mu^2 + (1.5)^2 < (\mu \times 1.5)^2$

$\Rightarrow \mu < \dfrac{3}{\sqrt{5}}$ i.e. minimum value of μ should be $\dfrac{3}{\sqrt{5}}$

32. (D)

Initially, $S_2L = 2\,m$

$$S_1L = \sqrt{2^2 + \left(\frac{3}{2}\right)^2} = \frac{5}{2} 2.5\,m$$

Path difference, $\Delta x = S_1L - S_2L = 0.5\,m = \dfrac{\lambda}{2}$

So we have minima here
Ar L', we have maxima
So, $\Delta x = \lambda$
$d - 2 = \lambda \Rightarrow d - 2 = 1 \Rightarrow d = 3\,m$

33. (C)

Optical path for first ray which travels a path L_1 through a medium of refractive index $n_1 = n_1L_1$

Optical path for second ray which travels a path L_2 through a medium of refractive index $n_2 = n_2L_2$

Path difference $= n_1L_1 - n_2L_2$

Now, phase difference

$= \dfrac{2\pi}{\lambda} \times$ path difference $= \dfrac{2\pi}{\lambda} \times (n_1L_1 - n_2L_2)$

34. (B)

Given : Wavelength of light, $\lambda = 500\,nm$

Distance width of the fringe formed,

$$\theta = \frac{\lambda}{d} = \frac{500 \times 10^{-9}}{0.05 \times 10^{-3}} = 0.01\,rad = 0.57^\circ$$

35. (A)

Path difference, $\Delta P = d\sin\theta = d\theta$

d = distance between slits = 1 mm = 10^{-3} mm

D = distance between the slits and screen = 100 cm = 1 m

y = distance between central bright fringe and observed fringe = 1.27 mm

$$\therefore\ \Delta P = \frac{dy}{D} = \frac{10^{-3} \times 1.270\,mm}{1\,m} = 1.27\,m$$

36. (D)

Let n_1 fringes are visible with light of wavelength λ_1 and n_2 with light of wavelength λ_2. Then

$$\frac{n_1D\lambda_1}{d} = \frac{n_2D\lambda_2}{d}$$

$$\Rightarrow \frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2} \Rightarrow n_2 = \frac{700}{400} \times 16 = 28$$

37. (A)

Fringe width, $\beta = \frac{\lambda D}{d}$ where, $\lambda =$ wavelength, D = distance of screen from slits, d = distance between slits ATQ

$15 \times \frac{\lambda_1 D}{d} = 10 \times \frac{\lambda_2 D}{d} \Rightarrow 15\lambda_1 = 10\lambda_2$

$\Rightarrow \lambda_2 = 1.5\lambda_1\ 15\lambda_1 = 1.5 \times 500\,\text{nm} \Rightarrow \lambda_2 = 750\text{ nm}$

38. (C)

Given, distance between screen and slits, D = 1.5 m

Separation between slits, d = 0.15 mm

Wavelength of source of light, $= 589\,\text{nm}$

Fringe-width, $w = \frac{D}{d}\lambda = \frac{15}{0.15 \times 10^{-3}} \times 589 \times 10^{-9}\text{ m}$

$= 589 \times 10^{-2}\text{ mm} = 5.89 \approx 5.9\text{ mm}$

39. (C)

Given, $\Delta = \beta$ or $\frac{D(\mu - 1)t}{d} = \frac{D\lambda}{d}$

$\therefore \quad t = \frac{\lambda}{(\mu - 1)}$

40. (B)

Given :

Intensity, $I_0 = 3.3\,\text{Wm}^{-2}$

Area, $A = 3 \times 10^{-4}\text{ m}^2$

Angular speed, $\omega = 31.4\,\text{rad/s}$

Average energy $I_0 A < \cos^2\theta > T$

$\because < \cos^2\theta > = \frac{1}{2}$

$\therefore$ Average energy $= \frac{(3.3) \times (3 \times 10^{-4})}{2} \times \frac{2\pi}{\omega} \simeq 10^{-4}\text{ J}$

41. (B)

According to question, the intensity of light coming out of the analyser is just 10% of the original intensity (I_0)

Using, $I = I_0 \cos^2\theta$

$\Rightarrow \frac{I_0}{10} = I_0 \cos^2\theta \Rightarrow \frac{1}{10} = \cos^2\theta$

$\Rightarrow \cos\theta = \frac{1}{\sqrt{10}} = 0.316 \Rightarrow \theta \approx 71.6°$

Therefore, the angle by which the analyser need to be rotated further to reduced the output intensity to be zero

$\phi = 90° - \theta = 90° - 71.6° = 18.4°$

42. (D)

Maximum intensity in interference pattern

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

43. (D)

Fringe width, $\beta = \frac{\lambda D}{d}$

Here, $\lambda =$ wavelength of light

D = Distance between sources and screen

d = distance between two slits

As $\lambda_{blue} < \lambda_{orange}$

So, $\beta_{blue} < \beta_{orange}$

44. (B)

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

$$\beta = \frac{D\lambda}{(d_0 + a_0 \sin \omega t)} \quad [\because d = d_0 + a_0 \sin \omega t]$$

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

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

45. (B)

Given:

$d = 0.5\,mm = 0.5 \times 10^{-3}\,m$ and $D = 0.5\,m$

Fringe width $\beta = \frac{\lambda D}{d} = \frac{5890 \times 10^{-10} \times 0.5}{0.5 \times 10^{-3}} = 589 \times 10^{-6}$ m

Hence, distance between the first and third bright fringe =

$2\beta = 2 \times 589 \times 10^{-6}\,m = 1178 \times 10^{-6}$ m

46. (A)

Fringe width,

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

Here, $\lambda =$ wavelength of light

D = Distance of screen from source

d = Distance between the slits

$\because \lambda_R > \lambda_V$

As wavelength of light decreases, fringe width will decreases and fringe line will come closer.

47. (A)

Fringe width, $\beta = \frac{\lambda D}{d}$

Where D is the distance between slit and screen, d is the distance between two slits, λ is the wavelength of light.

$\therefore\ \beta = \frac{500\times10^{-9}\times1}{2\times10^{-3}} = 250\times10^{-6} = 0.25\text{ mm}$

48. (D)

$\because\ \sin\theta = \frac{1.22\lambda}{D}$, where D is opening diameter.

When opening size diameter of the pinhole is increased, the diffraction size decreases but intensity increases.

49. (B)

We have given, $\frac{I_1}{I_2} = \frac{1}{4} \Rightarrow I_2 = 4I_1$

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

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

$\therefore\ \frac{I_{max}+I_{min}}{I_{max}-I_{min}} = \frac{9I_1+I_1}{9I_1-I_1} = \frac{10}{8} = \frac{5}{4} = \frac{2\alpha+1}{\beta+3}$

$\alpha = 2 \quad \beta = 1$

$\therefore\ \frac{\alpha}{\beta} = \frac{2}{1} = 2$

50. (C)

We have $\lambda_0 = 670\text{ nm}$

$\Delta\lambda = 0.7\text{ nm}$. This is case of red shift.

