VMC Vidyamandir Classes SINCE 1986

IIT JEE | MEDICAL | FOUNDATION

Wave Optics

Level - 0	CBSE Pattern

VSA: Very Short Answer Type

1. According to Huygen's principle, each point on a wavefront is a source of secondary waves, which add up to give a wavefront at any later time.

2. (i) Spherical wavefront emerges from a point source.
(ii) Plane wavefront emerges from a distant light source.

3. Two sources are said to be coherent, if they emit light waves of same frequency or wavelength and of a stable phase difference.

4. Fringe width is decreases by the factor 1.3. ; Fringe width, $\beta = \frac{D\lambda}{d}$

Wavelength of light in water $\lambda' = \frac{\lambda_{air}}{\mu} = \frac{\lambda_{air}}{1.3}$ $\therefore$ Fringe width in water, $\beta' = \frac{D\lambda'}{d} = \frac{D\lambda_{air}}{d \times 1.3} = \frac{\beta}{1.3}$

5. In a single slit diffraction separation between fringes $\theta \propto \frac{n\lambda}{a}$

So, there is no effects on angular separation 2θ by changing of the distance of separation 'D' between slit and the screen.

SA-I: Short Answer Type – I

6. Angular width of central maxima is given by $2\theta = \frac{2\lambda}{a}$

Since $\lambda_r > \lambda_b$. Therefore, width of central maxim of red light is greater than the width of central maxima of blue light.

7. (a) The essential condition, which must satisfied sources to be coherent are:
(i) The two light waves should be of same wavelength.
(ii) The two light waves should either be in phase or should have a constant phase difference.
(b) Because coherent sources emit light waves of same frequency or wavelength and of a stable phase difference.

8. Resolving power of a microscope is defined as the reciprocal of the lest separation between two closed object, so that they appear just separated, when seen through microscope.

R.P. of microscope $= \frac{1}{d} = \frac{2\mu \sin\theta}{\lambda}$

It depends upon refractive index of the medium.

9. Brewster's law: The tangent of the polarizing angle of incidence of a transparent medium is equal to its refractive index, i.e., $\mu = \tan(i_p)$; Brewster angle, $i_p = \tan^{-1}(\mu)$

Refractive index of a transparent medium depends on the wavelength of light which falls on the medium. So a transparent medium has different values of refractive index for light of different colours. Hence the value of Brewster angle for a transparent medium is different for light of different colours.

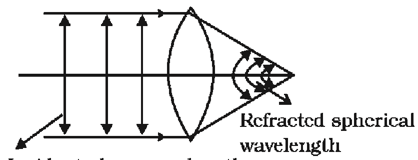
10. Here, $d = 1mm = 1 \times 10^{-3} m$

$D = 1m, \lambda = 500\,nm = 5 \times 10^{-7} m$

Fringe spacing,

$$\beta = \frac{\lambda D}{d} = \frac{5 \times 10^{-7} \times 1}{1 \times 10^{-3}} = 5 \times 10^{-4} m = 0.5\,mm$$

11. Wavefront: The continuous locus of all the particles of medium, which are vibrating in the same phase is called a wavefront.



12. (i) For interference fringe, the condition is $\frac{s}{D} < \frac{\lambda}{d}$

Where s = size of source, D = distance of source from slits

If the source slit width increases, fringe pattern gets less sharp or faint.

When the source slit is made wide which does not fullfil the above condition and interference pattern not visible.

(ii) The central fringes are white. On the either side of the central white fringe the coloured bands (few coloured maxima and minima) will appear. This is because fringes of different colours overlap.

SA-II: Short Answer Type – II

13. Resolving power of an astronomical telescope is the reciprocal of smallest angular separation between two distant objects whose images can be just resolved by it.

Resolving power $= \frac{1}{\alpha_{min}} = \frac{D}{1.22\lambda}$

(i) As resolving power $\propto D$, on increasing the aperture of the objective lens, resolving power also increases.

(ii) As resolving power $\propto \frac{1}{\lambda}$, so on increasing the wavelength of the light used, resolving power decreases.

14. For a single slit of width "a" the first minima of the interference pattern of a monochromatic light of wavelength λ occurs at an angle of (λ / a) because the light from centre of the slit differs by a half of a wavelength.

Whereas a double slit experiment at the same angle of (λ / a) and slits separation "a" produces maxima because one wavelength difference in path length from these two slits is produced.

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

$\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2} or \lambda_2 = \frac{\beta_2}{\beta_1}\lambda_1 = \frac{8.1}{7.2} \times 640 nm$; $\lambda_2 = 720 nm$; $x = n_1\beta_1 = n_2\beta_2$

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

$\because$ Bright fringes conincides at least distance x, if $n_1 = n_2 + 1 \Rightarrow n_2 \times 640 = (n_1 - 1) \times 720$

$\frac{n_1 - 1}{n_1} = \frac{640}{720} or\ n_1 = 9$

16. Unplorized light waves are those light waves whose planes of vibrations are randomly oriented about the direction of propagation of the wave.

Polarized light waves are those light waves in which planes of vibrations can occur in one particular plane only.

Yes, the intensity of polarized light emitted by a polaroid depends on its orientation. When polarized light is incident on a polaroid, the resultant intensity of light transmitted varies directly as the square of the cosine of the angle between polarization direction of light and axis of the polaroid.

The intensity of light transmitted can be given using Malus law as

$I = I_0 \cos^2\theta = I_0 \cos^2 60° = \frac{I_0}{4}$

Percentage of light is transmitted though the polaroid sheet is $= \frac{I_0 - \frac{I_0}{4}}{I_0} \times 100 = 75\%$.

17. (i) Angular width, $\theta = \frac{\lambda}{d}, or\, d = \frac{\lambda}{\theta}$; Here, $\lambda = 600\,nm = 6 \times 10^{-7} m$

$\theta = 0.1° = \frac{0.1 \times \pi}{180} rad = \frac{\pi}{1800} rad, d = ?$; $d = \frac{6 \times 10^{-7} \times 1800}{\pi} = 3.44 \times 10^{-4} m$

(ii) Frequency of a light depends on its source only. So, the frequencies of reflected and refracted light will be same as that of incident light.

Reflected light is in the same medium (air) so its wavelength remains same as 500 Å.

Wavelength of refracted light, $\lambda_r = \frac{\lambda}{\mu_w}$; $\mu_w =$ refractive index of water.

So, wavelength of refracted wave will be decreased.

18. **(i)** The intensity of light due to slit is directly proportional to width of slit.

$\frac{I_1}{I_2} = \frac{w_1}{w_2} = \frac{4}{1}$; $\frac{a_1^2}{a_2^2} = \frac{4}{1} or \frac{a_1}{a_2} = \frac{2}{1} or\, a_1 = 2a_2$; $\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(2a_2 + a_2)^2}{(2a_2 - a_2)^2} = \frac{9a_2^2}{a_2^2} = 9:1$

(ii) No, the appearance of bright and dark fringes in the interference pattern does not violate the law of conservation of energy.

When interference takes place, the light energy which disappears at the regions of constructive interference so that the average intensity of light remains the same. Hence, the law of conservation of energy is obeyed in the phenomenon of interference of light.

19. Intensity at a point, $I = 4I_0 \cos^2\left(\frac{\phi}{2}\right)$; Phase difference $= \frac{2\pi}{\lambda} \times Path\, difference$

At path difference λ, Phase difference, $\phi = \frac{2\pi}{\lambda} \times \lambda = 2\pi$

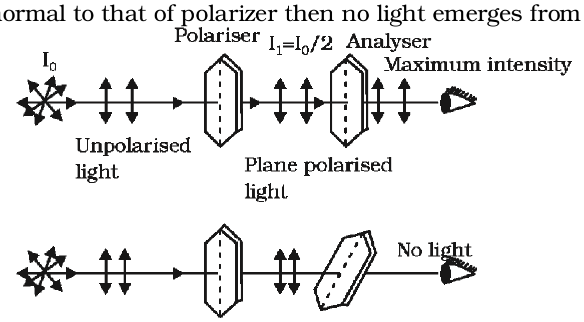
Intensity, $K = 4I_0 \cos^2\left(\frac{2\pi}{2}\right)$ $K = 4I_0 ....(i)$ $[\because I = K, at\, path\, difference\, \lambda]$

If path difference is $\frac{\lambda}{3}$, then phase difference will be $\phi' = \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = \frac{2\pi}{3}$

Intensity, $I' = 4I_0 \cos^2\left(\frac{2\pi}{6}\right) = \frac{K}{4}$ (Using (i))

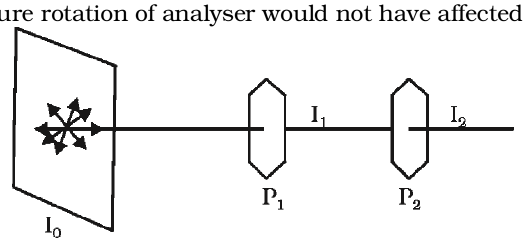
20. (i) When unpolarised light is made to pass through a tourmaline crystal, only those electric field vectors, parallel to its crystallographic axis emerge out of it. Thus the emerging light is plane polarized. Such a crystal is called polarizer.

If the emergent plane polarized light is passed through another crystal called analyser with its plane of transmission normal to that of polarizer then no light emerges from it has maximum intensity.



Demonstration of polarisation of light

This experiment proves that light exhibits polarization and hence light is transverse in nature. If the light was longitudinal in nature rotation of analyser would not have affected the outcoming intensity.



When P_1 and P_2 are parallel. ; $I_1 = \frac{I_0}{2}; I_2 = I_1 = \frac{I_0}{2}$

(ii) Intensity of light transmitted through $P_1 = I_0 / 2$

Intensity of light transmitted through $P_3 = (I_0/2) \times \cos^2 30° = 3I_0/8$ c

Intensity of light transmitted through $P_2 = \frac{3}{8} I_0 \cos^2 60° = \frac{3}{32} I_0$

21. Fringe width $(\beta) = \frac{\lambda D}{d}$; $y = \frac{\beta}{3} = \frac{\lambda D}{3d}$

Path difference $(\Delta p) = \frac{yd}{D} \Rightarrow \Delta p = \frac{\lambda D}{3d}.\frac{d}{D} = \frac{\lambda}{3}$; $\Delta\phi = \frac{2\pi}{\lambda}.\Delta p = \frac{2\pi}{\lambda}.\frac{\lambda}{3} = \frac{2\pi}{3}$

Intensity at point P $= I_0 \cos^2 \Delta\phi = I_0 \left[\cos\frac{2\pi}{3}\right]^2 = I_0 \left(\frac{I}{2}\right)^2 = \frac{I_0}{4}$

22. Here $d = 4.0\,mm = 4 \times 10^{-3} m, D = 1.0\,m$

For *wavelength* $\lambda_A = 600\,nm = 600 \times 10^{-9} m = 6 \times 10^{-7} m$

For wavelength $\lambda_B = 450\,nm = 450 \times 10^{-9} m = 4.5 \times 10^{-7} m$; As $\lambda_A = \lambda_B, n_A = n_B$

If $n_A = n\, then\, n_B = n+1$

$(y_n)\lambda_A = (y_{n+1})\lambda_B$; $n\lambda_A = (n+1)\lambda_B$ Or $n = \frac{\lambda_B}{\lambda_A - \lambda_B} = \frac{450}{150} = 3$

Least distance from central maxima,

$$\lambda_{min} = \frac{3 \times 1 \times 600 \times 10^{-9}}{4 \times 10^{-3}} = 0.45 \times 10^{-3} m = 0.45\,mm$$

23. $y_1 = a\cos\omega t, y_2 = a\cos(\omega t + \phi)$

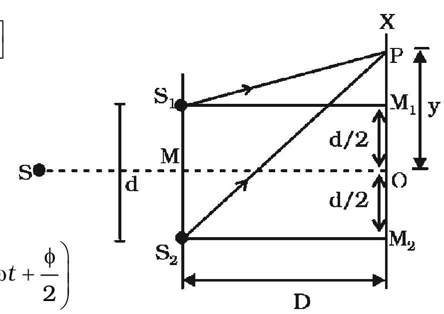
Where ϕ is phase difference between them.

Resultant displacement at point P will be

$$y = y_1 + y_2 = a\cos\omega t + a\cos(\omega t + \phi) = a[\cos\omega t + \cos(\omega t + \phi)]$$

$$= a\left[2\cos\frac{(\omega t + \omega t + \phi)}{2}\cos\frac{(\omega t - \omega t - \phi)}{2}\right]$$

$$y = 2a\cos\left(\omega t + \frac{\phi}{2}\right)\cos\left(\frac{\phi}{2}\right) \text{..........(i)}$$



Let $y = 2a\cos\left(\frac{\phi}{2}\right) = A$, the equation (i) becomes $y = A\cos\left(\omega t + \frac{\phi}{2}\right)$

Where A is amplitude of resultant wave, Now, $A = 2a\cos\left(\frac{\phi}{2}\right)$

On squaring, $A^2 = 4a^2\cos^2\left(\frac{\phi}{2}\right)$ Hence, resultant intensity ; $I = 4I_0 \cos^2\left(\frac{\phi}{2}\right)$

24. Given that distance between the two slits, $d = 0.15mm$

Wavelength of monochromatic light, $\lambda = 450nm$

Distance between the screen and slits, $D = 1m$

(i) Distance of nth bright fringe from central maximum $= \frac{n\lambda D}{d} = 2 \times \frac{450 \times 10^{-9} \times 1}{0.15 \times 10^{-3}} \left[\because n = 2\right]$

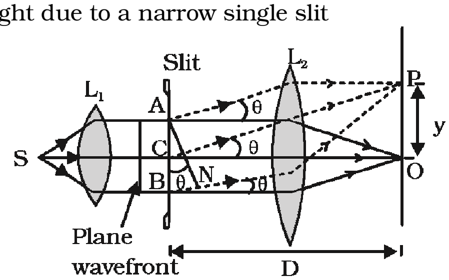
$= 6 \times 10^{-3} m = 6mm$

(ii) Distance of n^{th} dark fringe from central maximum

$= (2n-1)\frac{\lambda D}{2d} = (2 \times 2 - 1) \times \frac{450 \times 10^{-9} \times 1}{2 \times 0.15 \times 10^{-3}} \quad \left[\because n = 2\right] = \frac{3}{2} \times 3 \times 10^{-3} = 4.5mm$

LA: Long Answer Type

25. **(i)** Diffraction of light due to a narrow single slit



Consider a set of parallel rays from a lens L_1 falling on a slit, form a plane wavefront. According to Huygens principle, each point on the unblocked point of plane wavefront AB sends out secondary wavelets in all directions. The secondary waves from points equidistant from the centre C of the slit lying in the portion CA and CB of the wavefront travel the same distance in reaching at O and hence the path difference between them is zero. These secondary waves reinformce each other, resulting maximum intensity at point O.

