DRGP Institute

Chapter 10
Wave Optics

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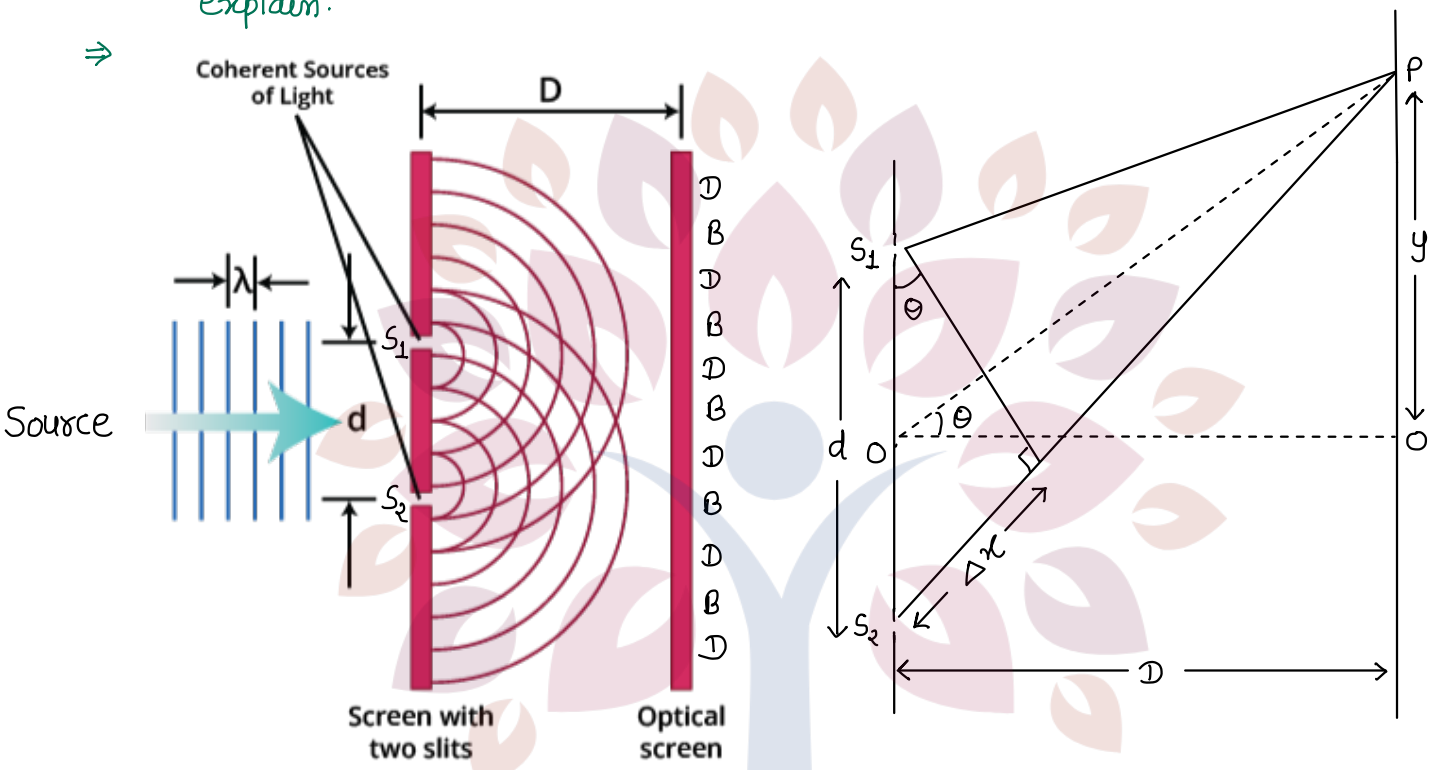
BOARD:- 2013

1. To produce interference fringe pattern, draw ray diagram of Young double slit experiment. Derive an expression of for bright interference fringe. If fringe width of bright fringe is 2mm, write the fringe width for dark fringe. whether centre point of interference dark or bright explain.

⇒



Due to constructive interference bright fringe is formed and due to destructive interference dark fringe is formed.

Position of bright fringe-

$$y = \frac{\Delta x D}{d}$$

$\Delta x = n\lambda$ (path difference for constructive interference)

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

Position of dark fringe-

$$y = \frac{\Delta x D}{d}$$

→ Centre fringe always bright fringe.