So, $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow v = c\frac{\Delta\lambda}{\lambda} \Rightarrow v = 3\times10^8\times\frac{0.7}{670}$

$\Rightarrow\ v = 3.13\times10^5\text{ m/s}$

51. (B)

$I_{P+2} = I + 9I + 2\sqrt{I.9I}\cos\frac{\pi}{2} = 10\,I$

$I_Q = I + 9I + 2\sqrt{I.9I}\cos\pi$

$= I + 9I + 2.3I\times-1 = 4I$

So, $I_P - I_Q = 10I - 4I = 6I$

52. (D)

$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2} = \frac{(\sqrt{9}+\sqrt{4})^2}{(\sqrt{9}-\sqrt{4})^2} = \frac{25}{1}$

53. (B)

Fringes width, $\beta = 12\text{ mm}$

Refractive index of water, $\mu = \frac{4}{3}$

The fringes width is given by,

$$\beta = \frac{D\lambda}{d} \qquad .....(i)$$

Here, λ is wavelength of light.

D is distance between screen and source.

d is distance between coherent source.

If the entire arrangement is placed in water then fringes with becomes

$$\beta' = \frac{D\lambda'}{'d} \qquad .....(ii)$$

Dividing equation (ii) by (i), we have

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

$$\Rightarrow \beta' = \frac{12\times 3}{4} \qquad \left(\because \mu = \frac{\lambda}{\lambda'}\right)$$

$$\Rightarrow \beta' = 9\text{ mm}$$

54. (D)

Width α Amplitude^2 α I

So, $\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2} = \frac{\left(\sqrt{9}+\sqrt{16}\right)^2}{\left(\sqrt{9}-\sqrt{16}\right)^2} = \frac{49}{1}$

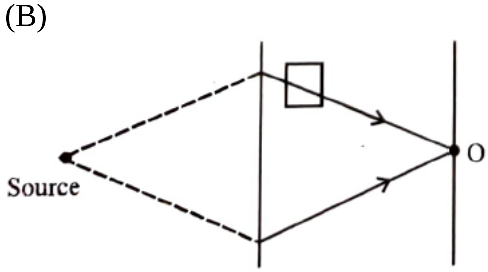
55. (D)

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

$\beta \propto \frac{\lambda}{d} \Rightarrow \frac{\beta_2}{\beta_1} = \frac{\lambda_2}{\lambda_1}\times\frac{d_1}{d_2} = \frac{6}{5}\times\frac{d_1}{2d_1} = \frac{3}{5}$

So, $\beta_2 = \frac{3}{5}\beta_1 = \frac{3}{5}\times 0.5\text{ mm} = 0.3\text{ mm}$

56. (B)



Path difference at $O = t(\mu - 1)$

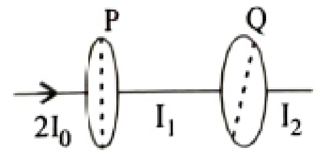
If the intensity at O remains (maximum) unchanged, path difference must be $n\lambda$

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

$\Rightarrow x\lambda(12-1) = n\lambda$

$\Rightarrow\ x = 2n$
For n = 1, x = 2.

57. (C)
The intensity of the light given by, $I = I_0 \cos^2\theta$



$$I_1 = \frac{1}{2}(2I_0)\cos^2\theta = I_0$$
$$I_2 = I_1\cos^2 30° = I_0 \cdot \frac{3}{4} = \frac{3I_0}{4}$$
Hence, the intensity of the emergent light is $\frac{3I_0}{4}$.

58. (B)
$$R.P = \frac{2\sin\theta}{1.22\lambda}$$
$$R.P \propto \frac{1}{\lambda} \Rightarrow (R.P)_{oil} = R_{air}\times\frac{\lambda_{air}}{\lambda_{oil}}$$
$$\Rightarrow\ (R.P)_{oil} = (R.P)_{air}\times\frac{\mu_{oil}}{\mu_{air}} = 2(R.P)_{air}$$

59. (C)
Resolving power is given by
$$R.P. = \frac{d}{1.22\lambda} = \frac{24.4\times10^{-2}}{1.22\times2440\times10^{-10}} = 8.2\times10^{5}$$

60. (D)
We know that when light strike the interface of two media at Brewster's angle, then reflected light will be plane polarized with its $\vec{E}$ vector vibrating in a single plane. Now, if there will be no electric field vector then there will no $\vec{E}'$ vibrating in reflected light. So there will be no reflected light.

61. (D)
$$\frac{(\text{Maximum intensity})\text{ coherent interference}}{(\text{Maximum intensity})\text{ incohenrent interference}} = \frac{n^2I_0}{nI_0} = n$$

62. (9)
In young's double slit experiment, intensity at a point is given by
$$I = I_0\cos^2\frac{\phi}{2} \qquad .....(i)$$
Where, $\phi =$ Phase difference,
Using phase difference, $\phi = \frac{2\pi}{\lambda}\times\text{path difference}$
For path difference λ, phase difference $\phi_1 = 2\pi$
For path difference, $\frac{\lambda}{6}$, phase difference $\phi_2 = \frac{\pi}{3}$
Using equation (i),

$$\frac{I_1}{I_2}=\frac{\cos^2\left(\frac{\phi_1}{2}\right)}{\cos^2\left(\frac{\phi_2}{2}\right)}=\frac{\cos^2\left(\frac{2\pi}{2}\right)}{\cos^2\left(\frac{\pi}{6}\right)}$$

$$\Rightarrow \frac{K}{I_2}=\frac{1}{\frac{3}{4}}=\frac{4}{3} \Rightarrow I_2=\frac{3K}{4}=\frac{9K}{12}$$

$\therefore\ n=9$

63. (1)

We have given (w) amplitude (a) $\propto$ slit width

Also intensity $\propto$ (Amplitude)^2 $\propto$ (Slit width)^2

$$\frac{I_2}{I_1}=\left(\frac{w_2}{w_1}\right)^2=\left(\frac{3w_1}{w_1}\right)^2=\left(\frac{3}{1}\right)^2=9 \quad (\because w_2=3w)$$

$\Rightarrow I_2=9I_1$

$$\Rightarrow \frac{I_{min}}{I_{max}}=\left(\frac{\sqrt{I_2}-\sqrt{I_1}}{\sqrt{I_1}+\sqrt{I_2}}\right)^2=\left(\frac{3-1}{3+1}\right)^2=\frac{1}{4}=\frac{x}{4}\Rightarrow x=1.00$$

64. (2)

The difference in the number of waves when yellow light propagates through air and vacuum column of the same thickness is one

So, thickness $t=n\lambda_{VBC}=(n+1)\lambda_{air}$

Or, $n\lambda=(n+1)\frac{\lambda}{\mu_{air}} \Rightarrow n=\frac{1}{\mu_{air}-1}=\frac{10^4}{3}$

$\therefore$ Thickness of air column

$$t=n\lambda=\frac{10^4}{3}\times 6000\text{Å}=2\text{ mm}$$

65. (450)

Given, $\frac{d}{2}=$ positive on 1st dark range

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

$$\Rightarrow \lambda=\frac{d^2}{D}=\frac{\left(0.6\times 10^{-3}\right)^2}{0.8}=450\times 10^{-9}\text{m}$$

66. (2)

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

and $I_B=I+4I+2\sqrt{I}\sqrt{4I}\cos\frac{\pi}{3}$

$$=5I+2I=7I$$

67. (630)

Fringe width, $\beta = \frac{D}{d}\lambda$ $\therefore\ \beta \propto \lambda$

$\therefore\ \lambda_2 = \frac{8.1}{7.2}\lambda_1 = \frac{9}{8}\lambda_1$

$\therefore$ Wavelength of second light, $\lambda_2 = \frac{9}{8}\lambda_1 = \frac{9}{8} \times 560 = 630 \text{ nm}$

68. (24)

We know that,

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

As, I_{max} for $\phi = 0$ and I_{min} for $\phi = \pi$

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{9I} + \sqrt{4I}\right)^2 = 25I$

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

So, $I_{max} - I_{min} = 25I - I = 24I$

WAVE OPTICS SOLUTIONS

EXERCISE - I (single choice)

1. Radius of secondary wavelets in denser medium is less than that in rarer medium hence (A)

2. frequency depends on source and hence remains Unchanged. (C)

3. All wavelengths interfere constructively at centre (D) for white light whereas for monochromatic light all bright fringes look alike.