Position of secondary minima: The secondary waves travelling in the direction making an angle θ with CO, will reach a point P on the screen. The intensity at P will depend on the path difference between the secondary waves emitted from the corresponding points of the wavefront. The wavelets from points A and B will have a path difference equal to BN. If this path difference is λ, then P will be a point of minimum intensity. This is because the whole wavefront can be considered to be divided into two equal halves CA and CB. I the path difference between secondary waves from A and B is λ, then the path difference between secondary waves from A and C will be $\frac{\lambda}{2}$ and also the path difference between secondary waves from A and B is λ, then the path difference between secondary waves from A and C will be $\lambda/2$. Also for every point in the upper half AC, there is a corresponding point in the lower half CB for which the path difference between secondary waves reaching P is $\lambda/2$. Thus, at P destructive interference will take place.

From the right-angled ΔANB given in figure $BN = AB\sin\theta$

$BN = a\sin\theta$

Suppose $BN = \lambda \, and \, \theta = \theta_1$

$\lambda = a\sin\theta_1 \quad ; \quad \sin\theta_1 = \frac{\lambda}{a}$

Such a point on the screen will be the position of the first secondary minimum,

If $BN = 2\lambda \, and \, \theta = \theta_2$, then,

$2\lambda = a\sin\theta_2 \quad ; \quad \sin\theta_2 = \frac{2\lambda}{a}$

Such a point on the screen will be the position of the second secondary minimum.

In general, for n[th] minimum at point P,

$\sin\theta_n = \frac{n\lambda}{a}$

For small $\theta_n, \theta_n = \frac{n\lambda}{a}$ ....(i)

Position of secondary maxima:

If any other P' is such that path difference at point is given by

$$a \sin\theta = \frac{3\lambda}{2}$$

Then P_1 will be position of first secondary maximum. Here, we can consider the wavefront to be divided into three equal parts, so that the path difference between secondary waves from corresponding points in the 1st two parts will be $\lambda/2$. This will give rise to destructive interference. However, the secondary waves from the third part remain unused and therefore, they will reinforce each other and produce first secondary maximum. Similarly if the path difference at that points given by

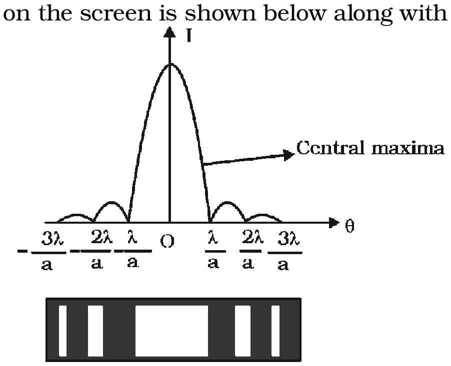
$$a \sin\theta_5 = \frac{5\lambda}{2}$$

We get second secondary maximum of lower intensity.

In general, for nth secondary maximum, we have $a \sin\theta_n = (2n+1)\frac{\lambda}{2}$

For small $\theta_n, \theta_n = (2n+1)\frac{\lambda}{2a}$

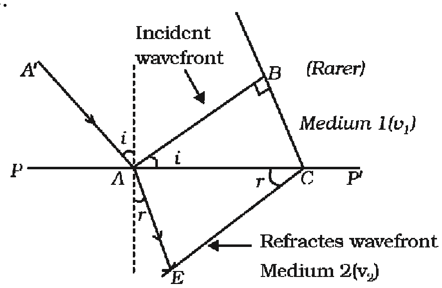
The diffraction pattern on the screen is shown below along with intensity distribution of fringes



(ii) The size of central band reduces by half according to the relation $\frac{\lambda}{a}$. Intensity of the central band will be four times as intensity is proportional to square of slit width.

26. **(i)** According to Huygen's principle, each point on a wavefront is a source of secondary waves, which add up to give a wavefront at any later time.

Snell's law of refraction: Let PP' represents the surface separating medium 1 and medium 2 as shown in figure.



Let v_1 *and* v_2 represents the speed of light in medium 1 and medium 2 respectively. We assume a plane wavefront AB propagating in the direction $A'A$ incident on the interface at an angle i. Let t be the time taken by the wavefront to travel the distance BC.

$$BC = v_1 t$$

In order to determine the shape of the refracted wavefront, we draw a sphere of radius $v_2 t$ from the point A in the second medium (the speed of the wave in second medium is v_2).

Let CE represents a tangent plane drawn from the point C. Then
CE would represent the refracted wavefront.
In ΔABC and ΔAEC, we have

$$\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC} \text{ and } \sin r = \frac{AE}{AC} = \frac{v_2 t}{AC}$$

Where i and r are the angles of incident and refraction respectively.

$$\frac{\sin i}{\sin r} = \frac{v_1 t}{AC}\frac{AC}{v_2 t} = \frac{v_1}{v_2}$$

If c represents the speed of light in vacuum, then

$$\mu_1 = \frac{c}{v_1} \text{ and } \mu_2 = \frac{c}{v_2}$$

Where μ_1 and μ_2 are the refractive indices of medium 1 and medium 2.

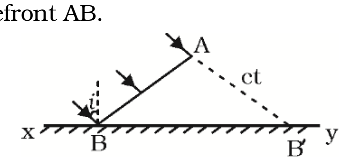
$$\frac{\sin i}{\sin r} = \frac{c/\mu_1}{c/\mu_2} \Rightarrow \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} \Rightarrow \mu_1 \sin i = \mu_2 \sin r$$

This is the Snell's law of refraction.

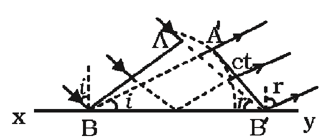
(ii) A source of light sends the disturbance in all the directions and continuous locus of all the particle vibrating in same phase at any instant is called as wavefront. Phase speed is the speed with which a wavefront moved outwards from the source.

Laws of reflection by Huygen's principle:

Let us consider a plane wavefront AB incident on the plane reflecting surface *xy.* Incident rays are normal to the wavefront AB.



Let in time t the secondary wavelets reaches B' covering a distance ct. Similarly from each point on primary wavefront AB. Secondary wavelets start growing with the speed c. To find reflected wavefront after time t, let us draw a sphere of radius ct taking B as center and now a tangent is drawn from B' on the sphere the tangent $B'A'$ represents reflected wavefront after time t.



For every point on wavefront AB a corresponding point lie on the reflected wavefront $A'B'$.
So, comparing two triangle $\Delta BAB'$ and $\Delta B'A'B$

We find that

$AB' = A'B = ct$

$BB' = common$

$\angle A = \angle A' = 90°$

Thus two triangles are congruent, hence $\angle i = \angle r$

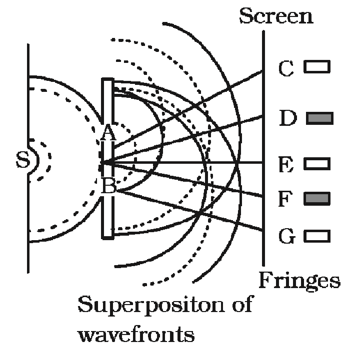
This proves first law of reflection

Also incident rays, reflected rays and normal to them all lie in the same plane. This gives second law of reflection.

27. Young's double slit experiment:

S is a narrow slit (of width about 1 mm) illuminated by a monochromatic source of light, S. At a suitable distance (about 10 cm) from S, there are two fine slits A and B about 0.5 mm apart placed symmetrically parallel to S. When a screen is placed at a large distance (about 2m) from the slits A and B, alternate bright and dark fringes running parallel to the lengths of slits appear on the screen. These are the interference fringes. The fringes disappear when one of the slits A or B is covered.

Expression for fringe width β.



Level - 1	**JEE Main Pattern**

1.(C)

2.(D) Let the angle of refraction be r

Then, Snell's law: $\dfrac{\sin i}{\sin r} = \mu$

The length of the path travelled by the ray inside the glass slab ; $P = \dfrac{t}{\cos r} = \dfrac{\mu t}{\sqrt{\mu^2 - \sin^2 i}}$

So, the time spent by the ray inside the slab ; $T = \dfrac{P}{\left(\dfrac{c}{\mu}\right)} = \dfrac{\mu^2 t}{c\sqrt{\mu^2 - \sin^2 i}}$

3.(B)

- Frequency will remain unchanged $\Rightarrow n_{\text{final}} = n$
- Velocity $\propto \dfrac{1}{\mu} \Rightarrow \text{velocity}_{\text{final}} = \dfrac{v}{\mu}$; $\lambda \propto \dfrac{1}{\mu} \Rightarrow \lambda_{\text{final}} = \dfrac{\lambda}{\mu}$

4.(C)

5.(A) Optical Path difference $(p) = \mu x$ $\therefore$ phase difference $= \dfrac{2\pi}{\lambda} p = \dfrac{2\pi}{\lambda}\mu x$

6.(C)

7.(B) $\dfrac{I_1}{I_2} = n$; $\dfrac{I_{\max}}{I_{\min}} = \left(\dfrac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right) = \left(\dfrac{\sqrt{n}+1}{\sqrt{n}-1}\right)^2$; $\dfrac{I_{\max}-I_{\min}}{I_{\max}+I_{\min}} = \dfrac{4\sqrt{n}}{2(n+1)} = \dfrac{2\sqrt{n}}{n+1}$

8.(C) $\dfrac{I_{\max}}{I_{\min}} = \dfrac{(a_1+a_2)^2}{(a_1-a_2)^2} = \dfrac{25}{1} \Rightarrow \dfrac{a_1+a_2}{a_1-a_2} = \dfrac{5}{1} \Rightarrow 5a_1 - 5a_2 = a_1 + a_2 \Rightarrow 4a_1 = 6a_2 \Rightarrow a_1 = \dfrac{3}{2}a_2$

$\dfrac{I_1^2}{I_2^2} = \dfrac{a_1^2}{a_2^2} = \left(\dfrac{3}{2}a_2^2\right)^2 \cdot \dfrac{1}{a_2^2} = \dfrac{9}{4}$

9.(A) At any point on a wavefront, light ray is along normal. **10.(B)**

11.(C) The wavefront due to any source situated at infinity is planar.

12.(B) For example, if a wave travelling in air is incident on a glass slab, then the wave that reflects acquires a phase difference of π.

13.(B) We already know from ray optics that a glass slab shifts rays coming from a point source, and this shift is such that the emergent rays are "effectively" coming from a point between the source and the slab. In other words, if viewed from the other side, the apparent position of the source is closer to the slab than its actual position.

This means that due to the introduction of the slab, the source has shifted closer as seen from "the point of view of the screen".
So, the given source, together with the slab, is functioning like an identical source kept closer than the given source.
Hence, the brightness at any point on the screen will increase due to the introduction of the slab.

14.(A) Wavefront is the locus of all points, where the particles of the medium vibrate with the same phase.

15.(C) Light undergoes interference, diffraction, and polarization. These phenomena establish that light is a wave motion. Therefore, out of the options, reflection isn't a suitable phenomenon to establish that light is wave motion

16.(C) Since, $\lambda \propto \frac{1}{\mu}$ and $\mu_{water} > \mu_{air}$, and $\omega \propto \lambda$ $\Rightarrow$ fringe width will decrease.

17.(B) $\frac{\omega_1}{\omega_2} = \frac{\lambda_1}{\lambda_2} \Rightarrow \omega_2 = \left(\frac{\lambda_2}{\lambda_1}\right)\omega_1 = 3.2\,\text{mm}$

18.(B) fringe width$_1 = \frac{D_1\lambda}{d}$; fringe width$_2 = \frac{D_2\lambda}{d}$

Change in fringe width $= \frac{5\times10^{-2}\times\lambda}{10^{-3}} = 3\times10^{-5}$ $\Rightarrow$ $\lambda = 6.0\times10^{-7}m$

19.(B) $I = 4I_0\cos^2\left(\frac{\Delta\phi}{2}\right)$ $\because$ at central maximum, $\Delta\phi = 0$

$I = 4I_0$ $\therefore$ $\frac{I}{I_0} = 4:1$

20.(D) $d = 5\times10^{-4}m$; $D = 1.0m$ $I = I_0\cos^2\left(\frac{\Delta\phi}{2}\right)$

In case I : $\Delta\phi = 0$

In case II : Path difference $= \frac{xd}{D} \pm t(\mu-1)$

$\left(\frac{\Delta\phi}{2}\right) = \left(\frac{\pi}{\lambda}\right)\times(\text{path diff.}) = \left(\frac{\pi}{\lambda}\right)\times(t(\mu-1)) = \frac{\pi\times5\times10^{-6}\times0.5}{500\times10^{-9}} = 5\pi$ $\Rightarrow$ $I = I_0\cos^2(5\pi) = I_0$

21.(D) $d = 1mm$; $D = 1.33m$; $\lambda_{air} = 6300\text{Å}$

$\lambda_{liquid} = \lambda_{air}\times\left(\frac{\mu_{air}}{\mu_{liquid}}\right) = 6300\times\frac{1}{1.33}\text{Å}$ $\therefore$ fringe width $= \frac{D\lambda_{liquid}}{d}$

$= \frac{1.33\times6300\times10^{-10}}{1\times10^{-3}\times1.33}m = 0.63mm$

22.(B) $\frac{I_{max}}{I_{max}} = \frac{(a_1+a_2)^2}{(a_1\sim a_2)^2} \Rightarrow \frac{4}{1} = \frac{(a_1+a_2)^2}{(a_1\sim a_2)^2} \Rightarrow \frac{a_1+a_2}{a_1\sim a_2} = \frac{2}{1} \Rightarrow a_1+a_2 = 2a_1-2a_2 \Rightarrow 3a_1 = a_1 \Rightarrow \frac{a_1}{a_2} = \frac{3}{1}$

23.(D) $\sin\theta = \frac{n\lambda}{d} = \frac{3\times589\times10^{-9}}{0.589} = 3\times10^{-6}$. $\Rightarrow \theta = \sin^{-1}\left(3\times10^{-6}\right)$

24.(C) $\beta = \frac{\lambda D}{d} \Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}.\frac{d_2}{d_1} = \left(\frac{\lambda_1}{2\lambda_1}\right).\left(\frac{d_1/2}{d_1}\right) \Rightarrow \frac{\beta_1}{\beta_2} = \frac{1}{2}\times\frac{1}{2} = \frac{1}{4} \Rightarrow \beta_2 = 4\beta_1 \Rightarrow \frac{\beta_2}{\beta_1} = 4$

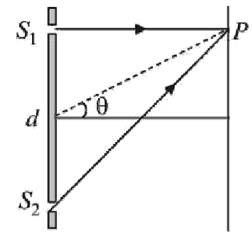
25.(A) $(\mu-1)t = n\lambda \Rightarrow t = \frac{n\lambda}{(\mu-1)} = \frac{1\times\lambda}{(1.5-1)} = 2\lambda$

26.(D) $n_2\lambda_2 = n_1\lambda_1 \therefore \lambda_2 = \frac{n_1\lambda_1}{n_2} = \frac{3\times700}{5} = 3\times140 = 420\,mm$

27.(D) The position of the maximum intensity in Young's two slits experiment is $x_n = \frac{n\lambda D}{d}$ where D is the distance between the slits and n is the order of the point for two wavelengths $n_1\lambda_1 = n_2\lambda_2$

$3 \times 600\text{Å} = 4 \times \lambda_2 \Rightarrow \lambda_2 = 4500\text{Å}$.

