CHAPTER 2: WAVE OPTICS

Test Your Concepts-I (Based on Interference)

1. (a) $\left(1-\frac{1}{\mu}\right)t=\frac{3\lambda}{\mu}$

$$\Rightarrow \quad t=\frac{3\lambda}{(\mu-1)}=\frac{3\times 0.78}{1.3-1}=7.8\ \mu\text{m}$$

(b) Upwards

$$\frac{yd}{D}-\left(1-\frac{1}{\mu}\right)t=\frac{4\lambda}{\mu}$$

$$\Rightarrow \quad y=4.2\text{ mm}$$

Downwards

$$t\left(1-\frac{1}{\mu}\right)+\frac{yd}{D}=\frac{4\lambda}{\mu}$$

$$\Rightarrow \quad y=0.6\text{ mm}$$

2. Since we are given that
Shift = 5 (fringe width)

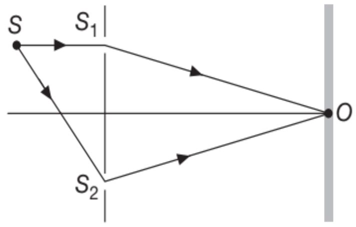
$$\Rightarrow \quad \frac{(\mu-1)tD}{d}=\frac{5\lambda D}{d}$$

$$\Rightarrow \quad t=\frac{5\lambda}{\mu-1}=\frac{25000}{1.5-1}=50{,}000\ \text{Å}=5\ \mu\text{m}$$

3. $\Delta x=SS_2O-SS_1O=\sqrt{d^2+\ell^2}-\ell$

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

$$\Rightarrow \quad \phi=\frac{2\pi}{\lambda}\left(\sqrt{d^2+\ell^2}-\ell\right)$$



(a) Geometric path difference between S_2P and S_1P is

$$y=\frac{\left(\frac{d}{2}\right)d}{D}=\frac{d^2}{2D}$$

Their optical path difference $=\frac{\mu d^2}{2D}$

Therefore, net path difference

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

So, phase difference is given by

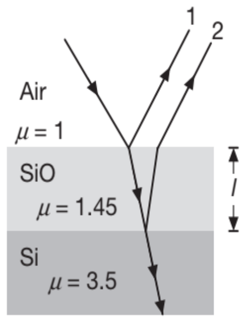
$$\phi=\frac{2\pi}{\lambda}\left[\left(\sqrt{d^2+\ell^2}-d\right)+\frac{\mu d^2}{2D}\right]$$

(b) When liquid is filled between slits and source S, then

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

$$\Rightarrow \quad \phi=\frac{2\pi}{\lambda}\left(\mu\left(\sqrt{d^2+\ell^2}-\ell\right)+\frac{d^2}{2D}\right)$$

4. The reflected light will be minimum when rays 1 and 2 (shown in figure) meet the condition of destructive interference.



Rays 1 and 2 both suffer an additional phase change of π (or 180°) after being reflected at surface of a denser medium. The net change in phase due to reflection is therefore zero and the condition for a reflection minimum requires a path difference of $\frac{\lambda}{2}$. Hence,

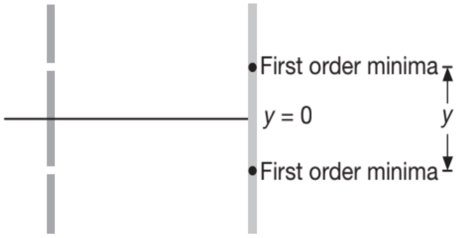
$$2\mu t=\frac{\lambda}{2}$$

$$\Rightarrow \quad t=\frac{\lambda}{4\mu}=\frac{550}{4(1.45)}=94.8\text{ nm}$$

5. The desired distance is

$$y=\text{fringe width }=\frac{\lambda D}{d}=\frac{546\times10^{-9}\times0.4}{0.4\times10^{-3}}$$

$$\Rightarrow \quad y=0.546\times10^{-3}\text{ m}=0.546\text{ mm}$$



6. For constructive interference in case of soap film,

$$2\mu t = \left(n - \frac{1}{2}\right)\lambda \qquad n = 1, 2, 3, \ldots.$$

For minimum thickness t, $n = 1$

$$\Rightarrow \quad 2\mu t = \frac{\lambda}{2}$$

$$\Rightarrow \quad t = \frac{\lambda}{4\mu} = \frac{600}{4 \times 1.33} = 112.78 \text{ nm}$$

7. (a) $\beta = \frac{\lambda D}{d} = \frac{(5000 \times 10^{-10})(1)}{1 \times 10^{-3}} = 0.5 \text{ mm}$

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

For $n = 5$

$$y = 2.25 \text{ mm}$$

(c) At $y = \frac{1}{3}$ mm, $y \ll D$

$$\Rightarrow \quad \Delta x = \frac{yd}{D}$$

$$\Rightarrow \quad \Delta\phi = \frac{2\pi}{\lambda}\Delta x = 2\pi\frac{yd}{\lambda D} = \frac{4\pi}{3}$$

Now resultant intensity, is given by

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

$$\Rightarrow \quad I = 4I_0 + I_0 + 2\sqrt{4I_0^2}\cos\Delta\phi$$

$$\Rightarrow \quad I = 5I_0 + 4I_0\cos\left(\frac{4\pi}{3}\right) = 3I_0$$

(d) $\frac{d}{\lambda} = \frac{10^{-3}}{0.5 \times 10^{-6}} = 2000$

$n = 1000$ is not very much less than 2000

Hence now $\Delta x = d\sin\theta$ must be used, so we get

$$d\sin\theta = n\lambda = 1000\lambda$$

$$\Rightarrow \quad \sin\theta = 1000\frac{\lambda}{d} = \frac{1}{2}$$

$$\Rightarrow \quad \theta = 30^\circ$$

Since, $y = D\tan\theta$

$$\Rightarrow \quad y = \frac{1}{\sqrt{3}} \text{ meter}$$

(e) Highest order maxima

$$n_{\max} = \left[\frac{d}{\lambda}\right] = 2000$$

Hence, $n = 5000$ is not possible.

8. (a) $\Delta x = 0.5\ \mu\text{m} = 5 \times 10^{-7}$ m

So, phase difference is given by

$$\phi = \left(\frac{2\pi}{\lambda}\right)(\Delta x) = \left(\frac{2\pi}{400 \times 10^{-9}}\right)(5 \times 10^{-7})$$

$$\Rightarrow \quad \phi = \frac{5\pi}{2}$$

(b) $\Delta x' = (\mu - 1)t = (1.5 - 1)(1.5) = 0.75\ \mu\text{m}$

$$\Rightarrow \quad (\Delta x)_{\text{net}} = \Delta x + \Delta x' = 1.25\ \mu\text{m} = 1.25 \times 10^{-6} \text{ m}$$

$$\Rightarrow \quad \phi' = \left(\frac{2\pi}{400 \times 10^{-9}}\right)(1.25 \times 10^{-6})$$

$$\Rightarrow \quad \phi' = \frac{25\pi}{4}$$

9. Since, shift $= 2$(Fringe Width)

$$\Rightarrow \quad \frac{(\mu - 1)tD}{d} = \frac{\lambda(2D)}{d}$$

$$\Rightarrow \quad \lambda = \frac{(\mu - 1)t}{2} = \frac{(1.6 - 1)(1.964 \times 10^{-6})}{2}$$

$$\Rightarrow \quad \lambda = 0.589 \times 10^{-6} \text{ m}$$

$$\Rightarrow \quad \lambda = 5890 \text{ Å}$$

10. Shift $= 5$ (fringe width)

$$\Rightarrow \quad (\mu - 1)\frac{tD}{d} = \frac{\lambda D}{d}$$

$$\Rightarrow \quad t = \frac{\lambda}{\mu - 1} = \frac{6 \times 10^{-7}}{(1.5 - 1)} = 1.2 \times 10^{-6} \text{ m}$$

$$\Rightarrow \quad t = 1.2\ \mu\text{m}$$

11. $\beta = \frac{(14.75 - 12.50)}{10 - 1}$ mm $= 0.25$ mm

$$\beta' = \frac{\lambda'}{\lambda}\beta = \frac{5500}{6000} \times 0.25 \text{ mm} = 0.23 \text{ mm}$$

Zero order maxima will remain unchanged. Earlier it was at $12.5 \text{ mm} - 12.25 \text{ mm}$.

Tenth order will now be at $12.25 \text{ mm} + 10\beta' = 14.55$ mm.

12. Given, $d = 0.1 \text{ mm} = 10^{-4}$ m, $D = 0.5$ m and $\lambda = 5000$ Å $= 5 \times 10^{-7}$ m

$$\Delta y = (y_{11})_{\text{dark}} - (y_7)_{\text{bright}} = \frac{(2 \times 11 - 1)\lambda D}{2d} - \frac{7\lambda D}{d}$$

$$\Rightarrow \quad \Delta y = \frac{7\lambda D}{2d} = \frac{7\times 5\times 10^{-7}\times 0.5}{2\times 10^{-4}}$$

$$\Rightarrow \quad \Delta y = 8.75\times 10^{-3} \text{ m} = 8.75 \text{ mm}$$

13. (a) Angular separation $\left(=\frac{\lambda}{d}\right)$ of the fringes remains constant. But the linear separation or fringe width increases in proportion to the distance (D) from the screen.

(b) As λ decreases, fringe width $(\beta \propto \lambda)$ decreases.

(c) As d increases, fringe width $\left(\beta \propto \frac{1}{d}\right)$ decreases.

(d) The interference pattern due to different component colours of white light overlap (in-coherently). The central bright fringes of different colours are at the same position. Therefore, the central fringe is white. Since blue colour has the lower λ, the fringe closest on either side of the central white fringe is blue; the farthest is red.

(e) Since in a medium the wavelength of light is $\lambda' = \frac{\lambda}{\mu}$, therefore the fringe width is given by

$$\beta = \frac{\lambda' D}{d} = \frac{\lambda D}{\mu d}.$$

Thus, fringe width decreases by μ.

14. For bright fringes to coincide, we have

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

$$\Rightarrow \quad \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{900}{750} = \frac{6}{5}$$

i.e., 5th order maxima of larger wavelength λ_2 will overlap with 6th order maxima of smaller wavelength λ_1.

$$\text{So, } y_{min} = \frac{6\lambda D}{d} = \frac{6\times 750\times 10^{-9}\times 2}{2\times 10^{-3}}$$

$$\Rightarrow \quad y_{min} = 4.5\times 10^{-3} \text{ m}$$

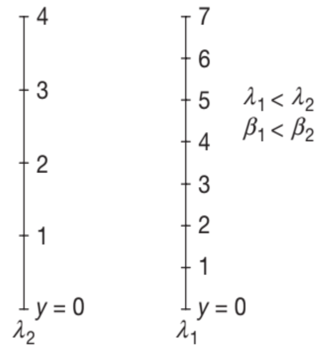
$$\Rightarrow \quad y_{min} = 4.5 \text{ mm}$$

15. Let n_1 bright fringe of λ_1 overlaps with n_2 bright fringe of λ_2. Then,

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

$$\Rightarrow \quad n_1\lambda_1 = n_2\lambda_2$$

$$\Rightarrow \quad \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{700}{400} = \frac{7}{4}$$



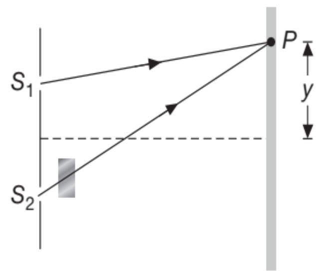
The ratio $\frac{n_1}{n_2} = \frac{7}{4}$ implies that 7th bright fringe of λ_1 will overlap with 4th bright fringe of λ_2. Similarly, 14th of λ_1 will overlap with 8th of λ_2 and so on.

So, the minimum order of λ_1 which overlaps with λ_2 is 7.

16. Without inserting the slab, path difference at P is given by

$$\Delta x = \frac{yd}{D} = \frac{0.15\times 10^{-3}\times 2\times 10^{-3}}{2}$$

$$\Rightarrow \quad \Delta x = 1.5\times 10^{-7} \text{ m}$$



Corresponding phase difference at P is

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

$$\Rightarrow \quad \phi = \left(\frac{2\pi}{6000\times 10^{-10}}\right)(1.5\times 10^{-7}) = \frac{\pi}{2}$$

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

Since, intensity at P is given by $I = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

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

Phase difference after placing the glass sheet is

$$\phi' = \phi + \frac{2\pi}{\lambda}(\mu - 1)t$$

$$\Rightarrow \quad \phi' = \frac{\pi}{2} + \frac{2\pi}{6000\times 10^{-10}}(1.5-1)(8000+10^{-10})$$

$$\Rightarrow \quad \phi' = \frac{11\pi}{6}$$

The intensity at P is now given by

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

$$\Rightarrow \quad I' = I_0 + \eta I_0 + 2\sqrt{\eta I_0^2}\cos\left(\frac{11\pi}{6}\right) = 2I_0 \quad \{\because I' = 2I_0\}$$

Solving this equation, we get,

$$\eta = 0.21$$

17. (a) Since, $\Delta x = \frac{yd}{D} = \frac{(0.3\times10^{-3})(10\times10^{-3})}{1} = 3\times10^{-6}$ m

$$\Rightarrow \quad \phi = \left(\frac{2\pi}{\lambda}\right)(\Delta x) = \left(\frac{2\pi}{546\times10^{-9}}\right)(3\times10^{-6})$$

$$\Rightarrow \quad \phi = 34.52 \text{ radian} = 1978^\circ$$

$$\Rightarrow \quad \frac{\phi}{2} = 989^\circ$$

Since, $I_P = I_0\cos^2\left(\frac{\phi}{2}\right)$

$$\Rightarrow \quad I_P = 3\times10^{-4} I_0$$

(b) Fringe width

$$\beta = \frac{\lambda D}{d} = \frac{(546\times10^{-9})(1)}{(0.3\times10^{-3})} = 1.82\times10^{-3} \text{ m}$$

$$\Rightarrow \quad \beta = 1.82 \text{ mm}$$

Therefore, number of fringes between point P and the central fringe are given by

$$N = \frac{10}{1.82} = 5.49$$

18. Let n_1 bright fringe corresponding to wavelength $\lambda_1 = 500$ nm coincides with n_2 bright fringe corresponding to wavelength $\lambda_2 = 700$ nm.

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

$$\Rightarrow \quad \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{7}{5}$$

This implies that 7^{th} maxima of λ_1 coincides with 5^{th} maxima of λ_2. Similarly 14^{th} maxima of λ_1 will coincides with 10^{th} maxima of λ_2 and so on.
So, minimum distance is

$$y_{min} = \frac{n_1\lambda_1 D}{d} = 7\times5\times10^{-7}\times10^3$$

$$\Rightarrow \quad y_{min} = 3.5\times10^{-3} \text{ m} = 3.5 \text{ mm}$$

19. Here $\lambda = 6\times10^{-5}$ cm, $t = 7.2\times10^{-4}$ cm

Displacement of the central bright fringe, $\Delta x = 6\beta$

Since $\Delta x = \frac{\beta}{\lambda}(\mu - 1)t$

$$\Rightarrow \quad \frac{\beta}{\lambda}(\mu-1)t = 6\beta$$

$$\Rightarrow \quad \mu - 1 = \frac{6\lambda}{t} = \frac{6\times6\times10^{-5}}{7.2\times10^{-4}} = 0.5$$

$$\Rightarrow \quad \mu = 0.5 + 1 = 1.5$$

Test Your Concepts-II (Based on Diffraction)

1. For first dark band, $\sin\theta = \frac{\lambda}{d}$

As the diffraction pattern is obtained in the focal plane of lens, therefore

$$\tan\theta = \frac{x}{f}$$

For small θ, $\tan\theta \simeq \sin\theta$

$$\Rightarrow \quad \frac{x}{f} = \frac{\lambda}{d}$$

$$\Rightarrow \quad x = \left(\frac{\lambda}{d}\right)f$$

Since, $\lambda = 5900$ Å $= 59\times10^{-8}$ m, $f = 50$ cm $= 0.50$ m

$d = 0.025$ m $= 2.5\times10^{-5}$ m

$$\Rightarrow \quad x = \frac{59\times10^{-8}\times0.50}{2.5\times10^{-5}} = 11.8\times10^{-3} \text{ m} = 11.8 \text{ mm}$$

2. Given, $\lambda_1 = 5890\times10^{-10}$ m, $\lambda_2 = 5896\times10^{-10}$ m,

$d = 2\ \mu\text{m} = 10^{-6}$ m, $D = 2$ m

Distance of first secondary maximum from the centre of the screen is

$$x = \frac{3}{2}\frac{D\lambda}{d}$$

For the two wavelengths, we have

$$x_1 = \frac{3}{2}\frac{D\lambda_1}{d} \text{ and } x_2 = \frac{3}{2}\frac{D\lambda_2}{d}$$

Spacing between the first two maximum of sodium lines is given by

$$\Delta x = x_2 - x_1 = \frac{3D}{2d}(\lambda_2 - \lambda_1)$$

$$\Rightarrow \quad \Delta x = \frac{3\times2\times(5896-5890)\times10^{-6}}{2\times2\times10^{-6}} = 9\times10^{-4} \text{ m}$$

3. The linear separation between n bright fringes in an interference pattern on the screen is given by

$$x_n = \frac{n\lambda D}{d}$$

Since, $x_n \ll D$, the angular separation between n bright fringes should be

$$\theta_n = \frac{x_n}{D} = \frac{n\lambda}{d}$$

For 10 bright fringes, we get, $\theta_{10} = \frac{10\lambda}{D}$

The angular width of the central maximum in the diffraction pattern due to slit of width a is

$$2\theta_1 = \frac{2\lambda}{a}$$

Since, 10 maxima of the double slit pattern within the central maximum of the single slit pattern

$$\Rightarrow \quad 10\frac{\lambda}{d} < 2\frac{\lambda}{a}$$

$$\Rightarrow \quad a \le \frac{d}{5}$$

$$\Rightarrow \quad a = \frac{1}{5}\text{ mm} = 0.2\text{ mm}$$

4. Since, $D_F = \frac{d^2}{\lambda}$

where $d = 4\text{ mm} = 4\times10^{-3}\text{ m}$,

$\lambda = 400\text{ nm} = 4\times10^{-7}\text{ m}$

$$\Rightarrow \quad D_F = \frac{(4\times10^{-3})^2}{4\times10^{-7}} = 40\text{ m}$$

Thus, ray optics is valid upto a distance of 40 m from the aperture.

5. Here size of Fresnel zone D_F at the middle hill must be less that 50 m.
Distance of either of the two hills from the middle hill is

$$D = \frac{40}{2}\text{ km} = 20{,}000\text{ m}$$

Since size of Fresnel's zone, $D_F = \sqrt{\lambda D}$

$$\Rightarrow \quad \sqrt{\lambda D} \ll 50$$

$$\Rightarrow \quad \lambda D \ll 2500$$

$$\Rightarrow \quad \lambda \ll \frac{2500}{D} = \frac{2500}{20{,}000} = 0.125\text{ m} = 12.5\text{ cm}$$

Thus, wavelengths longer than 12.5 cm will undergo serious diffraction effects.

6. Given, $\lambda = 6500\text{ Å} = 6500\times10^{-10}\text{ m}$, $\theta = 30°$

For first minimum, $d\sin\theta = \lambda$

$$\Rightarrow \quad d = \frac{\lambda}{\sin\theta} = \frac{6500\times10^{-10}}{\sin 30°} = \frac{6500\times10^{-10}}{0.5}$$

$$\Rightarrow \quad d = 1.3\times10^{-6}\text{ m} = 1.3\ \mu\text{m}$$

7. Given, $D = 2\text{ m}$, $x_1 = 5\text{ mm} = 5\times10^{-3}\text{ m}$,

$\lambda = 5000\text{ Å} = 5\times10^{-7}\text{ m}$

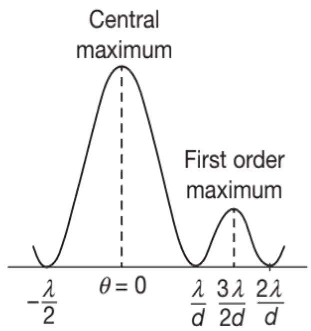
Width of central maximum is

$$\beta_0 = 2x_1 = 2\times5\times10^{-3}\text{ m} = 10^{-2}\text{ m}$$

So, slit width is

$$d = \frac{2D\lambda}{\beta_0} = \frac{2\times2\times5\times10^{-7}}{10^{-2}} = 2\times10^{-4}\text{ m} = 0.2\text{ mm}$$

8. From figure, it is clear that the angular separation between central maximum and first order minimum is



$$\theta = \frac{3\lambda}{2d} - 0 = \frac{3\lambda}{2d}$$

$$\Rightarrow \quad \theta = \frac{3\times5890\times10^{-10}}{2\times0.25\times10^{-13}}$$

$$\Rightarrow \quad \theta = 3.534\times10^{-3}\text{ rad}$$

9. Angular spread of central maximum on either side of incident light is given by

$$\sin\theta = \frac{\lambda}{a}$$

So, slit width is $a = \frac{\lambda}{\sin\theta} = \frac{5000\times10^{-10}}{\sin 30°} = 10^{-6}\text{ m}$

For $\theta = 90°$, we get

$$a = \frac{\lambda}{\sin(90°)} = \frac{5000\times10^{-10}}{1} = 5\times10^{-7}\text{ m}$$

10. Given that $P = 20\text{ mW} = 20\times10^{-3}\text{ W}$, $f = 0.05\text{ m}$,

$d = 1\text{ mm} = 10^{-3}\text{ m}$, $\lambda = 7000\text{ Å} = 7000\times10^{-10}\text{ m}$

(a) Angular spread of the laser beam,

$$\theta = \frac{1.22\lambda}{d} = \frac{1.22\times7000\times10^{-10}}{1\times10^{-3}}$$

$$\Rightarrow \quad \theta = 8.54\times10^{-4}\text{ radian}$$

(b) Linear spread of the laser is

$$f\cdot\theta = 5\times10^{-2}\times8.54\times10^{-4}\text{ m}$$

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So, areal spread of the laser, i.e., area of the target hit by it is

$$A=(5\times 8.54\times 10^{-6})^2=1.823\times 10^{-15}\ \text{m}^2$$

(c) Intensity of impact of the laser on the target is

$$I=\frac{\text{Power of laser}}{\text{Area hit}}=\frac{20\times 10^{-3}}{1.823\times 10^{-15}}$$

$$\Rightarrow\quad I=10.97\times 10^{12}\ \text{Wm}^{-2}$$

Test Your Concepts-III (Based on Polarisation)

1. Since, $I=\frac{I_0}{2}$

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

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

$$\Rightarrow\quad \cos\theta=\pm\frac{1}{\sqrt{2}}$$

$$\Rightarrow\quad \theta=\pm 45^\circ,\ \pm 135^\circ$$

The same effect occurs no matter which sheet is rotated or in which direction it is rotated.

2. According to Malus Law, $I=I_0\cos^2\theta$

(a) Here $\theta=30^\circ$

$$\Rightarrow\quad I=I_0\cos^2(30^\circ)=I_0\times\left(\frac{\sqrt{3}}{2}\right)^2=\frac{3}{4}I_0$$

$$\Rightarrow\quad \frac{I}{I_0}=0.75$$

(b) Here $\theta=60^\circ$

$$\Rightarrow\quad I=I_0\cos^2(60^\circ)=I_0\left(\frac{1}{2}\right)^2=\frac{I_0}{4}$$

$$\Rightarrow\quad \frac{I}{I_0}=0.25.$$

3. Let I_0 be intensity of incident unpolarised light. Then the intensity of light emerging from the first polaroid will be

$$I_1=\frac{I_0}{2}$$

If θ is the angle between the transmission directions of the two polaroids, then the intensity of light emerging from second polaroid is

$$I_2=I_1\cos^2\theta=\frac{I_0}{2}\cos^2\theta$$

Initially the two polaroids are crossed to each other i.e., $\theta=90^\circ$.