4. Position of maxima on screen $y = \frac{nD\lambda}{d}$

   hence $n_1 \lambda_R = n_2 \lambda_B$, $\frac{\lambda_R}{\lambda_B} = \frac{2}{3}$ hence (B)

5. lower orders of shorter wavelength interfere constructively next to central bright fringe (C)

6. fringe width is $\frac{D\lambda}{d}$, de broglie wavelength of electrons decreases with increasing voltage (B)

7. Resultant intensity

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

for coherent sources with $I_1 = I_2 = I_0$; $I_{max} = 4I_0$

for incoherent sources $\langle \cos\phi \rangle = 0$, $I = 2I_0$

hence (B)

8. If I_0 is the intensity of Each wave then for interference of two such waves $I_{max} = 4I_0$ (C)

9. for first minima

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

$$d\left(\frac{\pi\theta^\circ}{180}\right) = \frac{\lambda}{2} \quad \text{hence } d = \frac{180\lambda}{2\pi\theta^\circ} \quad \text{(A)}$$

10. Resultant intensity

$$I = I_0 \cos^2 \phi/2$$

$$\frac{3I_0}{4} = I_0 \cos^2 \phi/2 \;;\; \cos\phi/2 = \pm\frac{\sqrt{3}}{2}$$

$$\frac{\phi}{2} = n\pi \pm \frac{\pi}{6} \quad (n = 0, 1, 2 \ldots)$$

$$\boxed{\phi = 2n\pi \pm \frac{\pi}{3}}$$

$$\phi = \frac{2\pi}{\lambda}(d\sin\theta) \quad \text{where } d\sin\theta = \frac{yd}{D}$$

$y = \frac{D\lambda}{d}\left(\frac{\phi}{2\pi}\right)$ gives positions on screen where waves interfere with phase difference ϕ.

for $\phi = 2n\pi \pm \frac{\pi}{3}$

$y = \frac{D\lambda}{d}\left(\frac{2n \pm \frac{1}{3}}{2}\right)$ gives positions where intensity is $\frac{3}{4}I_0$. for minimum separation choose $n = 0$ or 1 or 2 ....

$$\Delta y = \frac{D\lambda}{3d} \quad \text{(D)}$$

11. Resultant intensity $I = I_0 \cos^2 \phi/2$

for $I = \frac{I_0}{4}$ i.e intensity due to single slit

$\cos \phi/2 = \pm 1/2$

$\frac{\phi}{2} = \left(n\pi \pm \frac{\pi}{3}\right)$ or $\phi = \left(2n\pi \pm \frac{2\pi}{3}\right)$

Positions on screen where phase difference of interfering waves is ϕ are

$$\boxed{y = \frac{D\lambda}{d}\left(\frac{\phi}{2\pi}\right)}$$

In the above case $y = \frac{D\lambda}{d} \frac{(2n \pm 2/3)}{2}$

Nearest to centre $\Rightarrow n = 0$ i.e $y = \pm \frac{D\lambda}{3d}$ (c)

12. If n_1^{th} bright order of λ_1 coincides with n_2^{th} bright order of λ_2 then

$n_1 \lambda_1 = n_2 \lambda_2$ $\quad \frac{n_1}{n_2} = \frac{4}{5}$

Position of n^{th} order maxima on screen $y = \frac{n_1 D\lambda_1}{d}$ or $\frac{n_2 D\lambda_2}{d}$

for least distance from centre $n_1 = 4$ or $n_2 = 5$

(13) Fringe width

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

$$\Delta\beta = \frac{(\Delta D)\lambda}{d} \qquad \boxed{\lambda = \frac{(\Delta\beta)\, d}{\Delta D}}$$

(14) Phase difference on Screen $\phi = \frac{2\pi}{\lambda} d\sin\theta$

$$\phi = \frac{2\pi}{\lambda}\left(\frac{dy}{D}\right)$$

for $y = \frac{1}{4}\frac{D\lambda}{d}$ $\quad \phi = \pi/2$

~~hence~~ $I = I_0 \cos^2 \phi/2$ hence $\frac{I_0}{I} = 2$ (A)

(15) Phase difference of interfering waves at P

$\phi = \frac{2\pi}{\lambda}\left(\frac{dy}{D}\right)$ hence as D increases ϕ decreases.

Initially at P $\phi = 2\pi$ and now decreases towards zero. hence intensity decreases as ϕ varies from 2π to π and then intensity increases as ϕ varies from π towards zero.

(C)

(16) $I = I_0 \cos^2 \phi/2$ and $\phi = \frac{2\pi}{\lambda}\left(\frac{d\,x}{D}\right)$ where $x = 4\times10^{-5}$ m.

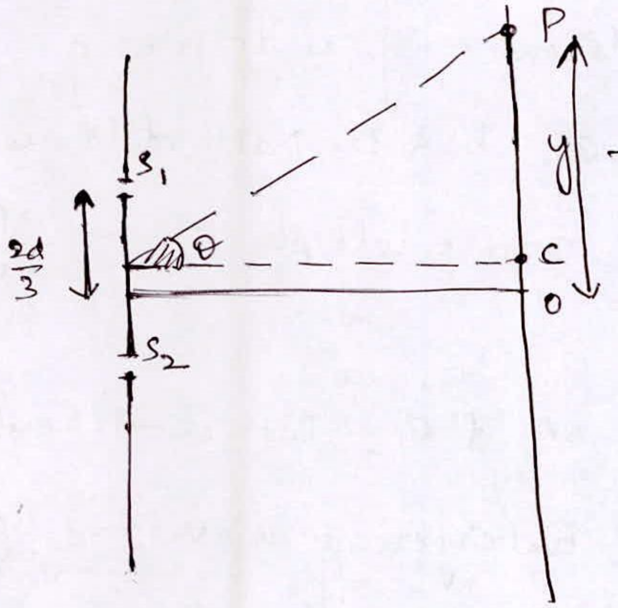
(17) Similar to solutions 10 and 11

(18) for maxima $d\sin\theta = n\lambda$; $\sin\theta = \frac{n\lambda}{d}$

In the range -30^0 to 30^0; $-\frac{1}{2} < \sin\theta < \frac{1}{2}$ or

(C) $\qquad -d/2\lambda < n < d/2\lambda$ or $-300 < n < 300$

19)



If C is center of screen then $OC = d/6$, let $OP = y$

Path difference at P

$S_2P - S_1P = d\sin\theta$

$$\boxed{P.d = \frac{d\left(y - \frac{d}{6}\right)}{D}}$$

for white spot $P.d = 0$

or $\boxed{y = d/6}$ (D)

20) At O, path difference $S_1P - S_2P = \frac{d^2}{6D}$ $(\because y=0)$

for maxima at O ; Path difference $= n\lambda$

i.e $\frac{d^2}{6D} = n\lambda$ or $\lambda = \frac{d^2}{6Dn}$ $[n = 1, 2 \dots]$

hence $\frac{d^2}{3D}$ is not possible (A)

