SOLVED EXAMPLE

Ex.1 Consider interference between waves from two sources of Intensites I & 4I. Find intensities at points where the phase difference is π.

(A) I (B) 5I (C) 4I (D) 3I

Sol. $I = R^2 = a_1^2 + a_2^2 + 2a_1 a_2 \cos\delta$

$= I + 4I + 4I \cos\pi$

$I = 5I - 4I = I$

Ex.2 The width of one of the two slits in a Young's double slit experiment is double of the other slit. Assuming that the amplitude of the light coming from a slit is proportional to slit-width. Find the ratio of the maximum to the minimum intensity in the interference pattern.

(A) 34 : 1 (B) 9 : 1

(C) 4 : 1 (D) 16 : 1

Sol. Suppose the amplitude of the light wave coming from the narrower slit is A and that coming from the wider slit is 2A. The maximum intensity occurs at a place where constructive interference takes place. Then the resultant amplitude is the sum of the individual amplitudes. Thus,

$A_{max} = 2A + A = 3A$

The minimum intensity occurs at a place where destructive interference takes place. The resultant amplitude is then difference of the individual amplitudes.

Thus, $A_{min} = 2A - A = A$.

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(A_{max})^2}{(A_{min})^2} = \frac{(3A)^2}{(A)^2} = 9.$$

Ex.3 The intensity of the light coming from one of the slits in a young's double slit experiment is double the intensity from the other slit. Find the ratio of the maximum intensity to the minimum intensity in the interference fringe pattern observed.

(A) 9 : 1 (B) 34 : 1

(C) 4 : 1 (D) 16 : 1

Sol. $\frac{I_1}{I_2} = \frac{2}{1}$

$$\frac{a_1}{a_2} = \sqrt{\frac{I_1}{I_2}} = \frac{\sqrt{2}}{1}$$

At the point of constructive interference, the resultant amplitude becomes $(a_1 + a_2) = \sqrt{2} + 1$ at the point of destructive interference, the resultant amplitude is $(a_1 - a_2) = \sqrt{2} - 1$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(\sqrt{2}+1)^2}{(\sqrt{2}-1)^2} = 34.$$

Ex.4 The intensity ratio of two waves is 9 : 1. These waves produce the event of interference. The ratio of maximum to minimum intensity will be

(A) 1 : 9 (B) 9 : 1 (C) 1 : 4 (D) 4 : 1

Sol. $\frac{I_1}{I_2} = \frac{9}{1}$,

$$\frac{I_{max}}{I_{min}} = \left[\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\sqrt{\frac{I_1}{I_2}} - 1}\right]^2 = \left[\frac{\sqrt{9}+1}{\sqrt{9}-1}\right]^2$$

$$\frac{I_{max}}{I_{min}} = \frac{4^2}{2^2} = \frac{4}{1}$$

Ex. 5 The equation of two light waves are $y_1 = 6\cos\omega t$, $y_2 = 8\cos(\omega t + \phi)$. The ratio of maximum to minimum intensities produced by the superposition of these waves will be

(A) 49 : 1 (B) 1 : 49

(C) 1 : 7 (D) 7 : 1

Sol. $a_1 = 6$ units

$a_2 = 8$ units

$$\frac{I_{max}}{I_{min}} = \frac{\left[\frac{a_1}{a_2} + 1\right]^2}{\left[\frac{a_1}{a_2} - 1\right]^2} = \frac{\left[\frac{6}{8} + 1\right]^2}{\left[\frac{6}{8} - 1\right]^2}$$

$$\frac{I_{max}}{I_{min}} = \frac{49}{1}$$

Ex. 6 In a Young's slit experiment, the separation between the slits is 0.10 mm, the wavelength of light used is 600 nm and the interference pattern is observed on a screen 1.0 m away. Find the separation between the successive bright fringes.

(A) 6.6 mm (B) 6.0 mm

(C) 6 m (D) 6 cm.

Sol. The separation between the sucessive bright fringes is-

$$\beta = \frac{D\lambda}{d} = \frac{1 \times 600 \times 10^{-9}}{1 \times 10^{-3}}$$

β = 6.0 mm.

Ex. 7 Two waves originating from source S_1 and S_2 having zero phase difference and common wavelength λ will show completely destructive interference at a point P if ($S_1P - S_2P$) is- **[MP PMT, 87]**

(A) 5λ (B) $3\lambda/4$

(C) 2λ (D) $11\lambda/2$

Sol. For destructive interference :

Path difference = $S_1P - S_2P = (2n - 1)\lambda/2$.

