Tutorial Sheet 1 (Interference)

Q.1 If in an interference pattern, the ratio between maximum and minimum intensities is 36:1, find the ratio between the amplitude and intensities of the two interfering waves.
Ans: 7:5, 49:25

Q.2 Two identical coherent waves produced interference pattern. Find the ratio of intensity at the centre of a bright fringe to the intensity at a point one quarter of the distance between two fringes from the centre. Ans: 2:1

Q.3 In an interference pattern with two coherent sources, the amplitude of intensity variation is found to be 5% of the average intensity. Calculate the relative intensities of the interfering sources. Ans: 1600:1

Q.4 Two coherent sources of intensity ratio 9:1 interfere. Prove that in the interference pattern, $(I_{max} - I_{min}) / (I_{max} + I_{min}) = 3/5$

Q.5 In a two slit interference pattern at a point we observe 10^{th} order maximum for $\lambda =$ 7000Å. What order will be visible here, if the source of light is replaced by light of wavelength 5000 Å? Ans: 14

Q.6 Two coherent sources are placed 0.18 mm apart and the fringes are observed on a screen 80 cm away. It is found that with a certain monochromatic source of light the fourth bright fringe is situated at a distance of 10.8 mm from the central fringe. Find the wavelength of light. Ans: 6075 Å

Q.7 Given light of wavelength 5100 Å from a narrow slit is incident on a double slit. If the overall separation of 10 fringes on a screen 200 cm away is 2.0 cm, find the double slit separation. Ans: 0.51mm

Q.8 In Young's double slit experiment the slits are 0.5mm apart and interference is observed on a screen placed at distance of 100cm from the slits. It is found that the 9^{th} bright fringe is at a distance of 8.835mm from second dark fringe from the center pattern. Find the wavelength of light used. Ans: 5890 Å

Q.9 In a particular two-slit interference pattern with $\lambda = 6000$ Å, the zero order and the 10^{th} order maxima fall at micrometer readings 12.34 mm and 14.73 mm. If λ is changed to 5000 Å, deduce the positions of the zero and 20th order fringes, other arrangements remaining the same. Ans: 12.34mm, 16.32mm, 8.36mm

Q.10 A double slit of separation 1.5 mm is illuminated by white light (between 4000 Å to 8000 Å). On a screen 120 cm away colored interference pattern is formed. If a pin hole is made on this screen at a distance of 3.0 mm from the central white fringe, what wavelengths will be absent in the transmitted light? Ans: 6818.2 Å, 5769.2 Å, 5000 Å, 4411.9 Å

Interference [Tutorial Sheet 1]

Ans. 1: Given that $\frac{I_{max}}{I_{min}} = \frac{36}{1}$

Let a_1 & a_2 are the amplitudes of source then

$$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{36}{1} \Rightarrow \frac{a_1+a_2}{a_1-a_2} = \frac{6}{1}$$

$$\Rightarrow a_1+a_2 = 6a_1 - 6a_2 \Rightarrow 7a_2 = 5a_1 \Rightarrow \frac{a_1}{a_2} = \frac{7}{5}$$

$$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{49}{25}$$

Ans. 2: ⇒ Intensity at centre $I_{centre} = a^2 + a^2 + 2a \cdot a \cos 0$

$$= 4a^2$$

Intensity at one quarter distance $I_{\pi/2} = a^2 + a^2 + 2a \cdot a \cos \pi/2$

$$I_{\pi/2} = 2a^2$$

$$\boxed{\frac{I_{centre}}{I_{\pi/2}} = \frac{4a^2}{2a^2} = \frac{2}{1}}$$

Ans. 3: Let average intensity is 100 then

$$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{100+5}{100-5} \Rightarrow \frac{a_1+a_2}{a_1-a_2} = \frac{\sqrt{105}}{\sqrt{95}}$$

$$\Rightarrow \frac{a_1^2}{a_2^2} = \frac{(\sqrt{105}+\sqrt{95})^2}{(\sqrt{105}-\sqrt{95})^2} = \frac{1600}{1}$$

Ans. 5: $\rightarrow$ Let $D, 2d$ are parameters, $n = 10$.