When polaroid is rotated through 60°, the angle between their polarising directions will become

$$\theta=90^\circ-60^\circ=30^\circ$$

$$\Rightarrow\quad I_2=\frac{I_0}{2}\cos^2(30^\circ)=\frac{I_0}{2}\times\left(\frac{\sqrt{3}}{2}\right)^2=\frac{3}{8}I_0$$

$$\Rightarrow\quad \frac{I_2}{I_0}=0.375$$

So, transmitted percentage is

$$\frac{I_2}{I_0}\times 100=0.375\times 100=37.5\%$$

4. Obviously, the axis of P_3 is inclined at 45° to the axes of P_1 and P_2

Let amplitude of linearly polarised light emerging from P_1 be E_0

The amplitude of light emerging from P_3 is

$$E_0\cos 45^\circ=\frac{E_0}{\sqrt{2}}$$

Next the amplitude of light emerging from P_2 is

$$\frac{E_0}{\sqrt{2}}\cos 45^\circ=\frac{E_0}{\sqrt{2}}\times\frac{1}{\sqrt{2}}=\frac{E_0}{2}$$

Let intensity transmitted by $P_1=I_0\propto E_0^2$

So, intensity after passing through P_2 and P_3 is

$$I\propto\left(\frac{E_0}{2}\right)^2$$

$$\Rightarrow\quad I=\frac{I_0}{4}$$

Thus, the intensity becomes one-fourth of the maximum transmitted intensity.

5. The planes of polarisation of light beams A and B are mutually at right angles. Initially, the beam B shows zero intensity. Therefore, $\theta=90^\circ$ for beam B and $\theta=0^\circ$ for beam A. When the polaroid is rotated through 30°, we have

$\theta=60^\circ$ for beam B and

$\theta=30^\circ$ for beam A

In this position, we have

$$\begin{pmatrix}\text{Intensity of emerging}\\ \text{beam } A\end{pmatrix}=\begin{pmatrix}\text{Intensity of emerging}\\ \text{beam } B\end{pmatrix}$$

$$\Rightarrow\quad I_A\cos^2(30^\circ)=I_B\cos^2(60^\circ)$$

$$\Rightarrow\quad \frac{I_A}{I_B}=\frac{\cos^2(60^\circ)}{\cos^2(30^\circ)}=\frac{\left(\frac{1}{2}\right)^2}{\left(\frac{\sqrt{3}}{2}\right)^2}=\frac{1}{3}=1:3$$

6. From Snell's Law, $\dfrac{\sin i_p}{\sin r_p}=\mu$

From Brewster Law, $\tan i_p=\dfrac{\sin i_p}{\cos i_p}=\mu$

$\Rightarrow \quad \dfrac{\sin i_p}{\sin r_p}=\dfrac{\sin i_p}{\cos i_p}$

$\Rightarrow \quad \sin r_p=\cos i_p$

$\Rightarrow \quad \sin r_p=\sin(90^\circ-i_p)$

$\Rightarrow \quad r_p=90^\circ-i_p$

$\Rightarrow \quad i_p+r_p=90^\circ$

Hence the reflected and transmitted rays are perpendicular to each other.

7. Let P_1, P_2, P_3 be the three polarisers and θ be the angle between the transmission axes of P_1 and P_2. As P_1 and P_3 are crossed, the angle between P_2 and P_3 is $(90^\circ-\theta)$.
Let I_0 be the intensity of the unpolarised light falling on P_1. Then the intensity of light emerging from P_1 will be

$$I_1=\frac{I_0}{2}$$

By Malus Law, the intensity of light emerging from P_2 is given by

$$I_2=I_1\cos^2\theta=\frac{I_0}{2}\cos^2\theta$$

The intensity of light emerging from P_3 is given by

$$I_3=I_2\cos^2(90^\circ-\theta)=\frac{1}{2}I_0\cos^2\theta\sin^2\theta=\frac{1}{8}I_0\sin^2(2\theta)$$

$\Rightarrow \quad \sin^2(2\theta)=\dfrac{8I_3}{I_0}=\dfrac{8\times 3}{32}=\dfrac{3}{4}$

$\Rightarrow \quad \sin(2\theta)=\dfrac{\sqrt{3}}{2}$

$\Rightarrow \quad 2\theta=60^\circ$

$\Rightarrow \quad \theta=30^\circ$

So, $I_3=\dfrac{I_0}{8}\sin^2(2\theta)$

I_3 will be maximum when $\sin^2(2\theta)=1$ (maximum), i.e., $\sin(2\theta)=1=\sin(90^\circ)$

$\Rightarrow \quad \theta=45^\circ$

8. Here $\mu=1.6640$

By Brewster law, $\tan i_p=\mu$

$\Rightarrow \quad \tan i_p=1.6640$

$\Rightarrow \quad i_p=\tan^{-1}(1.6640)=59^\circ$

If r is the angle of refraction, then $i_p+r=90^\circ$

$\Rightarrow \quad r=90^\circ-i_p=90^\circ-59^\circ=31^\circ$

9. (a) Thickness of a quarter wave plate is

$$t_{1/4}=\frac{\lambda}{4(\mu_0-\mu_e)}=\frac{5000\times10^{-10}}{4(1.544-1.533)}$$

$\Rightarrow \quad t_{1/4}=2.136\times10^{-5}$ m

(b) Thickness of a half-wave plate is

$$t_{1/2}=\frac{\lambda}{2(\mu_0-\mu_e)}=\frac{5000\times10^{-10}}{2(1.544-1.533)}$$

$\Rightarrow \quad t_{1/2}=2.762\times10^{-5}$ m

10. Specific rotation, $\alpha=\dfrac{\theta}{\ell c}=\dfrac{13.2}{2\times0.1}$

where $\theta=13.2^\circ$, $c=10\%=0.1$ g cm^{-1}

$\ell=20$ cm $=2$ decimetre

$\Rightarrow \quad \alpha=60^\circ\ \text{cm}^3\text{g}^{-1}(\text{dm})^{-1}$

11. Since 5% solution in a decimetre tube i.e. $\ell_1=10$ cm causes a rotation of 20°. Also, $\alpha=\dfrac{\theta}{\ell c}$

$\Rightarrow \quad 20=\alpha\times\ell_1\times\dfrac{5}{100}$ ...(1)

Let ℓ_2 length of the 10% solution of the same substance cause a rotation of 30°. Then

$30=\alpha\times\ell_2\times\dfrac{10}{100}$ ...(2)

Dividing (1) by (2), we get

$$\frac{20}{30}=\frac{\alpha\times\ell_1\times0.05}{\alpha\times\ell_2\times0.10}$$

$\Rightarrow \quad \ell_2=0.75\ell_1=(0.75)(10)=7.5$ cm

Single Correct Choice Type Questions

1. $I_{max}=I=(a+a)^2$

$\Rightarrow \quad I=4a^2=4I_0$

When either of the two slits is covered then

$$I'=(a+0)^2=a^2=\frac{I}{4}$$

Hence, the correct answer is (B).

2. $I'=\dfrac{3}{4}(4I)=3I$

$\Rightarrow \quad 3I=I+I+2I\cos\phi$

$\Rightarrow \quad \cos\phi=\dfrac{1}{2}$

$\Rightarrow \quad \phi = \frac{\pi}{3}$

For second minima, we have $\phi = 3\pi$ and for third maxima, we have $\phi = 6\pi$. So, this value should lie between 3π and 6π.

Hence, $\frac{\pi}{3}$ cannot be a possible value.

Hence, the correct answer is (A).

3. Specific rotation (α) is given by

$$\alpha = \frac{\theta}{\ell c}$$

$$\Rightarrow \quad c = \frac{\theta}{\alpha \ell} = \frac{0.4}{0.01 \times 0.25} = 160 \text{ kgm}^{-3}$$

So, percentage purity of sugar solution is

$$\% \text{ purity } = \frac{160}{200} \times 100 = 80\%$$

Hence, the correct answer is (A).

4. Since, angular width $= \frac{\lambda}{d} = 10^{-3}$ (Given)

So, number, of fringes within $0.12°$ will be

$$n = \frac{0.12 \times 2\pi}{360 \times 10^{-3}} \cong (2.09)$$

The number of bright spots will be three.
Hence, the correct answer is (B).

8. $\Delta\lambda = \frac{v_s}{c}\lambda$

$$\Rightarrow \quad v_s = \frac{\Delta\lambda \cdot c}{\lambda} = \frac{47 \times 3 \times 10^8}{4700}$$

$$\Rightarrow \quad v_s = 3 \times 10^6 \text{ ms}^{-1} \text{ away from earth}$$

Hence, the correct answer is (D).

9. The relation among angle of diffraction θ, order n and number of lines per cm of the grating N is $\sin\theta = Nn\lambda$. The maximum value of $\sin\theta = 1$. Hence maximum value for $n = \frac{1}{N\lambda}$. $\lambda = 6000 \times 10^{-8}$ cm, $N = 5000$ lines/cm, we get $n = 3.33$. The order of spectrum is an integer. Thus we cannot see the fourth order, but can see the third order.
Hence, the correct answer is (B).

10. Since $\mu\lambda$ = constant

$$\Rightarrow \quad \mu_1\lambda_1 = \mu_2\lambda_2$$

$$\Rightarrow \quad (1)\lambda_1 = n\lambda_2$$

$$\Rightarrow \quad \frac{\lambda_1}{\lambda_2} = n$$

Hence, the correct answer is (A).

11. $n_1\lambda_1 = n_2\lambda_2$

$$\Rightarrow \quad 62 \times 5893 = n_2 \times 4358$$

$$\Rightarrow \quad n_2 = 84$$

Hence, the correct answer is (D).

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

$$\Rightarrow \quad \beta = \frac{(5000 \times 10^{-10})(2)}{(10^{-3})}$$

$$\Rightarrow \quad \beta = 10^{-3} \text{ m} = 1 \text{ mm}$$

Hence, the correct answer is (D).

13. Let the required thickness be t Å. So, number of wavelengths in vacuum is $\frac{t}{6000}$.

$\Rightarrow$ Number of wavelengths in air is $\frac{1.003t}{6000}$

According to the problem

$$\frac{t}{6000} = \frac{1.003t}{6000} + 1$$

$$\Rightarrow \quad t = 2 \text{ mm}$$

Hence, the correct answer is (A).

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

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

Hence, the correct answer is (C).

15. Theoretically infinite colours are possible, hence infinite wavelengths.
Hence, the correct answer is (D).

17. $\Delta x = (\mu_2 - \mu_1)t$

$$\Rightarrow \quad \delta = \frac{2\pi}{\lambda}(\mu_2 - \mu_1)t$$

Hence, the correct answer is (C).

18. Because sound waves are longitudinal in nature.
Hence, the correct answer is (D).

19. The blue filter will allow only blue light to pass through. So, light from the object passes through filter. Similarly, the white background will also look blue through the filter. Thus, we have a blue object under a blue background, which makes it indistinguishable.
Hence, the correct answer is (D).

20. Intensity of illumination at a point is decided by three factors; (i) power of the source P (ii) distance from the source r and (iii) angle of incidence of rays $\cos\theta$

$$\Rightarrow \quad I = P\cos\frac{\theta}{r^2}$$

At noon the sun's rays are normally incident making $\theta = 0$. Hence I is maximum at noon.
Hence, the correct answer is (B).

21. Distance of third maxima from central maxima is

$$x = \frac{3\lambda D}{d} = \frac{3\times 5000\times 10^{-10}\times\left(200\times 10^{-2}\right)}{0.2\times 10^{-3}} = 1.5 \text{ cm}$$

Hence, the correct answer is (B).

23. For observation of colours, the thickness of the film should be of the order of the wavelength of visible light.
Hence, the correct answer is (C).

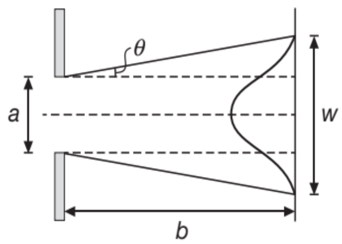
24. The red filter will pass only red light. Hence a blue cross will appear as black. The white background will appear as red when seen through a red filter. Thus, the observer will see a black cross under a red background.
Hence, the correct answer is (D).

25. The direction in which the first minima occurs is θ (say). Then

$$a\sin\theta = \lambda$$

$$\Rightarrow \quad a\theta = \lambda \qquad \{\because \theta \approx \sin\theta \text{ when } \theta \text{ small}\}$$

$$\Rightarrow \quad \theta = \frac{\lambda}{a}$$



Width of the central maximum is

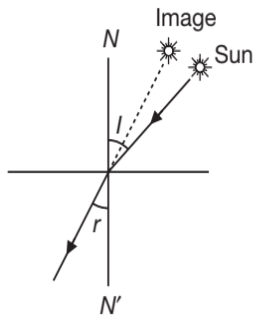
$$w = 2b\theta + a = 2b\left(\frac{\lambda}{a}\right) + a$$

Hence, the correct answer is (C).

26. Newton's concept of light is that it is made of corpuscles or particles. All particles are deflected by earth's gravitational field. Hence, they are also deflected by gravitational field. In the general theory of relativity. Einstein predicts deflection of light by the gravitational field. The angle of deflection predicted by both are however not the same. Einstein's prediction agrees with experimental results.
Hence, the correct answer is (B).

27. In photoelectric effect, the photon is treated as a particle having a quantum of energy $h\nu$. It emits one electron. Here the particle and wave aspect of light appear in two sides of equation. Einstein's photoelectric equation appears to be interlinking of the two aspects.
Hence, the correct answer is (D).

28. This is the effect of refraction. Rays from the sun are passing from vacuum to air when they enter into the earth's atmosphere. They bend towards the normal making the sun to appear at a higher altitude as shown in figure.



Hence, the correct answer is (A).

30. In the presence of thin glass plate, the fringe pattern shifts, but no change in fringe width.
Hence, the correct answer is (D).

31. If an unpolarised light is converted into plane polarised light by passing through a polaroid, it's intensity becomes half.
Hence, the correct answer is (C).

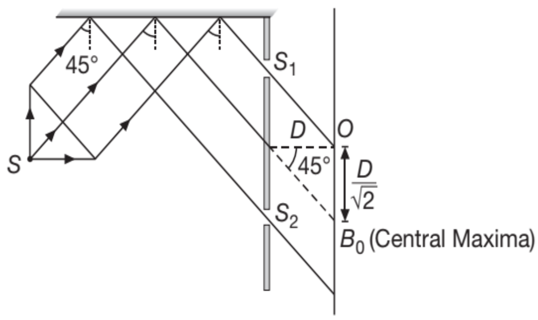
32. P to Q convergence increasing and Q to R direction changing.
Hence, the correct answer is (D).

33. $\beta = \dfrac{\lambda D}{d}$ and

$$\beta' = \frac{\lambda(D/2)}{2d} = \frac{\beta}{4}$$

Hence, the correct answer is (A).

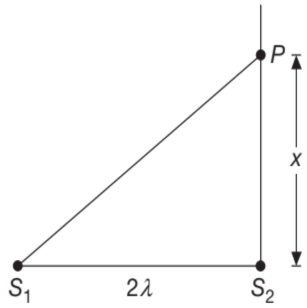
34. From the figure shown below it is clear that the distance of central maxima from O is $\dfrac{D}{\sqrt{2}}$.



Hence, the correct answer is (A).

CHAPTER 2

35. Path difference at s_2 is 2λ. Therefore, for minimum intensity at P



Let x be the minimum distance from s_2. Then

$$s_1P - s_2P = \frac{3\lambda}{2} \neq \frac{\lambda}{2} \quad \ldots(1)$$

$$\Rightarrow \sqrt{4\lambda^2 + x^2} - x = \frac{3\lambda}{2}$$

Solving this equation, we get

$$x = \frac{7\lambda}{12}$$

NOTE: If we substitute $s_1P - s_2P = \frac{\lambda}{2}$ in equation (1) we get $x = \frac{15\lambda}{4}$ which is greater than $\frac{7\lambda}{12}$.

Hence, the correct answer is (A).

36. Shift $= \frac{(\mu - 1)tD}{d}$

$$x = \frac{(1.5 - 1)tD}{d} \quad \ldots(1)$$

and $$\frac{3}{2}x = \frac{(\mu - 1)tD}{d} \quad \ldots(2)$$

Dividing equation (1) by (2)

$$\frac{2}{3} = \frac{0.5}{\mu - 1}$$

$$2\mu - 2 = 1.5$$

$$2\mu = 3.5$$

$$\mu = 1.75$$

Hence, the correct answer is (A).

37. Phase difference corresponding to $y_1 = -\frac{\pi}{2}$ and that for $y_2 = +\frac{\pi}{2}$

$\Rightarrow$ Average intensity between y_1 and y_2

$$\Rightarrow I_{av} = \frac{1}{\pi} \int_{-\pi/2}^{\pi/2} I_{\max} \cos^2\left(\frac{\phi}{2}\right) d\phi = I_{\max} \frac{(\pi + 2)}{2\pi}$$

So, the required ratio is $\frac{1}{2}\left(1 + \frac{2}{\pi}\right)$

Hence, the correct answer is (A).

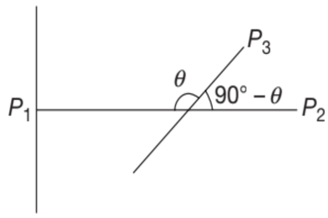
38. Intensity at the centre will be zero if path difference $= \frac{\lambda}{2}$

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

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

Hence, the correct answer is (C).

39. No light is emitted from the second polaroid, so P_1 and P_2 are perpendicular to each other



Let the initial intensity of light is I_0. So, Intensity of light after transmission from first polaroid $= \frac{I_0}{2}$.
Intensity of light emitted from P_3

$$I_1 = \frac{I_0}{2}\cos^2\theta$$

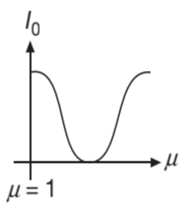
Intensity of light transmitted from last polaroid i.e., from

$$P_2 = I_1 \cos^2(90^o - \theta) = \frac{I_0}{2}\cos^2\theta \sin^2\theta$$

$$P_2 = \frac{I_0}{8}(2\sin\theta\cos\theta)^2 = \frac{I_0}{8}\sin^2 2\theta$$

Hence, the correct answer is (A).

40. In absence of film, intensity is maximum at the mid-point of screen. As the value of μ is increased, intensity decreases and then increases alternately. Hence the correct variation is



Hence, the correct answer is (C).

41. For secondary maxima, we have

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

$\Rightarrow \quad a\theta = a\left(\frac{y}{D}\right) = \frac{5\lambda}{2}$

Since $D \approx f$

$\Rightarrow \quad 2y = \frac{5\lambda f}{a} = \frac{5\times 0.8\times 10^{-7}}{4\times 10^{-4}} = 6\times 10^{-3}\text{ m} = 6\text{ mm}$

Hence, the correct answer is (A).

43. Path difference at P is

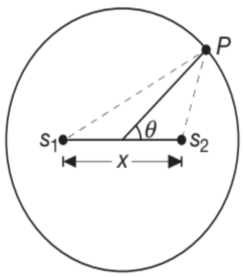
$$\Delta x = 2\left(\frac{x}{2}\cos\theta\right) = x\cos\theta$$

For intensity to be maximum

$\Delta x = n\lambda \qquad \{n = 0, 1, 2, 3, ...\}$

$\Rightarrow \quad x\cos\theta = n\lambda$

$\Rightarrow \quad \cos\theta = \frac{n\lambda}{x}$



Since, $\cos\theta \not> 1$

$\Rightarrow \quad \frac{n\lambda}{x} \not> 1$

$\Rightarrow \quad n \not> \frac{x}{\lambda}$

Substituting $x = 5\lambda$, we get

$n \not> 5$

$\Rightarrow \quad n = 1, 2, 3, 4, 5, ...$

Therefore, in all four quadrants there can be 20 maximas. There are more maximas at $\theta = 0°$ and $\theta = 180°$. But $n = 5$ corresponds to $\theta = 90°$ and $\theta = 270°$ which are coming only twice while we have multiplied it four times. Therefore, total number of maximas are still 20 i.e., $n = 1$ to 4 in four quadrants (total 16) plus four more at $\theta = 0°$, $90°$, $180°$ and $270°$.

Hence, the correct answer is (A).

44. Laser is intense, coherent (all photons in phase) and monochromatic (only single wavelength).

Hence, the correct answer is (A).

45. The focal length increases with increases of wavelength. $\frac{1}{f} \propto (n-1)$ nearly $\propto \frac{1}{\lambda^2}$ where λ is wavelength. In the given set of radiations. X-rays have the minimum wavelength. Hence focal length is minimum for X-rays.

Hence, the correct answer is (D).

46. As the star accelerates towards the earth, its velocity will increase. By Doppler effect in light, a source approaching an observer shows violet shift. So, the colour of the star will shift towards the shorter wavelength region, that is blue.

Hence, the correct answer is (D).

48. The direction of light is given by the normal vector $\vec{n} = \hat{i} + 2\hat{j} + 3\hat{k}$. So, angle made by the $\vec{n}$ with y-axis is given by $\cos\beta = \frac{2}{\sqrt{1^2+2^2+3^2}} = \frac{2}{\sqrt{14}}$

Hence, the correct answer is (C).

50. $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

$\Rightarrow \quad \frac{0.05}{100} = \frac{v}{3\times 10^8}$

$\Rightarrow \quad v = 1.5\times 10^5$

(Since wavelength is decreasing, so star coming closer)

Hence, the correct answer is (B).

51. Momentum of the electron will increase. So, the wavelength $\left(\lambda = \frac{h}{p}\right)$ of electrons will decrease and fringe width decreases as $\beta \propto \lambda$.

Hence, the correct answer is (B).

52. $I = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

At central position $I_1 = 4I_0$ ...(1)

Since the phase difference between two successive fringes is $2x$, the phase difference between two points separated by a distance equal to one quarter of the distance between the two, successive fringes are equal to

$\delta = (2\pi)\left(\frac{1}{4}\right) = \frac{\pi}{2}$ radian

$\Rightarrow \quad I_2 = 4I_0\cos^2\left(\frac{\frac{\pi}{2}}{2}\right) = 2I_0$ ...(2)

Using (1) and (2), $\frac{I_1}{I_2} = \frac{4I_0}{2I_0} = 2$

Hence, the correct answer is (A).

53. $I = I_0\left[\frac{\sin\alpha}{\alpha}\right]^2$, where $\alpha = \frac{\phi}{2}$

For n^{th} secondary maxima $d\sin\theta = \left(\frac{2n+1}{2}\right)\lambda$

$\Rightarrow \quad \alpha = \frac{\phi}{2} = \frac{\pi}{\lambda}[d\sin\theta] = \left(\frac{2n+1}{2}\right)\pi$

$\therefore \quad I = I_0\left(\frac{\sin\left(\frac{2n+1}{2}\right)\pi}{\left(\frac{2n+1}{n}\right)\pi}\right)^2 = \frac{I_0}{\left[\frac{(2n+1)}{2}\pi\right]^2}$

So $I_0 : I_1 : I_2 = I_0 : \frac{4}{9\pi^2}I_0 : \frac{4}{25\pi^2}I_0 = 1 : \frac{4}{9\pi^2} : \frac{4}{25\pi^2}$

Hence, the correct answer is (C).