For

n = 1, $S_1P - S_2P = (2 \times 1 - 1)\lambda/2 = \lambda/2$.

n = 2, $S_1P - S_2P = (2 \times 2 - 1)\lambda/2 = 3\lambda/2$.

n = 3, $S_1P - S_2P = (2 \times 3 - 1)\lambda/2 = 5\lambda/2$.

n = 4, $S_1P - S_2P = (2 \times 4 - 1)\lambda/2 = 7\lambda/2$.

n = 5, $S_1P - S_2P = (2 \times 5 - 1)\lambda/2 = 9\lambda/2$.

n = 6, $S_1P - S_2P = (2 \times 6 - 1)\lambda/2 = 11\lambda/2$.

So, destructive pattern is possible only for path difference = $11\lambda/2$.

Ex. 8 In an interference pattern, at a point we observe the 16th order maximum for λ_1=6000Aº. What order will be visible here if the source is replaced by light of wavelength λ_2 = 4800 Aº.

(A) 40 (B) 20 (C) 10 (D) 80.

Sol. The distance of a bright fringe from zero order fringe is given by-

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

D & d is constant

$n_1 \lambda_1 = n_2 \lambda_2$

$n_1 = 16$, λ_1 = 6000 Aº, λ_2 = 4800 Aº

$$n_2 = \frac{n_1\lambda_1}{\lambda_2} = \frac{16 \times 6000}{4800} = 20$$

Ex. 9 In Young's experiment the wavelength of red light is 7.5×10^{-5} cm. and that of blue light 5.0×10^{-5} cm. The value of n for which $(n + 1)^{th}$ the blue bright band coincides with n^{th} red band is-

(A) 8 (B) 4 (C) 2 (D) 1

Sol. $n_1 \lambda_1 = n_2 \lambda_2$ for bright fringe

$n(7.5 \times 10^{-5}) = (n + 1)(5 \times 10^{-5})$

$$n = \frac{5.0 \times 10^{-5}}{2.5 \times 10^{-5}} = 2.$$

Ex. 10 In Young's double slit experiment, carried out with light of wavelength λ = 5000 Aº, the distance between the slits is 0.2 mm and the screen is at 200 cm from the slits. The central maximum is at x = 0. The third maximum will be at x equal to.

(A) 1.67 cm (B) 1.5 cm

(C) 0.5 cm (D) 5.0 cm.

Sol. $X_n = \dfrac{n\lambda D}{d}$ or $X_3 = \dfrac{3\lambda D}{d}$

$$X_3 = \frac{3 \times (5000 \times 10^{-8}) \times 200}{0.02} = 1.5 \text{ cm.}$$

Ex. 11 Two slits separated by a distance of 1mm are illieminated with red light of wavelength 6.5×10^{-7} m. The interference fringes are observed on a screen placed 1m from the slits. The distance between third dark fringe & the fifth bright fringe is equal to.

(A) 0.65 mm (B) 1.63 mm

(C) 3.25 mm (D) 4.87 mm.

Sol. $\beta = \dfrac{\lambda D}{d} = \dfrac{6.5 \times 10^{-7} \times 1}{10^{-3}}$

$\beta = .65 \times 10^{-3}$ m = 0.65 mm

The distance between fifth bright fringe from third dark fringe = 2.5 β=2.5×.65 = 1.63 mm.

Ex. 12 In an experiment the two slits are 0.5 mm apart and the fringes are observed to 100 cm from the plane of the slits. The distance of the 11th bright fringe from the Ist bright fringe is 9.72 mm. Calculate the wavelength.

(A) 4.85×10^{-5} cm (B) 4.85×10^{-5} m

(C) 4.86×10^{-7} m (D) 4.86×10^{-5} cm

Sol. Given $d = 0.5$ mm $= 5 \times 10^{-2}$ cm

$D = 100$ cm.

$X_n = X_{11} - X_1 = 9.72$ mm.

$\therefore X_n = \frac{n\lambda d}{d}$

$\Rightarrow \lambda = \frac{X_n d}{nD} = \frac{.972 \times 5 \times 10^{-2}}{10 \times 100}$

$= 4.86 \times 10^{-5}$ cm.

Ex. 13 In a Young's experiment , two coherent sources are placed 0.90 mm apart and the fringes are observed one metre away. If it produces the second dark fringe at a distance of 1mm from the central fringe, the wavelength of monochromatic light used would be.

(A) 60×10^{-4} cm (B) 10×10^{-4} cm

(C) 10×10^{-5} cm (D) 6×10^{-5} cm

Sol. D = 1m. , d = .90 mm = $.9 \times 10^{-3}$ m

The distance of the second dark ring from centre = 10^{-3} m

$\therefore X_n = (2n - 1) \frac{\lambda}{2}$

for n = 2,

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

$\Rightarrow \lambda = \frac{2xnd}{3D} = \frac{2 \times 10^{-3} \times .9 \times 10^{-3}}{3}$

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

$\lambda = 6 \times 10^{-5}$ cm.