then, $x_n = n\frac{\lambda D}{2d}$

$$x_{10} = 10 \cdot 7000 \times 10^{-10}\left(\frac{D}{2d}\right) \quad (1)$$

Let n the order maxima for $\lambda = 5000 \times 10^{-10}$ m then

$$x_{10} = n \times 5000 \times 10^{-10}\left(\frac{D}{2d}\right) \quad (2)$$

$$\frac{\text{Eqn } 1}{\text{Eqn } 2} \Rightarrow 1 = \frac{10}{n} \times \frac{7}{5} \Rightarrow \boxed{n = 14}$$

Ans. 6: $\rightarrow$ $2d = 18 \times 10^{-5}$ m, $n = 4$

$D = 8 \times 10^{-1}$ m $\quad x_4 = 10.8 \times 10^{-3}$ m

$\lambda = ?$

$$x_4 = n\frac{\lambda D}{2d} \Rightarrow \lambda = \frac{x_4 \times 2d}{n \times D}$$

$$= \frac{10.8 \times 10^{-3} \times 18 \times 10^{-5}}{4 \times 8 \times 10^{-1}}$$

$$\lambda = 6075\ \text{Å}$$

Ans. 7: $\rightarrow$ $\lambda = 51 \times 10^{-8}$ m, $D = 2$ m, $n = 10$, $x_n = 2 \times 10^{-2}$ m

$2d = ?$

$$x_n = n\beta = n\frac{\lambda D}{2d} \Rightarrow 2d = \frac{n\lambda D}{x_n} = \frac{10 \times 51 \times 10^{-8} \times \cancel{2}}{\cancel{2} \times 10^{-2}}$$

$$\boxed{2d = .51 \text{ mm}}$$

Ans. 8: $\Rightarrow$ Given $2d = 5\times10^{-4}$ m, $D = 1$ m.

$x_9 - x_2' = 8.835\times10^{-3}$ m

$x_9 = 9\dfrac{\lambda D}{2d}$, $x_2' = (2\times2-1)\cdot\dfrac{\lambda D}{4d}$

$x_9 - x_2' = \left(9 - \dfrac{3}{2}\right)\dfrac{\lambda D}{2d}$

$x_9 - x_2' = \dfrac{15}{2}\times\dfrac{\lambda D}{2d}$

$\Rightarrow 8.835\times10^{-3} = \dfrac{15}{2}\times\dfrac{\lambda\times1}{5\times10^{-4}}$

$\Rightarrow \dfrac{8.835}{15}\times10^{-6} = \lambda = 5890\,A^0$.

Ans. 9: $\Rightarrow \lambda = 6000\times10^{-10}$ m

$x_0 = 12.34\times10^{-3}$ m

$x_{10} = 14.73\times10^{-3}$ m

$x_{10} - x_0 = 10\beta = 2.39\times10^{-3}$ m $\Rightarrow \beta = 2.39\times10^{-4}$ m

$\beta = \lambda\dfrac{D}{2d} \Rightarrow 2.39\times10^{-4} = 6000\times10^{-10}\times\dfrac{D}{2d}$.

$\Rightarrow \dfrac{D}{2d} = \dfrac{2.39}{6}\times10^{3} = 3.98\times10^{+2}$ m.

when $\lambda = 5000\times10^{-10}$ m., $x_0 = 12.34\times10^{-3}$ m.

$x_{20} = 20\times5000\times10^{-10}\times3.98\times10^{+2} = 3.98\times10^{-3}$ m

$x_{20} = (12.34+3.98)\times10^{-3}$ m $= 16.32\times10^{-3}$ m

$(12.34-3.98)\times10^{-3}$ m $= 8.36\times10^{-3}$ m

Ans. 10:

$2d = 1.5 \times 10^{-3}$ m.

$\lambda = (4000 - 8000)\ A^0$

$D = 1.2$ m

$x = 3 \times 10^{-3}$ m

we know for dark fringes

$$x_n = \frac{(2n-1)\lambda D}{4d}$$

$$\Rightarrow 3 \times 10^{-3} = \frac{(2n-1)\lambda \times 1.2}{2 \times 1.5 \times 10^{-3}}$$

$$\Rightarrow \lambda = \frac{90 \times 10^{-6}}{(2n-1)(1.2)}$$

$$= \frac{75 \times 10^{-7}}{(2n-1)} = \frac{75000}{(2n-1)}\ A^0$$

[6818.2, n = 6], [5769.2, n = 7], [5000 A^0 , n = 8], [4411.8 A^0, n = 9]