Interference, Young's double slit experiment and expression for fringe width

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 10
CHAPTER NAME : Wave Optics

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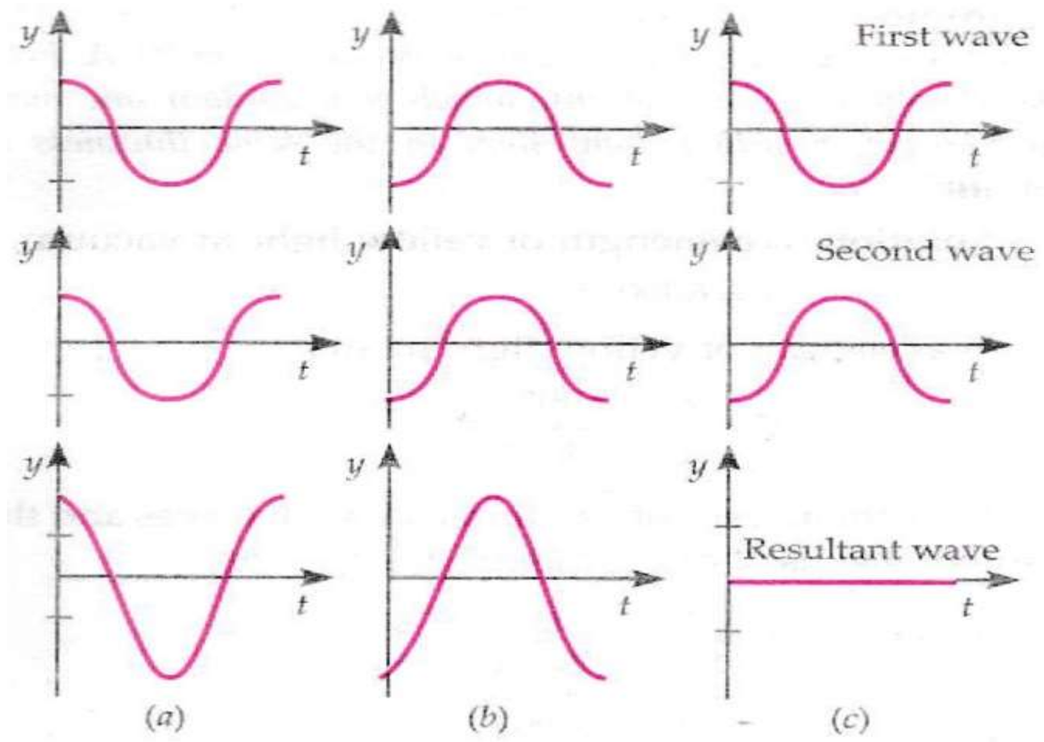
LEARNING OUTCOME

- Understand the concept of interference and its types.
- Understand YDSE.
- Understand the formation of fringes in YDSE
- Discuss the concept of fringe width.

Principle of superposition of waves:-

At a particular point in the medium, the resultant displacement produced by many waves is the vector sum of the displacements produced by each of the waves. i.e

$$\vec{y} = \vec{y}_1 + \vec{y}_2 + \vec{y}_3, \ldots\ldots\ldots\ldots + \vec{y}_n$$



Superposition of two waves of equal amplitudes coming from two very close point sources:-