Ex. 14 The young's double slits experiment is performed with blue and with green light of wavelength 4360 A° and 5460 A° respectively. If x is the distance of the 4th maxima from the central one, then

(A) $x_{blue} = x_{green}$

(B) $x_{blue} > x_{green}$

(C) $x_{blue} < x_{green}$

(D) $x_{blue}/x_{green} = 5460/4300$

Sol. Distance of n^{th} maximum

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

$\frac{x_{blue}}{x_{green}} = \frac{4360}{5460}$

$\therefore x_{blue} < x_{green}$

Ex. 15 A beam of light consisting of two wavelength 6500 A° & 5200 A° is used to obtain interference fringes in a young's double slit experiment. The distance between the slits is 2.0 mm and hie distance between the plane of the slits and the screen is 120 cm. What is the least distance from the central maximum where the bright fringes due to both the wave length coincide ?

(A) .156 cm (B) .152 cm

(C) .17 cm (D) .16 cm.

Sol. Suppose the m^{th} bright fringe of 6500Å coincides with the n^{th} bright fringe of 5200Å

$X_n = \frac{m\lambda_1 D}{d} = \frac{n\lambda_2 D}{d}$

$\Rightarrow \frac{m \times 6500 \times D}{d} = \frac{n \times 5200 \times D}{d}$

$\Rightarrow \frac{m}{n} = \frac{5200}{6500} = \frac{4}{5}$

$\therefore$ distance y is

$y = \frac{m\lambda_1 D}{d} = \frac{4 \times 6500 \times 10^{10} \times 1.2}{2 \times 10^{-3}}$

y = .156 cm.

Ex. 16 In an experiment similar to young's experiment, interference is observed using waves associated with electrons. The electrons are being produced in an electron gun. In order to increase the fringe width.

(A) electron gun voltage be increased.

(B) electron gun voltage be decreased.

(C) the slit be moved away.

(D) the screen be moved closer to interfering slits.

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

According to de Broglie,

Wavelength $\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mV}}$

As V decreases, λ increases, β increases.

Ex. 17 Interference fringes were produced in young's double slit experiment using light of wave length 5000 Å. When a film of material 2.5×10^{-3} cm thick was placed over one of the slits, the fringe pattern shifted by a distance equal to 20 fringe width. The refractive index of the material of the film is-

(A) 1.25 (B) 1.33 (C) 1.4 (D) 1.5

Sol. $n = \frac{(\mu - 1)tD}{d}$

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

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

$20\beta = (\mu - 1)\, 2.5 \times 10^{-3} \{ \beta/5000 \times 10^{-8}\}$

$\mu - 1 = \frac{20 \times 5000 \times 10^{-8}}{2.5 \times 10^{-3}} = .4 \mu = 1.4.$

Ex.18 The path difference between two interfering waves at a point on screen is 171.5 times the wavelength. If the path difference is 0.01029 cm. Find the wavelength.

(A) 6000×10^{-10} cm

(B) 6000 A°

(C) 6000×10^{-8} mm

(D) None

Sol. Path difference = 171.5λ

$= \frac{343}{2} \lambda$ = odd multiple of half wavelength .

It means dark fringe is observed.

According to question,

$0.01029 = \frac{343}{2} \lambda$

$\Rightarrow \lambda = \frac{0.01029 \times 2}{343} = 6 \times 10^{-5}$ cm

$\Rightarrow \lambda = 6000$ A°.

Ex.19 In young's double slit interference experiment, the distance between two sources is 0.1 / π mm.The distance of the screen from the source is 25 cm. Wavelength of light used is 5000 A°. Then the angular position of the first dark fringe is-

(A) .10° (B) .15° (C) .30° (D) .45°

Sol. The angular position

$\theta = \frac{\beta}{D} = \frac{\lambda}{d}$ $\left(\because \beta = \frac{\lambda D}{d}\right)$

The first dark fringe will be at half the fringe width from the mid point of central maximum. Thus the angular position of first dark fringe will be-

$\alpha = \frac{\theta}{2} = \frac{1}{2}\left[\frac{\lambda}{d}\right]$

$\alpha = \frac{1}{2}\left[\frac{5000 \times \pi}{0.1 \times 10^{-3}} \times 10^{-10}\right]\frac{180}{\pi} \Rightarrow \alpha = .45^\circ$

Ex. 20 In Young's double slit experiment the two slits are illuminated by light of wavelength 5890A° and the distance between the fringes obtained on the screen is 0.2°. If the whole apparatus is immersed in water then the angular fringe width will be, if the refractive index of water is 4/3

(A) 0.30° (B) 0.15° (C) 15° (D) 30°

Sol. $w_a = \lambda/d \Rightarrow w_a \propto \lambda$

$\frac{(w_a)_{water}}{w_a} = \frac{\lambda_{water}}{\lambda} = \frac{\lambda}{\mu_{water}\lambda}$