28.(C) $S_2P - S_1P = \frac{dy}{D} = \frac{d \times (d/2)}{D} = \frac{d^2}{2D}$; $\frac{d^2}{2D} = n\lambda$



$\lambda = \frac{d^2}{2nD}, n = 1, 2, ...$

$\lambda = \frac{d^2}{2D}, \frac{d^2}{4D}, \frac{d^2}{6D}$

29.(D) $n\lambda = (\mu - 1)t = \frac{n_2}{n_1} = \frac{t_2}{t_1} \Rightarrow t_2 = \frac{n_2}{n_1}t_1 \Rightarrow t_2 = \frac{20}{30} \times 4.8 = 3.2mm$

30.(B) We know that $I = I_0 \cos^2\left(\frac{\Delta\phi}{2}\right) = I_0 \cos^2\left(\pi\left(\frac{y}{\beta}\right)\right)$

We are given that $I = \frac{I_0}{4} \Rightarrow \cos\left(\pi\left(\frac{y}{\beta}\right)\right) = \pm\frac{1}{2}$

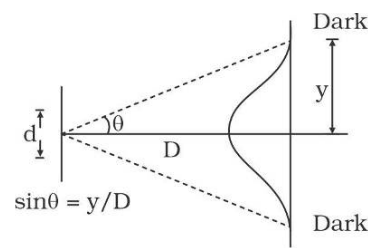
$\Rightarrow \pi\left(\frac{y}{\beta}\right) = -\frac{5\pi}{3}, -\frac{4\pi}{3}, -\frac{2\pi}{3}, -\frac{\pi}{3}, \frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3} ...$

$\Rightarrow y = -\frac{5\beta}{3}, -\frac{4\beta}{3}, -\frac{2\beta}{3}, -\frac{\beta}{3}, \frac{\beta}{3}, \frac{2\beta}{3}, \frac{4\beta}{3}, \frac{5\beta}{3} ...$

So, the closest separation between any two such points, $\Delta y_{min} = \frac{2\beta}{3} - \frac{\beta}{3} = \frac{\beta}{3}$

31.(D) For first dark fringe on either side. $d \sin\theta = \lambda$

Or $\frac{dy}{D} = \lambda$ $\therefore$ $y = \frac{\lambda D}{d}$



Therefore, distance two dark fringes on either side

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

Substituting the vales, we have

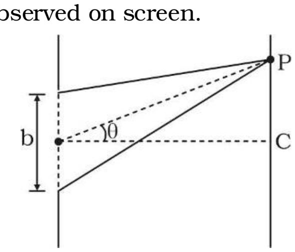
Distance $= \frac{2(600 \times 10^{-6} mm)(2 \times 10^3 mm)}{(1.00\ mm)} = 2.4\ mm$

32.(D)

33.(D) If we increase the slit width, the envelope of the fringe pattern changes so that its central peak is sharper. The fringe spacing which depends on slit separation does not change. Hence, less interference maxima fall within the central diffraction maximum.

34.(A) **(i)** If $\lambda << b, \sin\theta = \theta \to 0$

So, spreading of light will take place. Hence, no diffraction pattern is observed on screen. But a sharp image of slit is found on screen.



(ii) If $\lambda < b, 0 < \theta < \frac{\pi}{2}$

So, diffraction pattern is found on screen.

(iii) If $\lambda = b, \theta \to \frac{\pi}{2}$, so central maximum will extend from $-\frac{\pi}{2}$ to $\frac{\pi}{2}$.

(iv) If $\lambda = b, \sin\theta = \frac{\lambda}{b} > 1$, which is not realistic.

Hence, (i) → (Q, R) (ii) → (P) (iii) → (Q, S) (iv) → (Q)

35.(B) The angular limit of resolution is equal to the angular separation between the centre of central maximum and first minimum.

36.(B) $\because$ b sin $= \pm \lambda$ (for central maxima), when the b decreases, θ increases. So central maxima becomes wider.

37.(D) Polarisation takes place in transverse wave, but not in sound wave.

38.(B) $I = I_0 \cos^2 45°$; $kA'^2 = kA^2 \cos^2 45°$

$A'^2 = \dfrac{A^2}{2}$ $\therefore$ $A' = \dfrac{A}{\sqrt{2}}$

39.(B) $B_0 = E_0 / c, E_0$ and B_0 should be mutually perpendicular.

40.(B) Here, $\tan\theta = \dfrac{E_2}{E_1} =$ constant. Thus, wave is plane polarised.

41.(A) All the vibrations of unpolarised light at a given instant can be resolved in two mutually perpendicular direction.

42.(A) If incident light is unpolarised, then as vibrations are equally probable in all directions.

$\therefore$ $< I > = < I_0 \cos^1\theta >$; $= I_0 < \cos^2\theta > = \dfrac{I_0}{2}$

43.(C) $x_n = \dfrac{nf\lambda}{a}$ $\Rightarrow$ $\lambda = \dfrac{ax_n}{fn} = \dfrac{3\times10^{-4}\times5\times10^{-3}}{3\times1} = 5000\,\mathring{A}$ $[\because n = 3]$ **44.(C)**

45.(D) Longitudinal wave never be polarised.

46.(5) Fringe width, $\beta = \dfrac{\lambda D}{d} = \dfrac{(500\times10^{-9})(6)}{0.2\times10^{-3}} = 15\ mm$

If I_0 is the maximum intensity on the screen, then intensity at a point is

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

So, if $I = \dfrac{1}{4} I_0$, then $\cos^2\left(\dfrac{\Delta\phi}{2}\right) = \dfrac{1}{4}$

$\Rightarrow$ $\cos\left(\dfrac{\Delta\phi}{2}\right) = \pm\dfrac{1}{2}$ $\Rightarrow$ $\dfrac{\Delta\phi}{2} = \dfrac{\pi}{3}, \dfrac{2\pi}{3}, \dfrac{4\pi}{3}, OR\ \dfrac{5\pi}{3}$

$\Rightarrow$ $\Delta\phi = \dfrac{2\pi}{3}, \dfrac{4\pi}{3}, \dfrac{8\pi}{3}, OR\ \dfrac{10\pi}{3}$

Since we can always add or subtract 2π from the phase angle, we get only two unique values of $\Delta\phi$, which are $\dfrac{2\pi}{3}$ *and* $\dfrac{4\pi}{3}$.

So, the distance between two closest such points,

$$L = \frac{\beta}{2\pi}\left(\frac{4\pi}{3} - \frac{2\pi}{3}\right) = \frac{\beta}{3} = 5\ mm$$

47.(10) Shift on screen due to introduction of sheet,

$$S = \frac{Dt(\mu-1)}{d} = \frac{(2)(10^{-4})(1.5-1)}{10^{-3}} = 10\ cm$$

48.(100)

Fringe width, $\beta = \dfrac{\lambda D}{d}$ $\Rightarrow$ $d = \dfrac{\lambda D}{\beta} = \dfrac{(500\times10^{-9})(2)}{(0.01)} = 100\ \mu m$

49.(2.5) Path difference, $\Delta P = \frac{yd}{D} \quad \Rightarrow \quad y = \frac{(\Delta P)D}{d}$

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

So, $\frac{y}{\beta} = \frac{\Delta P}{\lambda} = \frac{5}{2}$

50.(51) Extra path difference due to transparent sheet,

$$\Delta P_{extra} = t(\mu - 1)$$

If the interference shifts by 5 fringe widths, this extra path difference must be equal to 50λ

Therefore, $\mu = \frac{50\lambda}{t} + 1 = \frac{(50)(510 \times 10^{-9})}{(50 \times 10^{-6})} + 1 = 1.51$

51.(2) As we know, $\beta = \lambda D / d$. In this question, we need to find $2 \times \beta$.

Therefore, $\beta = 500\ nm / 0.5mm$

= mm

Now, Separation between the second bright fringe on both sides of the central maxima = 2 × 1mm = 2mm

52.(450) For maximum, the path difference, $\Delta P = n\lambda$

$$\Rightarrow \quad \frac{yd}{D} = n\lambda \Rightarrow \quad \frac{(2 \times 10^{-2})(2 \times 10^{-4})}{2} = n\lambda \quad \Rightarrow \quad \lambda = \frac{2000\ nm}{n}$$

Therefore, the series of wavelengths that form a maximum at the given point is 2000, 1000, $\frac{2000}{3}$, 500, 400, and so on.

53.(1.6) Let the intensities reaching the screen from the two slits be I_1 *and* I_2 $(I_1 > I_2)$

Then, we know that $I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$ *and* $I_{\min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

We are given that $\frac{I_{\max}}{I_{\min}} = 4$; Solving, we get $\frac{I_1}{I_2} = 9$

Now, the phase difference at a point mid-way between a maximum and a minimum is $\Delta\phi = n\pi + \frac{\pi}{2}$

So, the intensity at this point, $I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos(\Delta\phi) = I_1 + I_2$

Therefore, $\frac{I_{\max}}{I} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{I_1 + I_2} = \frac{\left(\sqrt{\frac{I_1}{I_2}} + 1\right)^2}{\frac{I_1}{I_2} + 1} = \frac{16}{10}$

54.(24) Angular fringe width $= \frac{\beta}{D} = \frac{\lambda}{d} = \frac{480 \times 10^{-9}}{2 \times 10^{-4}} = 2.4 \times 10^{-4}\ rad$

55.(500)

At the point where the sixth order maximum is formed, the phase difference is $6(2\pi) = 12\pi$

At a point on the screen located at a distance y from the central maximum, the phase difference,

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

Therefore, $\lambda = \left(\frac{2\pi}{\Delta\phi}\right)\left(\frac{yd}{D}\right) = \left(\frac{2\pi}{12\pi}\right)\left(\frac{(0.03)(0.2\times10^{-3})}{2}\right) = 500\ nm$

56.(2) Separation between the slit d = 3 λ

So fringe width $p = \frac{\lambda D}{d} = \frac{\lambda D}{3\lambda} = \frac{D}{3}$

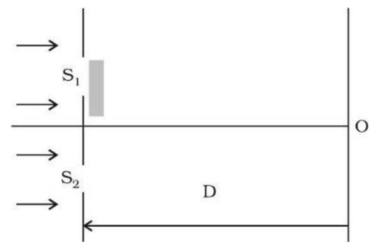
When A thin film of thickness 3 and refractive index 2 has been placed in front of the upper slit then distance of the central maxima on the screen from O is

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

here $\beta = \frac{D}{3}$, $t = 3\lambda$ and $\mu = 2$

So distance $x = \frac{D}{3\lambda}(2-1)\times 3\lambda$

$x = D$



57.(6) Path difference between waves reaching at P

$= S_1B$ (10 fringes) ; $= 10\lambda = 10\times 6000\times 10^{-10}$; $= 6\times10^{-6}$ m

58.(3) As we know, fringe width, $\beta = \lambda D/d$, where D is the distance between the slits and the screen and d is the distance between the slits.

Now, $\beta' = \lambda' D/d$

$\beta'/\beta = \lambda'/\lambda$; $\beta' = \beta/\mu$; $= 3.6\ \text{mm}/1.2$; $= 3$ mm.

59.(7) For violet light we have ; $y_v = \frac{n_v\lambda_v}{d}$

For red light we have, $y_r = \frac{n_r\lambda_r D}{d}$

For violet fringe to overlap with red fringe.

$y_v = y_r$

$\frac{n_v\lambda_v D}{d} = \frac{n_r\lambda_r D}{d} \Rightarrow \frac{n_v}{n_r} = \frac{\lambda_r}{\lambda_v} = \frac{700}{400}$; $\frac{n_v}{n_r} = \frac{7}{4} = \frac{14}{8} = \frac{21}{12} = \frac{28}{16} = \ldots\ldots\ldots$

Minimum 7th violet fringe overlaps with 4th red fringe.

