4-Sem-Gen

Light Wave optics - Interference [AB]

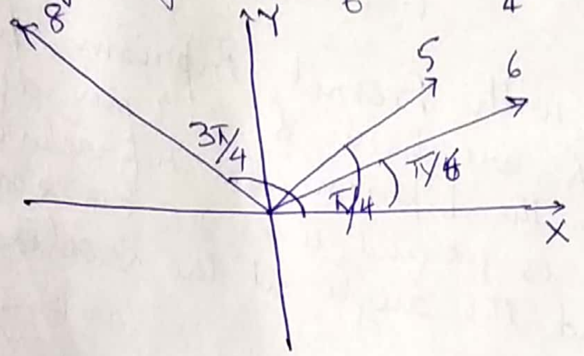
Problems (Sample)

① Three light waves represented by

$y_1 = 5\sin(\omega t + \frac{\pi}{4})$, $y_2 = 6\sin(\omega t + \frac{\pi}{6})$ and $y_3 = 8\sin(\omega t + \frac{3\pi}{4})$

superpose. Find the resultant disturbance.

Soln: We imagine three vectors of magnitudes 5, 6, 8 making angles $\frac{\pi}{4}$, $\frac{\pi}{6}$ and $\frac{3\pi}{4}$ with x-axis respectively.



The x and y component of the resultant vectors are:

$X = 5\cos\frac{\pi}{4} + 6\cos\frac{\pi}{6} + 8\cos\frac{3\pi}{4}$

$= 0.88$

$Y = 5\sin\frac{\pi}{4} + 6\sin\frac{\pi}{6} + 8\sin\frac{3\pi}{4}$

$= 14.39$

∴ Amplitude of the resultant disturbance is:

$A = \sqrt{(0.88)^2 + (14.39)^2} = 14.42$

Initial phase of the resultant disturbance is:

$\phi = \tan^{-1}\frac{Y}{X} = \tan^{-1}\frac{14.39}{0.88} = 0.48\pi$

∴ The resultant disturbance is given by,

$y = 14.42\sin(\omega t + 0.48\pi)$ (Ans)

② The two coherent waves of light having intensities $225\ W/m^2$ and $324\ W/m^2$ are superposed. Find the visibility of the fringe system.

Soln: Maximum and minimum intensities are given by. $I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$ and

$I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2}$

Here, $I_{max} = 225 + 324 + 2\sqrt{225 \times 324} = 1089$ and

$I_{min} = 225 + 324 - 2\sqrt{225 \times 324} = 9$

∴ Visibility, $V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{1089 - 9}{1089 + 9} = 0.984$ (Ans)

③ In Youngs double slit experiment, wavelength of light is 600nm, when a thin glass plate of refractive index 1.5 and thickness 1 μm is placed over one of the slit, find the number of fringes shifted as a result.

Soln: Shift of fringe system is, $x = (n-1)t \frac{D}{d}$ and width of a fringe is $w = \lambda D/d$

∴ Therefore, the number of the fringe shifted is:

$$m = \frac{x}{w} = \frac{(n-1)t}{\lambda} = \frac{0.5 \times 100 \times 10^{-6}}{600 \times 10^{-9}} = 83.33$$

$$\approx 83 \quad \text{(Ans)}$$

---

④ In an experiment with Fresnel Biprism, fringes of light of wavelength 5000Å are observed 0.2 mm apart at a distance of 175 cm from the biprism. The refractive index of the material of the prism is 1.5 and it is 25 cm from the illuminated slit. Find the angle at the vertex of the biprism.

Soln: We know, the width of the fringe, $W = \frac{\lambda(a+b)}{2a(n-1)\theta}$

Given here, $\lambda = 5000 \times 10^{-8}$ cm $= 5 \times 10^{-5}$ cm,

$W = 0.2$ mm, $n = 1.5$, $a = 25$ cm, $b = 17.5$ cm

Substituting we get, $\theta = 0.02$ radian.

Angle of vertex → $A = \pi - 2\theta = \pi - 2 \times 0.02$ radian

∴ $A = 177.71^\circ$. (Ans)

---

⑤ A parallel beam of light of wavelength 589 nm is incident on a thin glass plate of refractive index 1.5, such that the angle of refraction into the plate is 60°. Calculate the smallest thickness of the glass plate which will appear dark by reflection.

Soln: Condition of interference minima for glass plate with reflected wave is, $2nt \cos r = m\lambda$.

For the least thickness, $m = 1$, Given, $n = 1.5$, $r = 60°$,

$\lambda = 589 \times 10^{-9}$ m, substituting these we get,

$t = 3.926 \times 10^{-5}$ cm $= 3.926 \times 10^{-7}$ m

(Ans)

(6) In a Newton's ring experiment the diameters of the 15^{th} ring and 5^{th} ring are found to be 0.590 cm and 0.336 cm. The radius of the plano convex lens is 100 cm. Find the wavelength of light.

Soln: We have the formula for wavelength of light in Newton's ring as,

$$\lambda = \frac{D_{m+p}^2 - D_m^2}{4pR} = \frac{(0.590)^2 - (0.336)^2}{4 \times 10 \times 100}$$

$$= 5880 \times 10^{-8} \text{ cm} = 5880 \text{Å} \quad \text{(Ans)}$$

(7) In a Newton's ring arrangement the diameter of 12^{th} ring changes from 1.50 cm to 1.35 cm when a liquid is introduced between the lens and glass plate. Calculate the refractive index of the liquid.

Soln: For air and liquid of refractive index n the diameter of the 12^{th} ring are given respectively as

$$D_{12}^2 = \frac{4 \times 12 \lambda R}{1} \quad \text{and} \quad D_{12}'^2 = \frac{4 \times 12 \lambda R}{n}$$

$$\therefore n = \frac{D_{12}^2}{D_{12}'^2} = \frac{1.5^2}{1.35^2} = 1.235$$

(Ans)

(8) A beam of light of $\lambda = 582$ nm falls normally on a glass wedge. The wedge angle is 20 second. If $n = 1.5$ then find the number of dark fringes per cm of wedge length.

Soln: Width of the fringe is $W = \frac{\lambda}{2n\theta}$

We have $\theta = 20'' = \frac{20 \times \pi}{60 \times 60 \times 180}$ radian

$$\therefore W = \frac{582 \times 10^{-9} \times 60 \times 60 \times 180}{2 \times 20 \times \pi \times 1.5} = 0.002 \text{ m} = 0.2 \text{ cm}$$

$\therefore$ The number of fringes per cm $= \frac{1}{0.2} = 5$ (Ans)