$\Delta x = \left(\frac{2n+1}{2}\right)\lambda$ (Path difference for destructive interference)

$$y = \frac{(2n+1)\lambda D}{2d}$$

→ If fringe width for bright fringe is 2mm, then for dark fringe also 2mm.

BOARD:- 2013 (Supp.)

2. Define wave front.

⇒ Locus of particles vibrating in same phase is known as wave front. or it is a surface of constant phase.

3. Define polarisation.

⇒ Process of converting unpolarised light into polarised light is known as polarisation.

4. Define interference.

⇒ when two coherent wave of same frequency approx same amplitude propogates in same direction and superpose on each other then due to redistribution of energy at some point of medium intensity of light become max and at some point it become minimum. This phenomenon is called Interference of light.

BOARD:- 2014

5. In young double slit experiment the distance b/w the slits is 0.28 mm and the distance of the screen is 1.4 m. If the distance of the fourth bright fringe from the central bright fringe is 1.2 cm then find the wavelength of light used.

⇒ $y = 1.2\text{cm} = 1.2\times10^{-2}\text{m}$

$n = 4$

$d = 0.28\text{mm} = 0.28\times10^{-3}\text{m}$

$D = 1.4\text{m}$

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

$$\lambda = \frac{yd}{nD}$$

$$\lambda = \frac{1.2\times10^{-2}\times0.28\times10^{-3}}{4\times1.4}$$

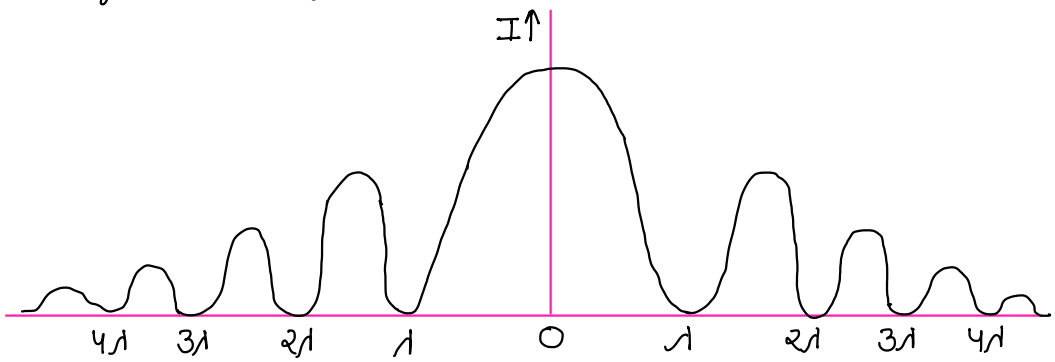
$$\lambda = 0.3\times10^{-2}\times0.2\times10^{-3}$$

$$\lambda = 6\times10^{-7}\text{m}$$

$$\lambda = 6000\text{A}^\circ$$

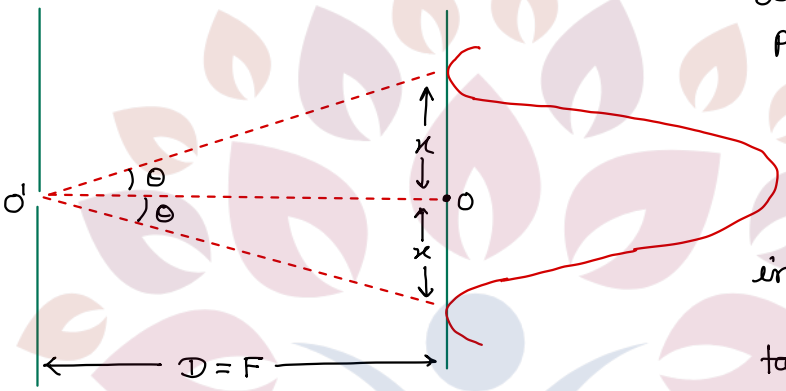
6. Draw a graph to show relative intensity distribution for single slit diffraction pattern. obtain an expression for the width of central maxima. If the width of the slit is doubled. what will be the effect on the width of central maximum.

⇒ (a) Graph for intensity distribution -



(b) Expression for width of central maxima -

Distance blw 1st minima both side the centre point will be equal to width of central maxima (β).



