QB365 Question Bank Software

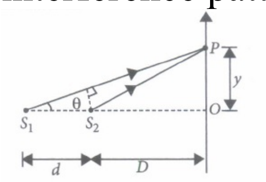
12th Physics Case study Questions Wave Optics For - 2024

12th Standard

Physics

SECTION - A 2 x 4 = 8

1) In Young's double slit experiment, the width of the central bright fringe is equal to the distance between the first dark fringes on the two sides of the central bright fringe.
In given figure below a screen is placed normal to the line joining the two point coherent source SI and S_2, The interference pattern consists of concentric circles.



(i) The optical path difference at P is

$(a)d\left[1+\frac{y^2}{2D}\right](b)d\left[1+\frac{2D}{y^2}\right](c)d\left[1-\frac{y^2}{2D^2}\right](d)d\left[2D-\frac{1}{y^2}\right]$

(ii) Find the radius of the n^{th} bright fringe.

$(a)D\sqrt{1\left(1-\frac{n\lambda}{d}\right)}(b)D\sqrt{2\left(1-\frac{n\lambda}{d}\right)}(c)2D\sqrt{2\left(1-\frac{n\lambda}{d}\right)}(d)D\sqrt{2\left(1-\frac{n\lambda}{2d}\right)}$

(iii) If d = 0.5 mm, λ= 5000 $\dot{A}$and D = 100 em, find the value of n for the closest second bright fringe

(a) 888 (b) 830 (c) 914 (d) 998

(iv) The coherence of two light sources means that the light waves emitted have

(a) same frequency	**(b) same intensity**
(c) constant phase difference	**(d) same velocity.**

(v) The phenomenon of interference is shown by

(a) longitudinal mechanical waves only	**(b) transverse mechanical waves only**
(c) electromagnetic waves only	**(d) all of these**

Answer : (i) (c):The optical path difference at P is

$$\Delta x=S_1P-S_2P=d\cos\theta$$

$$\because\quad \cos\theta=1-\frac{\theta^2}{2}\text{ for small }\theta$$

$$\therefore\quad \Delta x=d\left(1-\frac{\theta^2}{2}\right)=d\left[1-\frac{y^2}{2D^2}\right],\text{ where }D+d=D$$

(ii) (b) : For n^{th} maxima,

$$\Rightarrow\Delta x=n\lambda$$

$$d\left[1-\frac{y^2}{2D^2}\right]=n\lambda$$

Y = radius of the n^{th} bright ring

$$=D\sqrt{2\left(1-\frac{n\lambda}{d}\right)}$$

(iii) (d): At the central maxima, θ= 0.

$$\Delta x=d=n\lambda$$

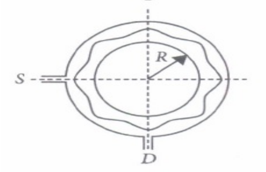
$$\Rightarrow n=\frac{d}{\lambda}=\frac{0.5}{0.5\times10^{-3}}=1000$$

Hence, for the closet second bright fringe, n = 998.

(iv) (c): Light waves from two coherent sources must have a constant phase difference.

(v) (d): Interference is shown by transverse as well as mechanical waves.

2) A narrow tube is bent in the form of a circle of radius R, as shown in figure. Two small holes S and D are made in the tube at the positions at right angle to each other. A source placed at S generates a wave of intensity Io which is equally divided into two parts: one part travels along the longer path, while the other travels along the shorter path. Both the waves meet at point D where a detector is placed.



(i) If a maxima is formed at a detector, then the magnitude of wavelength λ of the wave produced is given by
$(a) \pi R$ $(b) \frac{\pi R}{2}$ $(c) \frac{\pi R}{4}$ **(d) all of these**

(ii) If the intensity ratio of two coherent sources used in Young's double slit experiment is 49 : 1, then the ratio between the maximum and minimum intensities in the interference pattern is
(a) 1: 9 (b) 9: 16 (c) 25: 16 (d) 16: 9

(iii) The maximum intensity produced at D is given by
(a) $4I_0$ (b) $2I_0$ (c) I_0 (d) $3I_0$

(iv) In a Young's double slit experiment, the intensity at a point where the path difference is $\lambda/6$ (λ - wavelength of the light) is I. If I_0 denotes the maximum intensity, then I/I_0 is equal to
$(a) \frac{1}{2}$ $(b) \frac{\sqrt{3}}{2}$ $(c) \frac{1}{\sqrt{2}}$ $(d) \frac{3}{4}$

(v) Two identical light waves, propagating in the same direction, have a phase difference d. After they superpose the intensity of the resulting wave will be proportional to
$(a) \cos \delta$ $(b) \cos(\delta/2)$ $(c) \cos^2(\delta/2)$ $(d) \cos^2 \delta$

Answer : (i) (d): Path difference produced is
$$\Delta x = \frac{3}{2}\pi R - \frac{\pi}{2} R = \pi R$$
For maxima $\Delta x = n\lambda$
$$\therefore \quad n\lambda = \pi R$$
$$\Rightarrow \lambda = \frac{\pi R}{n}, n = 1, 2, 3, \ldots.$$
Thus, the possible values of λ are $\pi R, \frac{\pi R}{2}, \frac{\pi R}{3}, \ldots$

(ii) (d)

(iii) (b): Maximum intensity $I_{\max} = (\sqrt{I_1} + \sqrt{I_2})^2$
$$\text{Here, } I_1 = I_2 = \frac{I_0}{2} \text{ (given)}$$
$$\therefore \quad I_{\max} = \left(\sqrt{\frac{I_0}{2}} + \sqrt{\frac{I_0}{2}}\right)^2 = 2I_0$$

(iv) (d): Phase difference $\phi = \frac{2\pi}{\lambda}$ x path diffrerence
$$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{\pi}{3} = 60^\circ \text{ As } I = I_{\max} \cos^2 \frac{\phi}{2}$$
$$\therefore \quad I = I_0 \cos^2 \frac{60^\circ}{2} = I_0 \times \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4} I_0 \Rightarrow \frac{I}{I_0} = \frac{3}{4}$$

(v) (c): Here$A^2 = a_1^2 + a_2^2 + 2a_1a_2 \cos \delta \because a_1 = a_2 = a$
$$\therefore A^2 = 2a^2(1 + \cos \delta) = 2a^2 \left(1 + 2\cos^2 \frac{\delta}{2} - 1\right)$$
$$\text{or } A^2 \propto \cos^2 \frac{\delta}{2}$$
$$\text{Now } I \propto A^2 \quad \therefore I \propto A^2 \propto \cos^2 \frac{\delta}{2} \Rightarrow I \propto \cos^2 \frac{\delta}{2}$$