54. Let t be the thickness so corresponding

$$\Delta x = \mu t = \frac{3}{2}t$$

Also $I_{max} = 4I$

$$\Rightarrow \quad I_R = I = \frac{I_{max}}{2} = 2I$$

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

$$\Rightarrow \quad 2I_0 = I_0 + I_0 + 2\sqrt{I_0^2}\,\cos\left(\frac{3\pi t}{\lambda}\right)$$

$$\Rightarrow \quad \cos\left(\frac{3\pi t}{\lambda}\right) = 0$$

$$\Rightarrow \quad \frac{3\pi t}{\lambda} = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \ldots\ldots.$$

$$\Rightarrow \quad t = \frac{\lambda}{6}, \frac{3\lambda}{6}, \frac{5\lambda}{6}, \ldots\ldots..$$

$$\Rightarrow \quad t = \frac{\lambda}{2}$$

Hence, the correct answer is (C).

55. If I is the final intensity and I_0 is the initial intensity then

$$I = \frac{I_0}{2}\left(\cos^2 30°\right)^5$$

$$\Rightarrow \quad \frac{I}{I_0} = \frac{1}{2} \times \left(\frac{\sqrt{3}}{2}\right)^{10} = 0.12$$

Hence, the correct answer is (D).

56. For maxima $\Delta = d\sin\theta = n\lambda$

$$\Rightarrow \quad 2\lambda \sin\theta = n\lambda$$

$$\Rightarrow \quad \sin\theta = \frac{n}{2}$$

since value of $\sin\theta$ cannot be greater 1.

$\therefore \quad n = 0, 1, 2$

Therefore, only five maximas can be obtained on both side of the screen.

Hence, the correct answer is (B).

57. In this case, we can assume as if both the source and the observer are moving towards each other with speed v. Hence

$$v' = \frac{c - u_o}{c - u_s} v = \frac{c - (-v)}{c - v} v = \frac{c + v}{c - v} v$$

$$v' = \frac{(c+v)(c-v)}{(c-v)^2} v = \frac{c^2 - v^2}{c^2 + v^2 - 2vc} v$$

Since $v \ll c$, therefore $v' = \dfrac{c^2}{c^2 - 2vc} = \dfrac{c}{c - 2v} v$

Hence, the correct answer is (B).

58. Fringe width $\beta \propto \lambda$. Therefore, λ and hence β decreases 1.5 times when immersed in liquid. The distance between central maxima and 10^{th} maxima is 3 cm in vacuum. When immersed in liquid it will reduce to 2 cm. Position of central maxima will not change while 10^{th} maxima will be obtained at $y = 4$ cm.

Hence, the correct answer is (C).

59. For maximum intensity on the screen

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

$$\Rightarrow \quad \sin\theta = \frac{n\lambda}{d} = \frac{n(2000)}{7000} = \frac{n}{3.5}$$

Since maximum value of $\sin\theta$ is 1

So $n = 0, 1, 2, 3$ only. Thus, only seven maximas can be obtained on both sides of the screen.

Hence, the correct answer is (B).

60. Optical path difference $(O.P.D.)$ between P and Q is

$$(\text{O.P.D.}) = (2.25\lambda_0)(1) + (3.5\lambda_0)(2) + (3\lambda_0)(3)$$

$$\Rightarrow \quad (\text{O. P. D.}) = 18.25\lambda_0$$

Phase difference $\Delta\phi = \left(\dfrac{2\pi}{\lambda_0}\right)\Delta x = \dfrac{\pi}{2}$

Hence, the correct answer is (C).

61. If $d\sin\theta = (\mu - 1)t$, central fringe is obtained at O

If $d\sin\theta > (\mu - 1)t$, central fringe is obtained above O and

If $d\sin\theta < (\mu - 1)t$, central fringe is obtained below O

Hence, the correct answer is (D).

62. Resultant intensity $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

At central position with coherent source and $I_1 = I_2 = I_0$

$$I_{con} = 4I_0 \qquad \ldots(1)$$

In case of incoherent at a given point, ϕ varies randomly with time so $(\cos\phi)_{av} = 0$

$$\therefore \quad I_{Incoh} = I_1 + I_2 = 2I_0 \qquad \ldots(2)$$

Hence $\dfrac{I_{coh}}{I_{Incoh}} = \dfrac{2}{1}$

Hence, the correct answer is (B).

63. According to given condition

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

So, $(\mu - 1)t_{min} = \lambda$

$$t_{min} = \frac{\lambda}{\mu - 1} = \frac{\lambda}{1.5 - 1} = 2\lambda$$

Hence, the correct answer is (A).

64. $\left(\frac{I_1+I_2}{I_1-I_2}\right)^2 \to \infty$

$\Rightarrow \quad I_1 - I_2 \to 0$

$\Rightarrow \quad I_1 \simeq I_2$

Hence, the correct answer is (B).

65. Path difference between the waves reaching O will be

$$\Delta x = 2d\sin\alpha$$

For dark fringe at O, we have

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

$\Rightarrow \quad \sin\alpha = \frac{\lambda}{4d}$

$\Rightarrow \quad \alpha = \sin^{-1}\left(\frac{\lambda}{4d}\right)$

Hence, the correct answer is (B).

66. When unpolarised light is made incident at polarising angle, the reflected light is plane polarised in a direction perpendicular to the plane of incidence.
Therefore $\vec{E}$ in reflected light will vibrate in vertical plane with respect to plane of incidence.
Hence, the correct answer is (A).

67. If I is the intensity of the incident unpolarised light, the intensity transmitted by the first is $\frac{I}{2}$. This is the intensity of incident light on the second polaroid. Intensity transmitted by the second polaroid is $\left(\frac{I}{2}\right)\cos^2\theta$, where θ is the angle between the axes. Here $\sin\theta = \frac{3}{5}$, $\cos\theta$ is therefore $\frac{4}{5}$.

$$\frac{I}{2}\cos^2\theta = \frac{I}{2}\times\left(\frac{4}{5}\right)^2 = \frac{8}{25}I$$

$\frac{8}{25}$ is the required ratio.

Hence, the correct answer is (D).

69. If you divide the original slit into N strips and represents the light from each strip, when it reaches the screen, by a phasor, then at the central maximum in the diffraction pattern you add N phasors, all in the same direction and each with the same amplitude. The intensity is therefore N^2. If you double the slit width, you need $2N$ phasors, if they are each to have the amplitude of the each to have the amplitude of the phasors you used for the narrow slit. The intensity at the central maximum is proportional to $(2N)^2$ and is, therefore, four times the intensity for the narrow slit.
Hence, the correct answer is (D).

70. $\sin C = \frac{3}{5}$. Hence $n = \frac{5}{3}$. If i is the polarising angle $\tan i = n$. $i = \tan^{-1}(n) = \tan^{-1}\left(\frac{5}{3}\right)$.

Hence, the correct answer is (B).

71. Since $\theta \propto \ell$
Since the volume ratio is given to be $1:2$, so in a tube of length 30 cm means 10 cm length of first solution and 20 cm length of second solution.
Rotation produced by 10 cm length of first solution is

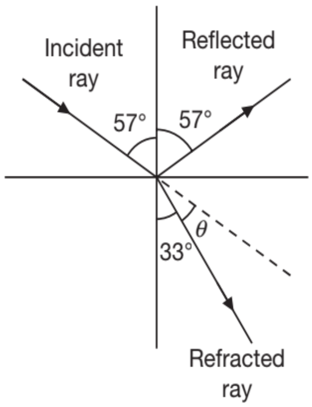
$$\theta_1 = \frac{38^\circ}{20}\times 10 = 19^\circ$$

Rotation produced by 20 cm length of second solution is

$$\theta_2 = \frac{24^\circ}{30}\times 20 = 16^\circ$$

So, net rotation produced is $\theta = 19^\circ - 16^\circ = 3^\circ$
Hence, the correct answer is (D).

72.



For glass of refractive index 1.5, polarising angle is 57°, $\tan i = 1.5$. At this stage the angle between the refracted ray and the reflected ray is 90°. The required angle from figure is $\theta = 57 - 33 = 24^\circ$.
Hence, the correct answer is (C).

73. The property of double refraction is shown by quartz, calcite and ice also.
Hence, the correct answer is (D).

74. For first minimum

$$\lambda = a\sin\theta$$

$\Rightarrow \quad 6.5\times10^{-7} = a\sin 30$

$\Rightarrow \quad a = 13\times10^{-7}$ m

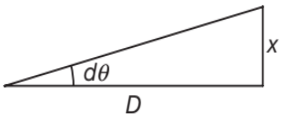
$\Rightarrow \quad a = 1.3\ \mu$m

Hence, the correct answer is (C).

75. The resolving power of the human eye is $\frac{1}{d\theta}$ is the smallest angle subtended by two objects just distinguishable, $d\theta = 1' = \frac{1}{60°}$. Converting this into radian and taking 1 radian as nearly $60°$ (Actually $57°\ 18'$) we get the resolving power as 3600.

Hence, the correct answer is (B).

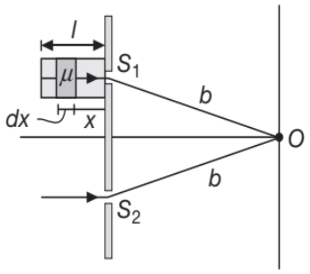
77.



If x is the distance between poles and D is the distance of the eye from the poles as shown in figure, we have $d\theta = \tan d\theta = \frac{x}{D}$. Here $D = 3.6\ \text{km} = 3600\ \text{m}$ and $d\theta = \frac{1}{3600}$ radian. Hence $x = 1\ \text{m}$.

Hence, the correct answer is (C).

78. When light passes through a medium of refractive index μ, the optical path it travels is μt.



Therefore, before reaching O, light through S_1 travels a distance $(\mu\ell + b)$ while that through S_2 travels a distance $(\ell + b)$

So, path difference $\Delta x = (\mu\ell + b) - (\ell + b) = (\mu - 1)\ell$

$$\Delta x = (\mu - 1)dx = (1 + ax - 1)dx$$

$$\Rightarrow \quad \Delta x = axdx$$

For the whole length, we have

$$\Delta x_{\text{total}} = \int_0^\ell axdx = \frac{a\ell^2}{2}$$

For a minima to be formed at O, we have

$$\Delta x_{\text{total}} = (2n+1)\frac{\lambda}{2}$$

$$\Rightarrow \quad \frac{a\ell^2}{2} = (2n+1)\frac{\lambda}{2}$$

For minimum a, n should be minimum, so $n = 0$

$$\Rightarrow \quad \frac{a\ell^2}{2} = \frac{\lambda}{2}$$

$$\Rightarrow \quad a = \frac{\lambda}{\ell^2}$$

Hence, the correct answer is (B).

79. $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

$$\Rightarrow \quad 1 = \frac{v}{c}$$

$$\Rightarrow \quad v = c$$

Hence, the correct answer is (A).

80. $\lambda' = \lambda\left(1 - \frac{v}{c}\right) = 5890\left(1 - \frac{4.5 \times 10^6}{3 \times 10^8}\right) \approx 5802\ \text{Å}$

Hence, the correct answer is (C).

81. $\frac{\lambda_1}{\lambda_2} = \frac{4500}{6000} = \frac{3}{4}$

$$\Rightarrow \quad 4\lambda_1 = 3\lambda_2$$

i.e. the fourth bright fringe of λ_1 coincides with the third bright fringe of λ_2.

Hence, the correct answer is (C).

82. From here, we must take a note that central maxima $(n = 0)$ is flanked by first minima $(n = 1)$ and then first maxima $(n = 1)$.

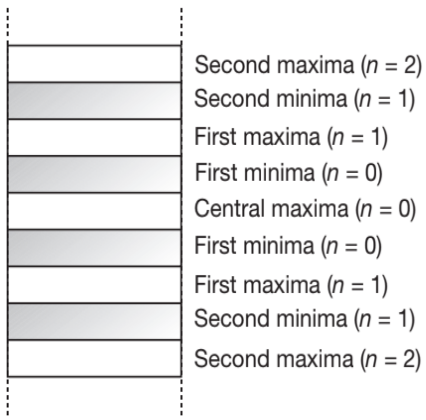
Position of the $(n+1)$th dark fringe is

$$x_{n+1} = (2n+1)\frac{\lambda D}{2d}$$

So, position of second dark fringe is

$$x_2 = [2(1)+1]\frac{\lambda D}{2d}$$

$$\Rightarrow \quad x_2 = \frac{3\lambda D}{2d}$$



Similarly, position of nth bright fringe is

$$x_n = n\left(\frac{\lambda D}{d}\right)$$

$$\Rightarrow \quad x_4 = \frac{4\lambda D}{d}$$

So, separation is

$$\Delta x = x_4 - x_2 = \frac{5}{2}\left(\frac{\lambda D}{d}\right)$$

$\Rightarrow \quad \Delta x = 1.5$ mm

Hence, the correct answer is (C).

83. Shift, $\Delta x = [(\mu - 1)t]\dfrac{D}{d}$

$$\Rightarrow \quad 20\beta = (\mu - 1)\frac{tD}{d}$$

$$\Rightarrow \quad 20\left(\frac{\lambda D}{d}\right) = (\mu - 1)\frac{tD}{d}$$

$$\Rightarrow \quad 20\lambda = (\mu - 1)t$$

$$\Rightarrow \quad \mu = \frac{20\lambda}{t} + 1$$

$$\Rightarrow \quad \mu = \frac{20 \times 5000 \times 10^{-10}}{2.5 \times 10^{-5}} + 1$$

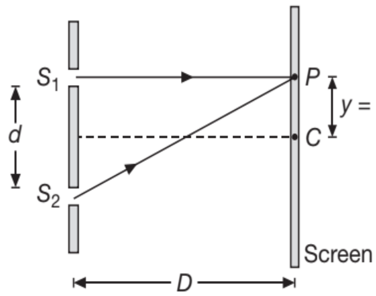
$$\Rightarrow \quad \mu = \frac{4}{10} + 1$$

$$\Rightarrow \quad \mu = 1.4$$

Hence, the correct answer is (C).

84. Suppose P is a point in front of one slit at which intensity is I_0. From figure, it is clear that $y = \dfrac{d}{2}$. Path difference between the waves reaching at P is

$$\Delta x = \frac{yd}{D} = \frac{\left(\frac{d}{2}\right)d}{10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$$



Hence corresponding phase difference is given by

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

Resultant intensity at P is

$$I = I_{max}\cos^2\left(\frac{\phi}{2}\right) = I_o\cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$$

Hence, the correct answer is (A).

85. For dark fringe at P

$$S_1P - S_2P = \Delta = \frac{(2n-1)\lambda}{2}$$

Here $n = 3$ and $\lambda = 6000$

So, $\Delta = \dfrac{5\lambda}{2} = 5 \times \dfrac{6000}{2} = 15000$ Å $= 1.5$ micron

Hence, the correct answer is (B).

86. Fringe width $\omega = \dfrac{\lambda D}{d}$. When the apparatus is immersed in a liquid, λ and hence w is reduced μ (refractive index) times.

$$10\omega' = (5.5)\omega$$

$$\Rightarrow \quad 10\lambda'\left(\frac{D}{d}\right) = (5.5)\frac{\lambda D}{d}$$

$$\Rightarrow \quad \frac{\lambda}{\lambda'} = \frac{10}{5.5} = \mu$$

$$\Rightarrow \quad \mu = 1.8$$

Hence, the correct answer is (A).

87. The intensity of light received is inversely proportional to the square of distance. Hence the amplitude of the light wave received is inversely proportional to the distance.

Hence, the correct answer is (B).

88. Fringe width $\beta \propto \lambda$. Therefore, λ and hence w will decrease 1.5 times when immersed in liquid. The distance between central maxima and 10^{th} maxima is 3 cm in vacuum. When immersed in liquid it will reduce to 2 cm. Position of central maxima will not change while 10^{th} maxima will be obtained at $y = 4$ cm.

Hence, the correct answer is (C).

89. $I = 4I_0\cos^2\left(\dfrac{\phi}{2}\right)$

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

$$\Rightarrow \quad \cos\left(\frac{\phi}{2}\right) = \frac{1}{2}$$

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

$$\Rightarrow \quad \phi = \frac{2\pi}{3} = \left(\frac{2\pi}{\lambda}\right)\Delta x$$

$$\Rightarrow \quad \frac{1}{3} = \left(\frac{1}{\lambda}\right)y\frac{d}{D} \qquad \left\{\because \Delta x = \frac{yd}{D}\right\}$$

$$\Rightarrow \quad y = \frac{\lambda}{3 \times \frac{d}{D}} = \frac{6 \times 10^{-7}}{3 \times 10^{-4}}$$

$$\Rightarrow \quad y = 2 \times 10^{-3} \text{ m} = 2 \text{ mm}$$

Hence, the correct answer is (A).

90. For third maximum

$$x = n\left(\frac{\lambda D}{d}\right)$$

$\Rightarrow \quad x = (3)\dfrac{5000 \times 10^{-10} \times 2}{0.2 \times 10^{-3}}$

$\Rightarrow \quad x = 1.5 \text{ cm}$

Hence, the correct answer is (B).

91. Rotation produced $\theta = \alpha \ell c$

Net rotation produced $\theta_r = \theta_1 - \theta_2 = \ell(\alpha_1 c_1 - \alpha_2 c_2)$

$\Rightarrow \quad \theta_r = 0.29 \times (0.01 \times 60 - 0.02 \times 30) = 0$

Hence, the correct answer is (B).

92. Blue of the sky is explained by scattering. Scattered light obeys Rayleigh's law. $I \propto \dfrac{1}{\lambda^4}$. Hence shorter wavelengths are scattered with more intensity. In visible light, violet and blue have the minimum wavelength. Of the two, blue is more intense.
Hence, the correct answer is (D).

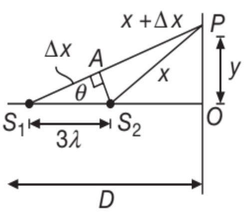
93. The interference fringes for two slits are hyperbolic.
Hence, the correct answer is (D).

94. Total phase difference
= Initial phase difference + Phase difference due to path

$\Rightarrow \quad \phi = 66° + \dfrac{360°}{\lambda} \times \Delta x = 66° + \dfrac{360°}{\lambda} \times \dfrac{\lambda}{4} = 66° + 90 = 156°$

Hence, the correct answer is (A).

95.



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

In this case path difference is $d\cos\theta$

$\Rightarrow \quad n\lambda = \lambda = 3\lambda \cos\theta$

$\Rightarrow \quad \cos\theta = \dfrac{1}{3}$

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

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

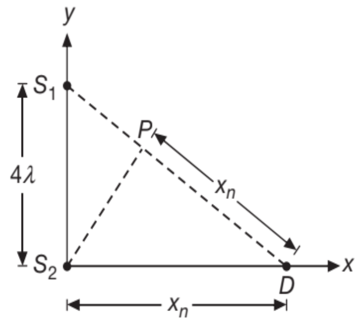
$\Rightarrow \quad y = \sqrt{8}D = 2\sqrt{2}D$

Hence, the correct answer is (B).

96. From ΔS_1S_2D,

$$(S_1D)^2 = (S_1S_2)^2 + (S_2D)^2$$

$$(S_1P + PD)^2 = (S_1S_2)^2 + (S_2D)^2$$



Here S_1P is the path difference $= n\lambda$ for maximum intensity.

$\therefore \quad (n\lambda + x_n)^2 = (4\lambda)^2 + (x_n)^2$

$\Rightarrow \quad x_n = \dfrac{16\lambda^2 - n^2\lambda^2}{2n\lambda}$

Then $x_1 = \dfrac{16\lambda^2 - \lambda^2}{2\lambda} = 7.5\lambda$

$x_2 = \dfrac{16\lambda^2 - 4\lambda^2}{4\lambda} = 3\lambda$

$x_3 = \dfrac{16\lambda^2 - 9\lambda^2}{6\lambda} = \dfrac{7}{6}\lambda$

$x_4 = 0$

So, Number of points for maxima becomes 3.
Hence, the correct answer is (B).

97. If a is the width of the slit, the minimum of Fraunhofer diffraction pattern appears for $a\sin\theta = n\lambda$, where n is an integer. For the first minimum $n = 1$. Then

$$\sin\theta = \frac{\lambda}{a} = 10^{-3} \text{ rad} ; 1 \text{ rad} = 57°.$$

Hence $\theta = 0.057° = 0.057 \times 60' = 3.42'$.

Hence, the correct answer is (B).

98. Angular limit of resolution of human eye is

$$\frac{1.22\lambda}{a} = R(\text{say})$$

$\Rightarrow \quad R = \dfrac{1.22 \times 5 \times 10^{-7}}{2 \times 10^{-3}} \text{rad}$

$\Rightarrow \quad R = \dfrac{1.22 \times 5 \times 10^{-7}}{2 \times 10^{-3}} \times \dfrac{180}{\pi} \text{ degree}$

$\Rightarrow \quad R = 0.0175 \text{ degree}$

$\Rightarrow \quad R = 0.0175 \times 60 \text{ minute}$

$\Rightarrow \quad R \simeq 1 \text{ minute}$

Hence, the correct answer is (B).

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

$\Rightarrow \frac{x+1}{x-1} = 3 \qquad \{\because x = \sqrt{I_1/I_2}\}$

$\Rightarrow x = 2$

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

$\Rightarrow I_1 = 4I_2$

i.e., if $I_2 = I_0$ then $I_1 = 4I_0$

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

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

$\Rightarrow \left(\frac{2\pi}{\lambda}\right)\left(\frac{yd}{D}\right) = \frac{2\pi}{3}$

$\Rightarrow y = \frac{\lambda D}{3d}$

Hence, the correct answer is (C).

100. $(n+1)5200 = n(7800)$

$\Rightarrow n = 2$

Hence, the correct answer is (A).

101. Angular width $\beta = \frac{2\lambda}{a}$

$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$

where $\beta_1 = \beta$ and $\beta_2 = \beta - \left(\frac{30}{100}\right)\beta = \left(\frac{70}{100}\right)\beta$

$\Rightarrow \frac{\beta}{\left(\frac{70}{100}\right)\beta} = \frac{6000}{\lambda_2} = 4200$ Å

Hence, the correct answer is (B).

103. Air has a refractive index slightly greater than one. So, when the chamber is evacuated, the refractive index decreases and hence wavelength increases as a result of which fringe width increases slightly.
Hence, the correct answer is (B).

104. Ultraviolet radiations, when fall on a fluorescent material, are converted into visible radiations. Hence, we should use ultraviolet radiation.
Hence, the correct answer is (D).

105. Using the same argument as in the SOLUTION 104.

$\frac{I}{2}\cos^2 30 = \frac{I}{2}\times\frac{3}{4} = \frac{3I}{8} = 0.375I$

Hence, the correct answer is (C).

106. $\lambda_{Red} > \lambda_{Violet}$
and all other colours have wavelength value lying in this region. Further, we have $X \propto \lambda$, so

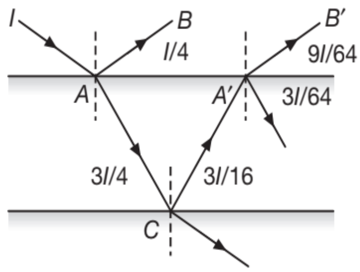
$X(\text{Blue}) < X(\text{Green})$

Hence, the correct answer is (B).

107. In double refraction, light rays always split into two rays (O-ray and E-ray). O-ray has same velocity in all directions but E-ray has different velocity in different directions. For calcite $\mu_E < \mu_O$, so $v_E > v_O$ and for quartz, we have $\mu_E > \mu_O$, so $v_O > v_E$.
Hence, the correct answer is (C).

108. From figure $I_1 = \frac{I}{4}$ and $I_2 = \frac{9I}{64}$

$\Rightarrow \frac{I_2}{I_1} = \frac{9}{16}$



By using $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_2}{I_1}}+1}{\sqrt{\frac{I_2}{I_1}}-1}\right) = \left(\frac{\sqrt{\frac{9}{16}}+1}{\sqrt{\frac{9}{16}}-1}\right) = \frac{49}{1}$

Hence, the correct answer is (D).

