9.12 Fill in the blanks

Answer :-

(i)- According to Huygen's principle, each point on a wavefront act as a source of secondary wavefront

(ii)- In Young's experiment the distance between two adjacent bright fringes for violet light is less than that for green light.

(iii)- The distance between bright fringes in the interference pattern increases as the wavelength of light used increases.

(iv)- A diffraction grating is used to make a diffraction pattern for yellow light and then for red light. The distance between the red spots will be more than that for yellow light

(v)- The phenomenon of polarization of light reveals that light waves are transverse wave.

(vi)- A Polaroid is a commercial polarizer

(vii)- A Polaroid glass eliminates glare of light produced at a road surface

NUMERICAL PROBLEMS

9.1 :- Light of wavelength 546nm is allowed to illuminate the slits of Young's experiment. The separation between the slits is 0.10 mm and the distance of the screen from the slits where interference effects are observed is 20cm. At what angle the first minimum will fall? What will be the linear distance on the screen between adjacent maxima?

SOLUTION :-

Given Data :- $\lambda = 546nm = 546 \times 10^{-9} m$

$d = 0.10\ mm = 0.10 \times 10^{-3}\ m$

$L = 20\ cm = 20 \times 10^{-2}\ m$

To Find

For Ist minimum $= \theta = ?$

Fringe Spacing $= \Delta y = ?$

Calculations:-

For minima

$$d \sin\theta = (m + \tfrac{1}{2})\lambda$$

For Ist minima $m = 0$

$$d \sin\theta = (0 + \tfrac{1}{2})\lambda$$

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

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

$$\sin\theta = \frac{546 \times 10^{-9}\ m}{2 \times 0.10 \times 10^{-3}\ m} = 0.00273$$

$$\theta = \sin^{-1}(0.00273)$$

$$\boxed{\theta = 0.16^\circ}$$

For fringe spacing

$$\Delta y = L\lambda/d$$

$$\Delta y = \frac{20 \times 10^{-2}\ m \times 546 \times 10^{-9}\ m}{0.10 \times 10^{-3}\ m}$$

$$\Delta y = 1.1 \times 10^{-3}\ m$$

$$\boxed{\Delta y = 1.1\ mm}$$

9.2 :- Calculate the wavelength of light, which illuminates two slits 0.5 mm apart and produces an interference pattern on a screen placed 200 cm away from slits. The first bright fringe is observed at a distance of 2.40 mm from central bright image.

Solution:- Data

$d = 0.5\ mm = 0.5 \times 10^{-3}\ m$

$L = 200\ cm = 2\ m$

$\Delta y = 2.40\ mm = 2.4 \times 10^{-3}\ m$

$m = 1$

$\lambda = ?$

Calculations As $y = \frac{mL\lambda}{d}$

$$\Rightarrow \lambda = \frac{dy}{mL}$$

$$= \frac{0.5\times10^{-3}\,m \times 2.40\times10^{-3}\,m}{1\times2}$$

$$= 6\times10^{-7}\,m$$

$$= 600\times10^{-9}\,m$$

$$\boxed{\lambda = 600\ nm}$$ **Answer**

9.3:- In a double slit experiment the second order maximum occurs at $\theta = 0.25°$. The wavelength is 650nm. Determine the slit separation.

Solution:-

Data

$m = 2$

$\theta = 0.25°$

$\lambda = 650nm = 650\times10^{-9}\,m$

$d = ?$

Calculation:-

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

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

$$= \frac{2\times650\times10^{-9}}{\sin 0.25°}$$

$$d = 2.98\times10^{-4}\,m$$

$$= 3\times10^{-4}\,m = 0.3\times10^{-3}\,m$$

$$\boxed{d = 0.3\ mm}$$

9.4:- A monochromatic light of $\lambda = 588\ nm$ is allowed to fall on the half silvered glass plate G_1 in the Michelson Interferometer. If mirror M_1 is moved through 0.233 mm, how many fringes will be observed to shift?

Data:- $\lambda = 588\,nm = 588 \times 10^{-9} m$

$L = 0.233\,mm = 0.233 \times 10^{-3} m$

$m = ?$

Calculations:-

$$L = m\,\lambda/2$$

$$m = \frac{2L}{\lambda} = \frac{2 \times 0.233 \times 10^{-3} m}{588 \times 10^{-9} m}$$

$$\boxed{m = 792}$$

9.5:- A second order spectrum is formed at an angle of 38°, when light falls normally on a diffraction grating have 5400 lines per centimetre. Determine wavelength of the light used.