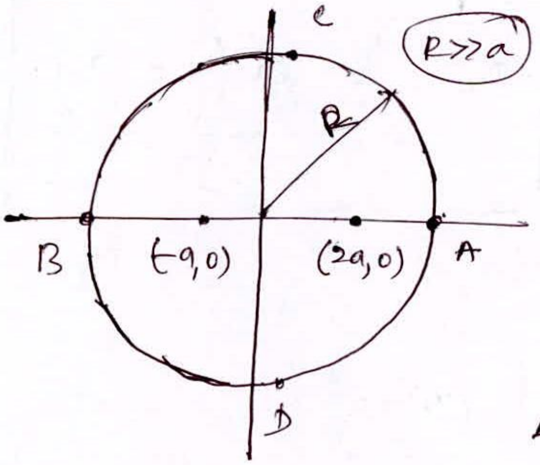
21) Path difference is zero below the centre of screen hence central maxima shifts downward and so do the other orders without change in fringe width (D)

22) Phase difference of the interfering waves at the centre of the screen $\boxed{\phi = \frac{2\pi}{\lambda}(\mu-1)t}$

$I = I_0\cos^2\phi$; At $\mu = 1$ $\phi = 0$ $I = I_0$ hence (C)

23. At A and C path difference of interfering waves is zero whereas at B & D path difference is 5 μm which is an odd multiple of λ. (D)

24.



At A & B, Path difference of interfering waves is $3a$

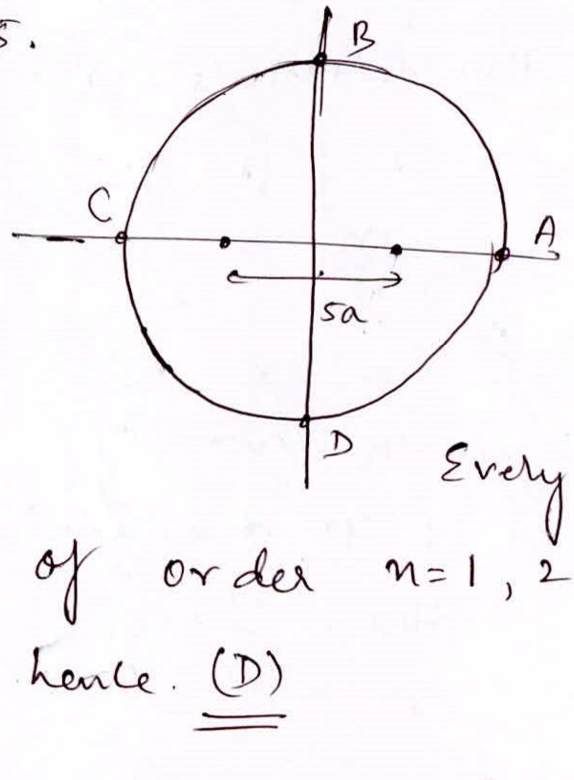
$3a = n\lambda$ for maxima

$n = 15$ Since $\lambda = \frac{a}{5}$

A & B have 15^{th} order maxima

Positions C & D have zeroeth order maxima. (A)

25.



At A and C path difference is $5a$.

hence $n = 3.75$ at A & C

whereas $n = 0$ at B & D

Every Quadrant has maxima of order $n = 1, 2$ & 3 with zeroth order at B & D

hence. (D)

26. Fringe pattern is narrow if d is large hence to observe the pattern d should be decreased.

(B)

27. optical path difference at a distance "x" apart in a medium of refractive index μ is μx.
hence phase difference $\phi = \frac{2\pi}{\lambda}(\mu x)$ where λ is wavelength in air. <u>(A)</u>

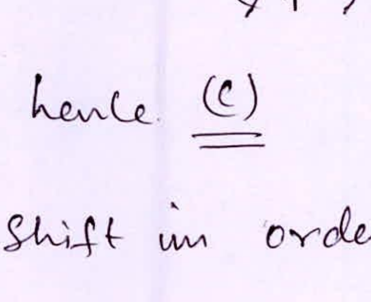
28. Path difference at Centre of Screen O
is $(\mu_1 - 1)t - (\mu_2 - 1)t = (\mu_1 - \mu_2)t$

for maxima at O

$$(\mu_1 - \mu_2)t = n\lambda \quad \text{or} \quad \lambda = \frac{1248}{n}\ (nm)$$

hence <u>(C)</u>

29. Shift in order due to glass plates $= (\mu_1 - \mu)t \times \frac{D}{d}$

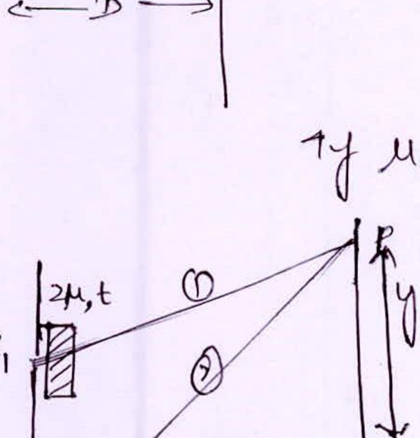


Shift $= D\,\theta^c$

$$(\mu_1 - \mu)t\frac{\cancel{D}}{d} = \cancel{D}\frac{\pi}{180}(6)$$

if $\mu_1 = 1.8$ then $\underline{\mu = 1.6}$ (A)

30.



Path difference at P is
optical path of ② − optical path of ①

$$P.d = [(S_2P - 2t) + \mu 2t] - [(S_1P - t) + 2\mu t]$$
$$= (S_2P - S_1P) - t$$

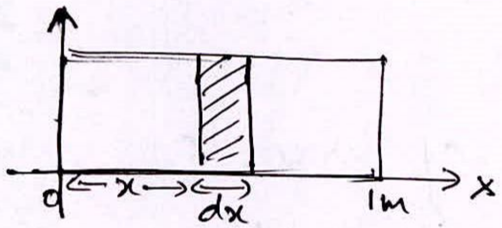
for Central maxima. P.d = 0

$$(S_2P - S_1P) - t = 0$$

$$\frac{dy}{D} = t \quad \boxed{y = \frac{Dt}{d}} \ (B)$$

31. If second minima is above then phase difference should be greater than 3π and less then 6π since third maxima is below hence (A)

32.



optical path of element dx is $\mu\, dx$

hence ~~total~~ total optical path is $\int_{x=0}^{x=1} \mu\, dx = \frac{4}{3}\,m$ (C)

WAVE OPTICS SOLUTIONS

EXERCISE II

1. frequency remains unchanged at $\frac{c}{\lambda_a}$ but wavelength varies as $\frac{\lambda_a}{\mu}$. (A) & (C)

2. At a point directly opposite to one of the slits $y = d/2$ hence path difference of the interfering waves is $\frac{dy}{D}$ or $\frac{d^2}{2D}$

for destructive interference $\frac{d^2}{2D} = (2n-1)\frac{\lambda}{2}$

$$\text{or } \lambda = \frac{d^2}{D(2n-1)} \quad (n = 1, 2, \ldots) \quad \text{(A) \& (C)}$$

3. All wavelengths interfere constructively at centre and shorter wavelengths slightly above (lower orders) Completely dark fringe is never formed because destructive interference for one wavelength may be constructive for the other wavelengths. (B) (C) & (D)

4. for maxima $d\sin\theta = n\lambda$ & $|\sin\theta| \le 1$

hence $-1 \le \frac{n\lambda}{d} \le 1$ or $\frac{-d}{\lambda} \le n \le \frac{d}{\lambda}$

reducing wavelength increases the orders (B) & (C)

5. Fringe width $\beta = \frac{D\lambda}{d}$ hence (B)

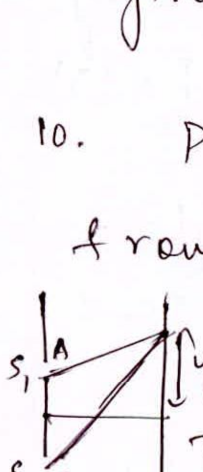
6. If $I_1 \neq I_2$ then $I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$ is non zero.
hence (B)

7. Introducing a glass plate increases optical path and orders shift to compensate accordingly (A) & (D). Intensity at bright & dark fringe increase.