60.(30) In this case, the path difference is given by

$\Delta x = \frac{xd}{D} + (d\sin\phi) - \left(\frac{3}{2}-1\right)(0.1\times10^{-3})$

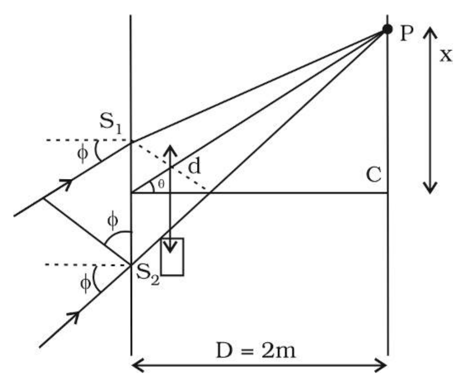
At central maxima path difference is = 0

$\frac{xd}{D} + d\sin\phi - 5\times10^{-5} = 0$

$\frac{xd}{D} = -d\sin\phi + 5\times10^{-5}$

$\frac{x(50\times10^{-6})}{2} = -50\times10^{-6}\times\frac{1}{2} + 5\times10^{-5}$

$x = -1 + \frac{5\times10^{-5}\times2}{50\times10^{-6}} = 1$ m ; $\sin\theta = \frac{x}{D} = \frac{1}{2}$; $\theta = 30°$



Level - 2	**JEE Advanced Pattern**

61.(B) We can draw normals and deduce quite easily that $\angle P'PQ$ is the angle of incidence *i*, and $\angle PQQ'$ is the angle of refraction *r*.

Therefore, $P'Q = PQ \sin i$ *and* $PQ' = PQ \sin r$

So, $\dfrac{P'Q}{PQ'} = \dfrac{\sin i}{\sin r} = \dfrac{\mu_2}{\mu_1}$

62.(1) Rewriting the second wave as a sine function, we get

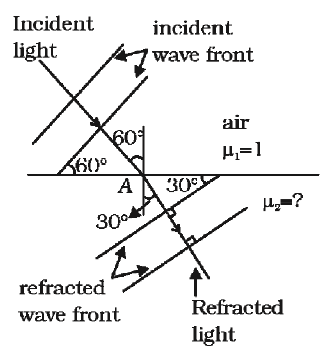
$y_1 = A\sin\left(\frac{\pi}{6}z + 4\pi t + \frac{\pi}{6}\right)$ *and* $y_2 = A\sin\left(\frac{\pi}{4}x + 4\pi t + \frac{5\pi}{6}\right)$

At the point $(2,0,-1)$, the waves become $y_1 = A\sin(4\pi t)$ *and* $y_2 = A\sin\left(\frac{4\pi}{3} + 4\pi t\right)$

Notice that the frequency of the waves is the same. This makes the phase difference between them constant with time. This phase difference is clearly $\Delta\phi = \frac{4\pi}{3}$

So, the resultant intensity, $I_R = \sqrt{I^2 + I^2 + 2I^2\cos(\Delta\phi)} = I$

63.(B) Light ray is along normal at any point on a wavefront.

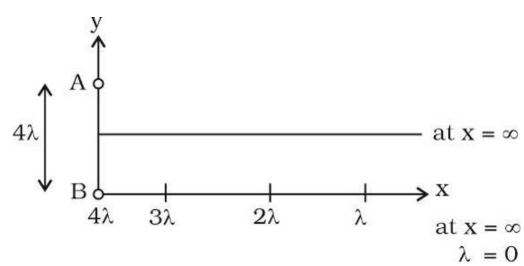


$\dfrac{\sin i}{\sin r} = \dfrac{\mu_2}{\mu_1} = \dfrac{\mu_1}{1}$

$\dfrac{\sin 60°}{\sin 30°} = \dfrac{\mu_2}{1}$

$\mu_2 = \dfrac{\sqrt{3}/2}{1/2} = \sqrt{3}$

64.(3)



Maximum path difference = 4 λ

maximum occurs at Δ x = 4 λ , 3 λ , 2 λ , λ , 0

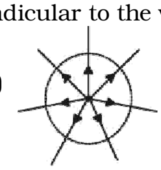
Now, first term and last term excluded.

So three maxima.

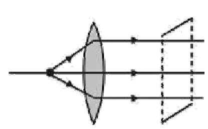
65. **[A-q]** **[B-p]** **[C-p]** **[D-p]**

To drawn the shape of wavefront, drawn the ray diagram. The light will propagate in a direction perpendicular to the wavefronts.

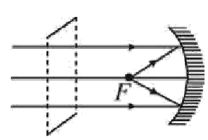
(A)



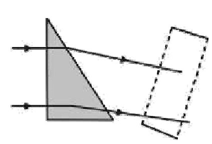
(B)



(C)



(D)



66.(ABD) (A) $\lambda_{air} = 589\,nm$ $\therefore f_{air} = \dfrac{v_{air}}{\lambda_{air}} = \dfrac{3\times10^8}{589\times10^{-9}} = 5.09\times10^{14}\,Hz$; Option (A) is correct

(B) Wavelength in water, $\lambda_w = \frac{\lambda_{air}}{\mu_w} = \frac{589}{1.33} \approx 433nm$; Option (B) is correct

(C) Frequency in water = frequency in air = $5.09\times10^{14}\ Hz$; Option (C) is incorrect

(D) Speed of light in water, $v_w = \frac{v_{air}}{\mu_w} = \frac{3\times10^8}{1.33} = 2.25\times10^8 m/\sec$; Option (D) is correct

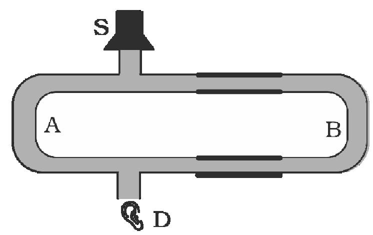
67.(AC) In general, when a beam of light is incident on the interface between two mediums, part of the intensity gets transmitted into the next medium and part of it gets reflected back into the first medium.

If $\theta > \theta_c$, then the beam undergoes total internal reflection, which means that all the incident intensity gets reflected and there is no transmitted beam.

And, as a consequence of the conservation of energy, $I_R + I_T = I$ *in all cases*.

So, $$\frac{P'Q}{PQ'} = \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$$

68.(5) Between successive maxima and minima, the path difference is $\frac{\lambda}{2}$



$$2\times1.65\times10^{-2} = \frac{\lambda}{2}$$

$$\lambda = 4\times1.65\times10^{-2} = 6.6\times10^{-2}m$$

$$f = \frac{v}{\lambda} = \frac{330}{6.6\times10^{-2}} = 5000Hz = 5\times10^3 Hz$$ Ans is 5

69.(B) P to Q: convergence increasing: Q to R: direction changing.

70.(7) I is the intensity of incident beam ab. The interfering waves are bc and ef, reflected from surface of I and II plate, respectively.

Reflection coefficient of intensity ; $r = 25\% = 0.25$

Transmission coefficient of intensity ; $t = 75\% = 0.75$

The intensity of beam bc, $I_1 = 0.25I = \frac{1}{4}I$; The intensity of beam bd = 0.75I

The intensity of beam de = $0.25\times0.75I$

The intensity of beam ef ; $I_2 = 0.75\times0.25\times0.75I = \frac{9}{64}I$

Ratio of maximum and minimum intensities

$$\frac{\sqrt{I_{max}}}{\sqrt{I_{min}}} = \frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}} = 7$$

71.(D) Path difference $= d\sin\phi + d\sin\theta$; For maxima, $\Delta x = m\lambda \Rightarrow \sin\phi + \sin\theta = \frac{m\lambda}{d}$

72.(AB) Let the intensity leaving any one slit be I

So, the intensity at point Q after one of the slits is covered with an opaque sheet is I itself, and therefore the intensity at point Q in the interference pattern with both slits open is also I

Let the phase difference at the point be $\Delta\phi$

Then, $I_Q = I + I + 2I\cos(\Delta\phi) = I \Rightarrow \cos(\Delta\phi) = -\frac{1}{2} \Rightarrow \Delta\phi = (2n-1)\pi \pm \frac{\pi}{3}$

Now, the path difference, $\Delta P = d\sin\theta = \left(\frac{\lambda}{2\pi}\right)(\Delta\phi)$

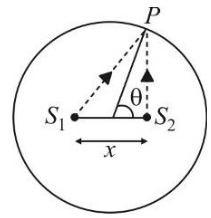
Combining the equations, we get the angular position of Q,

$$\theta = \sin^{-1}\left(\frac{\lambda}{2d}\left(2n-1\pm\frac{1}{3}\right)\right)$$

Therefore, the series of values of θ *is:*

$$\sin^{-1}\left(\frac{\lambda}{3d}\right), \sin^{-1}\left(\frac{2\lambda}{3d}\right), \sin^{-1}\left(\frac{4\lambda}{3d}\right), \sin^{-1}\left(\frac{5\lambda}{3d}\right), \sin^{-1}\left(\frac{7\lambda}{3d}\right), \sin^{-1}\left(\frac{8\lambda}{3d}\right), \ldots$$

73.(A) Path difference at P is $\Delta x = 2\left(\frac{x}{2}\cos\theta\right) = x\cos\theta$



For intensity to be maximum,

$$\Delta x = n\lambda \qquad (n = 0, 1, 2, 3, \ldots)$$

Or $\quad x\cos\theta = n\lambda \quad$ Or $\quad \cos\theta = \frac{n\lambda}{x} \le 1$

$\therefore \quad n \ge \frac{x}{\lambda}$

Substituting $x = 5\lambda$, we get $n \ge 5$ or $n = 1, 2, 3, 4, 5, \ldots$.

Therefore, in all four quadrants there can be 20 maxima. There are more maxima at $\theta = 0^\circ$ and $\theta = 180^\circ$.

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

74.(A) When mica sheet of thickness t and refractive index μ is introduced in the path of one of the interfering beams, optical path increases by $(\mu - 1)t$. therefore, the shift on the screen is given by :

$$y_0 = \frac{D}{d}(\mu - 1)t \qquad \ldots\ldots\ldots \text{(i)}$$

When the distance between the plane of slits and screen is changed from D to $2D$, then

$$\beta = \frac{2D}{d}\lambda \qquad \ldots\ldots\ldots \text{(ii)}$$

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

75.(AC) When considering points close to the central maximum, we can use the readymade formulae for angular fringe width and fringe width, i.e. $\frac{\lambda}{d}$ *and* $\frac{\lambda D}{d}$.

But these formulae are based on the assumption that if θ is the angular position of a point, then $\tan\theta \approx \sin\theta \approx \theta$. Obviously, this approximation fails if we are analysing points whose angular position is large.

So, we must start from the basic fact that the path difference at a point with angular position θ is $d\sin\theta$.

So, at $\theta = 30^o$, the path difference, $\quad \Delta P = d\sin 30^o = \frac{d}{2}$

Let us assume that at this point, the n^{th} order maximum is formed. Then,

$$\Delta P = \frac{d}{2} = n\lambda \qquad \Rightarrow \qquad n = \frac{d}{2\lambda}$$

But, we are already given that close to the central maximum, the fringe width is $\Delta\theta_0 = 0.0025\ rad.$ Therefore, using the readymade formula, we get

$$\frac{\lambda}{d} = 0.0025$$

So, we get $\quad n = \frac{1}{2(0.0025)} = 200$

So, the total number of maxima formed between (and including) the two points with angular position $\theta = 30^o$ on either side of the central maximum is 2(200) + 1 = 401.

And since between two points of maximum, there are two points of half intensity, there are 800 such points within the given range.

76.(3) Path difference at *C*,

$$\Delta x = t_1(\mu-1) - t_2(\mu-1) = \mu(t_1 - t_2) - (t_1 - t_2) = (t_1 - t_2)(\mu - 1) = (2.5 - 1.25)\left(\frac{1.4\times 3}{4\times 10} - 1\right)$$

$$= 1.25 \times \frac{2}{40} = \frac{2.5}{400} \Rightarrow \Delta x = \frac{1}{16}\mu m$$

$$\phi = \frac{2\pi}{\lambda}\cdot\Delta x = \frac{2\pi\times 4}{5000\times 3\times 10^{-10}}\cdot\frac{1}{16}\times 10^{-16} \qquad \Rightarrow \qquad I_{max} = 4I_0$$

I at C, $I_c = 2I_0(1+\cos\frac{\pi}{3}) = 3I_0$; Required ratio $I_c / I_0 = 3$

77.(ABCD) Δx at $O = d$ [path difference is maxima at *O*]

So, if $d = \frac{7\lambda}{2}, O$ will be minima. If $d = \lambda, O$ will be maxima. If $d = \frac{5\lambda}{2}, O$ will be minima and hence intensity is minimum. If $d = 4.8\lambda$, then total 10 minima can be observed on the screen, 3 above *O* and 5 below *O*, which correspond to $\Delta x = \pm\frac{\lambda}{2}, \pm\frac{3\lambda}{2}, \pm\frac{5\lambda}{2}, \pm\frac{7\lambda}{2}, \pm\frac{9\lambda}{2}$.

78.(BC) $\beta_2 = \frac{\lambda D}{d} = 2\frac{\lambda_1}{d}D$; As $\beta_1 = \frac{\lambda_1}{d}D$

n^{th} Order maxima of λ_2 coincides with $2n^{th}$ order maxima of λ_1.

n^{th} Order minima of λ_2 does not coincide with $2n^{th}$ order maxima of λ_1.

79.(D) When considering points close to the central maximum, we can use the readymade formulae for angular fringe width and fringe width, i.e. $\frac{\lambda}{d}$ *and* $\frac{\lambda D}{d}$.

But these formulae are based on the assumption that if θ is the angular position of a point, then $\tan\theta \approx \sin\theta \approx \theta$. Obviously, this approximation fails if we are analysing points whose angular position is large.

So, we must start from the basic fact that the path difference at a point with angular position θ is $d\sin\theta$.

If the distance of a point on the screen, measured from the central maximum, is *y*, and the path difference at this point is *P*, then the fringe width is just $\frac{\lambda}{\left(\frac{dP}{dy}\right)}$. Here, $\left(\frac{dP}{dy}\right)$ denotes the derivative of *P* with respect to y. In other words, the fringe width is an answer to the question – "how much distance do we need to move along the screen so that the path difference changes by one wavelength?"

For points close to the central maximum, the path difference is approximated as $\frac{yd}{D}$, so the derivative of path difference w.r.t. *y* just becomes $\frac{d}{D}$, which is constant. And therefore, the fringe width, $\frac{\lambda D}{d}$ is a constant. But this approximation is not valid if we move to points with large angular positions.