$$= y = 2a\cos\frac{\phi}{2}\cos\left(\omega t + \frac{\phi}{2}\right)$$

$$\Rightarrow I \propto 4a^2\cos^2\frac{\phi}{2}$$

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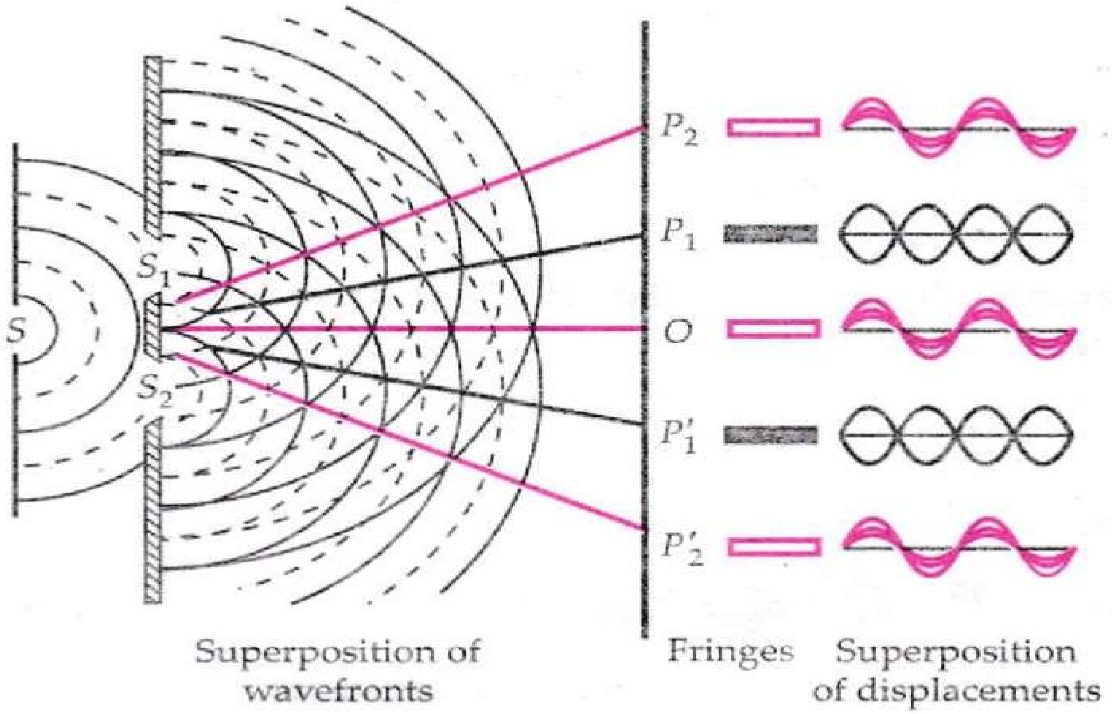
Interference of light

Types- (i) Constructive Interference
(ii)Destructive interference



- Resultant amplitude, a = $\sqrt{a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi}$
- Resultant intensity, $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$
- When $I_1 = I_2 = I_0, I = 2I_0(1+\cos\phi) = 4\,I_0\cos^2\frac{\phi}{2}$.
- Intensity of light ∝ Width of slit
- Ratio of slit widths, $\frac{w_1}{w_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$
- Intensity at maxima, $I_{max} \propto (a_1 + a_2)^2$
- Intensity at minima $I_{min} \propto (a_1 - a_2)^2$

  Intensity ratio at maxima and minima,
- $\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \left(\frac{r+1}{r-1}\right)^2$

  where $r = \frac{a_1}{a_2} = \sqrt{\frac{I_1}{1_2}}$ =amplitude ratio of two

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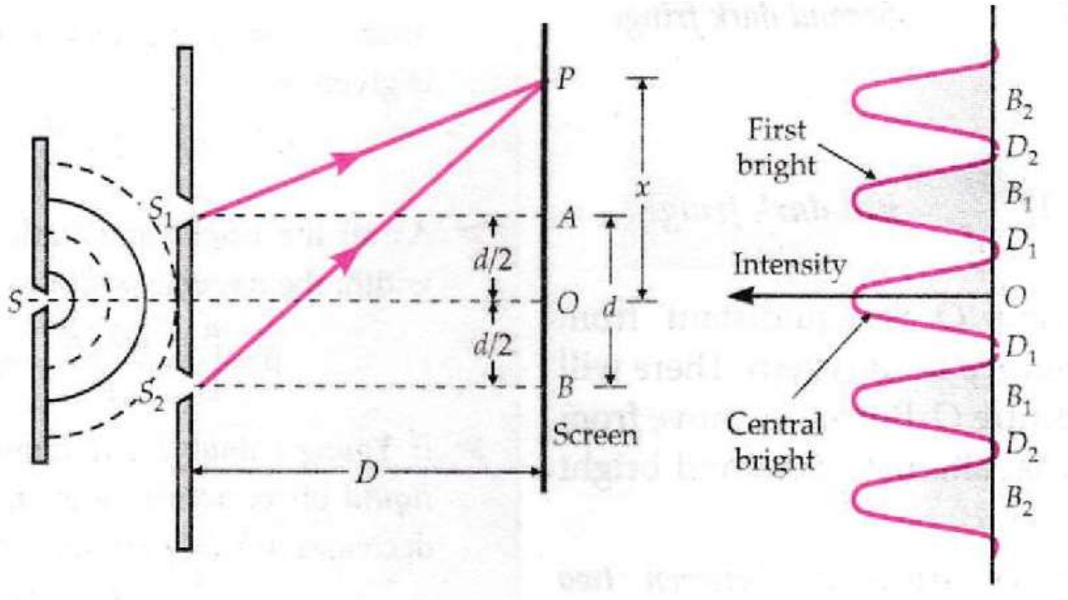
Young's double-slit experimental arrangement