Angular width = 2θ

in △OO'P

$$\tan\theta = \frac{x}{D} \text{ or } \frac{x}{f}$$

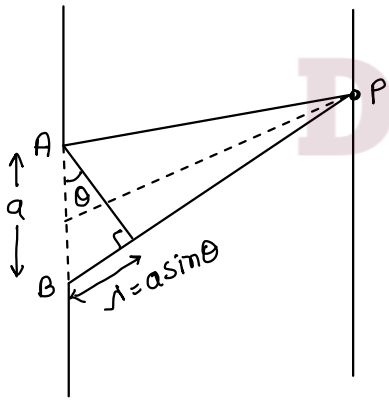
for small angle -

$$\theta = \frac{x}{D} \text{ or } \frac{x}{f}$$

$$2\theta = \frac{2x}{D} \text{ or } \frac{2x}{f} \quad -①$$

Again in △OO'P

$$\tan\theta = \theta = \frac{x}{D} \text{ or } \frac{x}{f}$$



$$x = \theta f \text{ or } \theta D \quad -②$$

W.K.T for minima

path difference $a\sin\theta = \lambda, 2\lambda, 3\lambda \cdots n\lambda$

for first minima

$$a\sin\theta = \lambda$$

for small angle

$$\sin\theta \simeq \theta$$

$$a\theta = \lambda$$

$$\theta = \frac{\lambda}{a}$$

put in eqn ②

$$x = \theta f \text{ or } \theta D$$

$$x = \frac{\lambda f}{a} \text{ or } \frac{\lambda D}{a}$$

Central width $\Rightarrow$ $\beta = 2x$

$$\beta = \frac{2\lambda f}{a} \text{ or } \frac{2\lambda D}{a}$$

Effect on β if a is doubled -

$$\beta \propto \frac{1}{a}$$

if a is doubled then β becomes half.

Extra note -

Condition for Maxima

$$a\sin\theta = \frac{3\lambda}{2}, \frac{5\lambda}{2} \ldots \frac{(2n+1)\lambda}{2}$$

$n = 1, 2, 3 \ldots$

Condition for minima

$$a\sin\theta = \lambda, 2\lambda, 3\lambda \ldots n\lambda$$

$n = 1, 2, 3 \ldots$

BOARD - 2015

7. Define Diffraction of Light.

$\Rightarrow$ The phenomenon of bending of light at the sharp edges of an obstacle or hole and reaches to geometrical shadow of object, is known as diffraction of Light.

8. Define interference of light wave. Draw a diagram of young's slit experiment to generate the interference fringe pattern. Derive the expression for fringe width for illuminated fringes.

BOARD:- 2016

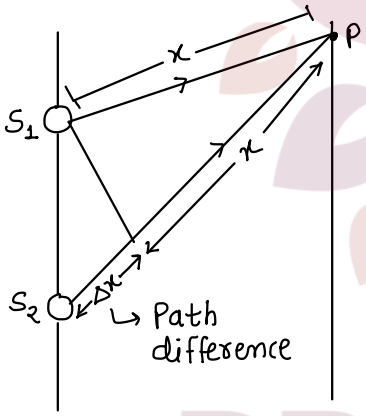
9. what is interference ? Derive conditions to obtain constructive and destructive interference. If in a double slit experiment a white light source is used instead of a monochromatic light source then what will happen to the interference fringes.

⇨ Interference - when two coherent wave of same frequency approx same amplitude propogates in same direction and superpose on each other then due to redistribution of energy at some point of medium intensity of light become max and at some point it become minimum. This phenomenon is called Interference of light.

→ Type of interference -

1. Constructive Interference
2. Destructive Interference

Conditions for constructive & destructive interference -



Amplitude of first wave -

$y_1 = a_1 \sin\omega t$

$y_2 = a_2 \sin(\omega t + \phi)$

By superposition principle -

$Y = y_1 + y_2$

$Y = a_1 \sin\omega t + a_2 \sin(\omega t + \phi)$

$Y = a_1 \sin\omega t + a_2 \sin\omega t \cos\phi + a_2 \cos\omega t \sin\phi$

$Y = \sin\omega t\,(a_1 + a_2\cos\phi) + \cos\omega t\,(a_2 \sin\phi)$

Suppose - $a_1 + a_2\cos\phi = R\cos\theta$ — ①

$a_2 \sin\phi = R\sin\theta$ — ②

$Y = \sin\omega t\, R\cos\theta + \cos\omega t\, R\sin\theta$

$Y = R\sin(\omega t + \theta)$

Ⓐ resultant amplitude (R) -

eqn ①^2 + eqn ②^2

$R^2\cos^2\theta + R^2\sin^2\theta = (a_1 + a_2\cos\phi)^2 + (a_2\sin\phi)^2$

$R^2(\cos^2\theta + \sin^2\theta) = a_1^2 + a_2^2\cos^2\phi + 2a_1a_2\cos\phi + a_2^2\sin^2\phi$