We know that for a point with angular position θ,

$$P = d\sin\theta \qquad and \qquad y = D\tan\theta$$

Therefore, $$\frac{dP}{dy} = \frac{d}{D}\cos^3\theta$$

So, the fringe width close to this point,

$$\beta = \left(\frac{\lambda D}{d}\right)\left(\frac{1}{\cos^3\theta}\right) = \frac{\beta_0}{\cos^3\theta}$$

80. **[A-r]** **[B-r]** **[C-s]** **[D-p]**

By using $(\mu-1)t = n\lambda$, we can find value of *n*, that is order of fringe produced at *P*, if that particular strip has been placed of fringe produced at *P*, if that strips are used in conjunction (over each other), path difference due to each is added to get net path difference created. If two strips are used over different slits, their path differences are subtracted to get net path difference. Now,

$$n_1 = \frac{(\mu_1 - 1)t_1}{\lambda} = 5 \; ; n = 4.5 \; ; n_3 = 0.5$$

For (a), order of the fringe is 4.5 *i.e.*, fifth dark.

For (b), net order is $5 - 0.5 = 4.5$, i.e., fifth dark.

For (c), net order is $5 - (0.5 + 4.5) = 0$, i.e., it is central bright again at *P*.

For (d), net order is $(5 + 0.5) - 4.5 = 1$, i.e., first bright.

81.(C) According to theory of diffraction at circular aperture.

$$\theta = 1.22\frac{\lambda}{d} = 1.22 \times \frac{7\times10^{-7}}{3\times10^{-3}} = 2.85\times10^{-5}\,rad$$

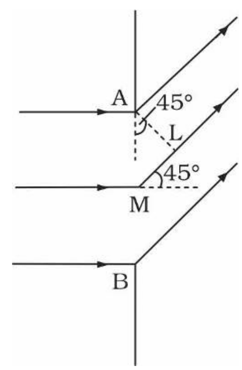
Now, if *r* is radius of image formed by the lens at the focus, $\theta = (r / f)$

$$r = f\theta = (5\times10^{-2})\times(2.85\times10^{-4}) \quad = 14.25\times10^{-6}m$$

and so, $A = \pi r^2 = 3.14(14.25\times10^{-6})^2 = 6.4\times10^{-10}m^2$

and so, $I = \frac{E}{St} = \frac{P}{S} = \frac{10\times10^{-3}}{6.4\times10^{-10}} = 15.6\frac{MW}{m^2} = 1.56\frac{kW}{cm^2}$

82.(C) Path difference of secondary waves emitted by the top end and the midpoint of the slit, for angle of diffraction 45°, will be LM.



In $\Delta ALM, \frac{LM}{AM} = \sin 45°$ $\quad\therefore\quad$ $LM = AM\sin 45°$

$$= \frac{AB}{2}\sin 45°$$

$$= \frac{0.3}{2}\times\frac{1}{\sqrt{2}}mm$$

[AB = 0.3 *mm*, given]

$LM = 1.06\times10^{-4}m$

Thus the path difference

$\Delta = 1.06\times10^{-4}m$

83.(C) Phase difference $\phi = \frac{2\pi}{\lambda}\times\text{Path difference}(\Delta)$

$$= \frac{2\pi}{6000\times10^{-10}}\times1.06\times10^{-4} = 353.33\pi$$

84.(B) If unpolarized light is passed through a polaroid P_1, its intensity will become half.

So $I_1 = \frac{1}{2}I_0$ with vibrations parallel to the axis of P_1.

Now this light will pass through the second polaroid P_2 whose axis is inclined at an angle of 30° to the axis of P_1 and hence, vibrations of I_1. So in accordance with Malus law, the intensity of light emerging from P_2 will be:

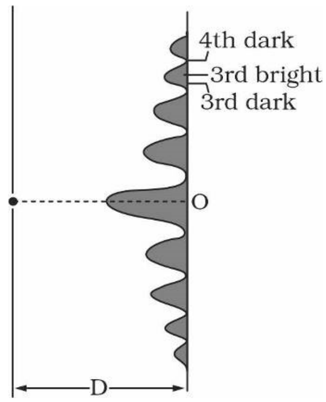
$$I_2 = I_1\cos^2 30° = \left(\frac{1}{2}I_0\right)\left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{8}I_0$$

So the fractional transmitted light

$$\frac{I_2}{I_0} = \frac{3}{8} = 37.5\%$$

85.(C) Distance between positions of zero intensity on both sides of central maximum is also the width of central maximum. Here it is 3.5mm, i.e, $3.5\times10^{-3}m$

Width of cental maximum $=\dfrac{2\lambda D}{d}$



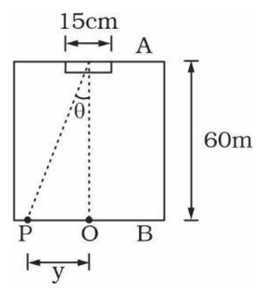
$\therefore \quad 3.5\times10^{-3}=\dfrac{2\times5890\times10^{-10}\times12}{d}$

$d = 0.0004\ m$

$\therefore$ Width of slit $d = 0.4\ mm$

86.(39.6)

Wavelength of sound waves can be obtained from the relation,



$v=f\lambda$

$f=4000\,Hz$

$v=330\,m\,/\,\text{sec}$

$\therefore \quad \lambda=\dfrac{v}{f}=\dfrac{330}{4000}$

$=0.0825m$

Or $\lambda=8.25\,cm$

Condition for minima in case of diffraction at a single slit can be expressed as

$d\sin\theta=n\lambda$

For first order minimum, $n=1$

$\therefore \quad d\sin\theta=\lambda$

and $\sin\theta=\dfrac{\lambda}{d}=\dfrac{8.25}{15}$

$\theta=33.4°$

Thus angle of diffraction for first order minimum is 33.4°.

In Figure 'P' is any point along the wall 'B' and $\tan\theta=\dfrac{y}{60}$

If P is at the position of first order minimum, $\theta=33.4°$

$\therefore \quad \tan 33.4°=\dfrac{y}{60}$

or $y=60\tan 33.4°=33.6\,m$

First order minimum will be formed on both sides of O at distance 39.6 *m*.

87.(440)

In a single slit diffraction experiment, position of minima is given by

$d\sin\theta=n\lambda$

So for first minima of red,

$\sin\theta = 1\times(\lambda_R / d)$

And as first maxima is midway between first and second minima, for wavelength λ' its position will be:

$d\sin\theta' = \dfrac{\lambda' + 2\lambda'}{2}$, *i.e.*, $\sin\theta' = \dfrac{3\lambda'}{2d}$

But according to given problem.

$\sin\theta = \sin\theta'$, *i.e.* $\lambda' = (2/3)\lambda_R$

So, $\lambda' = (2/3)\times 660\,nm = 440\,nm$

88.(5) The transmitted intensity of unpolarized light will be constant for all the orientations of the polarized sheet whereas intensity of polarized light will be expressed by the law of Malus,

$I'_P = I_P.\cos^2\theta$ [I_P and I_0 are the intensities of the polarized and unpolarized components in the incident beam, respectively.

Let us consider the intensity of transmitted, polarized and unpolarized components to be $I'_P = 0$ and for $\theta = 0°$, $I'_P = I'_P$ while for all orientations $I'_0 = \dfrac{I_0}{2}$

From given condition,

$I_{max} = I_P + \dfrac{I_0}{2}$ when $\theta = 0°$

and $I_{min} = \dfrac{I_0}{2}$ when $\theta = \pi/2$

$\therefore$ $I_P + \dfrac{I_0}{2} = 4.\dfrac{I_0}{2}$ Or $I_P = \dfrac{3I_0}{2}$

i.e. $\dfrac{I_P}{I_0} = \dfrac{3}{2}$

For $\theta = 45°, I = I_P\cos^2 45° + \dfrac{I_0}{2}$

$= \dfrac{3I_0}{2}\times\dfrac{1}{2} + \dfrac{I_0}{2}$

$= \dfrac{5I_0}{4}$

89.(A) If θ is the angle between the transmission axes of first polaroid P_1 and second P_2 polaroid while ϕ between the transmission axes of second polaroids P_2 and P_3, then according to given problem,

$\theta + \phi = 90°$ *or* $\phi = (90° - \theta)$ **. . . (i)**

Now if I_0 is the intensity of unpolarized light incident on polaroid P_1, the intensity of light transmitted through it,

$I_1 = \dfrac{1}{2}I_0 = \dfrac{1}{2}(32) = 16\,W/m^2$ . . . .(ii)

Now as angle between transmission axes of polaroids P_1 and P_2 is θ, in accordance with Malus law. Intensity of light transmitted through P_2 will be

$I_2 = I_1\cos^2\theta = 16\cos^2\theta$ [From Eq. (ii)] . . . . (iii)

Above equation in the light of (i), becomes

$I_3 = 16\cos^2\theta\cos^2(90° - \theta) = 4(\sin 2\theta)^2$ . . . . .(iv)

According to given problem $I_3 = 3\,W/m^2$

So, $4(\sin 2\theta)^2 = 3$ i.e., $\sin 2\theta = (\sqrt{3}/2)$ Or $2\theta = 60°$ *i.e.*, $\theta = 30°$

90.(B) Further in accordance with Eq. (iv), I_3 will be max, when $\sin 2\theta = \max.$, *i.e.*

$\sin 2\theta = I$ Or $2\theta = 90°$, *i.e.*, $\theta = 45°$

Archive	JEE Main

1.(A) Coherent sources are those sources which have the same frequency and which have a constant phase relationship.

2.(B) The condition for. Interference maximum is $d\sin\theta = n\lambda$

But $d = 2\lambda$ (given) $\therefore \quad 2\lambda\sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n}{2}$

Clearly, n can have only integral values $-2,-1,0,+1,+2$.

So the maximum number of possible interference maximum is 5.

3.(D) The angle of incidence at which reflected light gets totally polarized is called Brewster's angle $i = \tan^{-1}(n)$

4.(A) When an unpolarized light of intensity I_0 is incident on a polarizing sheet, the intensity of transmitted light, $I = I_0/2$

$\therefore$ Intensity of the light which does not get transmitted is

$I_1 = I_0 - I = I_0 - I_0/2 = I_0/2$

5.(B) When the slit width is doubled the energy failing per sec on the screen is doubled but angular width of central maxima $\left(\Delta\theta = \frac{2\lambda}{b}\right)$ is halved. Hence intensity of the central maxima will be $4I_0$

6.(C) For maximum intensity $\phi = 0$,

$I_0 = a^2 + a^2 + 2a \times a\cos\phi = 4a^2$

When $x = \lambda/6$, $\phi = \frac{2\pi}{\lambda}x = \frac{2\pi}{\lambda}\frac{\lambda}{6} = \frac{\pi}{3} = 60^\circ$. Then, $I = a^2 + a^2 + 2a \times a\cos 60^\circ = 3a^2 \quad \therefore \quad \frac{I}{I_0} = \frac{3a^2}{4a^2} = \frac{3}{4}$

7.(C) In Young's double slit experiment,

Path difference for bright fringes $\Delta x = \frac{xd}{D} = n\lambda$. Hence position of any point on screen, $x = \frac{\Delta x D}{d} = \frac{n\lambda D}{d}$

The central fringes coincide for all wavelengths when $\Delta x = 0$. The third bright fringe of $\lambda_1 = 590nm$ coincides with the fourth bright fringe of unknown wavelength λ.

$\Rightarrow \quad x = \frac{3 \times 590D}{4d} = \frac{4\lambda D}{d} \Rightarrow \lambda = 442.5nm.$

8.(B) $\mu = \mu_0 + m_2 I$

Since intensity is decreasing with increase in the radial distance from the axis of the beam. Hence `μ' also decreases with increase in the radial distance from the axis of beam. Hence, as the beam enters the medium, it will converge.

9.(D) Since initially parallel cylindrical beam is given. Hence initial shape of wave front of the beam is planar.

10.(A) Since the value of `μ' is maximum on the axis of the beam. Hence the speed of light in the medium is minimum on the axis of the beam.

11.(B) When the light is reflected from a denser medium, a phase change of π occurs in the reflected wave. Hence statement-1 is true.

Since the phase difference between the two reflected waves at the centre of interference pattern is π. Hence the centre of the interference pattern is dark. Hence statement-2 is true.

12.(A) Fact

13.(D) It is given, $A_2 = 2A_1$

We know, intensity $\propto (\text{Amplitude})^2$; Hence $\frac{I_2}{I_1} = \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{2A_1}{A_1}\right)^2 = 4$ $\Rightarrow$ $I_2 = 4I_1$

Maximum intensity, $I_m = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I_1} + \sqrt{4I_1}\right)^2 = \left(3\sqrt{I_1}\right)^2 = 9I_1$; Hence $I_1 = \frac{I_m}{9}$

Resultant intensity, $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi = I_1 + 4I_1 + 2\sqrt{I_1(4I_1)}\cos\phi$

$= 5I_1 + 4I_1\cos\phi = I_1 + 4I_1 + 4I_1\cos\phi$

$= I_1 + 4I_1(1+\cos\phi) = I_1 + 8I_1\cos^2\frac{1}{2}$ $\left(\because \; 1+\cos\phi = 2\cos^2\frac{\phi}{2}\right)$

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

Putting the value of I_1 from equation (i), we get $I = \frac{I_m}{9}\left(1 + 8\cos^2\frac{\phi}{2}\right)$

14.(C) When the slits are coherent sources, $I_1 = 4I$

When the slits are incoherent sources, $I_2 = \frac{I_{max} + I_{min}}{2} = \frac{4I + 0}{2} \Rightarrow \frac{I_1}{I_2} = 2$

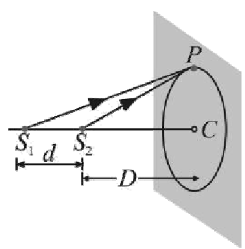
15.(C) At point `P' intensity is maximum $\therefore$ $I_P = 4I$

At point `Q', phase difference, $\delta = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2}$

$\therefore$ $I_Q = 4I\cos^2\left(\frac{\delta}{2}\right)$ $\therefore$ $I_Q = 4I\cos^2\left(\frac{\pi}{4}\right) = 4I \times \frac{1}{2} = 2I$ $\therefore$ $\frac{I_P}{I_Q} = 2$

16.(C) For bright fringe $S_1P - S_2P = n\lambda$

So, fringes are concentric circles.



