PROBLEMS

1. **In a young double slit experiment the separation of the slits is 1 mm and red light of wavelength 620 nm is falling on it. Determine the distance between the central bright band and the fifth bright fringe on the screen which is 3m way from the slit.**

SOLUTION

$d = 1\text{ mm} = 10^{-3}\text{ m}$ $\lambda = 620\text{ nm} = 620 \times 10^{-9}\text{ m}$ $L = 3\text{ m}$ $m = 5$

$(y_5)_{br} = ?$

$$(y_5)_{br} = m\frac{\lambda L}{d} = 5\times\frac{620\times10^{-9}\times 3}{10^{-3}} = 9.3\times 10^{-3}\text{ m} = 9.3\text{ mm}$$

2. **Monochromatic light of wavelength 589.2 nm is used to illuminate the narrow slits 1 mm apart. Find the positions of the first dark and first bright fringes on the screen 100 cm away.**

SOLUTION

Wavelength $\lambda = 589.2\text{ nm} = 589.2 \times 10^{-9}\text{ m}$

$d = 1\text{mm} = 10^{-3}\text{m}$ $L = 100\text{ cm} = 1\text{m}$ $m = 1$

$(y_1)_{dr} = ?$ $(y_1)_{br} = ?$

Since $(y_1)_{dr} = (m + \frac{1}{2})\, L\lambda / d = (1 + \frac{1}{2})\, L\lambda / d = = \frac{3}{2} L\lambda / d$

$$(y_1)_{dr} = \frac{3}{2} \times \frac{1\times589.2\times10^{-9}}{10^{-3}} = 8.838 \times 10^{-4}\text{ m}$$

And $(y_1)_{br} = m\, L\lambda / d = \dfrac{1\times589.2\times10^{-9}}{10^{-3}} = 5.892 \times 10^{-4}\text{ m}$

3. **Two parallel slits are illuminated by light of two wavelengths, one of which is 5.892×10^{-4} m. On the screen the fourth dark line of the known wavelength coincides with the fifth bright line of the light of unknown wavelength. Fine the unknown wavelength.**

SOLUTION

$\lambda_1 = 5.8\times 10^{-7}\text{ m}$ $m_1 = 4$ $m_2 = 5$ $\lambda_2 = ?$

$(y_4)_{dr} = (y_5)_{br}$

$(m_1 + \frac{1}{2})\, L\lambda_1 / d = m_2 L\lambda_2 / d$

$(4 + \frac{1}{2})\, L\lambda_1 / d = 5L\lambda_2 / d$

$(9/2)\ \lambda_1 = 5\ \lambda_2$

$\lambda_2 = (9 / 5 \times 2)\, \lambda_1 = (9 / 5 \times 2) \times 5.8 \times 10^{-7}\text{ m}$

$\lambda_2 = 5.2 \times 10^{-7}\text{ m}$

4. **When the movable mirror of a Michelson interferometer is moved 0.1 mm. How may dark fringes pass the reference point, if light of wavelength 580 nm is used.**

SOLUTION

$P = 0.1\text{ mm} = 0.1 \times 10^{-3}\text{ m}$ $\lambda = 580\text{ nm} = 580 \times 10^{-9}\text{ m}$ $m = ?$

$P = m\,\lambda/2$

$$\Rightarrow \qquad m = 2P/\lambda = \frac{2 \times 0.1 \times 10^{-3}}{580 \times 10^{-3}} = 345 \text{ fringes}$$

5. When the movable mirror on a Michelson interferometer is moved in one direction, 400 fringes appear to pass through the field of view when light of wavelength of 500 nm is used. What is the distance through which the mirror has been moved.

SOLUTION $m = 400$ fringes $\lambda = 500$ nm $= 500 \times 10^{-9}$

Distance moved the mirror P =?

Since $P = m\lambda/2 = \dfrac{400 \times 500 \times 10^{-9}}{204} = 1.0 \times 10^{-4}\,m = 0.1\,mm$

6. A soap film has a refractive index of 1.40. How thick must the film be, if it appears black, when mercury light of wavelength 546.1 nm falls on it normally?

SOLUTION $n = 1.4 \quad m = 1 \qquad \lambda = 546.1 \times 10^{-9}\,m \qquad t = ?$

Since $\qquad 2nt = m\lambda$

$$\Rightarrow \qquad t = \frac{m\lambda}{2n} = \frac{1 \times 546.1 \times 10^{-9}}{2 \times 1.4} = 1.95 \times 10^{-9}\,m$$

7. Find the polarizing angle for a glass of refractive index of 1.55.

SOLUTION Ref. index of air $n_1 = 1$

Ref. index of glass $n_2 = 1.55$

Polarizing angle $= i_p = ?$

$\tan i_p = n_2 / n_1$

$i_p = \tan^{-1}(n_2/n_1)$

$i_p = \tan^{-1}(1.55/1) = 57°$

The wavelength of light λ_n in a medium whose index of refraction is n. Where λ is the wavelength of the light in free space.

$\lambda_n = \lambda / n$

8. A diffraction grating has 5000 lines per centimeter. At what angle does the second order spectrum of the sodium yellow light of wavelength 589 nm occur?

SOLUTION $m = 2 \qquad \lambda = 589\,nm = 589 \times 10^{-9}\,m$

$d = 1\,cm/5000 = 1 \times 10^{-2}\,m/5000$

$d = 0.2 \times 10^{-2}\,m/\text{line}$

$d \sin\theta = m\lambda$

$\theta = \sin^{-1}(m\lambda/d) = \sin^{-1}(2 \times 589 \times 10^{-9}\,m / 2 \times 10^{-5}\,m)$

$\theta = 0.34°$

9. Light is incident normally on a grating which has 250 lines / mm. Find the wavelength of spectral line for which the deviation in second order is 12°.

SOLUTION $m = 2$

$d = 1\,mm/250 = 1 \times 10^{-3}\,m/250 = 4 \times 10^{-6}\,m$/line

$\theta = 12°$

$\lambda = ? \qquad \sin 12° = 0.2079$

Since $\qquad d \sin\theta = m\lambda$

$$\lambda = d \sin\theta / m$$

$$\lambda = \frac{4 \times 10^{-6} \times 0.2079}{2} = 4158 \times 10^{-10}\ m$$

10. In a certain X-rays diffraction experiment the first order image is observed at an angle of 5° for a crystal plane spacing of 2.8×10^{-10} m. What is the wavelength of X-rays used?

SOLUTION $m = 1$ $\theta = 5°$ $d = 2.8 \times 10^{-10}$ m $\lambda = ?$

Since; $m\lambda = 2d \sin\theta$

$$\Rightarrow \quad \lambda = \frac{2d \sin\theta}{m} = \frac{2 \times 2.80 \times 10^{-10} \times \sin 5^{o}}{1} = 0.49 \times 10^{-10}\ m$$

11. An X-ray beam of wavelength 0.48×10^{-10} m is used to get Bragg reflection from a crystal at an angle of 20° for the first order maximum. What are the possible layer plane spacing which give rise to this maximum?

SOLUTION

$m = 1$ Layer spacing $d = ?$

$\lambda = 0.48 \times 10^{-10}$ m

$\theta = 20°$

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

$$d = \frac{m\lambda}{2 \sin\theta} = \frac{1 \times 0.48 \times 10^{-10}}{2 \times \sin 20^{o}} = 0.70 \times 10^{-10}\ m$$