8. At O, path difference is 5.5λ, an odd multiple of λ hence dark fringe appears at O. Also path difference decreases with increasing "y" hence 5 maxima and 6 minima are observed on screen. (A) & (D).

9. Every order shifts by same length given by $\frac{(\mu-1)tD}{d}$ hence (A) & (C)

10. Path difference at any point at height y from centre of screen is



$$P.d = (\mu_2-1)t_2 - (\mu_1-1)t_1 + d\sin\theta.$$

for Central maxima $P.d = 0$

$$y = \frac{D}{d}\left[(\mu_2-1)t_2 + (\mu_1-1)t_1\right]$$

$$y = \frac{D}{d}\left[(t_2 - t_1)\right]$$ hence B & C

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

$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 \neq 0$ hence (A)

12. $SS_2 - SS_1 = (\sqrt{2}-1)d$ hence mica sheet of refractive index $\mu = 1.5$ & thickness $2(\sqrt{2}-1)d$ is placed in front of S_1 (A)

Path difference due to glass plate of thickness t and refractive index μ is $(\mu-1)t$.

EXERCISE – 3

1. (B)

Fringe width $(\beta)=\frac{\lambda D}{d}$

$\beta \propto \lambda$

$\Rightarrow$ As λ increases β increases

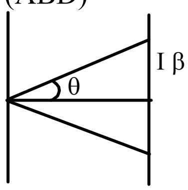
Central maxima is independent of wavelength

$\lambda_{violet} < \lambda_{red}$

$\therefore \beta_{violet} < \beta_{red}$

Hence violet maxima will be closet to central maxima

2. (ABD)



$\alpha = \frac{\beta}{D} = \frac{\lambda D}{dD} = \frac{\lambda}{d}$ independent of D.

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

$\Delta\beta = \frac{\lambda \Delta D}{d}$: dependent of λ

3. (BD)

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

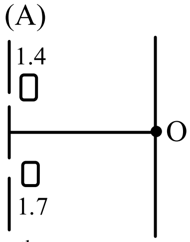
As d changes, θ changes

$\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \frac{1}{d}$

Central maxima does not change.

All positions of minima depend on d hence they will change.

4. (A)



5^{th} fringe is found at O

$\therefore$ optical path difference

$= 5\lambda$

$\Rightarrow (1.7-1.4)t = 5\lambda$

$\Rightarrow 0.3t = 5\lambda$

$\Rightarrow t = \frac{5\times 4800 \times 10^{-10}}{0.3} = 8\times 10^{-6}$

$= 8\mu m$

5. (B)

Phase difference at O is independent of d.

$\because$ maxima is formed at O,

Phase difference = O

6. (D)

Phase difference $= \frac{2\pi}{\lambda}\left(\left(1.55-1.4\right)t\right)$

$= \frac{2\pi}{4800\times10^{-10}}\left(0.15\times8\times10^{-6}\right)$

$= 5\pi$

$\Rightarrow$ minima is formed at O

7. (D)

Phase difference at O

$= \frac{2\pi}{4}\left(\mu_1 t-\mu_2 t\right) \quad ...\left[t = 2\times10^{-6}\ \mu m\right]$

$\frac{2\pi}{4800\times10^{-10}}\left(1.7-1.4\right)2\times10^{-6}$

$= \frac{5\pi}{2}$

$I = I_0 + I_0 + 2I_0\cos\frac{5\pi}{2}$

$= 2I_0$

EXERCISE – 4

1.

$$\because d = 0.2\,cm = 2mm,\ \lambda_1 = 600nm = 600\times10^{-9}\times10^{3}\,mm = 6\times10^{-4}\,mm,$$

$$\mu_1 = 1\,D = 1m = 100mm,\ \mu_2 = \frac{4}{3}, \lambda_2 = ?, \beta = ?$$

$$\therefore \mu_1\lambda_1 = \mu_2\lambda_2$$

$$\therefore 1\times6\times10^{-4}\,mm = \frac{4}{3}\times\lambda_2 : \lambda_2 = \frac{\cancel{18}^{\,9}}{\cancel{4}_{\,2}}\times10^{-4}\,mm = \frac{9}{2}\times10^{-4}\,mm$$

$$\therefore \beta_2 = \frac{\lambda_2\times D}{\lambda} = \frac{9\times10^{-4}\,mm\times1000mm}{2mm} = \frac{9}{4}\times10^{-1}\,mm = 0.225\,mm$$

2. $d_1 = n_1\lambda_1 \qquad d_1 = n_2\lambda_2$

$$\therefore n_1\lambda_1 = n_2\lambda_2$$

$$\therefore 12\times600 = n_2\times400$$

$$n_2 = \frac{\cancel{12}^{\,3}\times6}{\cancel{4}} = 18$$

3. Angular position of minima $= \dfrac{\lambda}{2d}$

$$\frac{\lambda}{2d} = 0.75\times\pi/180$$

$$\frac{180\times520\times10^{-9}}{0.75\times2\times\pi}\times1000$$

$$d = \frac{18\times52}{75\times2\times\pi}\times10^{-2}\,mm$$

$$= 1.98\times10^{-2}\,mm$$

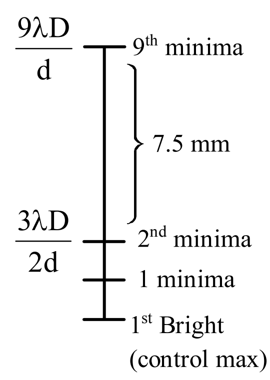
4.

$$\therefore \frac{9\lambda D}{d} - \frac{3\lambda D}{2d} = 7.5mm$$

$$\frac{15\lambda D}{2d} = 7.5 \qquad \text{(D = 100 xm d = 0.5 mm given)}$$

$$\lambda = 500\,mm$$

$$= 5000\,\mathring{A}$$



5. d = 1 mm

D = 1m = 10^3 mm

$$\lambda = 600nm = 10^{-6}nm\times600$$

$$k\Delta x = \phi \qquad \ldots\text{(phase diff)}$$

$$\frac{2\pi}{\lambda}.\frac{yd}{D} = \phi \qquad \ldots\text{(i)}$$

Now, 75% of maximum intensity $= \dfrac{3}{4}\times4I_0$

$$= 3I_0$$

$\therefore 3I_0 = 2I_0 + 2I_0 \cos\phi$

$\therefore \cos\phi = \frac{1}{2}$

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

$\therefore \frac{2\pi}{3}.\frac{yd}{D} = \frac{\pi}{3}$ ... (from 1)