17.(C) In Young's double slit experiment, the fringe width is given by $\omega = \frac{\lambda D}{d}$

18.(A) $I_1 = \frac{I}{4}, I_2 = \frac{9I}{64}$ $\therefore$ $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}}\right)^2 = \left(\frac{\frac{1}{2} + \frac{3}{8}}{\frac{1}{2} - \frac{3}{8}}\right)^2 = \left(\frac{7/8}{1/8}\right)^2 = 49:1$

19.(B) If a beam of unpolarized light of intensity I_0 is passed through the two polaroids. The intensity of the emergent light is

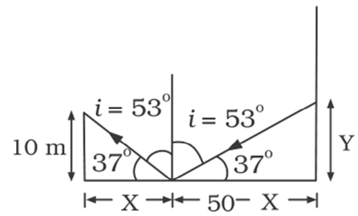
$I = \frac{I_0}{2}\cos^2\theta$; $I = \frac{I_0}{2}\cos^2 45° = \frac{I_0}{4}$

20.(B) i = Brews ter's angle

$= \tan^{-1}(\mu)$

$= \tan^{-1}\left(\frac{4}{3}\right)$

$i = 53°$ $\quad\therefore\quad$ $\tan 37° = 10/X$



$\frac{3}{4} = \frac{10}{X}$ $\quad\Rightarrow\quad$ $\frac{40}{3} = 13.3\ m$

Again, $\tan 37° = \frac{Y}{50 - X}$

$\frac{3}{4} = \frac{Y}{50 - X}$ $\quad\Rightarrow\quad$ $3\left(50 - \frac{40}{3}\right) = 4Y$

$\Rightarrow\quad 110 = 4Y \quad\therefore\quad Y = 27.5\ m$

21.(C) For constructive interference at `P'

$$\Delta r = (2n-1)\frac{\lambda}{2} \quad ; \quad \frac{4l}{\sqrt{3}} - 2l = (2n-1)\frac{\lambda}{2} \quad ; \quad l = \frac{(2l-1)\sqrt{3}\lambda}{4(2-\sqrt{3})}$$

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

23.(B) $d \sin\theta = (\mu - 1)t$ $\quad\Rightarrow\quad$ $\frac{dy}{D} = 0.6 \times 1.8 \times 10^{-6}\text{m}$

Since, $y = \beta' = \frac{2\lambda D}{d}$ $\quad\therefore\quad$ $\lambda = 540$ nm

24.(C) The angular width of central maximum of the single slit diffraction pattern is, $\Delta\theta = \frac{2\lambda}{b}$

In the young's double slit experiment, the angular width of a fringe is $\beta = \frac{\lambda}{d}$

$\therefore$ no. of intensity maxima observed within the central maximum of the single slit diffraction pattern is

$$n = \frac{\Delta\theta}{\beta} = \frac{2\lambda/b}{\lambda/d} = \frac{2d}{b} = 2 \times 6.1 = 12.2 \quad\therefore\quad n = 12\ (n \text{ is an integer})$$

25.(B) $I_A \cos^2 30 = I_B \cos^2 60$; $\quad \frac{I_A}{I_B} = \frac{1}{3}$

26.(B) $\frac{\lambda_{red}}{a} = \frac{3\lambda}{2a}$ $\quad\therefore\quad$ $\lambda = 4400\text{Å}$

27.(C) $\sin\theta_{1C} = \frac{1}{\mu}$

$\tan\theta_{1B} = \frac{1}{\mu}$

$\therefore\quad \frac{\sin\theta_{1C}}{\sin\theta_{1B}}\cos\theta_{1B} = 1 \quad\Rightarrow\quad \cos\theta_{1B} = \frac{1}{\eta}$

$\tan\theta_{1B} = \sqrt{\eta^2 - 1}$

28.(B) Intensity at any point on the screen is given by :

$I = 4I_0\cos^2\left(\frac{\phi}{2}\right); I_{max} = 4I_0$; $\quad$ Now, $\frac{I_{max}}{2} = 2I_0 = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

$\cos\left(\frac{\phi}{2}\right) = \frac{1}{\sqrt{2}} \;\therefore\; \frac{\phi}{2} = \frac{\pi}{4}; \phi = \frac{\pi}{2}$ Also $\frac{2\pi}{\lambda}\Delta x = \frac{\pi}{2}; \Delta x = \frac{\lambda}{4}$; $\quad y\frac{d}{D} = \frac{\lambda}{4} \;\therefore y = \frac{\lambda D}{4d} = \frac{\beta}{4}$

29.(C) According to Huygens' principle, each point on wavefront behaves as a point source of light.

30.(A) $d\sin\theta = \lambda$

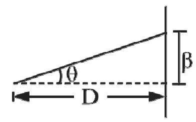
$\sin\theta = \dfrac{\lambda}{d} < 1 \qquad \therefore \qquad \lambda < d$

$\lambda = \dfrac{h}{|p_y|} \qquad \dfrac{h}{|p_y|} < d \qquad \Rightarrow \qquad h < |p_y|\, d$

31.(C) For a particular distance d_0 between the slits, the eye is not able to resolve two consecutive bright fringes.

Now, $\theta = \dfrac{\beta}{D}$ but $\beta = \dfrac{\lambda D}{d_0} \quad \therefore \quad \theta = \dfrac{\lambda}{d_0}$

or $\quad d_0 = \dfrac{\lambda}{\theta} = \dfrac{600\times 10^{-9}\,\text{m}}{\dfrac{1}{60}\times\dfrac{\pi}{180}\,\text{rad}} = 2.06\times 10^{-3}\,\text{m} \approx 2\,\text{mm}.$

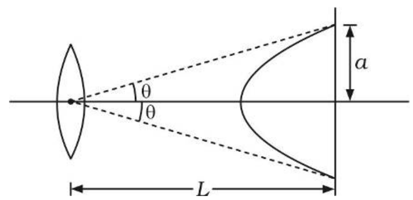


32.(C) $a\sin\theta = \lambda$

$a\left(\dfrac{a}{L}\right) = \lambda$

$\Rightarrow \quad a = \sqrt{\lambda L}$

Spread $= 2a = \sqrt{4\lambda L}$



33.(C) For $\lambda_1 \quad ; \quad y = \dfrac{m\lambda_1 D}{d}$

For $\lambda_2 \quad ; \quad y = \dfrac{n\lambda_2 D}{d}$

$\Rightarrow \quad \dfrac{m}{n} = \dfrac{\lambda_2}{\lambda_1} = \dfrac{4}{5} \quad \Rightarrow y = \dfrac{m\lambda_1 D}{d} = \dfrac{4\times 650\times 10^{-9}\times 1.5}{5\times 10^{-4}}\, m \simeq 7.8\, mm$

34.(B) $\sin 30^\circ = \dfrac{\lambda}{b} \quad \Rightarrow \quad \lambda = \dfrac{b}{2} = \dfrac{1\times 10^{-6}}{2} = 5\times 10^{-7} m$

Fringe width, $\omega = \dfrac{\lambda D}{d} \Rightarrow d = \dfrac{\lambda D}{\omega} = \dfrac{5\times 10^{-7}\times 0.5}{1\times 10^{-2}} \quad ; \quad d = 25\ \mu m$

35.(D) $I/2\cos^4\theta = \dfrac{I}{8} \quad \Rightarrow \quad \cos\theta = \dfrac{1}{\sqrt{2}} \quad \Rightarrow \quad \theta = 45^\circ$

36.(D) de-Broglie wavelength, $\lambda = \dfrac{h}{P} \qquad \therefore \qquad$ Angular width of centra maxima $= \dfrac{2\lambda}{d}$

$\therefore \qquad$ width of central maxima $= \dfrac{2\lambda D}{d}$

37.(C) Angular width = $\dfrac{\lambda}{d}$

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

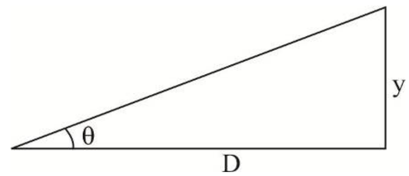
$d\sin 30^\circ = 0.320\times 10^{-3}\times\dfrac{1}{2} = 1.6\times 10^{-4}\ m = 16\times 10^{5} nm$

$n\lambda = 160000\, nm$

$n = \dfrac{160000}{500}$

Total Bright fringes $320\times 2 + 1 = 641$

38.(B) $\theta = \frac{y}{D}$



$\frac{1}{40} = \frac{n_1\lambda_1 \frac{D}{d}}{D}$

$\frac{1}{40} = \frac{n_1\lambda_1}{d} = \frac{n_1\lambda_1}{0.1\times10^{-3}} \Rightarrow n_1\lambda_1 = \frac{10^{-4}}{40}$

$= \frac{100000}{40}nm$; $= 2500\,nm$; $\lambda = \frac{2500}{n}$

$n = 1 \longrightarrow \lambda = 2500$; $n = 2 \longrightarrow \lambda = 1250$

$n = 3 \longrightarrow \lambda \approx 800$; $n = 4 \longrightarrow \lambda = 625$

$n = 5 \longrightarrow \lambda = 500$; Ans: $\lambda = 500, 625$

39.(B) $S_1P = 2d, \quad S_2P = \sqrt{4d^2 + d^2} = \sqrt{5}d$

$S_2P - S_1P = (\sqrt{5}-2)d$; $\frac{\lambda}{2} = (\sqrt{5}-2)d$; $d = \frac{\lambda}{2(\sqrt{5}-2)}$

40.(D) $\Delta\phi = k\Delta x = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{8} = \pi/4$; So, $I_P = I_0 + I_0 + 2I_0\cos(\pi/4) = 2I_0\left(1+\frac{1}{\sqrt{2}}\right)$

At central maxima, $I_{max} = 4I_0$; So, $\frac{I_p}{I_{max}} = \frac{1}{2}\left(1+\frac{1}{\sqrt{2}}\right) = 0.85$

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

Given $\frac{a_1}{a_2} = \frac{1}{3}$ $\Rightarrow$ $\frac{a_2+a_1}{a_2-a_1} = \frac{3+1}{3-1} = 2$ $\Rightarrow$ $\frac{I_{max}}{I_{min}} = 4$

42.(None) According to question shift = width of n fringe pattern

$\Rightarrow$ $(\Delta x)\frac{D}{a} = n\frac{D}{a}\lambda$ $\Rightarrow$ $(\mu-1)\,t\times\frac{D}{a} = n\frac{D}{a}\lambda$ $\therefore$ $t = \frac{n\lambda}{(\mu-1)}$

43.(D) $I_1 : I_2 = 4 : 1$; $\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2} = \left(\frac{3I}{I}\right)^2 = \frac{9}{1}$

44.(B) Optical path difference $= (\mu-1)t$

Shift $= \beta = \frac{\lambda D}{d}$ $\therefore$ $(\mu-1)t = \beta\cdot\frac{d}{D}$ $\Rightarrow$ $(\mu-1)t = \lambda$ $\therefore$ $t = \frac{\lambda}{\mu-1}$

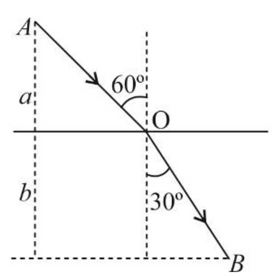
45.(C) Optical path $= \mu \times$ Geometrical path

So, optical path will be $= 1\times OA + \mu_{glass}\times(OB)$

From shells Law

$\sin 60^\circ = \mu\sin 30^\circ \Rightarrow \mu = \sqrt{3}$

So, optical path $= 2a + \sqrt{3}\times\frac{2b}{\sqrt{3}} = 2a + 2b$



46.(D) Let width of each slit be $a = 4.05\ \mu m$.