$(w_a)_{water} = \frac{2 \times 3}{4} = 0.15^\circ.$

LEVEL # 1

(D) $(2\pi/\lambda)\ \phi$

Questions based on Wave nature of light

Q.1 The path difference between two wavefronts emitted by coherent sources of wavelength 5460 Å is 2.1 micron . The phase difference between the wavefronts at that point is –

(A) 7.692 (B) $7.692\ \pi$

(C) $\frac{7.692}{\pi}$ (D) $\frac{7.692}{3\pi}$

Q.2 The similarity between the sound waves and light waves is -

(A) Both are electromagnetic waves

(B) Both are longitudinal waves

(C) Both have the same speed in a medium

(D) They can produce interference

Q.3 Monochromatic light is that light in which

(A) Single wavelength is present

(B) Various wavelengths are present

(C) Red and violet light is present

(D) Yellow and red light is present

Q.4 The colours are ascertained by –

(A) Frequency (B) Amplitude

(C) Speed (D) Intensity

Q.5 The ratio of phase difference and path difference is –

(A) 2π (B) $\frac{2\pi}{\lambda}$ (C) $\frac{\lambda}{2\pi}$ (D) $\frac{\pi}{\lambda}$

Q.6 The correct relation between time interval ∂ and phase difference δ is –

(A) $\partial = \frac{T}{2\pi}\delta$ (B) $\partial = \frac{2\pi}{T}\delta$

(C) $\partial = 2\pi\delta$ (D) $\partial = \frac{\delta}{2\pi}$

Q.7 The path difference between two waves $y_1 = A_1 \sin \omega t$ and $y_2 = A_2 \cos(\omega t + \phi)$ will be

(A) $(\lambda/2\pi)\ \phi$

(B) $(\lambda/2\pi)\ (\phi + \pi/2)$

(C) $(2\pi/\lambda)\ (\phi - \pi/2)$

Questions based on Interference of light

Q.8 The resultant amplitude in interference with two coherent source depends upon -

(A) Intensity

(B) Only phase difference

(C) On both the above

(D) None of the above

Q.9 The necessary condition for phenomenon of interference to occur is

(A) There should be two coherent sources.

(B) The frequency and amplitude of both the waves should be same

(C) The propagation of waves should be simultaneously and in same direction

(D) All of the above

Q.10 The necessary condition for interference pattern of light is that light sources should be –

(A) Of same amplitude, frequency, constant phase difference and of same state of polarisation

(B) Of same amplitude, frequency but with varying phase difference and of same state of polarisation

(C) Of same frequency constant phase difference and of different sate of polarisation

(D) Of same amplitude, different frequency, constant phase difference and of same state of polarisation

Q.11 For a persistent interference to occur, it is necessary that phase difference of waves should

(A) be zero

(B) Depend upon time

(C) Change at constant rate

(D) Not depend upon time

Q.12 Interference event is observed in

(A) Only transverse waves

(B) Only longitudinal waves

(C) Both types of waves

(D) Not observed in both type of waves

Q.13 In the phenomenon of interference, energy is
(A) Destroyed at bright fringes
(B) Created at dark fringes
(C) Conserved, but it is redistributed
(D) Same at all points

Q.14 The nature of light which is verified by the interference event is -
(A) Particle nature

(B) Wave nature
(C) Dual nature
(D) Quantum nature

Q.15 The phenomenon of interference is based on the principle of –
(A) Diffraction (B) Superposition
(C) Refraction (D) Polarisation

Q.16 For constructive interference the path difference should be (λ = wavelength of light)
(A) Even multiple of $\lambda/2$

(B) Odd multiple of $\lambda/2$
(C) Even or odd multiple of $\lambda/2$
(D) None of the above

Q.17 The equation for two waves obtained by two light sources are as given below :
$y_1 = A_1 \sin 3\omega t$, $y_2 = A_2 \cos (3\omega t + \pi/6)$. What will be the value of phase difference at the time t –
(A) $3\pi/2$ (B) $2\pi/3$ (C) π (D) $\pi/2$

Q.18 The maximum intensity produced of two coherent waves of intensity I_1 and I_2 will be -
(A) $I_1 + I_2$ (B) $I_1^2 + I_2^2$
(C) $I_1 + I_2 + 2\sqrt{I_1 I_2}$ (D) zero

Q.19 Two coherent waves are represented by $y_1 = a_1 \cos\omega t$ and $y_2 = a_2 \sin \omega t$. The resultant intensity due to interference will be -
(A) $(a_1 + a_2)$ (B) $(a_1 - a_2)$
(C) $(a_1^2 + a_2^2)$ (D) $(a_1^2 - a_2^2)$

Q.20 Two coherent sources have intensity ratio of 100 : 1, and are used for obtaining the phenomenon of interference. Then the ratio of maximum and minimum intensity will be -
(A) 100 : 1 (B) 121 : 81
(C) 1 : 1 (D) 5 : 1