Theory of interference fringes : Fringe Width

$$p = \frac{xd}{D}$$

Positions of bright fringes. For· constructive interference,

$$p = \frac{xd}{D} = n\lambda$$

or $x = \frac{nD\lambda}{d}$ where $n = 0, 1, 2, 3, \ldots\ldots.$

Positions of dark fringes. For destructive interference,

$$p = \frac{xd}{D} = (2n - 1)\frac{\lambda}{2}$$

or $x = (2n - 1)\frac{D\lambda}{2d}$ where $n = 1, 2, 3, \ldots\ldots$

Fringe width $\beta = \frac{}{d}$

Numerical

1.A beam of light consisting of two wavelengths, 800 nm and 600 nm is used to obtain the interference fringes in a Young's double slit experiment on a screen placed 1.4 m away. If the two slits are separated by 0.28 mm, calculate the least distance from the central bright maximum where the bright fringes of the two wavelengths coincide.

2. In Young's double slit experiment, the width of fringes obtained from a source of light of wavelength 5000 $\mathring{A}$ is 3.6 mm. Calculate the fringe width if the apparatus is immersed in a liquid of refractive index 1.2.

3. In Young's double slit experiment the light has a frequency of 6×10^{14} Hz and distance between the centers of adjacent fringes is 0.75 mm. If the screen is 1.5 m away, what is the distance between the slits ?

4. In a Young's double slit experiment, the distance between the slits and the screen is 1.60 m. Using light of wavelength 6×10^{-7} m, the distance between the center of the interference pattern and fourth bright fringe on either side is 16 mm. Calculate the slit separation.

Numerical

1.Two coherent sources, whose intensity ratio is 16:1 produce interference fringes. Calculate the ratio of intensity of maxima and minima in the fringe system.

2. The two slits in Young's experiment have widths in a ratio 25 : 1. Find the ratio of light intensity at the maxima and minima in the interference pattern.

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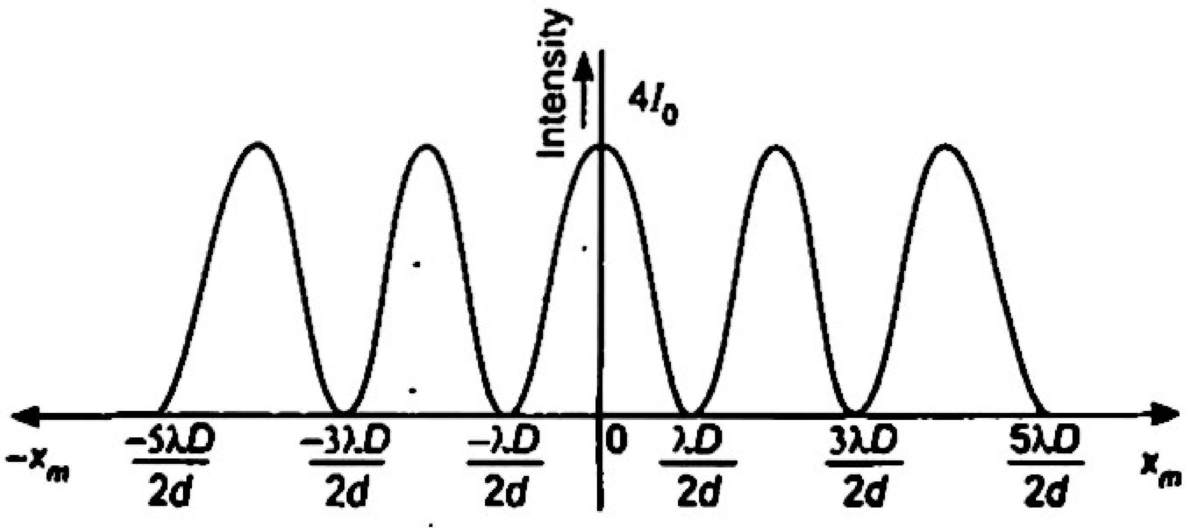
Intensity in the interference pattern



THANKING YOU

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