Separation between slits $d = 19.44\ \mu m$

Width of each Interference fringe: $W = \dfrac{\lambda D}{d}$

No. of fringes between Ist and IInd Minima of diffraction:

$$N = \frac{\lambda D / a}{\lambda D / d} = \frac{d}{a} = 4.8, \quad N \simeq 5.$$

47.(D) At air-liquid interface

$$\frac{\sin i}{\sin\theta} = \mu \quad \text{... (i)}$$

At liquid-glass interface, for reflected ray to be completely polarised

$$\tan\theta = \frac{1\cdot 5}{\mu} \quad \text{... (ii)}$$

For μ to min, θ max

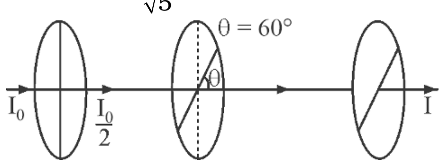
So from (i)

$$(\sin\theta)_{max} = \frac{1}{\mu} \Rightarrow (\tan\theta)_{max} = \frac{1}{\sqrt{\mu^2 - 1}} \Rightarrow \frac{1}{\sqrt{\mu^2 - 1}} = \frac{3}{2\mu}$$

$$9\mu^2 - 9 = 4\mu^2, \qquad 5\mu^2 = 9$$

$$\mu = \frac{3}{\sqrt{5}} \qquad \text{Option (D)}$$

48.(A)



$$\frac{I_0}{2}\cos^2\theta \cdot \cos^2 30° = I$$

$$\frac{I_0}{I} = \frac{2}{\frac{1}{4} \times \frac{3}{4}} = \frac{32}{3} = 10.67$$

49.(D) $d = 10^{-3} m$; $D = 1m$; $y = 1.27 \times 10^{-3} m$

Path difference $= d \sin\theta = d\dfrac{y}{D} = \dfrac{10^{-3} \times 1.27 \times 10^{-3}}{1} = 1.27\ \mu m$

50.(D) Let initial fringe width $= \beta_1$

Screen segment (used) width $= 16 \times \beta_1$

Fringe width, $\beta = \dfrac{D\lambda}{d} \propto \lambda$; $\dfrac{\beta_2}{\beta_1} = \dfrac{\lambda_2}{\lambda_1}$; $\beta_2 = \dfrac{400}{700} \times \beta_1 = \dfrac{4}{7}\beta_1$

No. of fringes in the same width of screen, $= \dfrac{16 \times \beta_1}{\beta_2} = \dfrac{16 \times \beta_1}{\frac{4}{7}\beta_1} = 28$

51.(C) Angular fringe width is $\beta = \dfrac{\lambda}{d} = \dfrac{500 \times 10^{-9}}{0.05 \times 10^{-3}} rad \Rightarrow \beta = 0.01 rad \Rightarrow \beta = 0.01 \times \dfrac{180}{\pi} = 0.57°$

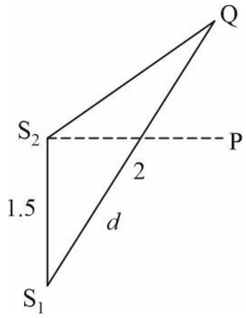
52.(C) Optical path of (1) ; $= n_1 L_1$

Optical path of (2) ; $= n_2 L_2$

So path difference ; $= n_1 L_1 - n_2 L_2$

So phase difference $= \dfrac{2\pi}{\lambda}(n_1 L_1 - n_2 L_2)$

53.(B)



In case 1 $S_1P - S_2P = 2.5 - 2 = .5 = \frac{\lambda}{2}$

In case 2 $S_1Q - S_2Q = \lambda$

54.(C) $I_B = I_0 \cos^2 \frac{\Delta\phi_B}{2} = I_0 \cos^2 \frac{\pi}{4} = \frac{I_0}{2}$

$\Delta\phi_A = \frac{\pi}{2} + \frac{2\pi}{\lambda}(5) = \frac{\pi}{2} + \frac{2\pi}{(20)} \times 5 = \pi \quad \Rightarrow \quad I_A = I_0 \cos^2 \frac{\Delta\phi_A}{2} = 0$

$\Delta\phi_C = \frac{\pi}{2} - \frac{2\pi}{\lambda}(5) = 0 \quad \Rightarrow \quad I_C = I_0 \cos^2\left(\frac{\Delta\phi_C}{2}\right) = I_0 \quad \Rightarrow \quad I_A : I_B : I_C = 0 : 1 : 2$

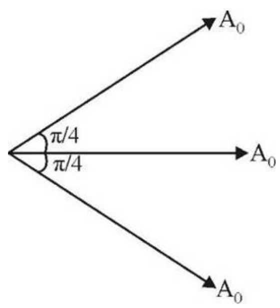
55.(9) $I(\Delta p) = I_0 \cos^2 \frac{\pi}{\lambda}\Delta p$; $I(\lambda/6) = k\cos^2\frac{\pi}{6} = \frac{3k}{4} = \frac{9k}{12}$

56.(C) $\beta = \frac{\lambda D}{d} = \frac{589 \times 10^{-9} \times 1.5}{15 \times 10^{-5}} = 589 \times 10^{-5} m = 5.9 mm$

57.(D) $I_p = I + I + 2I\cos\phi$; $\phi = \frac{2\pi}{\lambda}.\frac{\lambda}{8} = \frac{\pi}{4}$; $I_p = 2I\left(1 + \frac{1}{\sqrt{2}}\right)$

$I_m = 4I$; $Ratio = \frac{1 + \frac{1}{\sqrt{2}}}{2} = 0.85$

58.(A)



$A_{resultant} = A_0(\sqrt{2} + 1)$; $I_{resultant} = (\sqrt{2} + 1)^2 I_0 = 5.8 I_0$

59.(750) $n\lambda\frac{D}{d} = 15 \times 500 \times \frac{D}{d} = 10 \times \lambda \times \frac{D}{d}$ $\quad 750\ nm = \lambda$

60.(D) $\lambda = 6000 \times 10^{-8}\ cm$

For 2nd minimum $d\sin\theta_2 = 2\lambda \quad \Rightarrow \quad \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$

So, for 1st minimum, $d\sin\theta_1 = \lambda \quad \Rightarrow \quad \sin\theta_1 = \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$

$\therefore \quad \theta_1 = 25.65°$ (*from sin table*) , $\theta_1 \approx 25°$

61.(A) $I = I_0 \cos^2\theta$, $\quad \frac{I_0}{10} = I_0\cos^2\theta$; $\quad \cos\theta = \frac{1}{\sqrt{10}} = 0.31 < 0.707$

$\therefore \quad \theta > 45^\circ$ & $90^\circ - \theta < 45^\circ$; $\theta = 71.6^\circ \quad \therefore$ Angle rotated $= 90^\circ - 71.6^\circ = 18.4^\circ$

62.(D) $\omega = 31.4\ rad/s = 10\pi rad/s$

$I = 3.3Wm^{-2}$; $\quad A = 3\times10^{-4}m^2$

Energy $= \langle I \rangle AT = \frac{I}{2}.A.\frac{2\pi}{\omega} = \frac{\pi IA}{\omega} = \frac{\pi(3.3)\left(3\times10^{-4}\right)}{10\pi} = 0.99\times10^{-4}J \quad ; \quad \simeq 1.0\times10^{-4}J$

63.(200) Angular width $(\sin\theta) = \frac{\lambda}{a} = \frac{6000\times10^{-10}}{0.6\times10^{-4}} = \frac{6\times10^{-7}}{6\times10^{-5}} = 10^{-2}$

Number of minima produced will be equal to $2\times\frac{1}{10^{-2}}$

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1.(D) $\omega = \frac{\lambda D}{d}$

D is halved and D is doubled. Therefore, fringe width ω will become four times.

2.(C) Let $I_1 = I$ and $I_2 = 4I$

We know that intensity $\propto (\text{amplitude})^2$.

Let $I \propto a^2 \quad \therefore \quad I_1 \propto a^2$ and $I_2 \propto (2a)^2$

Maximum amplitude $= a + 2a = 3a \quad \therefore \quad I_{\max} \propto (3a)^2 \Rightarrow I_{\max} \propto 9a^2 \quad \Rightarrow \quad I_{\max} \propto 9I$

Minimum amplitude $= 2a - a = a \quad \therefore \quad I_{\max} \propto a^2 \Rightarrow I_{\max} \propto I$

3.(A) Locus of equal path difference are the lines running parallel to the axis of the cylinder. Hence, straight fringes are obtained.

4.(A) When slits are of equal width: $I_{\max} \propto (a+a)^2 (= 4a^2)$, $I_{\min} \propto (a-a)^2 (= 0)$

When one slits' width is twice that of the other:

$\frac{I_1}{I_2} = \frac{\omega_1}{\omega_2} = \frac{a^2}{b^2} \Rightarrow \frac{\omega}{2\omega} = \frac{a^2}{b^2} \Rightarrow b = \sqrt{2}a \quad \therefore \quad I_{\max} \propto \left(a + \sqrt{2}a\right)^2 \left(= 5.8a^2\right)$

$I_{\min} \propto (\sqrt{2}a - a)^2 (= 0.17a^2)$

5.(B) $I \propto (\text{amplitude})^2 \quad \therefore \quad I \propto I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi \qquad$ (i)

Applying Eq, (i) when phase difference is $\pi/2$.

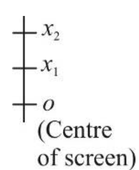
$I_{\pi/2} \propto I + 4I \Rightarrow I_{\pi/2} \propto 5I$

Again, applying Eq. (i) when phase difference is π.

$I_\pi \propto I + 4I + 2\sqrt{I}\sqrt{4I}\cos\pi \quad \therefore \quad I_\pi \propto I \Rightarrow I_{\pi/2} - I_\pi \propto 4I$

6.(B) In Young's double-slit experiment,

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



Given that $x_2 - x_1 = 12\frac{\lambda_1 D}{d}$

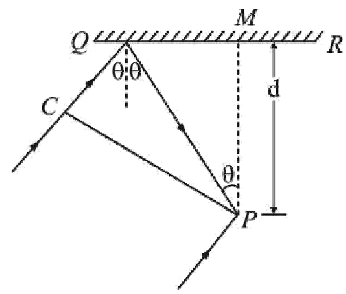
Where $\lambda_2 = 400 nm$. also, $x_2 - x_1 = k\frac{\lambda_2 D}{d}$; Where $\lambda_2 = 400nm$ and k is the number of fringes.

Dividing Eq. (i) by Eq. (ii), $1 = \frac{12\lambda_1}{k\lambda_2}$ $\therefore$ $k = \frac{12 \times 600}{400} = 18$

7.(A) Path difference $(\mu - 1)t = n\lambda$

For minimum $t, n = 1$ $\therefore$ $t = 2\lambda$

8.(B) In ΔOPM, $\frac{OM}{OP} = \cos\theta$ $\Rightarrow$ $OP = \frac{d}{\cos\theta}$



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

Path difference between the two rays reaching P is

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

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

Path difference between the two rays reaching P is $n\lambda$,

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

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

For $n = 1, \cos\theta = \frac{\lambda}{4d}$

9.(D) Let nth minima of 400 nm coincides with nth minima of 560 nm, then

$$(2n-1)\left(\frac{400}{2}\right) = (2m-1)\left(\frac{560}{2}\right) \quad \text{Or} \quad \frac{(2n-1)}{2m-1} = \frac{7}{5} = \frac{14}{10} = ...$$

i.e. 4th minim of 400 nm coincides with 3rd minima of 560 nm.

Location of this minima is,

$$Y_1 = \frac{(2 \times 4 - 1)(1000)(400 \times 10^{-6})}{2 \times 0.1} = 14mm$$

Next 11th minima of 400 nm will coincide with 8th minima of 560 nm

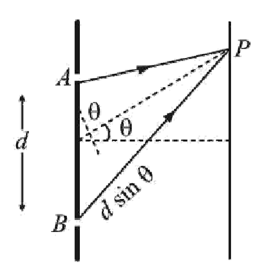
Location of this minima is,

$$Y_2 = \frac{(2 \times 11 - 1)(1000)(400 \times 10^{-6})}{2 \times 0.1} = 42mm$$

Required distance $= Y_2 - Y_1 = 28mm$

10.(C) Let P be the point on the central maxima whose intensity is one-fourth of the maximum intensity.

For interference we know that $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$, where I is the intensity at $P; I_1, I_2$ are the intensities of light originating from A and B, respectively; and ϕ is the phase difference at P in *YDSE*, $I_1 = I_2 = I$ and $I_{max} = 4I$. we are concentrating at a point where the intensity is one- fourth of the maximum intensity.



$$\therefore \quad I = I + I + 2I\cos\phi \Rightarrow -\frac{1}{2} = \cos\phi \Rightarrow \phi = \frac{2\pi}{3}$$

Note that we take the least value of the angle as the point is in central maxima.

For a phase difference of 2π, the path difference is λ.

For a phase difference of $\frac{2\pi}{3}$, the path difference is $\frac{\lambda}{2\pi} \times \frac{2\pi}{3} = \frac{\lambda}{3}$.

But the path difference (in terms of P and Q) is θ as shown in figure.

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

11.(C) $\lambda = \dfrac{h}{mv}$; v is increased, λ is decreased.

$\beta = \lambda D/d \quad \therefore \quad \beta$ decreases.

12.(A) frequency remains same. As speed decreases, wavelength decreases $(v = \lambda f)$

13.(D) Fringe with $\beta = \dfrac{\lambda D}{d}$. Hence, $\beta \propto \lambda$ As we know $\lambda_R > \lambda_G > \lambda_B$. Hence, $\beta_R > \beta_G > \beta_B$

14.(B) $\dfrac{I_{\max}}{2} = I_{\max}\cos^2\left(\dfrac{\phi}{2}\right) \Rightarrow \cos\left(\dfrac{\phi}{2}\right) = \dfrac{1}{\sqrt{2}}$

$\Rightarrow \dfrac{\phi}{2} = \dfrac{\pi}{4} \Rightarrow \phi = \dfrac{\pi}{2}(2n+1) \Rightarrow \Delta x = \dfrac{\lambda}{2\pi}\phi = \dfrac{\pi}{2\pi}\times\dfrac{\pi}{2}(2n+1) = \dfrac{\lambda}{4}(2n+1)$

15.(A) $P.d.$ at $O = d\alpha$

$P.d$ at $P = d\alpha + \dfrac{yd}{D}$; $\alpha = \dfrac{0.36}{\pi}$ degree $= \dfrac{0.36}{\pi}\times\dfrac{\pi}{180}\,rad = \dfrac{0.36}{180} = 0.002\,rad$

$P.d$ at $O = 0.3\times10^{-3}\times0.002 = 6\times10^{-7}m = 600\,nm \Rightarrow$ constructive interference at O

As $d\alpha = n\lambda$ where $n = 1$; $600nm = (1)\,(600\,nm)$

$P.d$ at $p = 600nm + \dfrac{11\times10^{-3}\times0.3\times10^{-3}}{1} = 600nm + 3300nm = 3900nm$

At P: $3900 = \dfrac{(2n-1)}{2}\times600 \Rightarrow 2n-1 = \dfrac{78}{6} = 13 \Rightarrow$ Destructive interference at P

Correct option is (A)

16.(BD) We know that $\dfrac{I_{\max}}{I_{\min}} = \dfrac{(a+b)^2}{(a-b)^2}$

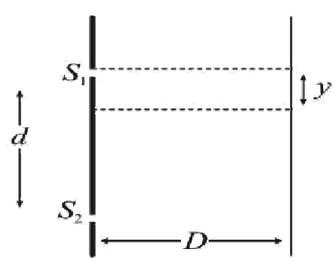
Where $I_1 \propto a^2$ (a is amplitude of 1 wave) and $I_2 \propto b^2$ (b is amplitude of 2 wave). Here,

$\dfrac{I_{\max}}{I_{\min}} = \dfrac{9}{1} \Rightarrow \dfrac{a+b}{a-b} = \dfrac{3}{1} \Rightarrow \dfrac{a}{b} = \dfrac{2}{1} \quad \therefore \quad \dfrac{I_1^2}{I_2^2} = \dfrac{a^2}{b^2} = \dfrac{4}{1}$

17.(AC) $y = (2n-1)\dfrac{\lambda}{2}\dfrac{D}{d} = (2n-1)\dfrac{\lambda}{2}\dfrac{D}{b}$ $(\because d = b)$ But $y = b/2$

$\therefore \dfrac{b}{2} = (2n-1)\dfrac{\lambda}{2}\dfrac{D}{d} \Rightarrow \lambda = \dfrac{b^2}{(2n-1)D}$

When $n = 1,2,\ \lambda = \dfrac{b^2}{D'}, \dfrac{b^2}{3D'}$



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

Where, $\delta = \dfrac{2\pi}{\lambda}(\Delta x) = \dfrac{2\pi}{\lambda}(d\sin\theta)$

(a) For $\theta = 30^\circ$; $\lambda = \dfrac{c}{v} = \dfrac{3\times10^8}{10^6} = 300m$ and $d = 150m$

$\delta = \left(\dfrac{2\pi}{300}\right)(150)\left(\dfrac{1}{2}\right) = \dfrac{\pi}{2}$; $\dfrac{\delta}{2} = \dfrac{\pi}{4}$; $I(\theta) = I_0\cos^2\left(\dfrac{\pi}{4}\right) = \dfrac{I_0}{2}$

(b) For $\theta = 90^\circ$; $\delta = \left(\dfrac{2\pi}{300}\right)(150)(1) = \pi$ or $\dfrac{\delta}{2} = \dfrac{\pi}{2}$ and $I(\theta) = 0$

(c) For $\theta = 0°, \delta = 0 \, or \, \frac{\delta}{2} = 0$; $I(\theta) = I_0$

19.(AB) For $d = \lambda$, there will be only one, central maxima. For $\lambda < d < 2\lambda$, there will be three maximum on the screen corresponding to path difference, $\Delta x = 0 \, and \, \Delta x = \pm\lambda$.