Solution:-

Data:- $\theta = 38^\circ$

$N = 5400$ lines per cm.

$N = 5400 \times 10^{2}$ lines per metre

$n = 2$

$\lambda = ?$

Calculation:-

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

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

As we have $d = \frac{1}{N}$

So

$$\lambda = \frac{1}{N} \frac{\sin\theta}{n}$$

$$= \frac{1}{540000\,m^{-1}} \times \frac{\sin 38^\circ}{2}$$

$$\lambda = 5.7 \times 10^{-7} m$$

$$= 570 \times 10^{-9} m$$

$$\boxed{\lambda = 570\,nm}$$

9.6:- A light is incident normally on a grating which has 2500 lines per cm. Compute the wavelength of a spectral line for which the deviation in second order is 15°.

Solution:-

Data:-

$N = 2500 \text{ lines cm}^{-1}$

$N = 250000 \text{ lines m}^{-1}$

$n = 2$

$\theta = 15^\circ$

$\lambda = ?$

Calculations:-

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

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

As

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

$\therefore$

$$\lambda = \frac{1}{N} \frac{\sin\theta}{n}$$

$$= \frac{1}{250000} \times \frac{\sin 15^\circ}{2} \text{ m}$$

$$= 5.18 \times 10^{-7} \text{ m}$$

$$= 518 \times 10^{-9} \text{ m}$$

$$\boxed{\lambda = 518 \text{ nm}}$$

9.7:- Sodium light (= 589 nm) is incident normally on a grating having 3000 lines per centimeter. What is the highest order of the spectrum obtained with this grating.

Solution:-

Data:-

$\lambda = 589 \text{ nm} = 589 \times 10^{-9} \text{ m}$

$N = 3000 \text{ lines cm}^{-1}$

$= 300000 \text{ lines m}^{-1}$

$n = ?$

$\theta = 90^\circ$

Calculations :- As

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

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

$$= \frac{1}{N} \cdot \frac{\sin\theta}{\lambda} \qquad (\because d = 1/N)$$

$$= \frac{1}{300000 \, m^{-1}} \times \frac{\sin 90^\circ}{589 \times 10^{-9} \, m}$$

$$= \frac{1}{0.1767}$$

$$n = 5.66$$

Hence, the highest spectrum obtained with this grating is 5 th one (as 6th is incomplete)

9.8 :- Blue light of wavelength 480 nm illuminates a diffraction grating. The second order image is formed at an angle of 30° from the central image. How many lines in a centimeter of the grating have been ruled?

Solution :- Data :- $\lambda = 480 \, nm = 480 \times 10^{-9} \, m$

$n = 2$

$\theta = 30^\circ$

$N = ?$

Calculation :-

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

As $d = 1/N$

$$\frac{1}{N} \sin\theta = n\lambda$$

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

$$N = \frac{\sin 30^\circ}{2 \times 480 \times 10^{-9} \, m}$$

$$N = \frac{0.5}{960 \times 10^{-9} \, m}$$

$$N = 5.2 \times 10^{5} \text{ lines per m}$$

$$\boxed{N = 5.2 \times 10^{3} \text{ lines per cm}}$$

9.9:- X-rays of wavelength 0.150 nm are observed to undergo a first order reflection at a Bragg angle of 13.3° from a quartz (SiO_2) crystal. What is the interplaner spacing of the reflecting planes in the crystal?

Solution:-

Data:-

$\lambda = 0.150\ nm = 0.15 \times 10^{-9}\ m$

$m = 1$

$\theta = 13.3°$

$d = ?$

Calculations:-

According to Bragg's equation

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

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

$$= \frac{1 \times 0.15 \times 10^{-9}\ m}{2 \times \sin 13.3°}$$

$$= 3.26 \times 10^{-10}\ m$$

$$= 0.326 \times 10^{-9}\ m$$

$$\boxed{d = 0.326\ nm}$$

9.10:- An X-ray beam of wavelength undergoes a first order reflection from a crystal when is angle of incidence to a crystal face is 26.5°, and an x-ray beam of wavelength 0.097 nm undergoes a third order reflection when its angle of incidence to that face is 60°. Assuming that the two beams reflect from the same family of planes, calculate

(a) - the interplaner spacing of the planes.

(b) - the wavelength.