109. Since, according to Malus Law

$I = I_0\cos^2\phi$

Hence, the correct answer is (D).

110. Since P is ahead of Q by $90°$ and path difference between P and Q is $\frac{\lambda}{4}$. Therefore at A, phase difference is zero, so intensity is $4I$. At C it is zero and at B, the phase difference is $90°$, so intensity is $2I$.
Hence, the correct answer is (D).

111. P is the position of 11^{th} bright fringe from Q. From central position O, P will be the position of 10^{th} bright fringe.
Path difference between the waves reaching at

$P = S_1B = 10\lambda = 10\times 6000\times 10^{-10} = 6\times 10^{-6}$ m

Hence, the correct answer is (A).

112. Since, $I = I_0 + I_0 + 2I_0\cos\phi$

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

Now, $I = 0.75 I_{max}$

$\Rightarrow \quad I = 3I_0$

$\Rightarrow \quad 3I_0 = I_0 + I_0 + 2I_0 \cos\phi$

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

$\Rightarrow \quad \phi = \frac{\pi}{3}, \left(2\pi - \frac{\pi}{3}\right), \left(2\pi + \frac{\pi}{3}\right), \left(4\pi - \frac{\pi}{3}\right)$

$\Rightarrow \quad \phi = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \ldots\ldots$

$\Rightarrow \quad \left(\frac{2\pi}{\lambda}\right)\Delta x = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \ldots\ldots \qquad \ldots(1)$

where $\Delta x = (\mu - 1)t = \frac{t}{2} \qquad \ldots(2)$

From Equation (1) and (2), we get

$$\left(\frac{2\pi}{\lambda}\right)\left(\frac{t}{2}\right) = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \ldots\ldots$$

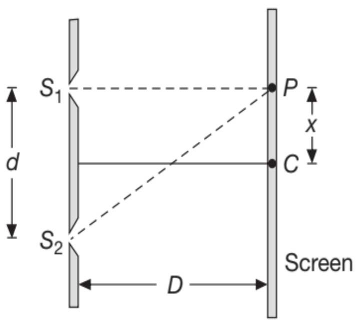
$\Rightarrow \quad t = \frac{\lambda}{3}, \frac{5\lambda}{3}, \frac{7\lambda}{3}, \frac{11\lambda}{3}, \ldots\ldots$

$\Rightarrow \quad t = 0.2\ \mu m,\ 1.0\ \mu m,\ 1.4\ \mu m,\ 2.2\ \mu m, \ldots$

Hence, the correct answer is (D).

113. Suppose P is a point infront of one slit at which intensity is to be calculated from figure it is clear that $x = \frac{d}{2}$. Path difference between the waves reaching at P

$$\Delta = \frac{xd}{D} = \frac{\left(\frac{d}{2}\right)d}{10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$$



Hence corresponding phase difference

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

Resultant intensity at P

$$I = I_{max} \cos^2\frac{\phi}{2} = \phi_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$$

Hence, the correct answer is (A).

114. If i is the polarising angle, $n = \tan i$ (Brewester's law). $n = \tan 67°$ is greater than 2. We also know $\frac{1}{\sin C} = n$. $\sin C = \frac{1}{n}$, where C is the critical angle, $\sin C$ is less than 0.5. Hence C is less than $30°$. The only possible answer is $22°$.

Hence, the correct answer is (A).

115. Only transverse waves can be polarised, while the other properties are common for all wave motion.

Hence, the correct answer is (D).

116. In the arrangement shown, the unpolarised light is incident at polarising angle of $90° - 33° = 57°$. The reflected light is thus plane polarised light. When plane polarised light is passed through Nicol prism (a polariser or analyser), the intensity gradually reduces to zero and finally increases.

Hence, the correct answer is (D).

117. If shift is equivalent to n fringes then

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

$\Rightarrow \quad n \propto t$

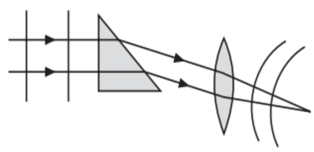
$\Rightarrow \quad \frac{t_2}{t_1} = \frac{n_2}{n_1}$

$\Rightarrow \quad t_2 = \frac{n_2}{n_1} \times t$

$$t_2 = \frac{20}{30} \times 4.8 = 3.2\ \text{mm}$$

Hence, the correct answer is (D).

118.

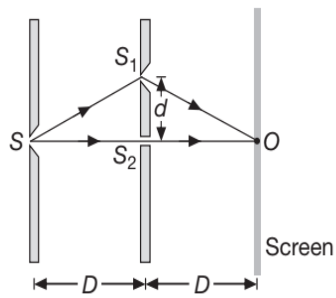


Hence, the correct answer is (B).

119. Path difference between the waves reaching at P,

$$\Delta = \Delta_1 + \Delta_2$$

where Δ_1 = Initial path difference



Δ_2 = Path difference between the waves after emerging from slits.

$$\Delta_1 = SS_1 - SS_2 = \sqrt{D^2+d^2} - D$$

and $\Delta_2 = S_1O - S_2O = \sqrt{D^2+d^2} - D$

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

$$\Rightarrow \quad \Delta = \frac{d^2}{D} \qquad \text{\{From Binomial expansion\}}$$

For obtaining dark at O, Δ must be equals to $(2n-1)\frac{\lambda}{2}$ i.e.,

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

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

For minimum distance $n = 1$ so $d = \sqrt{\frac{\lambda D}{2}}$

Hence, the correct answer is (C).

120. For destructive interference, path difference must be an odd multiple of $\frac{\lambda}{2}$.

Hence, the correct answer is (D).

121. These concentric bright and dark fringes are called Newton's Rings.

Hence, the correct answer is (C).

122. $I = I_0 + I_0 + 2I_0\cos(2\pi)$

$$\Rightarrow \quad I = 4I_0$$

For $x = \frac{\lambda}{4}$, $\phi = \frac{2\pi}{\lambda}x = \frac{\pi}{2}$

$$\Rightarrow \quad I' = I_0 + I_0 + 0$$

$$\Rightarrow \quad I' = 2I_0 = \frac{I}{2}$$

Hence, the correct answer is (B).

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

$$\Rightarrow \quad \beta \propto D$$

$$\Rightarrow \quad \frac{\beta_1}{\beta_2} = \frac{D_1}{D_2}$$

$$\Rightarrow \quad \frac{\beta_1 - \beta_2}{\beta_2} = \frac{D_1 - D_2}{D_2}$$

$$\Rightarrow \quad \frac{\Delta\beta}{\Delta D} = \frac{\beta_2}{D_2} = \frac{\lambda_2}{d_2}$$

$$= \lambda_2 = \frac{3\times10^{-5}}{5\times10^{-2}}\times10^{-3} = 6\times10^{-7}\,\text{m} = 6000\text{ Å}$$

Hence, the correct answer is (A).

124. Since, we have been given that, $\theta = a + \frac{\beta}{\lambda^2}$

$$\Rightarrow \quad 30 = a + \frac{b}{(5000)^2} \text{ and } 50 = a + \frac{b}{(4000)^2}$$

Solving for a, we get $a = \frac{50°}{9}\,(\text{mm})^{-1}$

Hence, the correct answer is (B).

125. $[(n-1)t]\frac{D}{d} = \frac{\lambda(2D)}{d}$

$$\Rightarrow \quad \lambda = \frac{(n-1)t}{2} = 5892\text{ Å}$$

Hence, the correct answer is (C).

127. $x = \frac{\lambda L}{d}$

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

Hence, the correct answer is (A).

128. Interference is a physical effect of superposition of wave motion. This can happen for any kind of wave motion, i.e., light waves, sound waves, matter waves, etc.

Hence, the correct answer is (C).

129. The extra path difference produced by the glass plate of thickness t and refractive index μ is $(\mu-1)t$. Due to this if n is the number of fringes which shift, $(\mu-1)t = n\lambda$. $t = 0.01\times10^{-3}$ m, $\lambda = 6000\times10^{-10}$ m, $\mu = 1.5$. This gives a value for $n = 8$.

Hence, the correct answer is (B).

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

$$\Rightarrow \quad n = \frac{(\mu-1)t}{\lambda} = \frac{\left(\frac{5}{3}-1\right)t}{\lambda} = \frac{2t}{3\lambda}$$

Displacement of fringe system is $\Delta y = n\left(\frac{D\lambda}{2d}\right)$

$$\Rightarrow \quad \Delta y = \left(\frac{2t}{3\lambda}\right)\left(\frac{D\lambda}{2d}\right) = \frac{Dt}{3d}$$

Hence, the correct answer is (A).

133. $I = a_1^2 + a_2^2 + 2a_1a_2\cos\phi$

Put $a_1^2 + a_2^2 = A$ and $a_1a_2 = B$

$$\Rightarrow \quad I = A + B\cos\phi$$

Hence, the correct answer is (D).

134. $\Delta\lambda = \lambda \dfrac{v}{c}$ and $v = r\omega$

$$v = 7\times10^{8}\times\frac{2\pi}{25\times24\times3600},\ c = 3\times10^{8}\ \text{ms}^{-1}$$

$\Rightarrow\ \Delta\lambda = 0.04\ \text{Å}$

Hence, the correct answer is (A).

135. Shift $= \dfrac{\beta}{\lambda}(\mu-1)t$

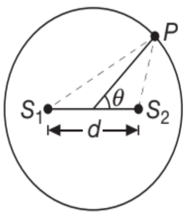
$\Rightarrow\ 7\beta = \dfrac{\beta}{\lambda}(\mu-1)t$

$\Rightarrow\ t = \dfrac{7\lambda}{(\mu-1)} = \dfrac{7\times600}{(1.5-1)} = 8400\ \text{nm}$

Hence, the correct answer is (C).

136. Here path difference at a point P on the circle is given by

$\Delta x = d\cos\theta$ ...(1)



For maxima at P

$\Delta x = n\lambda$ ...(2)

From equation (1) and (2)

$n\lambda = d\cos\theta$

$\Rightarrow\ \theta\cos^{-1}\left(\dfrac{n\lambda}{d}\right) = \cos^{-1}\left(\dfrac{4\lambda}{d}\right)$

Hence, the correct answer is (B).

137. $S_1 = \dfrac{\Delta_1 D}{d} = 11\times10^{-3}$ and $S_2 = \dfrac{\Delta_2 D}{d} = 12\times10^{-3}$

$\Rightarrow\ \dfrac{\Delta_1}{\Delta_2} = \dfrac{11}{12}$

$\Rightarrow\ 12\Delta_1 = 11\Delta_2$

Hence, the correct answer is (B).

138. The film appears bright when the path difference $(2\mu t\cos r)$ is equal to odd multiple of $\dfrac{\lambda}{2}$

i.e., $2\mu t\cos r = \dfrac{(2n-1)\lambda}{2}$ where $n = 1, 2, 3$ .....

$\Rightarrow\ \lambda = \dfrac{4\mu t\cos r}{(2n-1)}$

$\Rightarrow\ \lambda = \dfrac{4\times1.4\times10{,}000\times10^{-10}\times\cos0}{(2n-1)} = \dfrac{56000}{(2n-1)}\ \text{Å}$

$\Rightarrow\ \lambda = 56000\ \text{Å},\ 18666\ \text{Å},\ 8000\ \text{Å},\ 6222\ \text{Å},\ 5091\ \text{Å},\ 4308\ \text{Å},\ 3733\ \text{Å}.$

The wavelength which are not within specified range are to be refracted.

Hence, the correct answer is (A).

139. $\dfrac{\Delta\lambda}{\lambda} = \dfrac{v}{c}$

$\Rightarrow\ \dfrac{(401.8-393.3)}{393.3} = \dfrac{v}{3\times10^{8}}$

$\Rightarrow\ v = 6.48\times10^{6}\ \text{ms}^{-1} = 6480\ \text{kms}^{-1}$

Hence, the correct answer is (A).

140. Intensity of each source is $I_0 = \dfrac{I_{max}}{4} = \dfrac{100}{4} = 25$ unit

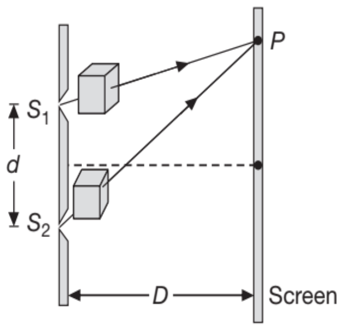
If the intensity of one of the sources is reduced by 36%, then $I_1 = 25$ unit and $I_2 = 25 - 25\times\dfrac{36}{100} = 16(\text{unit})$

Hence resultant intensity at the same point will now be

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2} = 25 + 16 + 2\sqrt{25\times16} = 81\ \text{unit}$$

Hence, the correct answer is (D).

141. Shift $\Delta x = \dfrac{\beta}{\lambda}(\mu-1)t$



Shift due to one plate $\Delta x_1 = \dfrac{\beta}{\lambda}(\mu_1 - 1)$

Shift due to another path $\Delta x_2 = \dfrac{\beta}{\lambda}(\mu_2 - 1)t$

Net shift $\Delta x = \Delta x_2 - \Delta x_1 = \dfrac{\beta}{\lambda}(\mu_2 - \mu_1)t$ ...(1)

Also it is given that $\Delta x = 5\beta$ ...(2)

Hence $5\beta = \dfrac{\beta}{\lambda}(\mu_1 - \mu_2)t$

$\Rightarrow\ t = \dfrac{5\lambda}{(\mu_2-\mu_1)} = \dfrac{5\times4800\times10^{-10}}{(1.7-1.4)} = 8\times10^{-6}\ \text{m} = 8\ \mu\text{m}$

Hence, the correct answer is (A).

143. At the polarising angle, the reflected ray is fully polarised while the transmitted ray is partially polarised. In fact a method to produce plane polarised light is by reflection at the polarising angle.
Hence, the correct answer is (B).

145. $a = \frac{\lambda}{\theta}$

$\Rightarrow \quad a = \frac{6500 \times 10^{-10}}{\left(\frac{\pi}{6}\right)}$

$\Rightarrow \quad a = 1.24 \times 10^{-6}$ m

$\Rightarrow \quad a = 1.24\ \mu$m

Hence, the correct answer is (B).

146. At the central maxima $\Delta x = 0$

$\Rightarrow \quad (2\mu - 1)t - (\mu - 1)(2t) - \frac{yd}{D} = 0$

$\Rightarrow \quad t - \frac{yd}{D} = 0$

$\Rightarrow \quad y = \frac{tD}{d}$

Hence, the correct answer is (B).

148. Using Malus Law, $I = I_0 \cos^2 \theta$
As here polariser is rotating i.e., all the values of θ are possible.

$$I_{av} = \frac{1}{2\pi}\int_0^{2\pi} I\,d\theta = \frac{1}{2\pi} = \int_0^{2\pi} I_0 \cos^2\theta\,d\theta$$

On integration we get $I_{av} = \frac{I_0}{2}$

where $I_0 = \frac{\text{Energy}}{\text{Area} \times \text{Time}} = \frac{p}{A} = \frac{10^{-3}}{3 \times 10^{-4}} = \frac{10}{3}\frac{\text{Watt}}{\text{m}^2}$

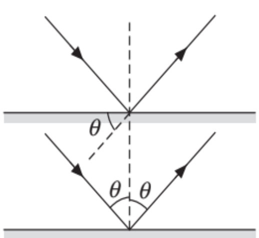
$\Rightarrow \quad I_{av} = \frac{1}{2} \times \frac{10}{3} = \frac{5}{3}$ Watt

and Time period $T = \frac{2\pi}{\omega} = \frac{2 \times 3.14}{31.4} = \frac{1}{5}$ sec

So, energy of light passing through the polariser per revolution $= I_{av} \times \text{Area} \times T = \frac{5}{3} \times 3 \times 10^{-4} \times \frac{1}{5} = 10^{-4}$ J

Hence, the correct answer is (A).

149.



Path difference $= 2d\sin\theta$
For constructive interference

$2d\sin\theta = n\lambda$

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

Hence, the correct answer is (C).

151. During sunset and sunrise we see the unscattered part of the sunlight. Sun's rays have to travel long distance and hence are incident obliquely. All shorter wavelengths are scattered by Rayleigh's law for scattered intensity $I \propto \frac{1}{\lambda^4}$. Only the red-orange rays reach us. During noon the sun's rays are normally incident on the earth. Hence a portion of both the shorter wavelengths and longer wavelengths reach us. The sun looks white.
Hence, the correct answer is (D).

152. $y_3 - y_1 = \frac{3\lambda x}{a} - \frac{\lambda x}{a}$

$\Rightarrow \quad 3 \times 10^{-3} = \frac{2 \times 600 \times 10^{-9} \times 0.5}{a}$

$\Rightarrow \quad a = 0.2$ mm

Hence, the correct answer is (D).

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

So, angular width, 2θ is

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

$\theta = \frac{6328 \times 10^{-10}}{0.2 \times 10^{-3}}$

$\Rightarrow \quad \theta = 3164 \times 10^{-6}$ radian

$\Rightarrow \quad \theta = 3164 \times 10^{-6} \times \frac{180}{\pi}$ degree

$\Rightarrow \quad \theta = 0.18$ degree

$\Rightarrow \quad 2\theta = 0.36$ degree

Hence, the correct answer is (D).

154. For maxima $2\pi n = \frac{2\pi}{\lambda}(XO) - 2\pi\ell$

$\Rightarrow \quad \frac{2\pi}{\lambda}(XO) = 2\pi(n + \ell)$

$\Rightarrow \quad (XO) = \lambda(n + \ell)$

Hence, the correct answer is (A).

CHAPTER 2

155. From the given data, note that the fringe width (β_1) for $\lambda_1 = 900$ nm is greater than fringe width (β_2) for $\lambda_2 = 750$ nm. This means that at though the central maxima of the two coincide, but first maximum for $\lambda_1 = 900$ nm will be further away from the first maxima for $\lambda_2 = 750$ nm and so on. A stage may come when this mismatch equals β_2, then again maxima of $\lambda_1 = 900$ nm, will coincide with a maxima of $\lambda_2 = 750$ nm, let this correspond to n^{th} order fringe for λ_1. Then it will correspond to $(n+1)^{th}$ order fringe for λ_2.

Therefore $\dfrac{n\lambda_1 D}{d} = \dfrac{(n+1)\lambda_2 D}{d}$

$\Rightarrow \quad n \times 900 \times 10^{-9} = (n+1)750 \times 10^{-9}$

$\Rightarrow \quad n = 5$

Minimum distance y from central maxima is

$$y = \frac{n\lambda_1 D}{d} = \frac{5 \times 900 \times 10^{-9} \times 2}{2 \times 10^{-3}}$$

$\Rightarrow \quad y = 45 \times 10^{-4}\,\text{m} = 4.5\,\text{mm}$

Hence, the correct answer is (C).

156. One of the essential condition to observe diffraction is that the dimension of the object should be of the order of wavelength of the wave. The velocity of sound in air as nearly $350\ \text{ms}^{-1}$. Hence the wavelength of sound waves produced by a tuning fork of frequency 384 Hz is $\lambda = \dfrac{V}{f} = 1\ \text{m}$ nearly. Hence the diameter of the sphere should be of the same order.

Hence, the correct answer is (C).

157. Distance between the first dark fringes is

$$\Delta x = \frac{2\lambda D}{d} = 2.4\ \text{mm}$$

Hence, the correct answer is (D).

158. The action of a nicol prism is based on double refraction and dichroism. When a ray of light enters into a calcite crystal, it is split into two rays O and E. Both are plane polarised in mutually perpendicular planes. One of them suffers total reflection and absorption while the other comes out as plane polarised. Selective absorption is called dichroism.

Hence, the correct answer is (D).

159. The line joining sources is parallel to screen. Hence, shape of fringes on screen will be circular.

Hence, the correct answer is (B).

160. Shift, $\Delta x = \left[(\mu - 1)t\right]\dfrac{D}{d}$

Here $\Delta x = 5\beta$

$\Rightarrow \quad 5\left(\dfrac{\lambda D}{d}\right) = \left[(\mu-1)t\right]\dfrac{D}{d}$

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

$\Rightarrow \quad \lambda = (\mu-1)\dfrac{t}{5}$

$\Rightarrow \quad \lambda = \dfrac{(0.5)(6 \times 10^{-6})}{5}$

$\Rightarrow \quad \lambda = 6 \times 10^{-7}$ m

$\Rightarrow \quad \lambda = 6000$ Å

Hence, the correct answer is (B).

161. Only transverse waves can be polarised. (A) and (C) and (D) are electromagnetic radiations, which are transverse waves while (B), that is, β rays are electrons.

Hence, the correct answer is (B).

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

$\Rightarrow \quad \dfrac{6}{1000} = \dfrac{\lambda(1.2)}{\left(\dfrac{0.1}{1000}\right)}$

$\Rightarrow \quad \lambda = 5000$ Å

Hence, the correct answer is (B).

170. Using the equation $\beta = \dfrac{D\lambda}{d}$, $\beta \propto \lambda$. Of the given colours, yellow has the maximum wavelength and hence the maximum fringe width.

Hence, the correct answer is (C).

172. The tubelight has coating of fluorescent material which converts ultraviolet light into visible light. Hence the light is more intense.

Hence, the correct answer is (B).

173. We take one wavelength in the visible region and calculate the energy just to know its order. Let us take 6000 Å (red) for convenience of a rough calculation. Energy $E = \dfrac{hc}{\lambda}$. Taking $h = 6.6 \times 10^{-34}$, $c = 3 \times 10^8$, $\lambda = 6000 \times 10^{-10}$ m we get $\dfrac{hc}{\lambda}$ in joules. Dividing this by 1.6×10^{-19} to convert to eV, we get $E = 2\ eV$. For energy $1\ \text{eV}$, wavelength will be 12000 Å. Energy 5 eV means wavelength $\dfrac{2}{5}$ of 6000, that is 2400 Å. Both these are invisible, recalling that the visible range is 4000 to 7000 Å.

Hence, the correct answer is (B).

174. $\Delta x = (SA + AP) - SP$

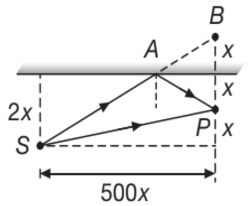
$$\Delta x = (SA + AB) - SP = SB - SP$$

$$\Rightarrow \Delta x = \sqrt{(500x)^2 + (3x)^2} - \sqrt{(500x)^2 + x^2}$$

$$\Rightarrow \Delta x = 500x\left(\sqrt{1+\frac{9}{500^2}} - \sqrt{1+\frac{1}{500^2}}\right)$$

$$\Rightarrow \Delta x = 500x\left(\left(1+\frac{9}{2\times 500^2}\right) - \left(1+\frac{1}{2\times 500^2}\right)\right)$$

$$\Rightarrow \Delta x = \frac{(500)(8)x}{2(500)^2}$$



Since reflection takes place at A i.e. denser medium, so for maxima, we have $\Delta x = (2n+1)\frac{\lambda}{2}$

$$\Rightarrow \Delta x = \frac{500x}{2(500)^2}(8) = \frac{\lambda}{2}$$

$$\Rightarrow x = \frac{500}{8}\lambda = 62.5\lambda$$

Hence, the correct answer is (C).

175. The torch produces light waves which are non-coherent in nature.
Hence, the correct answer is (C).

176. For unpolarised light

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

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

$$\Rightarrow I' = \frac{I}{4}$$

Hence, the correct answer is (D).

178. The path difference of two waves producing destructive interference or darkness is $(2n+1)\left(\frac{\lambda}{2}\right)$ where n is an integer 0, 1, 2, 3, etc. A path difference of λ corresponds to a phase difference of 2π rad and a path difference of $\frac{\lambda}{2}$ corresponds to a phase difference of π. Hence the corresponding phase difference is $(2n+1)\pi$.
Hence, the correct answer is (C).