$\therefore y = \frac{\lambda.D}{6.d}$

$= \frac{(600\times10^{-6})(10^{3})}{6(1)}$

y = 0.1 mm

y is distance of a point from central maxima therefore min distance between two points possible is 2.y = 2.(0.1)

= 0.2 mm

6. In equation position spring will compressed by $\frac{mg}{k}$

$\therefore$ position of the plate from equation position at any time t. $y = \frac{mg}{K}\cos\omega t$

$\therefore D' = D + \frac{mg}{k} - \frac{mg}{k}\cos\omega t$

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

$\therefore n^{th}$ maxima $= \frac{n\lambda D'}{d}$

$= \frac{n\lambda\left(D + \frac{mg}{k}(1-\cos\omega t)\right)}{d}$

7. $y_1 = \frac{\lambda D_1}{d}$ $y_2 = \frac{\lambda D_2}{d}$

$y_2 - y_1 = \frac{\lambda}{d}(D_2 - D_1)$

$3\times10^{-5} = \frac{\lambda}{10^{-3}}\times5\times10^{-2}$

$\lambda = \frac{3}{5}\times10^{-6}$

$= 0.6\times10^{-6}$

$= 6000\,\mathring{A}$

8. Case I

$d\sin\phi = d\frac{d}{2\ell}$

$\Delta x = \frac{d^2}{2\ell} + \frac{\mu d^2}{2d}$

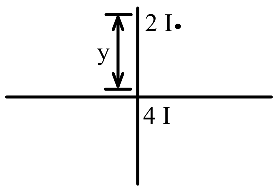
$$\frac{2\pi}{\lambda} = \frac{d^2}{2}\left(\frac{1}{\ell} + \frac{\mu}{D}\right)$$

$$\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x = \frac{2\pi}{\lambda} \times \frac{d^2}{2}\left(\frac{1}{\ell} + \frac{\mu}{D}\right)$$

Case II

(a) $\Delta x = \frac{d^2}{2}\left(\frac{\mu}{\ell} + \frac{1}{D}\right)$

(b) $\phi = \frac{\pi}{2}$



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

$$\frac{2\pi}{\lambda}\frac{dy}{D} = \frac{\pi}{2}$$

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

Sup sir

21. $D = 100\,cm = \frac{1}{10}\,m$

$\frac{\lambda D}{d} = 0.25mm$

$\frac{\lambda D}{d+\Delta d} = \frac{2}{3}\times 0.2mm$

$\therefore \frac{d+\Delta d}{d} = \frac{3}{2}$

$\Rightarrow d = \Delta d = 2.4mm$

$\therefore \lambda D = 0.25mm \times 2.4mm$

$\Rightarrow \lambda = 600nm$

Also fringe shift $(\mu - 1)t\frac{d}{D}$

$\Rightarrow 20\times(0.25mm) = (1.5-1)\times t \times \frac{d}{D}$

$\Rightarrow t = 24\mu m$

24. (I) $\Delta x_{min} = \theta$

$\Delta x_{max} = 4\lambda$

So number of times $\Delta x = \left(\frac{24+1}{2}\right)$

Occurs = 4 + 4 = 8 times

$\therefore$ 8 minima

(II) $\Delta x_{min} = 0 \quad (at\,\infty)$

$\Delta x_{max} = 4\lambda \quad (at\,B)$

$\therefore$ no. of minima = 4

25. $\Delta x = \int_0^3 (\mu - 1)\,dx$

$= \int_0^0 \sqrt[3]{x}.dx$

$= \frac{2}{3}\times 3\sqrt{3} = 2\sqrt{3}\,mm = 2\sqrt{3}\times 10^7\,\mathring{A}$

$\Delta\phi = \frac{2\pi}{\lambda}\times\Delta x = \frac{2\pi}{4000\sqrt{3}}\times 2\sqrt{3}\times 10^7$

$= 10^4\,\pi$

$\therefore$ constructive interference

So $I = 4I_0 = 4\times 10^{-15}\,Wm^{-2}$

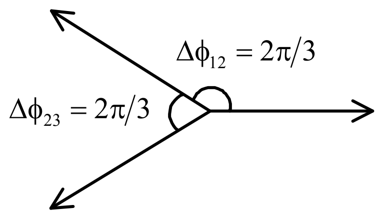
26. Fringe shift $= \frac{5\lambda D}{d}$

$= \left[(\mu_1 - 1)t_1 - (\mu_2 - 1)t_2\right]\frac{D}{d}$

$\Rightarrow \left|(1.7-1)t - (1.4-1)t\right| = 5\lambda$

$\Rightarrow 0.3t = 5 \times 4800\,\overset{\circ}{A}$
$\Rightarrow t = 8\mu m$

27.



$\Delta x_{23} = \Delta x_{12} = d \Rightarrow \Delta\phi_{12} = \Delta\phi_{23} = \frac{2\pi}{\propto} \times \Delta x$

From the above phrase

$\frac{2\pi}{\lambda} \times \Delta x = \frac{2\pi}{3} \Rightarrow \frac{2\pi}{\lambda} \times d = \frac{2\pi}{3}$

$\Rightarrow \frac{d}{\lambda} = \frac{1}{3}$

3) Angular position of minima $= \dfrac{\lambda}{2d}$

$$\frac{\lambda}{2d} = 0.75 \times \pi/180$$

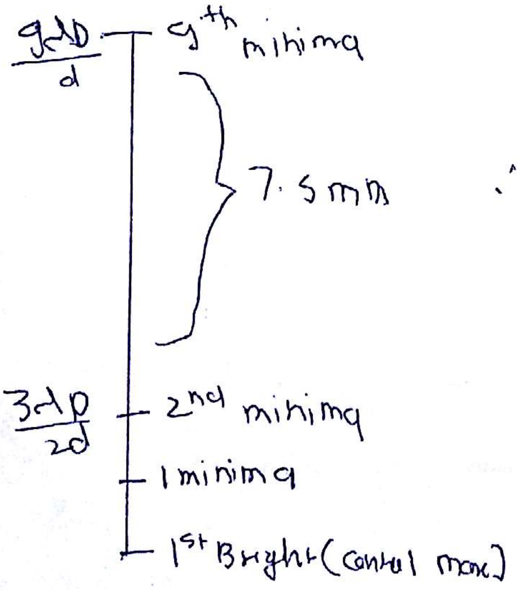
$$\frac{180 \times 520 \times 10^{-9}\,(\text{meter}) \times 1000\,\text{mm}}{0.75 \times 2 \times \pi} = d$$

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

$$d = \frac{18 \times 52}{75 \times 2 \times \pi} \times 10^{-2}\ \text{mm}$$

$$= 1.98 \times 10^{-2}\ \text{mm}$$

4)



$$\therefore \frac{9\lambda D}{d} - \frac{3\lambda D}{2d} = 7.5\ \text{mm}$$

$$\frac{15\lambda D}{2d} = 7.5$$

($D = 100$ cm $d = 0.5$ mm)
(given)

$$\lambda = 500\ \text{nm}$$

$$= 5000\ \text{Å}$$

• In eq^n position spring will be compressed by $\frac{mg}{k}$.