Q.21 Two phase coherent sources of intensity ratio 4 coincides. Visibility in the interference pattern will be -
(A) 1/4 (B) 1/5 (C) 3/4 (D) 4/5

Questions based on **Coherent sources**

Q.22 Two independent mono-chromatic sources of light are -
(A) Coherent
(B) Incoherent
(C) Coherent or incoherent depending upon the nature of source
(D) None of the above

Q.23 Two coherent sources of light can be obtained by -
(A) Two different lamps
(B) Two different lamps but of the same power
(C) Two different lamps of same power and having the same colour
(D) None of these

Q.24 Coherence is measure of -
(A) Capability of producing interference by waves
(B) Waves being diffracted
(C) Waves being reflected
(D) Waves being refracted

Q.25 In coherent sources it is necessary that their -
(A) Amplitudes are same
(B) Wavelengths are same
(C) Frequencies are same
(D) Initial phase remains constant

Q.26 Two coherent sources can be obtained by -
(A) Division of wavefront only
(B) Division of amplitude only
(C) Both by division of wavefront and amplitude
(D) None of the above

Q.27 Two independent monochromatic sodium lamps can not produce interference because

(A) The frequencies of two sources are different
(B) The phase difference between two sources changes with respect to time
(C) The two sources become coherent
(D) The amplitudes of two sources are different

Questions based on **Young's double slit exp.**

Q.28 The Young's double slit experiment is performed in succession using blue light of wavelength 4360Å and green light of wavelength 5460Å. If the distance of fourth maximum from central maximum is x, then -
(A) $x_{blue} > x_{green}$
(B) $x_{blue} < x_{green}$
(C) $x_{blue} = x_{green}$
(D) $\frac{x_{blue}}{x_{green}} = \frac{5460}{4360}$

Q.29 In Young's double slit experiment 62 fringes are visible in the field of view with sodium light (λ = 5893Å). If green light (λ = 5461Å) is used then the number of visible fringes will be -
(A) 62 (B) 67
(C) 85 (D) 58

Q.30 In Young's experiment coherent sources are produced by -
(A) Division of wave front
(B) Division of amplitude
(C) Division of wave front and amplitude
(D) None of the above

Q.31 In Young's double slit experiment, the distance of the n-th dark fringe from the centre is -
(A) $n\left(\frac{\lambda D}{2d}\right)$ (B) $n\left(\frac{2d}{\lambda D}\right)$
(C) $(2n-1)\frac{\lambda D}{2d}$ (D) $(2n-1)\frac{4d}{\lambda D}$

Q.32 The coherent source of light produces constructive interference when phase difference between them is -
(A) π (B) $\frac{1}{2}\pi$
(C) $\frac{3}{2}\pi$ (D) 2π

Q.33 The interference fringes produced by mono-chromatic light here -
(A) Equal intensity
(B) Equal width
(C) All the bright fringes and all the dark fringes have uniform brightness and darkness and the width of fringes is also equal
(D) The intensity all bright is same the darkness of all dark fringes is also same but have different widths

Q.34 If the yellow light is replaced by the violet light then the interference fringes -
(A) Will become fainter
(B) Will become brighter
(C) The fringe width will increase
(D) The fringe width will decrease

Q.35 In Young's double slit experiment with monochromatic light the central fringe will be
(A) Coloured (B) White
(C) Bright (D) Black

Q.36 If the path difference between the interfering waves is nλ, then the fringes obtained on the screen will be -
(A) Dark (B) Bright
(C) coloured (D) White

Q.37 Mark the correct statement while performing Young's experiment the width of the slits is gradually increased, then -
(A) Fringe width increase and finally the fringes disappear
(B) Fringe width decreases and finally the fringes disappear
(C) Fringes get blurred
(D) Fringe width remains constant and they appear brighter

Q.38 The fringe width in a Young's double slit experiment can be increased. If we decrease
(A) Width of the slits
(B) Separation of the slits
(C) Wavelength of the light used

(D) Distance between slits and screen

Q.39 If in Young's double slit experiment, the distance between the slits is halved and the distance between slit and screen is doubled, then the fringe width will become –

(A) half (B) double
(C) four times (D) unchanged

Q.40 What happens when the width of slit aperture is increased by keeping 'd' as constant in Young's experiment -

(A) Fringe width will increase
(B) Fringe width will decrease
(C) Fringe width will remain unchanged
(D) Gradually the fringes will be disappear

Q.41 In young's double slit experiment, interference pattern is observed on the screen L distance apart from slits, average distance between adjacent fringes is x and slits separation is d, then the wavelength of light will be –

(A) xd/ L (B) xL/d
(C) Ld/x (D) Ldx

Ex.1 The first diffraction minima due to a single slit diffraction is at θ = 30^0 for a light of wavelength 5000 Å. The width of the slit is-

