WAVE OPTICS

DPP – 2

CLASS – 12th

TOPIC – Interference of Light and Young's Double Slit Experiment

Q.1 If the two slits in Young's experiment have widths in the ratio 4:9, then find the ratio of intensity at the maximum to the intensity at the minimum in the interference pattern

Q.2 In Young's double slit experiment, using monochromatic light of wavelength λ, the intensity of light at a point on the screen, where path difference is λ, is K units. Find out the intensity of light at a point, where path difference is $\lambda/3$

Q.3 In a Young's double slit experiment, the fringe width obtained is 0.6 cm, when light of wavelength 4,800 Å is used. If the distance between the screen and the slit is reduced to half, what should be the wavelength of light used to obtain fringes 0.0045 m wide?

Q.4 In a Young's double slit experiment, the slits are 1.5 mm apart. When the slits are illuminated ty by a monochromatic source and the screen is kept 1m apart from the slits, width of 10 fringes is measured as 3.93 mm. Calculate the wavelength of light used. What will be the width of 10 fringes, when the distance at between the slits and the screen is increased by 0.5 m? The source of light used remains the same.

Q.5 Two slits in Young's experiment are 0.02 cm apart. The interference fringes for light of wavelength 6,000 Å are formed on a screen 80 cm away. Calculate the distance of the fifth bright fringe

Q.6 In a Young's double slit experiment, the two slits are 0.03 cm apart and the screen is placed 1.5 m away. The distance between the central bright fringe and the fourth bright fringe is measured to be 1 cm. Determine the wavelength of light used.

Q.7 Two slits 0.125 mm apart are illuminated by light of wavelength 4,500 Å. The screen is one metre away from the plane of the slits. Find the separation between the second bright fringes on both sides of the central maximum.

Q.8 In a Young's double slit experiment, the fringes are formed at a distance of 1 m from double slit of separation 0.12 mm. Calculate the distance of 3rd dark band from the centre of the screen.

Given that λ=6,000 Å

Q.9 In a Young's double slit experiment, the slits are 0.2 mm apart and the screen is 1.5 m away. is observed that the distance between the central bright fringe and fourth dark fringe is 1.8 cm. Find the wavelength of light used.

Q.10 In a Young's experiment, the width of the fringes obtained with light of wavelength 6,000 Å is 2.0 mm. What will be the fringe width, if the entire apparatus is immersed in a liquid of refractive index 1.33?

SOLUTION

(PHYSICS) **WAVE OPTICS**

DPP – 2

CLASS – 12th

TOPIC – Interference of Light and Young's Double Slit Experiment

Sol.1. The intensity of light due to a slit is directly proportional to the width of the slit. Therefore,

$$\frac{I_1}{I_2} = \frac{w_1}{w_2}$$

Since $w_1/ w_2 = 4/9$ we have

$$\frac{I_1}{I_2} = \frac{4}{9}$$

If a_1 and a_2 are amplitudes of the waves from the two slits, then

$$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$$

From the equations (i) and (ii), we have

$$\frac{a_1^2}{a_2^2} = \frac{4}{9} \text{ or } \frac{a_1}{a_2} = \frac{2}{3}$$

or $a_2 = 1.5\, a_1$

Now, $\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(a_1 + 1.5a_1)^2}{(a_1 - 1.5a_1)^2} = \frac{25}{1}$

= 25 : 1

Sol.2. In interference pattern, the intensity of light at a point is given by

$$I = I_0 \cos^2 \frac{\phi}{2} \qquad ...(i)$$

The phase difference (φ) is related to path difference (x) as

$$\phi = \frac{2\pi}{\lambda} x$$

When $x = \lambda$, $I = K$

On setting this condition, the equation (*i*) becomes

$$K = I_0 \cos^2 \frac{\pi}{\lambda}\lambda = I_0 \cos^2 \pi = I_0 \times (-1)^2 = I_0$$

In the equation (ii), setting $I_0 = K$ we have

$$I = K \cos^2 \frac{\pi}{\lambda} x$$

Hence, when $x = \lambda /3$, the intensity of light will be

$$I = K \cos^2 \left(\frac{\pi}{\lambda} \times \frac{\lambda}{3}\right) = K \cos^2 \frac{\pi}{3} = K \times \left(\frac{1}{2}\right)^2$$

= K/4

Sol.3. Here, $\lambda = 4{,}800$ Å $= 4{,}800 \times 10^{-10}$ m;

$\beta = 0.6\text{cm} = 0.6 \times 10^{-2}\text{m}$

Now, $\beta = \frac{D}{d}\lambda$

or $\frac{d}{D} = \frac{\lambda}{\beta} = \frac{4{,}800 \times 10^{-10}}{0.60 \times 10^{-2}} 8 \times 10^{-5}$ ...... (i)

When the distance between the screen and the slits is reduced to half of its initial value:

Here, β = 0.0045m ; D' = D/2 and d' = d

Let λ'be the wavelength of the light source.