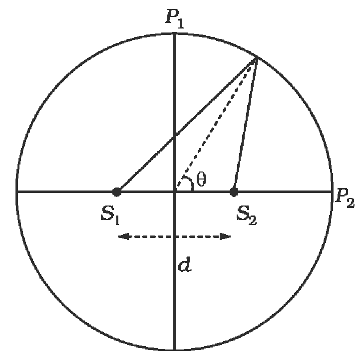
20.(ABC) $\beta = \frac{D\lambda}{d} \; \therefore \; \lambda_2 > \lambda_1 \; \Rightarrow \; \beta_2 \beta_1$; Also $m_1\beta_2 = m_2\beta_2 \; \Rightarrow \; m_1 > m_2$

Also $3\left(\frac{D}{d}\right)(600\,\text{nm}) = (2 \times 5 - 1)\left(\frac{D}{2d}\right)40\text{nm}$; Angular width $\theta = \frac{\lambda}{d}$

21.(BC) Since S_1S_2 line is perpendicular to screen shape of pattern is concentric semicircle

At O, $\frac{2\pi}{\lambda}(S_1O - S_2O) = \frac{2\pi \times 0.6003 \times 10^{-3}}{600 \times 10^{-3}} = 2001\pi$

$\therefore$ darkness close to O



22.(BC) Path difference at point P

$\Delta x = d \cos\theta$; At $P_1, \theta = 90° \Rightarrow \Delta x = 0 \rightarrow$ maxima

At $P_2, \theta = 0 \Rightarrow \Delta x = d = n\lambda$

$\Rightarrow \quad n = \frac{1.8 \times 10^{-3}}{00 \times 10^{-9}} = 3000 \quad \rightarrow$ maxima

For maxima at P, d cos $\theta = (dn)\lambda$

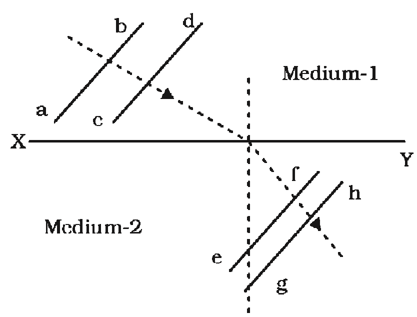
Angular fringe width, $\left|\frac{d\theta}{dn}\right| = \frac{\lambda}{d \sin\theta}$; As $\theta \uparrow d\theta \uparrow$

23.(A) Wavefronts are parallel in both media. Therefore, light which is perpendicular to wavefront travels as a parallel beam in each medium.

24.(C) All points on a wavefront are at the same phase.

$\phi_d = \phi_c \, and \, \phi_f = \phi_e$; $\phi_d - \phi_f = \phi_c - \phi_e$

25.(B) 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.



26.(13.9)

27.(5892) $x_0 = \frac{\beta}{\lambda}(\mu - 1)t$ . . . . (i)

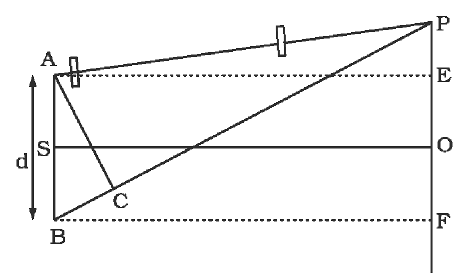
(x_0 = is displacement of the central bright fringe)

β is fringe width and λ is wavelength of the light

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

Where D is the distance between the slit and screen and d is the distance between slits.

The distance between successive maxima in the second



$ase = \frac{2\lambda D}{d}$ **. . . . (ii)**

From (i)

$x_0 = (\mu - 1)t\frac{D}{d}$ **. . . . (iii)**

From (ii) and (iii) we get

$\lambda = \frac{(\lambda - 1)t}{2}$; $= \frac{(1.6 - 1.0)\times(1.964\times10^{-6})}{3} = 5.892\times10^{-7}\,m = 5892\,\mathring{A}$

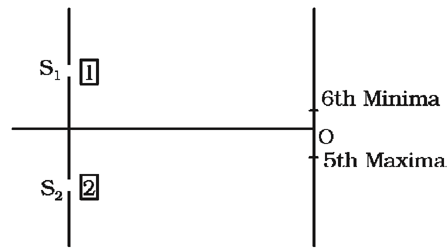
28.(9.3) $\mu_1 = 1.4$ and $\mu_2 = 1.7$ and let t be the thickness of each glass plates.

Path difference at O, due to insertion of glass plates will be

$\Delta x = (\mu_2 - \mu_1)t = (1.7 - 1.4)t = 0.3t$ ....(i)

Now, since 5th maxima (earlier) lies below O & 6th minima lies above O.

This path difference should lie between $5\lambda\, and\, 5\lambda + \frac{\lambda}{2}$



So, let $\Delta x = 5\lambda + \Delta$ ....(ii)

Where $\Delta < \frac{\lambda}{2}$

Due to the path difference Δx, the phase difference at O will be

$\phi = \frac{2\pi}{\lambda}\Delta x = \frac{2\pi}{\lambda}(5\lambda + \Delta) = \left(10\pi + \frac{2\pi}{\lambda}, \Delta\right)$ ....(iii)

Intensity at O is given $\frac{3I_{max}}{4}$ and since

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

$\frac{3}{4}I_{max} = I_{max}\cos^2\left(\frac{\phi}{2}\right)$; $\frac{3}{4} = \cos^2\left(\frac{\phi}{2}\right)$ ....(iv)

From equation (iii) and (iv), we find that

$\Delta = \frac{\lambda}{6}$; $\Delta x = 5\lambda + \frac{\lambda}{6} = \frac{31\lambda}{6} = 0.3t$; $t = \frac{31\lambda}{6(0.3)} = \frac{31\times5400\times10^{-10}}{1.8} = 9.3\times10^{-6}m = 9.3\mu m$

29. **(i)** $\mathbf{7\times10^{-6m}}$ **(ii)** $\mathbf{(1.6,\ 5.7\times10^{-5}\ )}$

30. **(i)(4.33nm)** d = 0.45 mm ; D = 1.5 m

$\lambda = 600\ nm$; $\mu_m = 4/3, \mu_t = 3/2$; $t = 10.4\ \mu m$

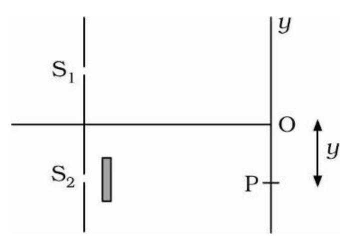
Optical path difference at

$P = (\mu_t - \mu_m)\,t - \mu_m(S_1P - S_2P) = (\mu_t - \mu_m)\,t - \mu_m\frac{yd}{D}$

According to question optical path difference should be zero at P

$\Rightarrow$ $y = \frac{D}{d}\left(\frac{\mu_t}{\mu_m} - 1\right)t = 4.33\ mm$

(ii)(3/4) Net path difference at O



$\Delta x = \left(\frac{\mu_1}{\mu_m} - 1\right)$

Corresponding phase difference

$\frac{2\pi}{\lambda}\Delta x = \frac{13}{3}\pi$; Intensity at $O = I_{max}\cos^2\left(\frac{\phi}{2}\right) = \frac{3}{4}I_{max}$

(iii)(650, 433.33) At O, path difference $\Delta x = n\lambda$ (where n = 1, 2, 3, 4, 5.....)

$\lambda = 1300\ nm, \frac{1300}{2} nm, \frac{1300}{3} nm....$

Thus 650 nm. 433.33 nm have maxima at O.

31.(3.5) $y_1 = \frac{nD\lambda_1}{d}$; $y_2 = \frac{mD\lambda_2}{d}$; $y_1 = y_2 \Rightarrow n = \frac{7}{5} m$

For the first location, m = 5, n = 7 $\therefore$ $y = 7 \times 1000 \times 5 \times 10^{-7} = 35 \times 10^{-4} = 3.5\ mm$

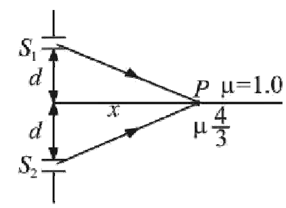
32.(3) If light travels a distance x in medium, then the effective distance travelled in vacuum is μx. for the given case, consider two rays undergoing interference at a point P.

For S_1P : optical path: $l_1 = \sqrt{x^2 + d^2}$

For S_2P : optical path: $l_2 = \mu\sqrt{x^2 + d^2}$

Path difference : $\Delta l = l_2 - l_1 = (\mu - 1)\sqrt{x^2 + d^2}$

For maxima, $\Delta l = m\lambda$



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

Solving this, we get $x^2 = 9m^2\lambda^2 - d^2$

i.e., $p = 3$

33. **[A-p, s]** **[B-q]** **[C-t]** **[D-r, s, t]**

(A) This is young's double slit experiment. The path difference is zero for P_0

$\therefore \quad I(P_0) > I(P_1)\ \delta(P_0) = 0$ and $I(P_0) > I(P_1)$.

(B) The path difference for the second beam is less for P_0. at P_1, path difference is zero. Therefore P_1 is the brightest central fringe and $\delta(P_1) = 0$.

(C) Now the extra path different is $\lambda / 2\ I(P_2) > I(P_1)$

(D) $(\mu - 1)t = \frac{3\lambda}{4} \therefore \delta(P_0) = \frac{3\pi}{2}$

$I(P_1) = 0, I(P_2) > 0, I(P_0) > 0$

34.(2×10^8 **m / s, 4000**Å

35.(2) In case YDSE, at mid-point intensity will be $I_{max} = 4I_0$

In the second case when sources are incoherent, the intensity will be $I = I_0 + I_0 = 2I_0$

Therefore, the desired ratio is

$\frac{4I_0}{2I_0} = 2$; Here, I_0 is the intensity due to one slit.

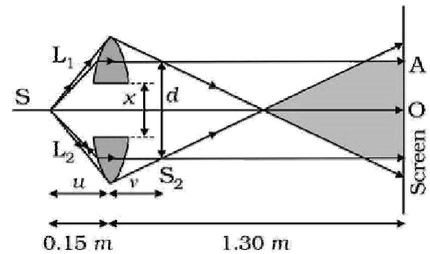
36. $\left(\sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}\right)$ According to the electromagnetic wave theory, velocity of light in vacuum $(c) = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ and velocity of light in medium $(v) = \frac{1}{\sqrt{\mu\varepsilon}}$ where ε stands for electric permittivity and μ for magnetic permeability. By definition $n = \frac{c}{v}$

37. (i) (1mm) (ii) (increase)

The split lenses L_1 and L_2 form real image S_1 and S_2 of the same source S. These images S_1 and S_2 from two coherent sources in same way as the double slit in Young's experiment.

Let 'v' be the distance of S_1 *and* S_2 from L_1 and L_2 and 'u'

Now $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$; $\frac{1}{v}+\frac{1}{0.15}=\frac{1}{0.10}$



$\therefore \quad v=\frac{0.15\times 0.10}{0.15-0.10}=0.3\ m$

Let 'd' be the separation between sources

S_1 and S_2 then $\frac{d}{x}=\frac{v+u}{u}$

or $\quad d=\frac{x(v+u)}{u}=\frac{0.5\ \times 10^{-3}(0.15+0.30)}{0.15}=1.5\times 10^{-3}m$

$D=1.30-V=1m \quad ; \quad y=\frac{n\lambda D}{d}$

As the point A is third maxima then $OA=\frac{3\lambda D}{d}=10^{-3}\ m=1\ mm$

(ii) $OA=\frac{3\lambda D}{d}=\frac{3\lambda Du}{x(v+v)}$

Therefore the distance OA will increase on decreasing the gap between the lenses

38.(5×10^{14}, 4000)

As frequency does not depend on medium, $v=\frac{c}{\lambda}=\frac{3\times 10^{8}}{6000\times 10^{-10}}\ Hz=\frac{10^{15}}{2}Hz=5\times 10^{14}Hz$

Wavelength in the medium $=(\lambda/\mu)=(6000)(2/3)=4000\mathring{A}$

39.(True) To obtain interference, sources must be coherent. Two different light sources can never be coherent.

40.(False) With white light we get coloured fringes (not only black and white) with centre as white.

41.(A) The upper and lower part behave as converging lens while the middle part behaves as diverging lens.