179. $\beta' = \frac{\beta}{\mu} < \beta$

Hence, the correct answer is (B).

180. $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{9}{4}$

$$\Rightarrow \frac{a_1}{a_2} = \frac{3}{2}$$

Since, $\frac{I_{max}}{I_{min}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2 = \left(\frac{3+2}{3-2}\right)^2$

$$\Rightarrow \frac{I_{max}}{I_{min}} = \frac{25}{1}$$

Hence, the correct answer is (A).

181. Position of first minima is same as the position of third maxima.

$$\frac{1\times\lambda_1 D}{a} = \frac{(2\times3+1)}{2}\frac{\lambda_2 D}{a}$$

$$\Rightarrow \lambda_1 = 3.5\lambda_2$$

Hence, the correct answer is (C).

182. Using the equation $\beta = \frac{D\lambda}{d}$; $\beta \propto \lambda$

Hence, the correct answer is (A).

185. In a biprism, the distance between sources is due to deviation produced by two small angled prisms. The deviation produced by each prism is $(\mu-1)\alpha$. The total deviation is $2(\mu-1)\alpha$. Separation of sources $2(\mu-1)\alpha a$.

Hence, the correct answer is (B).

187. Shift $= \frac{\beta}{\lambda}(\mu-1)t = \frac{\beta}{(5000\times10^{-10})}(1.5)\times2\times10^{-6} = 2\beta$

i.e., 2 fringes upwards.
Hence, the correct answer is (A).

188. Separation n^{th} bright fringe and central maxima is

$$x_n = \frac{n\lambda D}{d}$$

So, $x_3 = \frac{3\times6000\times10^{-10}\times1}{0.5\times10^{-3}} = 3.5$ mm.

Hence, the correct answer is (B).

189. $\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2 = 9$

Hence, the correct answer is (C).

190. For second dark fringe, $n = 1$

Since, $x = (2n+1)\frac{\lambda D}{2d}$

$$\Rightarrow \quad 3 = \frac{3\lambda D}{2d} \qquad \ldots(1)$$

For fourth bright fringe, $n = 4$. Since

$$x = n\left(\frac{\lambda D}{d}\right)$$

$$\Rightarrow \quad x = 4\left(\frac{\lambda D}{d}\right) \qquad \ldots(2)$$

$$\Rightarrow \quad \frac{x}{3} = \frac{4}{(3/2)}$$

$$\Rightarrow \quad x = 8 \text{ mm}$$

Hence, the correct answer is (B).

191. For same field of view

$$n_1\beta_1 = n_2\beta_2$$

$$\Rightarrow \quad n_1\left(\frac{\lambda_1 D}{d}\right) = n_2\left(\frac{\lambda_2 D}{d}\right)$$

$$\Rightarrow \quad n_1\lambda_1 = n_2\lambda_2$$

$$\Rightarrow \quad 60(4000) = n_2(6000)$$

$$\Rightarrow \quad n_2 = 40$$

Hence, the correct answer is (A).

192. $\beta' = \frac{\beta}{\mu} = 1 \text{ mm}$

Hence, the correct answer is (B).

193. $\frac{a_1}{a_2} = \frac{5}{1}$

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

$$\Rightarrow \quad \frac{I_{max}}{I_{min}} = \frac{36}{16} = \frac{9}{4}$$

Hence, the correct answer is (C).

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

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

For contrast to be good $I_1 = I_2$ and hence

$$I_{max} = 4I_1$$

$$I_{min} = 0$$

Hence, the correct answer is (D).

Multiple Correct Choice Type Questions

1. Shift due to the first plate is $x_1 = \frac{\beta}{\lambda}(\mu_1 - 1)t$

Shift due to the first plate is $x_1 = \frac{\beta}{\lambda}(\mu_1 - 1)t$

Net shift is towards the plate with higher μ, so

$$\Delta x = 3\beta = \frac{\beta}{\lambda}(\mu_2 - \mu_1)t$$

$$\Rightarrow \quad t = \frac{3\lambda}{\mu_2 - \mu_1} = \frac{3(4000 \times 10^{-10})}{1.7 - 1.4} = 4\ \mu\text{m}$$

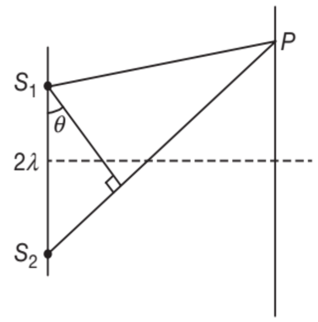
Hence, (A) and (C) are correct.

2. $AC = vt$, $BD = ct$, $\mu = \frac{c}{v} = \frac{ct}{vt} = \frac{BD}{AC}$

$$\mu = \frac{\sin\phi}{\sin\phi'} = \frac{\cos\theta}{\cos\theta'}$$

Hence, (A), (C) and (D) are correct.

3. The phase difference corresponding to $OS_1 - OS_2 = \frac{\lambda}{4}$ is $\frac{\pi}{2}$.



Hence, the net phase difference is given by

$$\phi = \frac{\pi}{2} - \frac{2\pi}{\lambda}(2\lambda\sin\theta)$$

$$\Rightarrow \quad \phi = \frac{\pi}{2} - 4\pi\sin\theta$$

For maxima, we have $\phi = n\pi$, where $n = 0, \pm 1, \pm 2 \ldots$

$$\Rightarrow \quad \frac{\pi}{2} - 4\pi\sin\theta = n\pi$$

$$\Rightarrow \quad \sin\theta = \frac{\frac{1}{2} - n}{4}$$

For, $n = 0$, $\sin\theta = \frac{1}{8}$

$n = \pm 1$, $\sin\theta = -\frac{1}{8}, +\frac{3}{8}$

$n = \pm 2$, $\sin\theta = -\frac{3}{8}, \frac{5}{8}$

$n = \pm 3$, $\sin\theta = -\frac{5}{8}, \frac{7}{8}$

$n = 4$, $\sin\theta = -\frac{7}{8}$

Hence, (A) and (D) are correct.

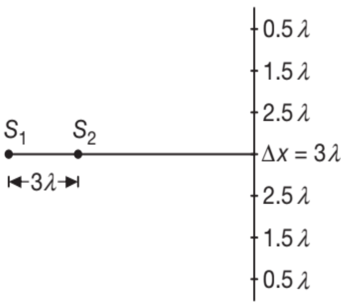
6. Path difference at O is d

if $d = \lambda, 2\lambda, 3\lambda, \ldots$,, then O is a maxima.

if, $d = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \ldots$ then O is a minima

The path difference on screen is > 0

For $d = 3\lambda$, we have



Hence, (A), (B) and (C) are correct.

10. $I_1 = I_2 = I$

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

$$I_{min} = \left(\sqrt{I} - \sqrt{\frac{I}{2}}\right)^2 > 0$$

Hence, (A), (C) and (D) are correct.

11. Path difference $= \sqrt{D^2 + d^2} - D = 1$ cm

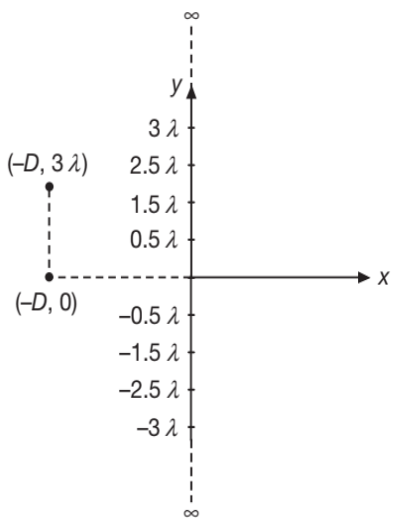
Also, $\left(\sqrt{D^2 + d^2} - D\right) = (2n-1)\frac{\lambda}{2}$

$$\Rightarrow \quad \lambda = \frac{2(1)}{2n-1}$$

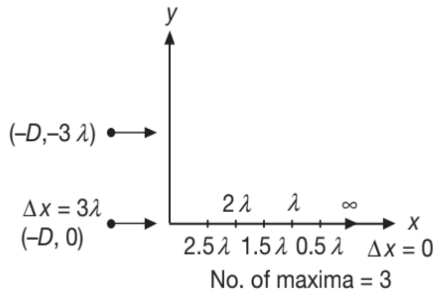
$$\Rightarrow \quad \lambda = 2 \text{ cm}, \frac{2}{3} \text{ cm}, \frac{2}{5} \text{ cm} \ldots\ldots\ldots$$

Hence, (A) and (C) are correct.

12.



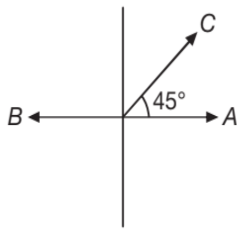
Δx at ∞ on y-axis is 3λ and -3λ there will be 6 minima and 5 maxima



Hence, (A), (B) and (C) are correct.

13. $\sqrt{D^2 + 4d^2} - D = \frac{\lambda}{2}$

gives, $\lambda = \frac{4d^2}{D}$



Resultant intensity at P is due to C only i.e. $I_R = I_0$

Hence, (B) and (D) are correct.

14. Direction of propagation of light is always perpendicular to the wave front, which is best satisfied by $x = c$

Hence, the correct answer is (A).

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

For increasing β, d must be decreased and λ must be increased (i.e. frequency must be decreased).

Hence, (A) and (B) are correct.

Reasoning Based Questions

2. Fringe width $\beta = \frac{\lambda D}{d}$ shall remain the same as the waves travel in air only, after passing through the thin transparent sheet. Due to introduction of thin sheet, only path difference of the wave is changed due to which there is shift of position of fringes only, which is given as $\Delta x = \frac{D(n-1)t}{d}$, where n is refractive index of thin sheet and t is its thickness.

Hence, the correct answer is (D).

3. If both the slits are illuminated by two bulbs of same power, no interference pattern will be observed on the screen. This is because waves reaching at any point on the screen do not have a constant phase difference.

as phase difference from two non coherent sources changes randomly. Therefore, maxima and minima would also change their positions randomly and in quick succession. This will result in general illumination of the screen.
Hence, the correct answer is (D).

5. $\Delta x = d = n\lambda$, for $n = 1$, $d = \lambda$ and here we will have three maxima.
Hence, the correct answer is (D).

9. Statement-1 is false but Statement-2 is true.
Hence, the correct answer is (D).

14. Statement–1 is false, Statement–2 is true.
Hence, the correct answer is (D).

15. Statement-1 is true & Statement-2 is true and Statement-2 is correct explanation of the Statement-1.
Hence, the correct answer is (A).

Linked Comprehension Type Questions

1. It will be shifted upward
Hence, the correct answer is (A).

2. Cannot be predicted without knowing the thickness of thin plate.
Hence, the correct answer is (D).

3. $(\mu_1 - \mu_2)t = \Delta x = 0.3t$
Hence, the correct answer is (B).

4. $(\mu_1 - \mu_2)t = \Delta x = \dfrac{\lambda}{2}$

$$\Rightarrow \quad t = \frac{\lambda}{2(0.3)} = \frac{\lambda}{0.6}$$

Hence, the correct answer is (A).

5. $\dfrac{3}{4}I_0 = I_0 \cos^2\dfrac{\phi}{2} = \dfrac{\sqrt{3}}{2}$

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

$$\Rightarrow \quad \Delta x = \frac{\Delta\phi}{2\pi}\lambda = \frac{\lambda}{6}$$

$$(\mu_1 - \mu_2)t = \frac{\lambda}{6}t = \frac{\lambda}{(6)(0.3)} = \frac{5000\text{ Å}}{1.8} = 2777.7\text{ Å}$$

Hence, the correct answer is (A).

6. Optical Path Difference $(OPD) = 2n_1 t$
Hence, the correct answer is (A).

7. For destructive interference, we have

$$2n_1 t_{\min} = \frac{\lambda}{2} \qquad \{\because n_1 < n_2\}$$

$$\Rightarrow \quad t_{\min} = \frac{550}{4 \times 1.38} = 99.64\text{ nm}$$

Hence, the correct answer is (C).

8. $2n_1 t = \dfrac{3\lambda}{2}$

$$\Rightarrow \quad t = 3t_{\min} \cong 298.9\text{ nm}$$

Hence, the correct answer is (A).

9. Power received at A,

$$P_A = \frac{10}{\pi}\pi(0.001)^2 = 10^{-5}\text{ W}$$

Hence, the correct answer is (A).

10. Power received at B,

$$P_B = \frac{10}{\pi}\pi(0.002)^2 = 4 \times 10^{-5}\text{ W}$$

Hence, the correct answer is (B).

11. Power transmitted through A,

$$P'_A = \frac{10}{100} \times 10^{-5} W = 10^{-6}\ W$$

Hence, the correct answer is (C).

12. Power transmitted through B,

$$P'_B = \frac{10}{100} \times 4 \times 10^{-5}\ W = 4 \times 10^{-6}\ W$$

Hence, the correct answer is (D).

13. Path difference,

$$\Delta = (\mu - 1)t = (1.5 - 1) \times 2000 \times 10^{-10}\text{ m}$$

$$\Delta = 10^{-7}\text{ m}$$

Hence, the correct answer is (C).

14. Phase difference, $\phi = \dfrac{2\pi}{\lambda}\Delta = \dfrac{2\pi \times 10^{-7}}{6000 \times 10^{-10}}$

$$\Rightarrow \quad \phi = \frac{\pi}{3}\text{ radian}$$

Hence, the correct answer is (C).

15. We know that, $P \propto a^2$ or $P = ka^2$, where k is any arbitrary positive constant.

Now, $a_A = \sqrt{\dfrac{10^{-6}}{k}}$, $a_B = \sqrt{\dfrac{4 \times 10^{-6}}{k}}$

Resultant amplitude,

$$a_r = \sqrt{a_A^2 + a_B^2 + 2a_A a_B \cos\phi}$$

Substituting values and simplifying,

$$a_r^2 = \frac{7 \times 10^{-6}}{k}$$

Resultant power, $P_r = ka_r^2 = 7\times10^{-6}$ W $= 7\ \mu$W

Hence, the correct answer is (D).

16. Anywhere on screen because there is no relation between θ, μ.
Hence, the correct answer is (D).

17. Total path difference is given by

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

For central bright fringe to be obtained at O, we have

$$\Delta x = 0$$

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

Hence, the correct answer is (A).

18. $\Delta\phi = (2n-1)\pi$, where $n=5$
Hence, the correct answer is (B).

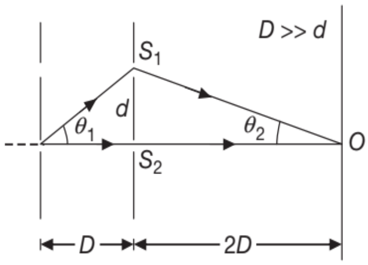
19. Fringe width $\beta = \dfrac{\lambda D}{d} = 4\times10^5$ nm

Hence, the correct answer is (B).

20. Since, $\Delta x = d\sin\theta - (\mu-1)t$, so if θ increases then $d\sin\theta$ will increase and hence Δx increases, so that the central maxima will shift upward.
Hence, the correct answer is (B).

21. Net path difference is given by

$$d\sin\theta_1 + d\sin\theta_2 = \frac{\lambda}{2} \qquad \{\text{for minimum } d\}$$



$$\Rightarrow \quad d\left(\frac{d}{D}\right) + d\left(\frac{d}{2D}\right) = \frac{\lambda}{2} (\sin\theta \approx \tan\theta)$$

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

$$\Rightarrow \quad d = \sqrt{\frac{\lambda D}{3}}$$

Hence, the correct answer is (B).

22. For central maxima, we have

$$d\sin\theta_1 + d\sin\theta_2 = 0$$

$$\Rightarrow \quad \frac{d}{D} + d\frac{y}{2D} = 0$$

$$\Rightarrow \quad y = -2d$$

So, the position of first bright fringe is given by

$$y = -2d + \frac{d}{2} = -\frac{3}{2}d$$

So, the first bright fringe is located $\frac{3}{2}d$ below O

Hence, the correct answer is (C).

23. $d\sin\theta_1 + d\sin\theta_2 = n\lambda$

$$\Rightarrow \quad \frac{d^2}{D} + \frac{nyd}{2D} = n\lambda \qquad \ldots(1)$$

Also, $\dfrac{d^2}{D} + \dfrac{nyd+1}{2D} = (n+1)\lambda \qquad \ldots(2)$

(2) – (1) we get $\dfrac{d}{2D}\beta = \lambda$

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

Hence, the correct answer is (D).

24. In reflected light system, for constructive interference, we have

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

For minimum thickness, we have

$$n = 1$$

$$\Rightarrow \quad 2\mu t = \frac{\lambda}{2}$$

$$\Rightarrow \quad t = \frac{900}{4\times1.5}$$

$$\Rightarrow \quad t = 150 \text{ nm}$$

Hence, the correct answer is (B).

25. In transmitted light system, for destructive interference, we have

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

Again, for minimum thickness, we have

$$n = 1$$

$$\Rightarrow \quad t = \frac{900}{4\times1.5} = 150 \text{ nm}$$

Hence, the correct answer is (A).

26. Path difference between the waves reaching D is

$$\Delta x = \frac{3\pi R}{2} - \frac{\pi R}{2} = \frac{2\pi R}{2} = \pi R$$

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

$$\Rightarrow \quad I_R = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 \text{ when } \phi = 2n\pi,\ n = 0, 1, 2, 3, \ldots$$

Since the wave generated is divided equally in two parts, so we have

$$I_1 = I_2 = \frac{I_0}{2}$$

$$\Rightarrow \quad I_R = \left(\sqrt{\frac{I_0}{2}} + \sqrt{\frac{I_0}{2}}\right)^2$$

$$\Rightarrow \quad I_R = 2I_0$$

Hence, the correct answer is (C).

27. Since $\Delta x = \pi R$

For maxima, we have

$$\Delta\phi = (2n)\pi \text{, where } n = 0, 1, 2, 3, \ldots.$$

$$\Rightarrow \quad \left(\frac{2\pi}{\lambda}\right)(\pi R) = (2n)\pi$$

$$\Rightarrow \quad \lambda_{\text{max}} = \frac{\pi R}{n_{\text{min}}} = \frac{\pi R}{1}$$

$$\Rightarrow \quad \lambda_{\text{max}} = \pi R$$

Hence, the correct answer is (A).

28. Similarly, for minima, we have

$$\Delta\phi = (2n+1)\pi \text{, where } n = 0, 1, 2, 3, \ldots.$$

$$\Rightarrow \quad \left(\frac{2\pi}{\lambda}\right)(\pi R) = (2n+1)\pi$$

$$\Rightarrow \quad \lambda_{\text{max}} = \frac{2\pi R}{2n+1}$$

$$\Rightarrow \quad \lambda_{\text{max}} = 2\pi R$$

Hence, the correct answer is (B).

29. Since, $d_{air} = 2a(\mu - 1)\alpha$

and $d_{\text{water}} = 2a\left(\frac{\mu}{\mu_w} - 1\right)\alpha$

$$\Rightarrow \quad \frac{d_{\text{water}}}{d_{\text{air}}} = \frac{\frac{\mu}{\mu_w} - 1}{\mu_w - 1}$$

$$\Rightarrow \quad \frac{d_{\text{water}}}{0.5} = \frac{\frac{3/2}{4/3} - 1}{\frac{3}{2} - 1} = \frac{1}{4}$$

$$\Rightarrow \quad d_{\text{water}} = \frac{1}{4} \times 0.5 = \frac{1}{8} \text{ mm}$$

Hence, the correct answer is (D).

30. Since, $\beta_{\text{air}} = \dfrac{D\lambda_{\text{air}}}{2a(\mu - 1)\alpha}$

and $\beta_{\text{water}} = \dfrac{D\lambda_{\text{air}}}{2a(\mu - \mu_w)\alpha}$

$$\Rightarrow \quad \frac{\beta_{\text{water}}}{\beta_{\text{air}}} = \frac{\mu - 1}{\mu - \mu_w} = \frac{\frac{3}{2} - 1}{\frac{3}{2} - \frac{4}{3}}$$

$$\Rightarrow \quad \beta_{\text{water}} = 3 \times 1 = 3 \text{ mm}$$

Hence, the correct answer is (C).

31. Since, $\beta = \dfrac{\lambda D}{d}$

$$\Rightarrow \quad 1 \times 10^{-3} = \frac{1 \times \lambda}{0.5 \times 10^{-3}}$$

$$\Rightarrow \quad \lambda = 5 \times 10^{-7} \text{ m} = 5000 \text{ Å}$$

Hence, the correct answer is (C).

32. At O, optical path difference is

$$\Delta x = (\mu_g - 1)t - \mu_w d \sin\theta$$

$$\Rightarrow \quad \Delta x = 0.5 \times 0.41 \times 10^{-3} - \frac{4}{3} \times 3 \times 10^{-4} \times \frac{1}{2}$$

$$\Rightarrow \quad \Delta x = 5 \times 10^{-6} \text{ m}$$

Since, $\lambda = 5000$ Å, so we observe that

$$\Delta x = 10\lambda$$

So, 10^{th} bright fringe, will be formed at 0.

Hence, the correct answer is (D).

33. For central maxima, we have

$$\Delta x = 0$$

where, $\Delta x = \dfrac{yd}{D} + (\mu_g - 1)t - \mu_w d \sin\theta$

$$\Rightarrow \quad \frac{yd}{D} + (\mu_g - 1)t - \mu_w d \sin\theta = 0$$

Substituting values, we get

$$\frac{yd}{D} = -10\lambda$$

$$\Rightarrow \quad y = -10\left(\frac{\lambda D}{d}\right) = -\frac{5}{3} \times 10^{-2} \text{ m}$$

Hence, the correct answer is (D).

34. At P, we have

$$\Delta x = \frac{yd}{D} + (\mu_g - 1)t - \mu_w d \sin\theta$$

$$\Rightarrow \quad \Delta x = \frac{10^{-2} \times 3 \times 10^{-4}}{8 \times 1} + 10\lambda = 10\lambda + \frac{3\lambda}{4}$$

$$\Delta\phi = \frac{2\pi}{\lambda}\left(10\lambda + \frac{3\lambda}{4}\right) = 20\pi + \frac{3\pi}{2}$$

So, $I_P = \sqrt{I^2 + I^2 + 2I^2 \cos\left(20\pi + \dfrac{3\pi}{2}\right)}$

Since $\cos\left(20\pi+\frac{3\pi}{2}\right)=\cos\left(\frac{3\pi}{2}\right)=0$

$\Rightarrow \quad I_P=\sqrt{2}I$

Further $I_{\max}=\frac{I}{2}+\frac{I}{2}+2\sqrt{\left(\frac{I}{2}\right)\left(\frac{I}{2}\right)}\cos(0°)$

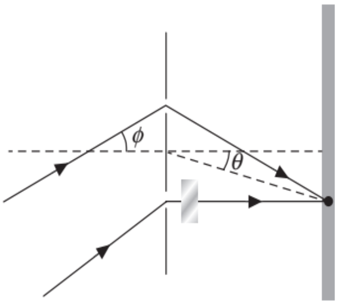
$\Rightarrow \quad I_{\max}=I+I=2I$

$\Rightarrow \quad \frac{I_P}{I_{\max}}=\frac{\sqrt{2}I}{2I}=\frac{1}{\sqrt{2}}$

Hence, the correct answer is (C).