∴ position of the plate from eq^n position at any time t, $y = \frac{mg}{k}\cos\omega t$

$$\therefore \quad D' = D + \frac{mg}{k} - \frac{mg}{k}\cos\omega t$$

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

$$\therefore \; n^{th} \text{ maxima} = \frac{n\lambda D'}{d}$$

$$= \frac{n\lambda\left(D + \frac{mg}{k}(1-\cos\omega t)\right)}{d}$$

7] $d \neq$ $y_1 = \frac{\lambda D_1}{d}$ $y_2 = \frac{\lambda D_2}{d}$

$$y_2 - y_1 = \frac{\lambda}{d}(D_2 - D_1)$$

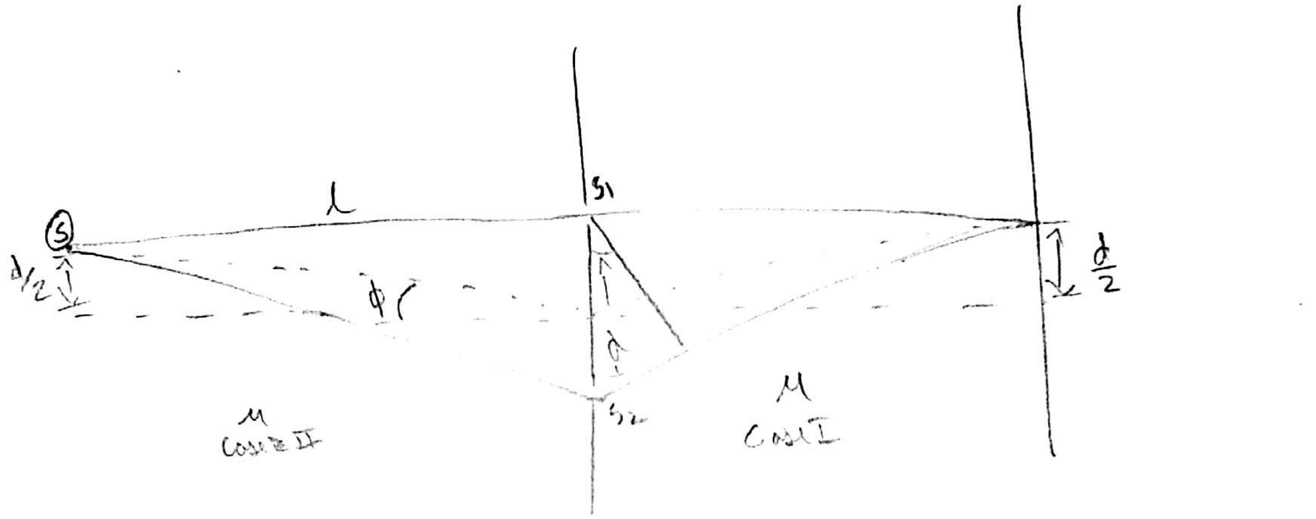
$$3\times10^{-5} = \frac{\lambda}{10^{-3}} \times 5\times10^{-2}$$

$$\lambda = \frac{3}{5}\times10^{-6}$$

$$= 0.6\times10^{-6}$$

$$= 6000\,\mathring{A}$$

8]



Case I) $d\sin\phi = d\frac{d}{2l}$

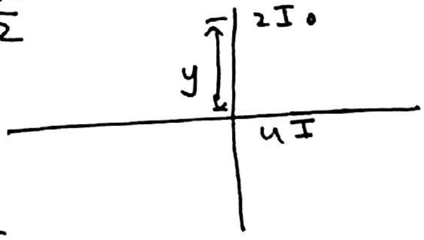
$$\Delta x = \frac{d^2}{2l} + \frac{\mu d^2}{2d}$$

$$= \frac{d^2}{2}\left(\frac{1}{l} + \frac{\mu}{D}\right)$$

$$\Delta\phi = \frac{2\pi}{\lambda}\times\Delta x = \frac{2\pi}{\lambda}\times\frac{d^2}{2}\left(\frac{1}{l}+\frac{\mu}{D}\right)$$

Case II] a) $\Delta x = \frac{d^2}{2}\left(\frac{\mu}{\lambda} + \frac{1}{D}\right)$

b) $\phi = \frac{\pi}{2}$



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

$$\frac{2\pi}{\lambda} d\frac{y}{D} = \frac{\pi}{2}$$

$$\boxed{y = \frac{\lambda D}{2d}}$$

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) $d = 1mm$
$D = 1m = 10^3 mm$
$\lambda = 600nm = 10^{-6} \times 600 \; mm$

$k \Delta x = \phi$ .... (phase diff)

$$\frac{2\pi}{\lambda} \cdot \frac{yd}{D} = \phi \quad \text{....(i)}$$

Now, 75 % of maximum itensity $= \frac{3}{4} \times 4I_0$
$= 3I_0$

$$\therefore \; 3I_0 = 2I_0 + 2I_0 \cos\phi$$

$$\therefore \; \cos\phi = \frac{1}{2}$$

$$\therefore \; \phi = \frac{\pi}{3}$$

$$\therefore \; \frac{2\pi}{\lambda} \cdot \frac{yd}{D} = \frac{\pi}{3} \quad \text{... (from i)}$$

$$\therefore \; y = \frac{\lambda \cdot D}{6 \cdot d}$$

$$= \frac{(600 \times 10^{-6})(10^3)}{6 \;\; (1)}$$

$$y = 0.1mm$$

y is distance of a point from central maxima. Therefore min distance between two points possible is ~~2y~~ $2 \cdot y$

$= 2 \cdot (0.1)$
$= 0.2mm$

$\rightarrow$ $\because$ $d = 0.2cm = 2mm$, $\lambda_1 = 600nm = 600 \times 10^{-9} \times 10^{3} mm = 6 \times 10^{-4} mm$, $\mu_1 = 1$.
$D = 1m = 1000mm$. , $\mu_2 = \frac{4}{3}$, $\lambda_2 = ?$ $\beta_2 = ?$

$\therefore$ $\mu_1 \lambda_1 = \mu_2 \lambda_2$.

$\therefore$ $1 \times 6 \times 10^{-4} mm = \frac{4}{3} \times \lambda_2$ $\therefore$ $\lambda_2 = \frac{\cancel{18}^{9}}{\cancel{4}2} \times 10^{-4} mm = \frac{9}{2} \times 10^{-4} mm$

$\therefore \beta_2 = \frac{\lambda_2 \times D}{d} = \frac{\frac{9}{2} \times 10^{-4} mm \times 1000 \cancel{mm}}{2 \cancel{mm}} = \frac{9}{4} \times 10^{-1} mm = 0.225mm$.

Q-2].

$\rightarrow$ $d_1 = n_1 \lambda_1$ $d_1 = n_2 \lambda_2$.

$\therefore$ $n_1 \lambda_1 = n_2 \lambda_2$.

$\therefore$ $12 \times 600 = n_2 \times 400$

$n_2 = \frac{\cancel{12}^{3} \times 6}{\cancel{4}} = 18$.