(A) 5×10^{-5} cm (B) 1.0×10^{-4} cm

(C) 2.5×10^{-5} cm (D) 1.25×10^{-5} cm

Sol. The distance of first diffraction minimum from the central principal maximum $x = \lambda D/d$

$\therefore \quad \sin\theta = \dfrac{x}{D} = \dfrac{\lambda}{d}$

$\Rightarrow \quad d = \dfrac{\lambda}{\sin\theta}$

$\Rightarrow \quad d = \dfrac{5000 \times 10^{-8}}{\sin 30^o} = 2 \times 5 \times 10^{-5}$

$\Rightarrow \quad d = 1.0 \times 10^{-4}$ cm ,

Hence correct answer is (B)

Ex.2 Two spectral line of sodium D_1 & D_2 have wavelengths of approximately 5890Å and 5896Å. A sodium lamp sends incident plane wave on to a slit of width 2 micrometre. A screen is located 2m from the slit. Find the spacing between the first maxima of two sodium lines as measured on the screen.

(A) 10^{-4} m (B) 9×10^{-4} m

(C) 9×10^{4} m (D) None

Sol. Here, $\lambda_1 = 5890\text{Å} = 5890 \times 10^{-10}$ m

$\lambda_2 = 5896\ A^0 = 5896 \times 10^{-10}$ m

$a = 2\mu m = 2 \times 10^{-6}$ m, D = 2m

for first maxima,

$\sin\theta = \dfrac{3\lambda_1}{2a} = \dfrac{x_1}{D} \Rightarrow x_1 = \dfrac{3\lambda_1 D}{2a}$

And $x_2 = \dfrac{3\lambda_1 D}{2a}$

$\therefore$ spacing between the first maxima of two sodium lines $= x_2 - x_1 = \dfrac{3D}{2a}(\lambda_2 - \lambda_1)$

$= \dfrac{3 \times 2(5896 - 5890) \times 10^{-10}}{2 \times 2 \times 10^{-6}}$

$= 9 \times 10^{-4}$ m, Hence correct answer is (B)

Ex. 3 Width of slit is 0.3mm. Fraunhoffer diffraction is observed at 1 m focal length in focus planed lense. If third minima is at 5 mm distance from central maxima, then wavelenght of light is-

(A) 7000Å (B) 6500Å (C) 6000Å (D) 5000Å

Sol. $ax/f = n\lambda$

$\lambda = \dfrac{ax}{nf} \Rightarrow \lambda = \dfrac{0.3 \times 10^{-3} \times 5 \times 10^{-3}}{3 \times 1}$

$\lambda = 5 \times 10^{-7}$ m

λ = 5000Å, Hence correct answer is (D)

Ex.4 A screen is placed 2m away from the single narrow slit. Calculate the slit width if the first minimum lies 5mm on either side of the central maximum. Incident plane waves have a wavelength of 5000Å.

(A) 2×10^{-4} m

(B) 2×10^{-3} cm

(C) 2×10^{-4} m

(D) None

Sol. Here distance of the screen from the slit,

D = 2m, a = ?, $x = 5\text{ mm} = 5 \times 10^{-3}$ m,

$\lambda = 5000A^0 = 5000 \times 10^{-10}$ m

for the first minima, $\sin\theta = \lambda/a = x/D$,

$a = D\lambda/x = \dfrac{2 \times 5000 \times 10^{-10}}{5 \times 10^{-3}} = 2 \times 10^{-4}$ m. ,

Hence correct answer is (A)

Ex.5 Red light of wavelength 6500Å from a distant source falls on a slit 0.5 mm wide. What is the distance between two dark bands on each side of central bright band of diffraction pattern observed on a screen placed 1.8 m from the slit.

(A) 4.68×10^{-3} cm (B) 4.68×10^{-3} mm

(C) 4.68×10^{-3} nm (D) 4.68×10^{-3} m

Sol. Here, $\lambda = 6500A^0 = 6.5 \times 10^{-7}$ m,

$a = 0.5\text{ mm} = 5 \times 10^{-4}$ m,

D = 1.8 m

Angular separation of two dark bands on each side of central bright band $2\theta = 2\lambda/a$

Actual distance between them,

$2x = 2\lambda/a \times D \Rightarrow 2x = \dfrac{2 \times 6.5 \times 10^{-7} \times 18}{5 \times 10^{-4}}$

$2x = 4.68 \times 10^{-3}$ m ,

Hence correct answer is (D)

Ex.6 Fraunhoffer diffraction pattern is observed at a distance of 2m on screen, when a plane-wavefront of 6000Å is incident perpendicularly on 0.2 mm wide slit.Width of central maxima is:

(A) 10 mm (B) 6mm

(C) 12 mm (D) None of these

Sol. Width of central maxima = $\frac{2f\lambda}{a}$

$= \frac{2\times2\times6000\times10^{-10}}{0.2\times10^{-3}}$ = 12 mm ,

Hence correct answer is (C)