35. Path difference is given by

$$\Delta x=d\sin\phi+d\sin\theta-(\mu-1)t$$



For central maxima, $\Delta x=0$

$\Rightarrow \quad \sin\theta=\frac{(\mu-1)t}{d}-\sin\phi$

$\Rightarrow \quad \sin\theta=\frac{\left(\frac{3}{2}-1\right)(0.1)}{50\times10^{-3}}-\sin(30°)=\frac{1}{2}$

$\Rightarrow \quad \theta=30°$

Hence, the correct answer is (C).

36. At C, $\theta=0°$, so we get

$$\Delta x=d\sin\phi-(\mu-1)t$$

$\Rightarrow \quad \Delta x=\left(50\times10^{-3}\right)\left(\frac{1}{2}\right)-\left(\frac{3}{2}-1\right)(0.1)$

$\Rightarrow \quad \Delta x=0.025-0.05=-0.025$ mm

Substituting, $\Delta x=n\lambda$, we get

$$n=\frac{\Delta x}{\lambda}=\frac{-0.025}{500\times10^{-6}}=-50$$

Hence, at C there will be maxima. Therefore, the order of minima closest to the C are -49.

Hence, the correct answer is (B).

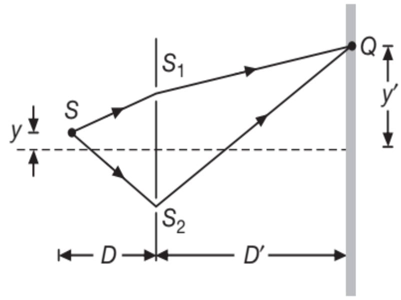
37. Number of fringes shifted upwards is

$$N=\frac{(\mu-1)t}{\lambda}=\frac{\left(\frac{3}{2}-1\right)(0.1)}{500\times10^{-6}}=100$$

Hence, the correct answer is (A).

38. Net path difference of the waves reacting at Q, is

$$\Delta x=\frac{yd}{D}+\frac{y'd}{D'}$$



For central maximum, $\Delta x=0$

$\Rightarrow \quad y'=-\frac{D'}{D}y'$

$\Rightarrow \quad y'=-\left(\frac{2}{1}\right)(0.5\sin(\pi t))$

$\Rightarrow \quad y'=-\sin(\pi t)$ mm

$\Rightarrow \quad y'=\sin(\pi+\pi t)=-\sin(\pi t)$

Hence, the correct answer is (D).

39. $y'=\frac{d}{2}$, at point P exactly in front of S_1, so we have

$$\Delta x=\left(\frac{yd}{D}\right)+\frac{\left(\frac{d^2}{2}\right)}{D'}$$

For maximum intensity, we have path difference to be an even multiple of $\frac{\lambda}{2}$, so

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

Substituting the values, we get

$$0.5\sin(\pi t)+0.25=0.5n$$

$\Rightarrow \quad \sin(\pi t)=\frac{0.5n-0.25}{0.5}$

For minimum value of t, we have $n=1$

$\Rightarrow \quad \sin(\pi t)=0.5$

$\Rightarrow \quad \pi t=\frac{\pi}{6}$

$\Rightarrow \quad t=\frac{1}{6}$

Hence, the correct answer is (C).

40. For minimum intensity, path difference is an odd multiple of $\frac{\lambda}{2}$, so

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

$\Rightarrow \quad 0.5\sin(\pi t)+0.25=\dfrac{0.5}{2} \qquad \{\because n=1\}$

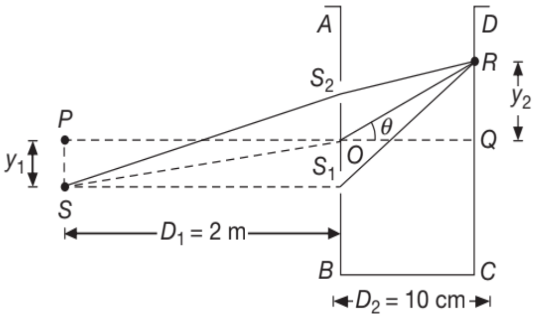
$\Rightarrow \quad \sin(\pi t)=0$

$\Rightarrow \quad \pi t=\pi$

$\Rightarrow \quad t=1\text{ s}$

Hence, the correct answer is (A).

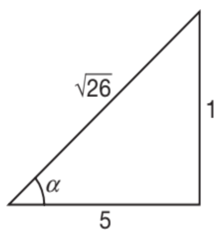
41. Given $y_1=40\text{ cm},\ D_1=2\text{ m}=200\text{ cm},\ D_2=10\text{ cm}$



$$\tan\alpha=\frac{y_1}{D_1}=\frac{40}{200}=\frac{1}{5}$$

$\Rightarrow \quad \alpha=\tan^{-1}\left(\dfrac{1}{5}\right)$

$\Rightarrow \quad \sin\alpha=\dfrac{1}{\sqrt{26}}\approx\dfrac{1}{5}=\tan\alpha$



Path difference between SS_1 and SS_2 is

$$\Delta x_1=SS_1-SS_2$$

$\Rightarrow \quad \Delta x_1=d\sin\alpha=(0.8\text{ mm})\left(\dfrac{1}{5}\right)$

$\Rightarrow \quad \Delta x_1=0.16\text{ mm} \qquad \ldots(1)$

Now, let at point R on the screen, central bright fringe is observed (i.e., net path difference $=0$).

Path difference between S_2R and S_1R is

$$\Delta x_2=S_2R-S_1R$$

$\Rightarrow \quad \Delta x_2=d\sin\theta \qquad \ldots(2)$

Central bright fringe will be observed when net path difference is zero.

$\Rightarrow \quad \Delta x_2-\Delta x_1=0$

$\Rightarrow \quad \Delta x_2=\Delta x_1$

$\Rightarrow \quad d\sin\theta=0.16$

$\Rightarrow \quad (0.8)\sin\theta=0.16$

$\Rightarrow \quad \sin\theta=\dfrac{0.16}{0.8}=\dfrac{1}{5}$

$\Rightarrow \quad \tan\theta=\dfrac{1}{\sqrt{24}}$

$\Rightarrow \quad \sin\theta\approx\dfrac{1}{5}$

$\Rightarrow \quad \tan\theta\approx\sin\theta=\dfrac{y_2}{D_2}=\dfrac{1}{5}$

$\Rightarrow \quad y_2=\dfrac{D_2}{5}=\dfrac{10}{5}=2\text{ cm}$

Therefore, central bright fringe is observed at 2 cm above point Q on side CD.

Hence, the correct answer is (B).

Alternate solution for (a)

Δx at R will be zero if $\Delta x_1=\Delta x_2$

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

$\Rightarrow \quad \alpha=\theta$

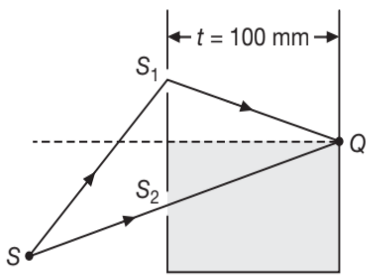
$\Rightarrow \quad \tan\alpha=\tan\theta$

$\Rightarrow \quad \dfrac{y_1}{D_1}=\dfrac{y_2}{D_2}$

$\Rightarrow \quad y_2=\dfrac{D_2}{D_1}\cdot y_1=\left(\dfrac{10}{200}\right)(40)\text{ cm}$

$\Rightarrow \quad y_2=2\text{ cm}$

42. The central bright fringe will be observed at point Q, if the path difference created by the liquid slab of thickness $t=10\text{ cm}$ or 100 mm is equal to Δx_1, so that the net path difference at Q becomes zero.



$\Rightarrow \quad (\mu-1)t=\Delta x_1$

$\Rightarrow \quad (\mu-1)(100)=0.16$

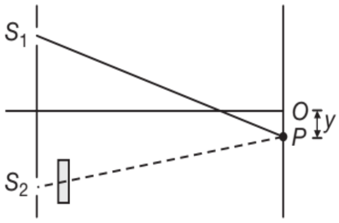
$\Rightarrow \quad \mu-1=0.0016$

$\Rightarrow \quad \mu=1.0016$

Hence, the correct answer is (C).

43. Given $\lambda=600\text{ nm}=6\times10^{-7}\text{ m}$,

$$d=0.45\text{ mm}=0.45\times10^{-3}\text{ m and } D=1.5\text{ m}$$



Thickness of glass sheet, $t = 10.4\ \mu\text{m} = 10.4 \times 10^{-6}$ m

Refractive index of the medium, $\mu_m = \frac{4}{3}$

And refractive index of glass sheet, $\mu_g = 1.5$

Let central maximum is obtained at a distance y below point O.

$\Rightarrow \quad \Delta x_1 = S_1P - S_2P = \frac{yd}{D}$

Path difference due to glass sheet is given by

$$\Delta x_2 = \left(\frac{\mu_g}{\mu_m} - 1\right)t$$

Net path difference will be zero, when we have

$$\Delta x_1 = \Delta x_2$$

$$\Rightarrow \quad \frac{yd}{D} = \left(\frac{\mu_g}{\mu_m} - 1\right)t$$

$$\Rightarrow \quad y = \left(\frac{\mu_g}{\mu_m} - 1\right)t\frac{D}{d}$$

Substituting the values, we get

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

$$\Rightarrow \quad y = 4.33 \times 10^{-3}\,\text{m}$$

$$\Rightarrow \quad y = 4.33\ \text{mm} = \frac{13}{3}\ \text{mm}$$

Hence, the correct answer is (D).

44. At O, $\Delta x_1 = 0$ and $\Delta x_2 = \left(\frac{\mu_g}{\mu_m} - 1\right)t$

So, net path difference

$$\Delta x = \Delta x_2$$

Corresponding phase difference $\Delta\phi = \left(\frac{2\pi}{\lambda}\right)\Delta x$

Substituting the values, we get

$$\phi = \Delta\phi = \frac{2\pi}{6 \times 10^{-7}}\left(\frac{1.5}{4/3} - 1\right)(10.4 \times 10^{-6})$$

$$\Rightarrow \quad \phi = \left(\frac{13}{3}\right)\pi$$

Now, $I(\phi) = I_{\max}\cos^2\left(\frac{\phi}{2}\right)$

$$\Rightarrow \quad I = I_{\max}\cos^2\left(\frac{13\pi}{6}\right)$$

$$\Rightarrow \quad I = \frac{3}{4}I_{\max}$$

Hence, the correct answer is (C).

45. At O, path difference is $\Delta x = \Delta x_2 = \left(\frac{\mu_g}{\mu_m} - 1\right)t$

For maximum intensity at O, we have

$$\Delta x = n\lambda, \text{ where } n = 1, 2, 3, \ldots\ldots$$

$$\Rightarrow \quad \lambda = \frac{\Delta x}{1}, \frac{\Delta x}{2}, \frac{\Delta x}{3}, \ldots\ldots \text{ and so on}$$

$$\Rightarrow \quad \Delta x = \left(\frac{1.5}{4/3} - 1\right)(10.4 \times 10^{-6}\,\text{m})$$

$$\Rightarrow \quad \Delta x = \left(\frac{1.5}{4/3} - 1\right)(10.4 \times 10^{3}\ \text{nm}) = 1300\ \text{nm}$$

So, maximum intensity will be corresponding to

$$\lambda = 1300\ \text{nm}, \frac{1300}{2}\ \text{nm}, \frac{1300}{3}\ \text{nm}, \frac{1300}{4}\ \text{nm}, \ldots$$

$$\Rightarrow \quad \lambda = 1300\ \text{nm}, 650\ \text{nm}, 433.33\ \text{nm}, 325\ \text{nm}, \ldots.$$

The wavelength in the range 400 nm to 700 nm are 650 nm and 433.33 nm$\left(= \frac{1300}{3}\ \text{nm}\right)$

Hence, the correct answer is (C).

46. The optical path difference between the two waves arriving at P is

$$\Delta x = \frac{y_1 d}{D_1} + \frac{y_2 d}{D_2} = \frac{(1)(10)}{10^3} + \frac{(5)(10)}{2 \times 10^3}$$

$$\Rightarrow \quad \Delta x = 3.5 \times 10^{-2}\ \text{mm} = 0.035\ \text{mm}$$

To calculate the order of interference, we shall calculate

$$n = \frac{\Delta x}{\lambda}$$

$$\Rightarrow \quad n = \frac{0.035 \times 10^{-3}\ \text{m}}{5000 \times 10^{-10}\ \text{m}}$$

$$\Rightarrow \quad n = 70$$

$$\Rightarrow \quad \Delta x = 70\lambda$$

So, 70^{th} order maxima is obtained at P.

Hence, the correct answer is (C).

47. At O, $\Delta x = \frac{y_1 d}{D_1} = 10^{-2}\ \text{mm} = 0.01\ \text{mm}$

Now, we observe that $\Delta x = 20\lambda$

So, 20^{th} order maxima is obtained at O.

Hence, the correct answer is (D).

48. $(\mu - 1)t = 0.01$ mm

$\Rightarrow \quad t = \dfrac{0.01}{1.5-1} = 0.02 \text{ mm} = 20\ \mu\text{m}$

Since the pattern has to be shifted upwards, therefore, the film must be placed infront of S_1.

Hence, the correct answer is (D).

49. Using the concept of Displacement Method, we get

$$O = \sqrt{I_1 I_2} = 3 \text{ mm}$$

Since, $m = \dfrac{f}{f+u}$

$\Rightarrow \quad \dfrac{100-x}{x} = 4$

$\Rightarrow \quad x = 20$ cm

So, we get $u = -20$, $v = +80$

Since $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$

$\Rightarrow \quad f = 16$ cm

50. $\beta = \dfrac{\lambda D}{d} = \dfrac{6000 \times 10^{-10} \times 1}{3 \times 10^{-3}} = 0.2$ mm

Hence, the correct answer is (B).

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

When D is increased, then β is increased.

Hence, the correct answer is (D).

52. At point P on the screen, y is the same. But $D' > D$.

Since, we know that $y = n\left(\dfrac{\lambda D}{d}\right) = n'\left(\dfrac{\lambda D'}{d}\right)$

$\Rightarrow \quad nD = n'D'$

Since, $D' > D$, so $n' < n$

Similarly, even if we would have been getting a minima at P, then too the order of the fringe will decrease at P.

Hence, the correct answer is (B).

53. At $t = 0$, at the point P, a fifth bright is formed. So, we get

$$y_P = y_{5B} = 5\left(\frac{\lambda D}{d}\right) \qquad \ldots(1)$$

At the point P, at time t, third minima is formed, so we have

$$y_P = y_{3B} = \left(3 - \frac{1}{2}\right)\frac{\lambda D'}{d}$$

$$\Rightarrow \quad y_P = y_{3B} = \frac{5}{2}\frac{\lambda(D+Vt)}{d} \qquad \ldots(2)$$

Equating (1) and (2), we get

$$D = Vt$$

$\Rightarrow \quad t = \dfrac{D}{V}$

Hence, the correct answer is (B).

54. Order of the fringe can be counted on either side of the central maximum, so third order bright is fringe number 5.

Hence, the correct answer is (D).

55. $\Delta\phi = 4\pi$

$\Rightarrow \quad \Delta\phi = 2(2\pi)$

So, this phase difference corresponds to second maxima, represented by fringe number 4.

Hence, the correct answer is (C).

56. $\Delta x_3 = \lambda$, $\Delta x_1 = \dfrac{\lambda}{2}$

$\Rightarrow \quad \Delta x_3 - \Delta x_1 = \dfrac{\lambda}{2} = 300$ nm

Hence, the correct answer is (B).

57. For reflected light, constructive interference takes place when

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

For minimum thickness, we have

$$n = 1$$

$\Rightarrow \quad 2\mu t = \dfrac{\lambda}{2}$

$\Rightarrow \quad t = \dfrac{900}{4 \times 1.5}$

$\Rightarrow \quad t = 150$ nm

Hence, the correct answer is (B).

58. For transmitted light, destructive interference takes place, when

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

For minimum thickness $n = 1$

$\Rightarrow \quad t = \dfrac{900}{4 \times 1.5} = 150$ nm

Hence, the correct answer is (A).

59. $d_{\text{air}} = 2a(\mu_p - 1)\alpha$,

where μ_p = Refractive Index of prism

$$d_{\text{water}} = 2a\left(\frac{\mu_p}{\mu_\ell} - 1\right)\alpha,$$

where μ_ℓ = Refractive Index of water/liquid.

$$\Rightarrow \frac{d_{\text{water}}}{d_{\text{air}}} = \frac{\frac{\mu_p}{\mu_\ell} - 1}{\mu_p - 1}$$

$$\Rightarrow \frac{d_{\text{water}}}{0.5} = \frac{\frac{3/2}{4/3} - 1}{\frac{3}{2} - 1} = \frac{1}{4}$$

$$\Rightarrow d_{\text{water}} = \frac{1}{4} \times 0.5 = \frac{1}{8} \text{ mm}$$

Hence, the correct answer is (D).

60. $\beta_{\text{air}} = \frac{D\lambda_{\text{air}}}{2a(\mu_p - 1)\alpha}$

$$\Rightarrow \beta_{\text{water}} = \frac{D\lambda_{\text{air}}}{2a(\mu_p - \mu_\ell)\alpha}$$

$$\Rightarrow \frac{\beta_{\text{water}}}{\beta_{\text{air}}} = \frac{\mu_p - 1}{\mu_p - \mu_\ell} = \frac{3/2 - 1}{3/2 - 4/3}$$

$$\Rightarrow \beta_{\text{water}} = 3 \times 1 = 3 \text{ mm}$$

Hence, the correct answer is (A).

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

$$\Rightarrow 1 \times 10^{-3} = \frac{1 \times \lambda}{0.5 \times 10^{-3}}$$

$$\Rightarrow \lambda = 5 \times 10^{-7} \text{ m} = 5000 \text{ Å}$$

Hence, the correct answer is (A).

62. $\Delta y = \frac{7\lambda' D}{d} - \frac{3\lambda' D}{d}$, where $\lambda' = \frac{\lambda}{\mu}$

Hence, the correct answer is (A).

63. Since, $\Delta y = \frac{D}{d}\left(\frac{\mu_g}{\mu_w} - 1\right)t$

Minimum separation between, maxima and minima, say n^{th} maxima and n^{th} minima is

$$\Delta y = \frac{n\lambda' D}{d} - \left(n - \frac{1}{2}\right)\frac{\lambda' D}{d} = \frac{\lambda' D}{2d}$$

where $\lambda' = \frac{\lambda}{\mu_w}$

$$\Rightarrow \frac{\lambda' D}{2d} = \frac{D}{d}\left(\frac{\mu_g}{\mu_w} - 1\right)t$$

$$\Rightarrow \left(\frac{\mu_g}{\mu_w} - 1\right)t = \frac{\lambda}{2\mu_w}$$

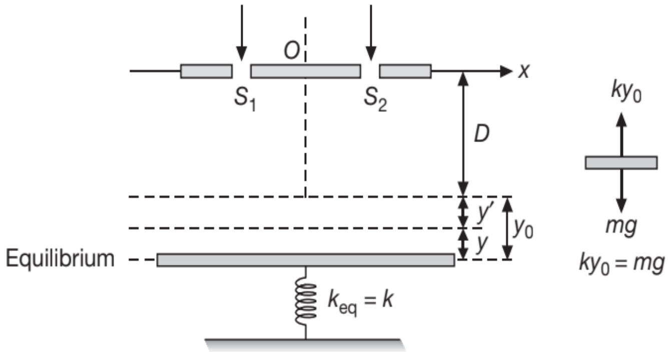
$$\Rightarrow \left(\frac{1.53}{1.33} - 1\right)t = \frac{6300 \times 10^{-10}}{2(1.33)}$$

$$\Rightarrow t = 15750 \times 10^{-10} \text{ m}$$

$$\Rightarrow t = 1.575 \times 10^{-6} \text{ m} = 1.575\ \mu\text{m}$$

Hence, the correct answer is (B).

64. Let us first replace two springs each of spring constant $\frac{k}{2}$ by a single spring of spring constant $k_{eq} = \frac{k}{2} + \frac{k}{2} = k$.



For equilibrium of plate, we have

$$mg = ky_0$$

$$\Rightarrow y_0 = \frac{mg}{k}$$

The equation governing motion of plates is

$$y = y_0 \cos(\omega t)$$

Let y' be instantaneous position of plate from O, then

$$y' = y_0 - y$$

$$\Rightarrow y' = y_0 - y_0 \cos(\omega t)$$

$$\Rightarrow y' = y_0(1 - \cos(\omega t))$$

Instantaneous fringe width is given by

$$\beta = \frac{(D + y')\lambda}{d}$$

Rate of change of fringe width is

$$\frac{d\beta}{dt} = \left(\frac{\lambda}{d}\right)\frac{dy'}{dt} = \frac{\lambda}{d}\left[y_0 \omega \sin(\omega t)\right]$$

$$\Rightarrow \frac{d\beta}{dt} = \left(\frac{\lambda}{d}\right)\left(\frac{mg}{k}\right)\sqrt{\frac{k}{m}}\sin(\omega t)$$

Now, acceleration of plates is zero at equilibrium i.e. at $t = 0$ i.e. when $\cos(\omega t) = 1$ i.e. when $\sin(\omega t) = 1$

So, rate at which fringe width will increase is

$$\frac{d\beta}{dt} = \frac{\lambda g}{d}\sqrt{\frac{m}{k}}$$

Hence, the correct answer is (A).

65. Plate is momentarily at rest, at the extreme positions i.e. when

$$y' = 0$$

$\Rightarrow \quad \cos(\omega t) = 1$

So, fringe width is $\beta_1 = \dfrac{\lambda D}{d}$

Also, plate is momentary at rest when

$y' = 2y_0$

$\Rightarrow \quad \cos(\omega t) = -1$

So, fringe width is $\beta_2 = (D + 2y_0)\dfrac{\lambda}{d}$

$$\Rightarrow \quad \Delta\beta = \beta_2 - \beta_1 = \frac{\lambda(D + 2y_0)}{d} - \frac{\lambda D}{d}$$

$$\Rightarrow \quad \Delta\beta = \frac{2y_0\lambda}{d} = \frac{2\lambda}{d}\left(\frac{mg}{k}\right) = \frac{2\lambda mg}{kd}$$

Hence, the correct answer is (C).

66. Displacement of n^{th} bright fringe is given by

$$\Delta x = \frac{D}{d}(\mu - 1)t$$

Since first maxima shift to the position of central maxima, so

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

$$\Rightarrow \quad \frac{\lambda D}{d} = \frac{D}{d}(\mu - 1)t \quad \Rightarrow \quad t = \frac{\lambda}{\mu - 1}$$

Hence, the correct answer is (D).

Matrix Match/Column Match Type Questions

1. A → (p, s)
B → (q, r)
C → (p, q, r)
D → (q, r, s)
Concept based (see theory)

2. A → (p, q)
B → (s)
C → (p, q)
D → (r)
Concept based (see theory)

3. A → (q)
B → (p)
C → (s)
D → (r)
Concept based (see theory)

4. A → (r)
B → (s)
C → (q)
D → (p)
Concept based (see theory)

5. A → (p)
B → (s)
C → (r)
D → (q, r)
Concept based (see theory)

6. A → (r)
B → (t)
C → (r)
D → (p)
If glass slab is introduced across S_2 this effective path increases so central maxima will be shifted downward but fringe width remains same.