Then, $\beta' = \frac{D'\lambda'}{d'}$

or $\lambda' = \beta' \frac{d'}{D'} = 0.0045 \frac{d}{D/2} = 0.009 \frac{d}{D}$ ...(ii)

From the equations (i) and (ii), we have

$\lambda = 0.009 \times 8 \times 10^{-5} = 7.2 \times 10^{-7}$ m

= 7 ,200 Å

Sol.4. Here, d = 1.5mm = 1.5×10^{-3}m, D = 1m

and the width of 10 fringes = 3.93 mm

Therefore, fringe width,

$\beta \frac{3.93}{10} = 0.393\text{mm} = 0.393 \times 10^{-3}\text{m}$

Now, $\lambda = \beta \frac{d}{D} = 0.393 \times 10^{-3} \times \frac{1.5 \times 10^{-3}}{1}$

$= 5.895 \times 10^{-7}$ m

When the distance between the screen and the slits is changed:

Here, D' = 1 + 0.5 = 1.5m; $\lambda = 5.895 \times 10^{-7}$ m;

d = 1.5×10^{-3}m ;

Therefore, width of 10 fringes = 10 β

$= 10 \times \frac{D}{d}\lambda = 10 \times \frac{1.5}{1.5 \times 10^{-3}} \times 5.895 \times 10^{-7}$

= 5.895×10^{-3}m

Sol.5. Here, d = 0.02cm; D = 80cm

$\lambda = 6{,}000 \times 10^{-8}$ cm = 6×10^{-5}cm ;

For the bright fringe,

$Y_n = \frac{nD\lambda}{d}$

For fifth maximum, n = 5

$\therefore \quad y_5 = \frac{5 \times 80 \times 6 \times 10^{-5}}{0.02} = 1.2\text{cm}$

Sol.6. Here, d = 0.3cm = 3×10^{-4}m, D = 1.5m

Now, distance of the fourth bright fringe,

y_4 = 1cm = 10^{-2} m

But $\quad Y_4 \frac{4D\lambda}{d}$

or $\quad \lambda = \frac{y_4 \times d}{4D} = \frac{10^{-2} \times 3 \times 10^{-4}}{4 \times 1.5} 5 \times 10^{7}\text{m}$

Sol.7. Here, d = 0.125mm = 0.125×10^{-3} m

λ= 4 ,500 Å =$4{,}500 \times 10^{-10}$ m ; D = 1m

The distance of the ath bright fringe from the central maximum,

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

Therefore, distance of the 2nd bright fringe from the central maximum

$$y2 = 2 \times \frac{1}{0.125 \times 10-3} \times 4,500 \times 10^{-10} m = 7.2 \times 10-3m$$

Hence, the separation between the second bright fringes formed on both sides of the central maximum,

$2y_2 = 2 \times 7.2 \times 10^{-3} = 14.4 \times 10^{-3}$ m = 14.4mm

Sol.8. Here, d = 0.12mm = 0.012cm ;

D = 1m = 100cm ;

λ= 6000 Å = 6000 × 10^{-8} cm

For (n + 1) th dark fringe $y_n = (2n+1)\frac{D\lambda}{2d}$

For third dark fringe, n = 2

$$\therefore\ y_2' = (2\times 2+1)\times\frac{100}{2\times 0{\cdot}012}\times 6{,}000\times 10^{-8}$$

= 1.25 cm

Sol.9. Here, d = 0.2mm = 2 × 10^{-4} m ; D = 1.5m ;

Now, distance of fourth dark fringe,

y_3' = 1.8cm = 1.8 × 10^{-2} m

But $y_3' = \frac{7D\lambda}{2d}$

or $\lambda = \frac{2y_3'd}{7D} = \frac{2\times 1{\cdot}8\times 10^{-2}\times 2\times 10^{-4}}{7\times 1{\cdot}5}$

= 6.86 ×10^{-7} m

Sol.10. In air: β'= 2.0mm = 2.0 × 10^{-3}m;

λ = 6,000 Å = 6 × 10^{-7}m;

Now $\beta = \frac{D\lambda}{d}$

or $\frac{D}{d} = \frac{\beta}{\lambda} = \frac{2{\cdot}0\times 10^{-3}}{6\times 10^{-7}}$

In liquid: Let 'be the wavelength of light in liquid nd ß'be the corresponding fringe width. Then,

$$\lambda' = \frac{\lambda}{\mu} = \frac{6\times 10^{-7}}{1{\cdot}33}$$

Now, $\beta' = \frac{D\lambda'}{d} = \frac{2{\cdot}0\times 10^{-3}}{6\times 10^{-7}}\times\frac{6\times 10^{-7}}{1{\cdot}33}$

= 1.5 × 10^{-3} m = 1.5mm