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Only One Option Correct

1. (B)

Intensity $I = I_0 \cos^2 \frac{f}{2}$ where I_0 is the peak intensity

Here $I = \frac{I_0}{2}$, $\therefore \frac{I_0}{2} \cos^2 \frac{\phi}{2}$, $\quad \therefore \phi = \frac{\pi}{2}(2n+1)$

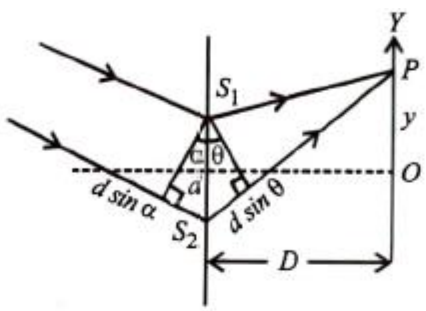
$\therefore \phi = \frac{\pi}{2}, \frac{3}{2}\pi, \frac{5}{2}\pi....$

And path difference,

$\Delta x = \left(\frac{\lambda}{2\pi}\right)\phi \qquad \therefore \Delta x = \frac{\lambda}{4}, \frac{3}{4}\lambda..... \frac{(2n+1)}{4}\lambda$

2. (C)

Path difference, $\Delta x = d\sin\alpha + d\sin\theta = d\alpha + \frac{yd}{D}$ [when α and θ are small]



(A) For $\alpha = 0$, path difference $\Delta x = \frac{yd}{D}$

$= \frac{0.3 \times 11}{1000} = 33 \times 10^{-4}$ mm

Now $\frac{\Delta x}{\lambda} = \frac{33 \times 10^{-4}}{600 \times 10^{-6}} = \frac{11}{2}$

$\therefore \Delta x = \frac{11}{2}\lambda \Rightarrow \Delta x = (2n-1)\frac{\lambda}{2}$

Hence interference at P is destructive.

(B) Fringe width $\beta = \frac{\lambda D}{d}$ is independent of α

(C) For $\alpha = \frac{0.36}{\pi}$ degree (at point P)

$\Delta x = d\left[\alpha + \frac{y}{d}\right] = 0.3 \times 10^{-3}\left[\frac{0.36}{180} + \frac{11 \times 10^{-3}}{1}\right] m = 3900$ nm

Now $\frac{\Delta x}{\lambda} = \frac{3900}{600} = \frac{13}{2}\lambda$

Hence destructive interference at P.

(D) For $\alpha = \frac{0.36}{\pi}$ degree (at point O)

$\Delta x = d\alpha = 0.3 \times 10^{-3} \times \frac{0.36}{180}$

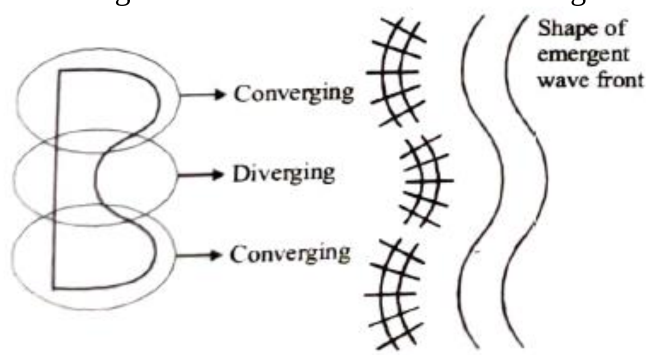
$= 600 \times 10^{-9} m = 600\,nm$

Now $\frac{\Delta x}{\lambda} = 1 \Rightarrow \Delta x = 1\lambda$

Hence constructive interference at O.

3. (A)

Clearly middle part of glass is diverging and upper and lower part are converting so correct shape of the emergent wavefront is as shown in the figure.



One or More than One Option Correct

1. (A, B, C)

We Know that fringe width, $\beta = \frac{\lambda D}{d}$

$\because\ \lambda_2 > \lambda_1 \qquad \therefore\ \beta_2 > \beta_1$

Number of fringes in a given width $m \propto \frac{1}{\beta} \qquad \therefore\ m_1 > m_2$

$3 \times \frac{\lambda_2 D}{d} = \frac{(2 \times 5 - 1)\lambda_1}{2} \frac{D}{d}$

$3 \times 600 = 4.5 \times 400$

Angular separation $\frac{\lambda}{d} \propto \lambda$

So it is greater for λ_2.

2. (B, C)

At P_2,

$\Delta x = 0$. So we will have maxima there.

It will be very much like central maxima in YDSE with n = 0.

So (A) is incorrect.

At P_1

$\Delta x = S_1P - S_2P = s = 1.8\,mm$

For maxima, $\Delta x = n\lambda$

$$n = \frac{\Delta x}{\lambda} = \frac{1.8\times10^{-3}}{600\times10^{-9}} = \frac{1.8}{600}\times10^{6} = 3000.$$

So, number of fringes between P_1 and P_2 will be 3000.

So, (C) is correct. And it will also be highest order fringe.

So, (B) is correct.

As, for bright fringe,

$$d\cos\theta = n\lambda$$

$$\Rightarrow \quad -d\sin\theta\Delta\theta = \Delta n\lambda$$

$$\Rightarrow \quad \Delta\theta = -\frac{(\Delta n)\lambda}{d\sin\theta}$$

As, we move from P_1 to P_2, $\theta\downarrow\downarrow$.

So $\sin\theta\downarrow\downarrow$, therefore $\Delta\theta\uparrow\uparrow$.

So, (D) is incorrect.

3. (A, B)

We have,

$AB = d\tan\theta$ and $BC = AB\sin\alpha = d\tan\theta\sin\alpha$

Also, $AD = AB\sin\theta = d\tan\theta\sin\theta$

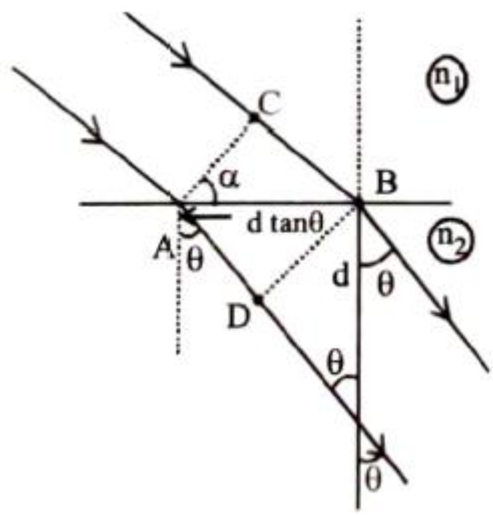
So, optical path difference

$n_1BC - n_2AD$

$= n_1(d\tan\theta\sin\alpha) - n_2(d\tan\theta\sin\theta)$

$= d\tan\theta(n_1\sin\alpha - n_2\sin\theta) = d\tan\theta\times0 = 0$

So, (A), (B) are correct and (C), (D) are incorrect.

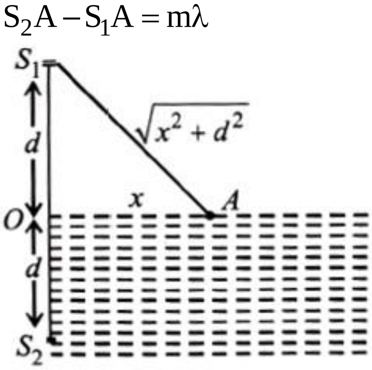


Integer / Numerical Answer Type

1. (3)

For maxima, Path deference $= m\lambda$

$\therefore \quad S_2A - S_1A = m\lambda$



$$\therefore \quad \left[(n-1)\sqrt{d^2+x^2} + \sqrt{d^2+x^2}\right] - \sqrt{d^2-x^2} = m\lambda$$

$\therefore \quad (n-1)\sqrt{(d^2+x^2)} = m\lambda$

$\therefore \quad \left(\frac{4}{3}-1\right)\sqrt{d^2+x^2} = m\lambda$

$\therefore \quad \sqrt{d^2+x^2} = 3m\lambda$

$\therefore \quad d^2+x^2 = 9m^2\lambda^2$

$\therefore \quad x^2 = 9m^2\lambda^2 - d^2$

Comparing this equation with the given equation

$x^2 = p^2m^2\lambda^2 - d^2$, we get

$p^2 = 9$

$\therefore \quad p = 3$