7. A → (p)
B → (s)
C → (r)
D → (q)
Concept based (see theory)

8. A → (p, q, r, s)
B → (p, q, r, s)
C → (p, q, r, s)
D → (p, q, r)
Concept based (see theory)

9. A → (q, r)
B → (q, s)
C → (p, s)
D → (p, q, r, s)
Concept based (see theory)

Integer/Numerical Answer Type Questions

1. Shift $\Delta y = \left|(\mu_2 - 1)t_2 - (\mu_1 - 1)t_1\right|\dfrac{D}{d}$

$$\Rightarrow \quad \Delta y = \left|(1.2 - 1)\times 15\times 10^{-6} - (1.6 - 1)\times 10\times 10^{-6}\right|\left(\frac{1.5}{1.5\times 10^{-3}}\right)$$

$$\Rightarrow \quad \Delta y = 3\times 10^{-3}\ \text{m}$$

$$\Rightarrow \quad \Delta y = 3\ \text{mm}$$

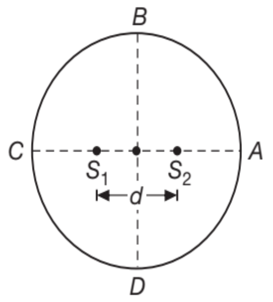
2. Since, $\lambda = 0.25$ m and $d = 2$ m $= 8\lambda$

At A and C, $\Delta x = d = 8\lambda$

Since this is an even multiple of λ, so maximum intensity is obtained.

At B and D, $\Delta x = 0$

Since this is an even multiple of λ, so again maximum intensity will be obtained.



Further, between A and B seven maximas corresponding to $\Delta x = 7\lambda$, 6λ, 5λ, 4λ, 3λ, 2λ and λ are obtained.

Similarly between B and C, C and D, and D and A.

So, total number of maximas is $N = 4\times 7 + 4 = 32$

3. Ray 1 has a longer path than that of ray 2 by a distance $d\sin(45°)$, before reaching the slits. Afterwards ray 2 has a path longer than ray 1 by a distance $d\sin\theta$. The net path difference is therefore, $d\sin\theta - d\sin 45°$

(a) Central maximum is obtained where, net path difference is zero, so we have

$$d\sin\theta - d\sin(45°) = 0$$

$$\Rightarrow \theta = 45°$$

(b) Third order maxima is obtained where net path difference is 3λ, so we have

$$d\sin\theta - d\sin(45°) = 3\lambda$$

$$\Rightarrow \sin\theta = \sin(45°) + \frac{3\lambda}{d}$$

Substituting $d = 20\lambda$, we get

$$\sin\theta = \sin(45°) + \frac{3\lambda}{20\lambda}$$

$$\Rightarrow \theta \approx 59°$$

4. (a) $\frac{1}{10} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R} + \frac{1}{R}\right)$

$$\Rightarrow R = 10 \text{ cm}$$

Now applying $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ twice, we get

$$\frac{3/2}{v_1} - \frac{1}{-20} = \frac{3/2 - 1}{10} \text{ and} \quad \ldots(1)$$

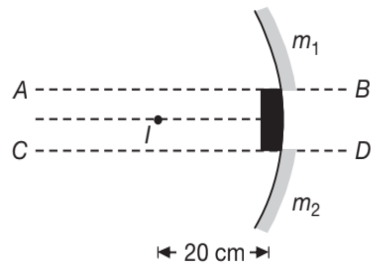
$$\frac{4/3}{v_2} - \frac{3/2}{v_1} = \frac{4/3 - 3/2}{-10} \quad \ldots(2)$$

Adding equation (1) and (2), we get

$$v_2 = 80 \text{ cm}$$

(b) The image formed by (lens + water) system will act as an object for the mirror.

This is below the axis of m_1 and at the same distance as the centre is, therefore, its image will be formed vertically above at 1 mm from AB. Similarly m_2 will form an image of I_1, 1 mm below CD.



$$\Rightarrow I_1I_2 = 1 + 1 + 1 + 1 = 4 \text{ mm}$$

(c) $d = I_1I_2 = 4$ mm, $D = 80$ cm

Since, $\lambda = \frac{v}{f}$

$$\Rightarrow \lambda = \frac{c}{\mu_w f} = \left(\frac{3\times 10^8}{7.5\times 10^{14}} \times \frac{3}{4}\right)$$

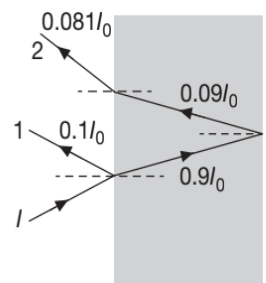
$$\Rightarrow \beta = \frac{\lambda D}{d} = \frac{3}{4}\left(\frac{3\times 10^8}{7.5\times 10^{14}}\right)\left(\frac{80\times 10^{-2}}{4\times 10^{-3}}\right) \text{ m}$$

$$\Rightarrow \beta = 6\times 10^{-5} \text{ m}$$

$$\Rightarrow \beta = 60\ \mu\text{m}$$

5. The intensities of the rays due to successive reflections and refractions are shown in figure. So,

$$I_1 = 0.1I_0,\ I_2 = 0.081I_0$$



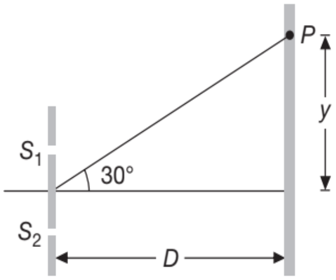
$$\Rightarrow \sqrt{\frac{I_1}{I_2}} = \frac{10}{9}$$

$$\Rightarrow \frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\sqrt{\frac{I_1}{I_2}} - 1}\right)^2 = (19)^2 = 361$$

6. Fringe width $\beta = \dfrac{\lambda D}{d}$ and $y = \dfrac{D}{\sqrt{3}}$

Therefore, number of fringe widths in a distance y are given by

$$n = \frac{y}{\beta} = \frac{d}{\sqrt{3}\lambda} = \frac{0.32\times10^{-3}}{(\sqrt{3})(500\times10^{-9})} = 369.5$$



Therefore, total number of maxima obtained in the angular range $-30° < \theta < 30°$ (including the central one) is

$$N = 2\times369+1 = 739$$

7. Here, $d = 2\text{ mm} = 2\times10^{-3}\text{ m}$, $D = 10\text{ cm} = 0.10\text{ m}$, $t = 0.5\text{ mm} = 0.5\times10^{-3}\text{ m}$, $\Delta x = 5\text{ mm} = 5\times10^{-3}\text{ m}$, $\lambda = 6\times10^{-7}\text{ m}$

Since, $\Delta x = \dfrac{D}{d}(\mu-1)t$

$$\Rightarrow \quad \mu - 1 = \frac{\Delta x d}{Dt} = \frac{5\times10^{-3}\times2\times10^{-3}}{0.10\times0.5\times10^{-3}} = 0.2$$

$$\mu = 1+0.2 = 1.2$$

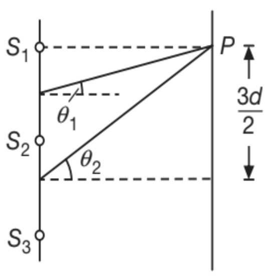
$$\Rightarrow \quad 5\mu = 6$$

9. $S_2P - S_1P = d\sin\theta_1 = d\left(\dfrac{\frac{d}{2}}{D}\right) = \dfrac{d^2}{2D} = \dfrac{\lambda}{3}$

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

$$S_3P - S_2P = d\sin\theta_2 = d\left(\frac{\frac{3d}{2}}{D}\right) = \frac{3d^2}{2D} = \lambda$$

$$\Rightarrow \quad \Delta\phi = 2\pi$$



If I_R be the resultant intensity of the wave at the point P, then

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

$$\Rightarrow \quad I_R = I_0 + 4I_0 + 2\sqrt{(I_0)(4I_0)}\cos(120°)$$

$$\Rightarrow \quad I_R = 3I_0 = 3(12\text{ Wm}^{-2}) = 36\text{ Wm}^{-2}$$

10. Angular fringe width $\theta = \dfrac{\beta}{D} = \dfrac{\lambda}{d}$

According to the given condition

$$\frac{\lambda}{d} \geq \frac{\pi}{180\times60}$$

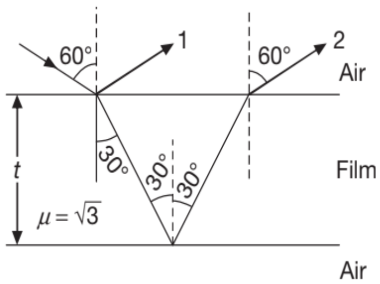
$$\Rightarrow \quad d < \frac{6\times10^{-7}\times180\times60}{\pi}$$

$$d_{\max} = 2.06\times10^{-3}\text{ m} = 2.06\text{ mm}$$

11. According to Snell's Law, we have

$$1\sin(30°) = \sqrt{3}\sin r$$

$$\Rightarrow \quad r = 30°$$



The Optical path difference is given by

$$\Delta x = 2\mu t\sec r - 2t\tan r\sin i$$

$$\Rightarrow \quad \Delta x = 2\sqrt{3}(t\sec30°) - 2t\tan(30°)\sin(60°)$$

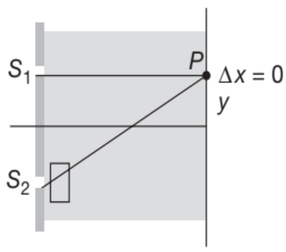
$$\Delta x = 4t - 2t\left(\frac{1}{\sqrt{3}}\right)\left(\frac{\sqrt{3}}{2}\right) = 3t$$

Since the Ray 1 is reflected at the surface of the denser medium so it suffers an additional phase change of π or a path change of $\dfrac{\lambda}{2}$. So, for constructive interference, we have

$$3t = \frac{\lambda}{2}$$

$$\Rightarrow \quad t = \frac{\lambda}{6} = 1000\text{ Å} = 100\text{ nm}$$

12.



The path difference at O is

$$\Delta x = (S_2P - T)_{liquid} + T_{glass} - (S_1P)_{liquid}$$

$$\Delta x = \frac{yd}{D} + \left(\frac{\mu T}{\mu_\ell} - T\right)_{liquid}$$

At the central maxima, we have path difference

$$\Delta x = 0$$

$$\Rightarrow \quad y = -\frac{DT}{d}\left(\frac{\mu - \mu_\ell}{\mu_\ell}\right) = -\frac{TD}{d}\left(\frac{4-t}{10-t}\right)$$

Central maxima will be at O when $y = 0$

$$\Rightarrow \quad t = 4 \text{ s}$$

Now, the speed of the central maxima is given by

$$v = \left|\frac{dy}{dt}\right| = \frac{6DT}{(10-t)^2 d}$$

At $t = 4$ s, we have $v = \frac{6DT}{36d} = \frac{DT}{6d}$

$$\Rightarrow \quad v = \frac{(1)(36\times10^{-6})}{(6)(2\times10^{-3})} = 3\times10^{-3} \text{ ms}^{-1} = 3 \text{ mms}^{-1}$$

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

Since the wavelength is decreasing from 600 nm to 400 nm, so fringe width also decreases by a factor of $\frac{4}{6} = \frac{2}{3}$. So the number of fringes will increase by a factor of $\frac{3}{2}$. Hence the new number of fringes formed is

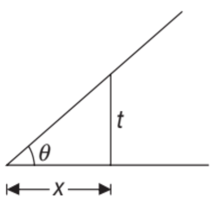
$$N = \frac{3}{2}(12) = 18$$

14. $\theta = 0.01$ radian

$n = 10$

$\lambda = 6000\times10^{-8}$ cm

$\Delta x = 2t = n\lambda$



Since, $\theta = \frac{t}{x}$

$$\Rightarrow \quad t = \theta x$$

$$\Rightarrow \quad 2\theta x = n\lambda$$

$$\Rightarrow \quad x = \frac{n\lambda}{2\theta} = 3\times10^{-1} \text{ m} = 3 \text{ mm}$$

15. When coherent, then Δx at centre is zero, so, we have the resultant intensity to be

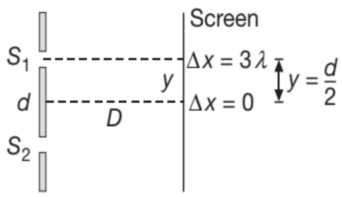
$$I_1 = 4I$$

When incoherent, then the sources will not interfere and it will be a general illumination at the point, so we have the resultant intensity to be,

$$I_2 = 2I$$

$$\Rightarrow \quad \frac{I_1}{I_2} = 2$$

16. Figure shows the *YDSE* setup as described in the problem.



At a distance y from the centre of the screen, path different between the waves from S_1 and S_2 is given by $\Delta x = \frac{yd}{D}$

Since, at $y = \frac{d}{2}$, path difference should be 3λ (because third bright fringe is located in front of one slit on the screen). So, we have at $y = \frac{d}{2}$ and $\Delta x = 3\lambda$. Since

$$\Delta x = \frac{yd}{D}$$

$$\Rightarrow \quad 3\lambda = \frac{\left(\frac{d}{2}\right)d}{D}$$

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

$$\Rightarrow \quad d = \sqrt{6\lambda D} = \sqrt{6\times6\times10^{-7}\times1}$$

$$\Rightarrow \quad d = \sqrt{36\times10^{-7}} \text{ m}$$

$$\Rightarrow \quad d = 0.6\sqrt{10} \text{ mm} = 1.9 \text{ mm}$$

$$\Rightarrow \quad d \approx 2 \text{ mm}$$

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1. $\frac{a_1}{a_2} = \frac{3}{1}$

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

Hence, the correct answer is (A).

2. Since $(\mu - 1)t = n\lambda$

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

Hence, the correct answer is (B).

3. $I_1 = 4I_0, I_2 = I_0$

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

Hence, the correct answer is (D).

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

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

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

Hence, the correct answer is (D).

5. $I = \left(\frac{I_0}{2}\right)\cos^2(30°)\cos^2(60°) = \frac{I_0}{2} \times \frac{3}{4} \times \frac{1}{4} = \frac{3I_0}{32}$

$\Rightarrow \frac{I_0}{I} = \frac{32}{3} = 10.67$

Hence, the correct answer is (C).

6. $\frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2} = 16$

$\Rightarrow \frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}} = 4$

$\Rightarrow \frac{\sqrt{I_1}}{\sqrt{I_2}} = \frac{4+1}{4-1} = \frac{5}{3}$

$\Rightarrow \frac{I_1}{I_2} = \frac{25}{9}$

Hence, the correct answer is (A).

7. $N = \frac{d\sin\theta}{\lambda} = \frac{0.320 \times 10^{-3}}{500 \times 10^{-9}} \times \frac{1}{2}$

$\Rightarrow N = 320$

Number of Bright fringes $= 2(320) + 1 = 641$

Hence, the correct answer is (D).

8. $\theta d = n_1\lambda_1$

$\theta d = n_2\lambda_2$

where $\theta d = \frac{0.1 \times 10^{-3}}{40} \times 10^9$ nm

$\Rightarrow \theta d = \frac{1}{40} \times 10^5 = 2500$ nm

$\Rightarrow n_1\lambda_1 = n_2\lambda_2 = 2500$

$\Rightarrow \theta d = 2500$ is LCM of λ_1 and λ_2

$\Rightarrow \lambda_1 = 625$ nm and $\lambda_2 = 500$ nm [By observation]

Hence, the correct answer is (B).

9. For 1^{st} minima, we have $\Delta x = \frac{\lambda}{2}$

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

$\Rightarrow \sqrt{5}d - 2d = \frac{\lambda}{2}$

$\Rightarrow d = \frac{\lambda}{2\left(\sqrt{5} - 2\right)}$

Hence, the correct answer is (A).

10. $\Delta\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{8} = \frac{\pi}{4}$

Since, $I = I_{max}\cos^2\left(\frac{\phi}{2}\right) = 4I_0\cos^2\left(\frac{\pi}{8}\right)$

$\Rightarrow \frac{I}{4I_0} = \cos^2\left(\frac{\pi}{8}\right) = 0.85$

Hence, the correct answer is (D).

11. Angular width between second and first diffraction minima $= \frac{\lambda}{a}$

Angular width of a fringe $= \frac{\lambda}{d}$

$\Rightarrow n = \frac{d}{a} = \frac{19.44}{4.05}$

$\Rightarrow$ Number of bright fringes $= 04$

Hence, the correct answer is (D).

12. Polarizers A and B are oriented with parallel pass axis. Suppose polarizer C is at angle θ with A then it also makes angle θ with B,

Using Malus' law, we get

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

$I_B = I_C\cos^2\theta = \frac{I}{2}\cos^4\theta$

$$\Rightarrow \frac{I}{8}=\frac{I}{2}\cos^4\theta \qquad \left\{\because I_B=\frac{I}{8}\right\}$$

$$\cos^4\theta=\frac{1}{4}=\frac{1}{(\sqrt{2})^4}$$

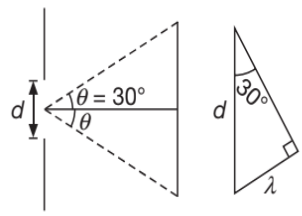
$$\Rightarrow \cos\theta=\frac{1}{\sqrt{2}}=\cos(45^\circ)$$

$$\Rightarrow \theta=45^\circ$$

Hence, the correct answer is (C).

13. In a single slit diffraction, $a\sin\theta=\lambda$.

$$\Rightarrow a\sin(30^\circ)=\lambda$$



$$\Rightarrow \lambda=\frac{a}{2}=\frac{1\times10^{-6}\text{ m}}{2}$$

$$\Rightarrow \lambda=5000\text{ Å}$$

In Young's double slit experiment, fringe width is

$$\beta=\frac{\lambda D}{d} \quad (d \text{ is slit separation})$$

$$\Rightarrow 10^{-2}=\frac{5000\times10^{-10}\times0.5}{d}$$

$$\Rightarrow d=25\times10^{-6}\text{ m}=25\ \mu\text{m}$$

Hence, the correct answer is (A).

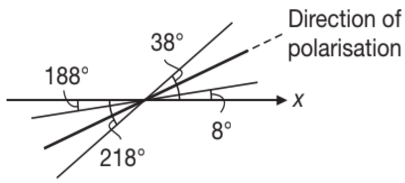
14. If the angular position of second minima from central maxima is θ then, $\sin\theta=\frac{2\lambda}{a}=\frac{2\times550\times10^{-9}}{22\times10^{-7}}=\frac{1}{2}$

$$\Rightarrow \theta=\frac{\pi}{6}\text{ rad}$$

Hence, the correct answer is (C).

15. The direction of polarisation must be equally inclined to 8° and 38° OR 188° and 218° positions. So, the required angle is

$$\frac{8^\circ+38^\circ}{2}=23^\circ \quad \text{OR} \quad \frac{188^\circ+218^\circ}{2}=203^\circ$$



Hence, the correct answer is (A).

16. Polarizers A and B are oriented with parallel pass axis. Suppose polarizer C is at angle θ with A then it also makes angle θ with B.
Using Malus' law,

$$I_C=\left(\frac{I}{2}\cos^2\theta\right) \text{ and } I_B=I_C\cos^2\theta=\frac{I}{2}\cos^4\theta$$

$$\Rightarrow \frac{I}{3}=\frac{I}{2}\cos^4\theta \qquad \left\{\because I_B=\frac{I}{3}\right\}$$

$$\Rightarrow \cos^4\theta=\frac{2}{3}$$

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

Hence, the correct answer is (B).

17. Frequency of the microwave measured by the observer will be given by Doppler's effect of light.

$$\frac{v'}{v}=\sqrt{\frac{1+\beta}{1-\beta}} \qquad \left\{\text{Here } \beta=\frac{v}{c}\right\}$$

$$\Rightarrow \frac{v'}{v}=\sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}}=\sqrt{\frac{c+v}{c-v}}$$

$$v'=v\sqrt{\frac{\left(c+\frac{c}{2}\right)}{c-\frac{c}{2}}}=10\sqrt{3}\text{ GHz}$$

$$\Rightarrow v'=17.3\text{ GHz}$$

Hence, the correct answer is (C).

18. Let y be the distance from the central maximum to the point where the bright fringes due to both the wavelengths coincides.

Now, for λ_1, $y=\frac{n_1\lambda_1 D}{d}$

For λ_2, $y=\frac{n_2\lambda_2 D}{d}$

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

$$\Rightarrow \frac{n_1}{n_2}=\frac{\lambda_2}{\lambda_1}=\frac{520}{650}=\frac{4}{5}$$

i.e. with respect to central maximum 4^{th} bright fringe of λ_1 coincides with 5^{th} bright fringe of λ_2

Now, $y=\frac{4\times650\times10^{-9}\times1.5}{0.5\times10^{-3}}$ m

$$\Rightarrow y=7.8\times10^{-3}\text{ m}$$

$$\Rightarrow y=7.8\text{ mm}$$

Hence, the correct answer is (B).

CHAPTER 2

19. For single slit diffraction, $\sin\theta = \frac{n\lambda}{b}$

Position of n^{th} minima from central maxima $= \frac{n\lambda D}{b}$

When $n = 2$, then $x_2 = \frac{2\lambda D}{b} = 0.03$ ...(1)

When $n = 4$, then $x_4 = \frac{4\lambda D}{b} = 0.06$ ...(2)

Equation (2) − Equation (1) gives

$$x_4 - x_2 = \frac{4\lambda D}{b} - \frac{2\lambda D}{b} = 0.03$$

$$\Rightarrow \frac{\lambda D}{b} = \frac{0.03}{2}$$

So, width of central maximum is

$$\frac{2\lambda D}{b} = 2\times\frac{0.03}{2} = 0.03 \text{ m} = 3 \text{ cm}$$

Hence, the correct answer is (D).

20. Here, $d = 0.1$ mm, $\lambda = 6000$ Å, $D = 0.5$ m

For third dark band, $d\sin\theta = 3\lambda$

$$\Rightarrow \sin\theta = \frac{3\lambda}{d} = \frac{y}{D}$$

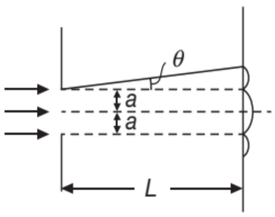
$$\Rightarrow y = \frac{3D\lambda}{d} = \frac{3\times0.5\times6\times10^{-7}}{0.1\times10^{-3}} = 9\times10^{-3} \text{ m} = 9 \text{ mm}$$

Hence, the correct answer is (C).

21. Size of spot, b = Geometrical spread + diffraction spread

$$\Rightarrow b = a + L\frac{\lambda}{a}$$

Now, value of b would be minimum if $\frac{db}{da} = 0$



$$\Rightarrow 1 + L\left(\frac{-\lambda}{a^2}\right) = 0$$

$$\Rightarrow a^2 = \lambda L$$

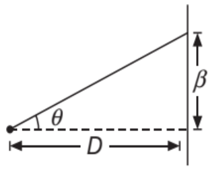
$$\Rightarrow a = \sqrt{\lambda L}$$

$$\Rightarrow b_{min} = \sqrt{\lambda L} + \frac{\lambda L}{\sqrt{\lambda L}} = 2\sqrt{\lambda L} = \sqrt{4\lambda L}$$

Hence, the correct answer is (C).

22. For a particular distance d_0 between the slits, the eye is not able to resolve two consecutive bright fringes.

Now, $\theta = \frac{\beta}{D}$ but $\beta = \frac{\lambda D}{d_0}$

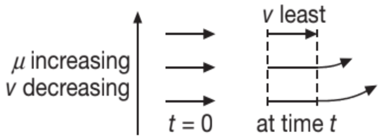


$$\Rightarrow \theta = \frac{\lambda}{d_0}$$

$$\Rightarrow d_0 = \frac{\lambda}{\theta} = \frac{600\times10^{-9} \text{ m}}{\frac{1}{60}\times\frac{\pi}{180} \text{ rad}} = 2.06\times10^{-3} \text{ m} \approx 2 \text{ mm}$$

Hence, the correct answer is (C).

23. Consider a light beam travelling horizontally. Since refractive index of air increases with height, so speed of wavefront decreases with height, due to which the light beam bends upwards.



Hence, the correct answer is (B).