Ex.7 A diffraction pattern is produced by a single slit of width 0.5mm with the help of a convex lens of focal length 40cm. If the wave length of light used is 5896Å. then the distance of first dark fringe from the axis will be-

(A) 0.047 cm (B) 0.047 m
(C) 0.047 mm (D) 47 cm

Sol. $\theta = \frac{\lambda}{a}$ .....(A)

$\theta = \frac{x}{f}$ .....(B)

From eqs. (A) and (B)

$\frac{\lambda}{a} = \frac{x}{f}$, $x = \frac{f\lambda}{a}$ .....(C)

According to question x = ?, f = 40 cm

$\lambda = 5896 \times 10^{-8}$ cm

$a = 0.5 \times 10^{-1}$ cm .....(D)

From eqs. (C) and (D)

$x = \frac{40\times5896\times10^{-8}}{5\times10^{-2}}$ 96

= 0.047 cm , Hence correct answer is (A)

Ex.8 What should be the size of the aperture of the objective of telescope which can just resolve the two stars of angular width of 10^{-3} degree by light of wavelength 5000A^0?

(A) 3.5 cm (B)3.5 mm (C) 3.5 m (D) 3.5 km

Sol. $d\theta = \frac{1.22\lambda}{a}$ or $a = \frac{1.22\lambda}{d\theta}$

According to question

$d\theta = 10^{-3}$ degree $= \frac{10^{-3}\times\pi}{180}$ Radian,

$\lambda = 5 \times 10^{-5}$ cm

$a = \frac{1.22\times5\times10^{-5}\times180}{10^{-3}\times3.14} \Rightarrow a = 3.5$ cm

Hence the correct answer will be (A)

Ex.9 Image of sun formed due to reflection at air water interface is found to be very highly polarised. Refractive index of water being μ = 4/3, find the angle of sun above the horizon.

Sol. Since the reflected light is very highly polarised, it implies that incident light falls at polarising angle of incidence θ_P. From Brewster's law,

$\mu = \tan\theta_p$

$\therefore$ $\theta_P = \tan^{-1}(\mu) = \tan^{-1}(4/3) = 53.1°$

Since θ_P is the angle which the rays from sun make with the normal to the interface, angle with the interface will be 90° – 53.1° = 36.9°.

Ex.10 When light of a certain wavelength is incident on a plane surface of a material at a glancing angle 30°, the reflected light is found to be completely plane polarised. Determine (a) refractive index of given material and (b) angle of refraction.

Sol. Angle of incident light with the surface is 30°. Hence angle of incidence = 90° – 30° = 60°. Since reflected light is completely polarised, therefore, incidence takes place at polarising angle of incidence θ_p.

(a) $\therefore$ $\theta_p = 60°$

Using Brewster's law

$\mu = \tan\theta_p = \tan 60°$

$\therefore$ $\mu = \sqrt{3}$

(b) From Snell's law

$\mu = \frac{\sin i}{\sin r}$

$\therefore$ $\sqrt{3} = \frac{\sin 60°}{\sin r}$

or $\sin r = \frac{\sqrt{3}}{2} \times \frac{1}{\sqrt{3}} = \frac{1}{2}$

r = 30°

Ex.11 Two polaroids as oriented with their planes perpendicular to incident light and transmission axis making an angle of 30° with each other. What fraction of incident unpolarised light is transmitted ?

Sol. If unpolarised light is passed through a polariod 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 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

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

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

LEVEL # 1

Questions based on **Properties of Diffraction**

Q.1 The bending of a beam of light around comers of an obstacle is called -

(A) Refraction (B) Reflection
(C) Diffraction (D) Interference

Q.2 The phenomenon of diffraction can be observed, when the obstacle is -

(A) Quite large as compared to the wavelength of light used
(B) Quite small as compared to the wavelength of light used
(C) Of the same order as the wavelength of light used
(D) Bears no relation with the wavelength of light used

Q.3 Who first discovered the phenomenon of diffraction

(A) Fresnel (B) Fraunhofer
(C) Arago (D) Grimaldi

Q.4 The occurrence of diffraction pattern depends on

(A) The width of slit
(B) Wavelength of light
(C) Relative sizes of width of slit and wavelength
(D) Neither the width of slit nor wavelength

Q.5 Light after being a wave motion, appears to travel in straight line because -

(A) Velocity of light more
(B) Frequency of light is less
(C) Wave length of light is less
(D) None of these

Q.6 Phenomenon of diffraction occurs -

(A) Only in case of light and sound waves
(B) For all kinds of waves
(C) For electromagnetic waves and not for matter waves
(D) For-light waves but not is case of X-rays

Q.7 Diffraction of light is observed only, when the obstacle size is -

(A) Very large
(B) Very small
(C) Of the same order that of wavelength of light
(D) Any size

