Numerical Problems

1) In a Young double slit experiment the separation of the slits is 1mm and red light of wavelength 620 mm is falling on it. Determine the distance between the central bright hand and fifth bright fringe on the screen which is 3m away from the slit.

Data:

Separator of the slits = d = 1mm = 1.0×10^{-3} m

Wavelength of red light = λ = 620 nm = 620×10^{-9} m

Distance between screen and slit = L = 3m

Distance between central bright band and fifth bright fringe = Yn=?

Solution

Since $$Yn = \frac{n\lambda L}{d}$$

$$Yn = \frac{5 \times 620 \times 10^{-9} \times 3}{1.0 \times 10^{-3}}$$

$$\boxed{Yn = 9.3mm}$$

2) Monochromatic Light of wave length 589.2 nm is used to illuminate the narrow slits 1mm apart. Find the position of 1st dark and 1st bright fringes on the screen 100 cm away.

Data:

Wave length of light = λ = 589.2×10^{-9}

Separation between slits = d = 1.0×10^{-3}

Distance between screen and slit = L = 100 cm = 1 m

Position of 1st dark fringe = y_1 = ?

Position of 1st bright fringe = $y_1' = ?$

Solution

Since expression for the height of dark fringes is given as

$$y_n = \left(n + \frac{1}{2}\right)\frac{\lambda L}{d}$$

(i) For 1st dark fringe n=1 so

$$y_1 = \left(1 + \frac{1}{2}\right) \times \frac{589.2 \times 10^{-9} \times 1}{1 \times 10^{-3}}$$

$$\boxed{y_1 = 9.0 \times 10^{-4}\,m}$$

(ii) Expression for height of bright fringes is given as

$$y_n = \frac{n\lambda L}{d}$$

For first bright fringe n = 1

$$y_1' = \frac{1 \times 589.2 \times 10^{-9} \times 1}{1 \times 10^{-3}}$$

$$\boxed{y_1' = 5.89 \times 10^{-4}\,m}$$

3) Two parallel slits are illuminated by light of two wave lengths, one of which is 5.8x10^{-7} m. On the screen the fourth dark line of the known wave length coincides with the fifth bright line of the light of unknown wavelength. Find the unknown wavelength.

Data:

According to given condition

$$\left(n_1 + \frac{1}{2}\right)\frac{\lambda_1 L}{d} = \frac{n_{...}\lambda_2 L}{d} \qquad ....(1)$$

Since $n_4 = 4$ & $n_5 = 5$

Equation (1)

$$\Rightarrow \qquad \left(4 + \frac{1}{2}\right)\frac{\lambda_1 L}{d} = \frac{5\lambda_{...}L}{d}$$

$$\Rightarrow \qquad \lambda_2 = \frac{9 \times 5.8 \times 10^{-7}}{2 \times 5}$$

$$\boxed{\lambda_2 = 5.1 \times 10^{-7}\,m}$$

4) When a moveable mirror of a Michelson Interferometer is moved 0.1 mm. How many dark fringes pass the reference point, if light of wavelength 580 nm is used?

Data:

The distance covered by moveable mirror = L = 0.1×10^{-3}m

Number of dark fringes = n = ?

Wavelength of light = λ = 580×10^{-9} m

Solution

Since $L = \frac{n\lambda}{2}$

$\Rightarrow$ $n = \frac{2L}{\lambda}$

$\Rightarrow$ $n = \frac{2 \times 0.1 \times 10^{-3}}{580 \times 10^{-9}}$

$\boxed{n = 345 \text{ fringes (approximately)}}$

5) When a moveable mirror on a Michelson Interferometer is moved in one direction, 400 fringes appear to pass through the field of view when light of wave length of 500 nm is used. What is the distance through which the mirror has been moved?

Data:

Number of fringes = n = 400

Wavelength of light = λ = 500 nm = 500×10^{-9} m

Distance through which the mirror used = L = ?

Solution

Since $L = \frac{n\lambda}{2}$

$\Rightarrow$ $L = \frac{n\lambda}{2}$

$\Rightarrow$ $L = \frac{400 \times 500 \times 10^{-9}}{2}$

$L = 1.0 \times 10^{-4}\ m$

$\boxed{L = 0.1\ mm}$

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

Data:

Refractive index of soap film n = 1.40

Thickness of the film x = ?

Wavelength of mercury light = $\lambda = 546.1 \times 10^{-9}$ m

Angle of incidence = $\theta = 90°$

Solution

As we know that

$$2x = \frac{n\lambda}{2}$$

$$x = \frac{n\lambda}{4}$$

$$x = \frac{1.4 \times 436.1 \times 10^{-9}}{4}$$

$$\boxed{x = 1.95 \times 10^{-7}\ m}$$

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

Data:

Polarizing angle for glass θ_p=?

Refractive index of the glass $n_2 = 1.55$

Refractive index of the air $n_1 = 1$

Solution

$$\tan\theta_p = \frac{n_2}{n_1}$$

Putting values

$$\theta_p = \tan^{-1} \times \frac{1.55}{1}$$

$$\boxed{\theta_p = 57^\circ}$$

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

Data:

Number of lines on grating per centimeter, N=5000

Wavelength of sodium yellow light λ = 589 nm = 589×10^{-9}m

Order of diffraction n=2

Angle of incidence on grating θ=?

Solution

Since $d\sin\theta = n\lambda$ ....(1)

But $d = \frac{1}{N} = \frac{1}{5000} = 2\times10^{-4}m$

$d = 2\times10^{-6}m$

Putting values in equation (1) we get

$$2\times10^{-6}m\times\sin\theta = 2\times289\times10^{-9}$$

$$\sin\theta = \frac{2\times289\times10^{-9}}{2\times10^{-6}}$$

$$\sin\theta = 589\times10^{-3}$$

$$\theta = \sin^{-1}(0.589)$$

$$\boxed{\theta = 36^{\circ}}$$

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

Data

Wave length of spectral line = λ = ?

Angle of deviation = θ = 12°

Order of the diffraction = n = 2

Number of lines/nm N = 250

Solution

Since $d = \frac{1}{N}$

$$d = \frac{1}{250}$$

$$d = 4 \times 10^{-3} mm$$

$$d = 4 \times 10^{-6} m$$

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

$$\lambda = \frac{d\sin\theta}{n}$$

$$\lambda = \frac{4 \times 10^{-6} \times \sin 12}{2}$$

$$\lambda = 0.42 \times 10^{-6}$$

$$\boxed{\lambda = 4158 \times 10^{-6}}$$

10) In a certain x-rays diffraction experiment the first order image is observed at an angel of 5° for a crystal plane spacing 2.8x10^{-10}m. What is the wavelength of light used?

Data:

Order of diffraction = n = 1

Wavelength of x-rays = **λ** = ?

Angle of incidence = **θ** = 5°

Crystal plane spacing = d = 2.8 x 10^{-10} m

Solution

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

$$\lambda = \frac{2d\sin\theta}{n}$$

$$\lambda = \frac{2 \times 2.8 \times 10^{-10} \times \sin 5^\circ}{1}$$

$$\boxed{\lambda = 0.49 \times 10^{-10} m}$$

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

Data

Wave length of x-rays, $\lambda = 0.48 \times 10^{-10}$ m

Order of diffraction n = 1

Angle of reflection $\theta = 20°$

Plane spacing d = ?

Solution

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

$$d = \frac{n\lambda}{2\sin\theta}$$

$$d = \frac{1 \times 0.48 \times 10^{-10}}{2 \times \sin 20^\circ} \Rightarrow$$

$$\boxed{d = 0.70 \times 10^{-10}\ \text{m}}$$