24. Intensity at any point on the screen is given by

$$I = 4I_0\cos^2\left(\frac{\phi}{2}\right), \text{ where } I_{max} = 4I_0$$

Since, $I = \frac{I_{max}}{2} = 2I_0 = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

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

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

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

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

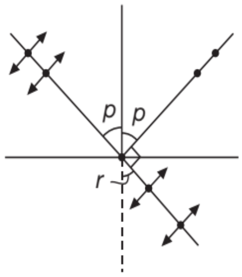
$$\Rightarrow \Delta x = \frac{\lambda}{4}$$

$$\Rightarrow y\frac{d}{D} = \frac{\lambda}{4}$$

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

Hence, the correct answer is (B).

25. At Brewster's angle, $p = \tan^{-1}(\mu)$, the reflected light is completely polarized, whereas refracted light is partially polarized. Thus, the reflected ray will have lesser intensity compared to refracted ray.



$$\Rightarrow \quad I_{\text{reflected}} < \frac{I_0}{2}$$

Hence, the correct answer is (C).

26. When a polaroid rotated through $30°$ with respect to beam A, then beam B is at $60°$ with it.

So, $I_A \cos^2(30°) = I_B \cos^2(60°)$

$$\Rightarrow \quad I_A\left(\frac{3}{4}\right) = I_B\left(\frac{1}{4}\right)$$

$$\Rightarrow \quad \frac{I_A}{I_B} = \frac{1}{3}$$

Hence, the correct answer is (A).

27. When the screen is placed perpendicular to the line joining the sources, the fringes will be concentric circles.

Hence, the correct answer is (A).

28. Intensity of unpolarised light after passing polaroid A is

$$I_1 = \frac{I_0}{2}$$

Now this light will pass through the second polaroid B whose axis is inclined at an angle of $45°$ to the axis of polaroid A. So, in accordance with Malus law, the intensity of light emerging from polaroid B is

$$I_2 = I_1 \cos^2(45°) = \left(\frac{I_0}{2}\right)\left(\frac{I}{\sqrt{2}}\right)^2 = \frac{I_0}{4}$$

Hence, the correct answer is (D).

29. Here, $A_2 = 2A_1$

$$\Rightarrow \quad \text{Intensity} \propto (\text{Amplitude})^2$$

$$\Rightarrow \quad \frac{I_2}{I_1} = \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{2A_1}{A_1}\right)^2 = 4$$

$$\Rightarrow \quad I_2 = 4I_1$$

Maximum intensity, $I_m = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

$$\Rightarrow \quad I_m = \left(\sqrt{I_1} + \sqrt{4I_1}\right)^2 = \left(3\sqrt{I_1}\right)^2 = 9I_1$$

$$\Rightarrow \quad I_1 = \frac{I_m}{9} \qquad \ldots(1)$$

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

$$\Rightarrow \quad I_R = I_1 + 4I_1 + 2\sqrt{I_1(4I_1)}\cos\phi$$

$$\Rightarrow \quad I_R = 5I_1 + 4I_1\cos\phi = I_1 + 4I_1 + 4I_1\cos\phi$$

$$\Rightarrow \quad I_R = I_1 + 4I_1(1 + \cos\phi)$$

$$\Rightarrow \quad I_R = I_1 + 8I_1\cos^2\frac{\phi}{2} \qquad \left\{\because\ 1 + \cos\phi = 2\cos^2\frac{\phi}{2}\right\}$$

$$\Rightarrow \quad I_R = I_1\left(1 + 8\cos^2\frac{\phi}{2}\right)$$

Putting the value of I_1 from equation (1), we get

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

Hence, the correct answer is (C).

30. The centre of interference pattern is dark thus showing that the phase difference between two interfering waves is π. However, this does not imply Statement-1.

Hence, the correct answer is (C).

31. For interference, by Young's double slits, the path difference is

$$x = n\left(\frac{\lambda D}{d}\right) \text{ for bright fringes and}$$

$$x = \left(n - \frac{1}{2}\right)\frac{\lambda D}{d} \text{ for dark fringes}$$

The central fringe, when $x = 0$, coincides for all wavelengths. The third fringe of $\lambda_1 = 590$ nm coincides with the fourth bright fringe of unknown wavelength λ_2. So, $3\lambda_1 = 4\lambda_2$

$$\Rightarrow \quad 3 \times 590 \text{ nm} = 4\lambda_2$$

$$\Rightarrow \quad \lambda_2 = \frac{3 \times 590}{4} = 442.5 \text{ nm}$$

Hence, the correct answer is (C).

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Single Correct Choice Type Problems

1. $I = I_{max}\cos^2\left(\frac{\phi}{2}\right)$

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

$$\Rightarrow \cos\left(\frac{\phi}{2}\right) = \pm\frac{1}{\sqrt{2}}$$

$$\Rightarrow \frac{\phi}{2} = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}, \ldots$$

$$\Rightarrow \phi = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \frac{7\pi}{2}, \ldots$$

$$\Rightarrow \Delta x = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}, \ldots$$

$$\Rightarrow \Delta x = (2n+1)\frac{\lambda}{4}$$

Hence, the correct answer is (B).

2. As $\lambda_R > \lambda_G > \lambda_B$

$$\Rightarrow \beta_R > \beta_G > \beta_B \text{ as } \beta \propto \lambda$$

Hence, the correct answer is (D).

3. $I = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

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

$$\Rightarrow \Delta x \times \left(\frac{2\pi}{\lambda}\right) = \frac{2\pi}{3} = \frac{\lambda}{3}$$

$$\Rightarrow \sin\theta = \frac{\Delta x}{d}$$

$$\Rightarrow \sin\theta = \frac{\lambda}{3d}$$

Hence, the correct answer is (C).

4. Let n^{th} minima of 400 nm coincides with mth minima of 560 nm, then

$$(2n-1)\left(\frac{400}{2}\right) = (2m-1)\left(\frac{560}{2}\right)$$

$$\Rightarrow \frac{2n-1}{2m-1} = \frac{7}{5} = \frac{14}{10} = \ldots\ldots$$

i.e., 4^{th} minima of 400 nm coincides with 3^{rd} minima of 560 nm.

Location of this minima is,

$$Y_1 = \frac{(2\times4-1)(1000)(400\times10^{-6})}{2\times0.4} = 14 \text{ mm}$$

Next 11^{th} minima of 400 nm will coincide with 8^{th} minima of 560 nm

Location of this minima is,

$$Y_2 = \frac{(2\times11-1)(1000)(400\times10^{-6})}{2\times0.1} = 42 \text{ mm}$$

$\therefore$ Required distance $= Y_2 - Y_1 = 28$ mm

Hence, the correct answer is (D).

5. $PR = d$

$\therefore \quad PO = d\sec\theta$

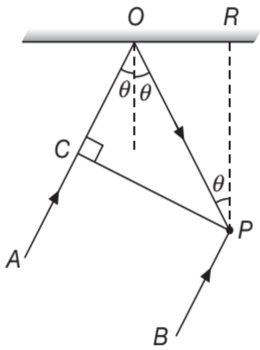
and $CO = PO\cot2\theta = d\sec\theta\cos2\theta$

Path difference between the two rays is

$$\Delta x = CO + PO = (d\sec\theta + d\sec\theta\cos2\theta)$$

Phase difference between the two rays is

$\Delta\phi = \pi$ (one is reflected, while another is direct)



Therefore, condition for constructive interference should be

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

$$\Rightarrow d\sec\theta(1+\cos2\theta) = \frac{\lambda}{2}$$

$$\Rightarrow \left(\frac{d}{\cos\theta}\right)(2\cos^2\theta) = \frac{\lambda}{2}$$

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

Hence, the correct answer is (B).

6. Path difference due to slab should be integral multiple of λ or $\Delta x = n\lambda$

$\Rightarrow \quad (\mu-1)t = n\lambda \qquad n = 1, 2, 3, ...$

$$\Rightarrow \quad t = \frac{n\lambda}{\mu-1}$$

For minimum value of t, $n = 1$

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

Hence, the correct answer is (A).

7. $n_1\lambda_1 = n_2\lambda_2$

$$\Rightarrow \quad n_2 = n_1 \times \frac{\lambda_1}{\lambda_2} = 12 \times \frac{600}{400} = 18$$

Hence, the correct answer is (B).

8. $I(\phi) = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi \qquad \ldots(1)$

Here $I_1 = I$ and $I_2 = 4I$

At point A, $\phi = \frac{\pi}{2}$

$\Rightarrow \quad I_A = I + 4I = 5I$

At point B, $\phi = \pi$

$\Rightarrow \quad I_B = I + 4I - 4I = I$

$\Rightarrow \quad I_A - I_B = 4I$

Hence, the correct answer is (B).

Equation (1) for resultant intensity can be applied only when the sources are coherent. In the question it is given that the rays interfere. Interference takes place only when the sources are coherent. That is why we applied equation number (1). When the sources are incoherent, the resultant intensity is given by $I = I_1 + I_2$.

9. In interference we know that

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 \text{ and } I_{min} = \left(\sqrt{I_1} \sim \sqrt{I_2}\right)^2$$

Under normal conditions (when the widths of both the slits are equal)

$I_1 \approx I_2 = I \qquad$ (say)

$\Rightarrow \quad I_{max} = 4I$ and $I_{min} = 0$

When the width of one of the slits is increased. Intensity due to that slit would increase, while that of the other will remain same. So let

$I_1 = I$ and $I_2 = \eta I \qquad \{\eta > I\}$

Then, $I_{max} = I\left(1+\sqrt{\eta}\right)^2 > 4I$

and $I_{min} = I\left(\sqrt{\eta}-1\right)^2 > 0$

$\Rightarrow$ Intensity of both maxima and minima is increased.

Hence, the correct answer is (A).

10. Diffraction is obtained when the slit width is of the order of wavelength of light (or any electromagnetic wave) used. Here, wavelength of x-rays $(1-100\text{ Å}) \ll$ slit width (0.6 mm). Therefore, no diffraction pattern will be observed.

Hence, the correct answer is (D).

11. Locus of equal path difference is the lines running parallel to the axis of the cylinder. Hence, straight fringes are obtained.

Hence, the correct answer is (A).

Circular rings (also called Newton's rings) are observed in interference pattern when a plano-convex lens of large focal length is placed with its convex surface in contact with a plane glass plate because locus of equal path difference in this case is a circle.

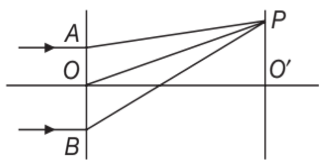
12. At first minima of the diffraction pattern, path difference is

$$\Delta x = b\sin\theta = \lambda$$

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

Hence, the correct answer is (D).

13. The diagrammatic representation of the given problem is shown in figure.



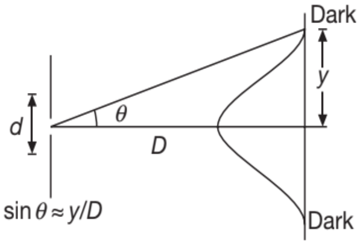
For P to be a minimum, the phase difference of secondary waves from O and A (or B) is π (Out of phase) Hence, the phase difference between the wavelets from the opposite edges is 2π.

Hence, the correct answer is (C).

14. For first dark fringe on either side $d\sin\theta = \lambda$

$$\Rightarrow \quad \frac{yd}{D} = \lambda$$

$$\Rightarrow \quad y = \frac{\lambda D}{d}$$



Therefore, distance between two dark fringes on either side is $2y = \dfrac{2\lambda D}{d}$

Substituting the values, we get

$$2y = \frac{2(600\times10^{-6}\text{ mm})(2\times10^{3}\text{ mm})}{(1.0\text{ mm})} = 2.4\text{ mm}$$

Hence, the correct answer is (D).

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

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

Hence, the correct answer is (C).

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

d is halved and D is doubled

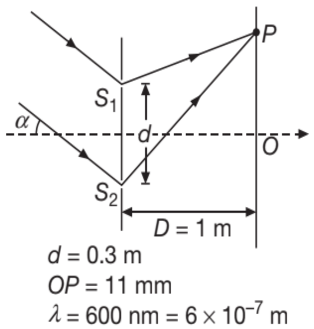
So, Fringe width β will become four times.

Hence, the correct answer is (D).

Multiple Correct Choice Type Problems

1. Total geometric path difference for point P is

$$\Delta x = d\sin\alpha + \frac{yd}{D}$$



For **OPTION (A),**

$$\alpha = \frac{0.36}{\pi}\text{ degree}$$

Since α is small, so

$$\Delta x \approx \alpha d + \frac{yd}{D}$$

$\Rightarrow \quad \Delta x = 3900\text{ nm}$

Since $\Delta x = 3900\text{ nm}$ is an odd multiple of $\dfrac{\lambda}{2}$ i.e., 300 nm.

$\Rightarrow \quad (2n-1)\dfrac{\lambda}{2} = \Delta x$ (for destructive interference)

$\Rightarrow \quad n = 7$

For **OPTION (B),**

Fringe width in all the above case remain unchanged.

For **OPTION (C),**

$$\Delta x_0 = 0 \text{ and } \frac{yd}{D} = 3300\text{ nm}$$

As $(\alpha = 0)$ (Destructive interference at P)

For **OPTION (D)**

If $\alpha = \dfrac{0.36}{\pi}$ degree

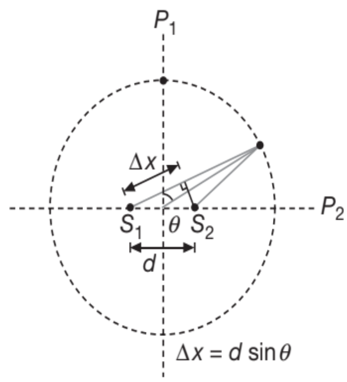
Then $\Delta x_0 = \alpha d = 600\text{ nm}$

$\Rightarrow \quad \Delta x_0 = n\lambda$ (for $n = 1$) (Constructive interference)

Hence, the correct answer is (A).

2. From the figure, we observe that the path difference x between the waves arriving at the circle from sources S_1 and S_2 is

$$x = d\sin\theta$$



At P_1, $\theta = 0°$

$\Rightarrow \quad x = 0$

At P_2, $\theta = 90°$

$\Rightarrow \quad x = d$

Since for maxima, we have $d\sin\theta = n\lambda$

$\Rightarrow \quad \sin\theta = \dfrac{n\lambda}{d}$

Since at P_2, $\theta = 90°$

$\Rightarrow \quad \dfrac{n\lambda}{d} = 1$

$\Rightarrow \quad n = \dfrac{d}{\lambda} = \dfrac{1.8\times10^{-3}}{600\times10^{-9}} = 3000$

So, total number of fringes produced between P_1 and P_2 in first quadrant is close to 3000.

Since, $x = d\sin\theta$

$\Rightarrow \quad \Delta x = \Delta(d\sin\theta)$

Since for maxima, we have $x = (2n)\frac{\lambda}{2} = n\lambda$

$\Rightarrow \quad \Delta(n\lambda) = d\Delta(\sin\theta)$

$\Rightarrow \quad \lambda\Delta n = (d\cos\theta)\Delta\theta$

Now, between any two consecutive maxima, we have

$|\Delta n| = 1$

$\Rightarrow \quad \lambda = (d\cos\theta)\Delta\theta$

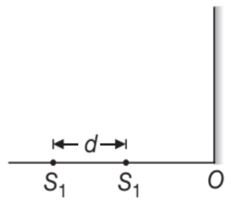
$\Rightarrow \quad \Delta\theta = \frac{\lambda}{d\cos\theta}$

Now, as we move from P_1 to P_2, θ increases, $\cos\theta$ decreases and hence $\Delta\theta$ increases.

Hence, (C) and (D) are correct.

3. Path difference at point O is $d = 0.6003$ mm $= 600300$ nm.

We observe this path difference to be equal to $\left(100\lambda + \frac{\lambda}{2}\right)$



So, minima is formed at point O.

Line S_1S_2 and screen are $\perp$ to each other, so fringe pattern is circular (semi-circular because only half of screen is available)

Hence, (A) and (B) are correct.

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

$\Rightarrow \quad \beta \propto \lambda$

Since, $\lambda_2 > \lambda_1$

$\Rightarrow \quad \beta_2 > \beta_1$

Number of fringes in a given width

$m = \frac{y}{\beta}$

$\Rightarrow \quad m \propto \frac{1}{\beta}$

$\Rightarrow \quad m_2 < m_1$ as $\beta_2 > \beta_1$

Distance of 3rd maximum (third bright) of λ_2 from central maximum

$$y_{3B} = \frac{3\lambda_2 D}{d} = \frac{1800D}{d}$$

Distance of 5th minimum (fifth dark) of λ_1 from central maximum

$$y_{5D} = \frac{9\lambda_1 D}{2d} = \frac{1800D}{d}$$

So, 3rd maximum of λ_2 will overlap with 5th minimum of λ_1.

Angular separation (or angular fringe width) $= \frac{\lambda}{d} \propto \lambda$

$\Rightarrow$ Angular separation for λ_1 will be lesser.

Hence, (A) and (C) are correct.

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

$\Rightarrow \quad \log_e d = \log_e \lambda - \log_e 2 - \log_e(\sin\theta)$

$\Rightarrow \quad \frac{\Delta(d)}{d} = 0 - 0 - \frac{1}{\sin\theta} \times \cos\theta(\Delta\theta)$

Fractional error $= \left|\frac{\Delta d}{d}\right| = (\cot\theta)\Delta\theta$

Absolute error $\Delta d = (d\cot\theta)\Delta\theta = \left(\frac{\lambda}{2\sin\theta}\right)\left(\frac{\cos\theta}{\sin\theta}\right)\Delta\theta$

Now, given that $\Delta\theta =$ constant

As θ increases, $\sin\theta$ increases, $\cos\theta$ and $\cot\theta$ decrease.

$\Rightarrow$ Both fractional and absolute errors decrease.

Hence, the correct answer is (D).

6. For $d = \lambda$, there will be only one, central maxima.

For $\lambda < d < 2\lambda$, there will be three maximas on the screen corresponding to path difference, $\Delta x = 0$ and $\Delta x = \pm\lambda$.

Hence, (A) and (B) are correct.

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

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

(i) For $\theta = 30°$, $\lambda = \frac{c}{v} = \frac{3\times 10^8}{10^6} = 300$ m and $d = 150$ m, we get

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

$$\Rightarrow \frac{\delta}{2} = \frac{\pi}{4}$$

$$\Rightarrow I(\theta) = I_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2} \qquad \text{\{option (A)\}}$$

(ii) For $\theta = 90°$

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

$$\Rightarrow \frac{\delta}{2} = \frac{\pi}{2} \text{ and } I(\theta) = 0$$

(iii) For $\theta = 0°$, $\delta = 0$ or $\frac{\delta}{2} = 0$

$$I(\theta) = I_0 \qquad \text{\{option (C)\}}$$

Hence, (A) and (C) are correct.

8. $x = \text{Path Difference} = \sqrt{b^2 + d^2} - d$

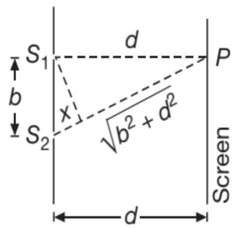
$$\Rightarrow x = d\left(\sqrt{1 + \frac{b^2}{d^2}} - 1\right)$$

$$\Rightarrow x \simeq d\left(1 + \frac{b^2}{2d^2} - 1\right)$$

$$\left\{\text{Since } \frac{b^2}{d^2} \ll 1, \text{ Hence } \sqrt{1 + \frac{b^2}{d^2}} \simeq 1 + \frac{b^2}{2d^2}\right\}$$

$$\Rightarrow x \simeq \frac{b^2}{2d}$$

For wavelengths to be missing we must find positions of minima.



At minima path difference is an odd multiple of $\frac{\lambda}{2}$

$$\Rightarrow x = \frac{b^2}{2d} = (2n-1)\frac{\lambda}{2} \quad n = 1, 2, 3, \ldots\ldots$$

$$\Rightarrow \lambda = \frac{b^2}{(2n-1)d}; \ n = 1, 2, \ldots\ldots\ldots\ldots$$

$$\Rightarrow \lambda = \frac{b^2}{d}, \frac{b^2}{3d}, \frac{b^2}{5d}, \ldots\ldots\ldots\ldots\ldots$$

Hence, (A) and (C) are correct.

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

$$\Rightarrow \sqrt{I_1} + \sqrt{I_2} = 3\left(\sqrt{I_1} - \sqrt{I_2}\right)$$

$$\Rightarrow 2\sqrt{I_1} = 4\sqrt{I_2}$$

$$\Rightarrow I_1 = 4I_2$$

Since, $\dfrac{I_1}{I_2} = \left(\dfrac{A_1}{A_2}\right)^2$

$$\Rightarrow \frac{A_1}{A_2} = \sqrt{\frac{I_1}{I_2}} = 2$$

Hence, (B) and (D) are correct.

Comprehension Type Questions

1. Wavefronts are parallel in both media. Therefore, light which propagates perpendicular to wavefront travels as a parallel beam in each medium.

Hence, the correct answer is (A).

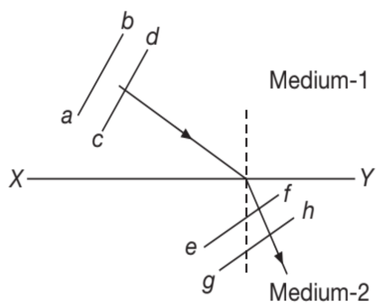
2. All points on a wavefront are at the same phase

$$\Rightarrow \phi_d = \phi_c \text{ and } \phi_f = \phi_e$$

$$\Rightarrow \phi_d - \phi_f = \phi_c - \phi_e$$

Hence, the correct answer is (C).

3. In medium-2 wavefront bends away from the normal after refraction. Therefore, ray of light which is perpendicular to wavefront bends towards the normal in medium-2 during refraction. So, medium-2 is denser or its speed in medium-1 is more.



Hence, the correct answer is (B).

Matrix Match/Column Match Type Questions

1. A → (p, s)
B → (q)
C → (t)
D → (r, s, t)

(A) → (p, s) → Intensity at P_0 is maximum. It will continuously decrease from P_0 towards P_2

(B) → (q) → Path difference due to slap will be compensated by geometrical path difference. Hence, $\delta(P_1)=0$.

(C) → (t) → $\delta(P_0)=\frac{\lambda}{2}$, $\delta(P_1)=\frac{\lambda}{2}-\frac{\lambda}{4}=\frac{\lambda}{4}$ and $\delta(P_2)=\frac{\lambda}{2}-\frac{\lambda}{3}=\frac{\lambda}{6}$. When path difference increases from 0 to $\frac{\lambda}{2}$, intensity will decrease from maximum to zero. Hence, in this case,

$$I(P_2)>I(P_1)>I(P_0)$$

(D) → (r, s, t)

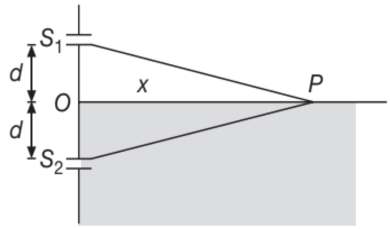
$$\delta(P_0)=\frac{3\lambda}{4},\ \delta(P_1)=\frac{3\lambda}{4}-\frac{\lambda}{4}=\frac{\lambda}{2}$$

and $\delta(P_2)=\frac{3\lambda}{4}-\frac{\lambda}{3}=\frac{5\lambda}{12}$.

In this case $I(P_1)=0$.

Integer/Numerical Answer Type Questions

1.



$$\mu(S_2P)-S_1P=m\lambda$$

$$\Rightarrow\quad \mu\sqrt{d^2+x^2}-\sqrt{d^2+x^2}=m\lambda$$

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

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

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

Squaring this equation, we get

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

$$\Rightarrow\quad p^2=9$$

$$\Rightarrow\quad p=3$$

CHAPTER 2