Q.8 Diffraction of sound is more evident in daily lifte than light waves, because the than diffraction of light. Because the

(A) Wave length of sound waves is greater than that of light
(B) Sound waves are longitudinal, while light waves are transverse
(C) Velocity of sound waves is less than that of light
(D) None of the above

Q.9 If the wave length of a wave is large the degree of diffraction observed is

(A) Less
(B) More
(C) Zero
(D) Insufficient information

Q.10 What is necessary for easy occurrence of Fresnel's diffraction -

(A) Obstacle should be of the order of wave length
(B) Narrow opening should be of the order of wave length
(C) Source and screen should be at finite distance from the obstacle
(D) All of the above

Q.11 The correct relation between the size of the obstacle and the wavelength of light in order to observe the diffraction event is -

(A) $\frac{a}{\lambda} \approx 1$ (B) $\frac{a}{\lambda} = 0$
(C) $\frac{a}{\lambda} = \infty$ (D) $\frac{a}{\lambda} = 150$

Q.12 In young's double slit experiment, the diffraction is of the type

(A) Fresnel
(B) Fraunhoffer
(C) Both Fresnel and Fraunhoffer

(D) Neither Fresnel nor Fraunboffer

Q.13 The diffraction effect of light expresses that
(A) Light is transverse wave motion
(B) Light is wave motion
(C) Light is longitudinal wave motion
(D) Light has quantum nature

Questions based on Resolving power

Q.14 Which colour should be used to increase the resolving power of a microscope -
(A) Violet (B) Red
(C) Yellow (D) Green

Questions based on Diffraction by single slit

Q.15 Central fringe obtained in diffraction pattern due to a single slit -
(A) is of minimum intensity
(B) is of maximum intensity
(C) intensity depends upon slit width
(D) None of the above

Q.16 In the diffraction pattern of a single slit aperture, the width of the central fringe compared to widths of the other fringes, is
(A) Equal (B) Less
(C) Little more (D) Double

Q.17 What happens, when the width of the slit aperture, is increased in an experiment of single slit diffraction
(A) Spread of diffraction region is increased
(B) Spread of diffraction region is decreased
(C) Spread of diffraction region will be decreased but mid-band becomes narrow
(D) None of above

Q.18 In a single slit diffraction pattern, if the light source is used of less wave length then previous one. Then width of the central fringe will be -
(A) Less (B) Increase
(C) Unchanged (D) None of these

Q.19 For fraunhoffer single slit diffraction
(A) Width of central maxima is proportional to λ
(B) On increasing the slit width, the width of central maxima decreases.
(C) On making the slit width $a = \lambda$, central spreads in the range $\pm 90^o$
(D) All of the above are correct

Q.20 The positions of minima in the diffraction pattern due to a single slit are expressed by the formula-
(A) $a \sin \theta = n\lambda$
(B) $a \sin \theta = (2n + 1) \frac{\lambda}{2}$
(C) $a \sin \theta = \frac{n\lambda}{2}$
(D) $a \sin\theta = (2n - 1) \times \frac{\lambda}{2}$

Q.21 The fringe width in single slit diffraction pattern is proportional to
(A) a/λ (B) λ/a
(C) $a\lambda$ (D) λ

Q.22 The condition for obtaining maxima in the diffraction pattern due to a single slit is -
(A) $a \sin \theta = (2n - 1) \frac{\lambda}{2}$
(B) $a \sin\theta = n\lambda$
(C) $a \sin\theta = \frac{n\lambda}{2}$
(D) $a \sin\theta = (2n + 1)\lambda$

Q.23 For n^{th} order maxima in Fraunhoffer diffraction by a single slit aperture, the value of path difference should be
(A) $n\lambda$ (B) $2n\lambda$
(C) $\lambda/2 (2n + 1)$ (D) $\lambda(2n + 1)$

Q.24 A slit of width 12×10^{-7} m is illuminated by light of wavelength 6000Å. The angular width of the central maximum is approximately -
(A) 30^o (B) 60^o (C) 90^o (D) 0^o

Questions based on Polarisation

Q.25 Polarisation of light proves the -

(A) corpuscular nature of light

(B) quantum nature of light

(C) transverse wave nature of light

(D) longitudinal wave nature of light

Q.26 Waves that cannot be polarised are -

(A) light waves

(B) electromagnetic waves

(C) transverse waves

(D) longitudinal waves

Q.27 The angle of incidence at which reflected light is totally polarised for reflection from air to glass (refractive index n) is -

(A) $\sin^{-1}(n)$ (B) $\sin^{-1}(1/n)$

(C) $\tan^{-1}(1/n)$ (D) $\tan^{-1}(n)$

Q.28 The polaroid glass is used in sunglasses as -

(A) it is a fashion

(B) this reduce glare

(C) this is cheaper than other types

(D) this looks more beautiful