$R^2 = a_1^2 + a_2^2 + 2a_1a_2\cos\phi$

$$R = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$$

Ⓑ θ :- eqn ② / eqn ①

$$\frac{R\sin\theta}{R\cos\theta} = \frac{a_2\sin\phi}{a_1 + a_2\cos\phi}$$

$$\tan\theta = \frac{a_2\sin\phi}{a_1+a_2\cos\phi}$$

$$\theta = \tan^{-1}\left(\frac{a_2\sin\phi}{a_1+a_2\cos\phi}\right)$$

© Intensity - $I \propto R^2$

$$I = KR^2$$

$$I = K[a_1^2 + a_2^2 + 2a_1a_2\cos\phi]$$

$$I = Ka_1^2 + Ka_2^2 + 2Ka_1a_2\cos\phi$$

$$I = Ka_1^2 + Ka_2^2 + 2(\sqrt{Ka_1^2})(\sqrt{Ka_2^2})\cos\phi$$

$$I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$$

(i) Constructive interference - In constructive interference amplitude & intensity is max. It is only possible for $\cos\phi = 1$

$$\phi = 0, 2\pi, 4\pi \cdots 2n\pi$$

$$R = a_1 + a_2$$

$$I = I_1 + I_2$$

(ii) Destructive interference - In destructive interference amplitude & intensity is min. It is only possible for $\cos\phi = -1$

$$\phi = \pi, 3\pi, 5\pi \cdots (2n+1)\pi$$

$$R = a_1 - a_2$$

$$I = I_1 - I_2$$

Effect of use of white light - Colourful fringes will be obtained and central fringe will be white.

BOARD - 2017

10. Light added to light can produce darkness. Write the name of process.

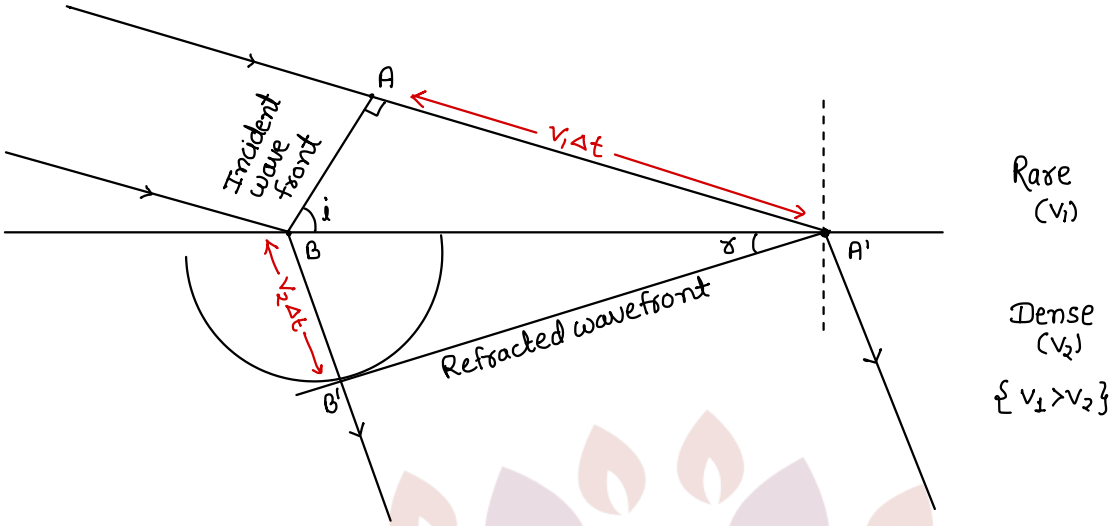
⇒ Interference. (dest.)

11. What is called wavefront? Explain Laws of refraction of light on the basis of Huygens wave theory.

⇒ wavefront - Locus of particles vibrating in same phase is known as wave front. or it is a surface of constant phase.

Explanation of Refraction using Huygen wave theory -

Let AB is a incident wavefront whose angle with surface is i. Speed of incident wavefront in rare medium is v_1. when point A reaches to A' ($AA' = v_1\Delta t$). In this same time period wavelet emitted by B travels $v_2\Delta t$ distance. when we draw a tangent on wavelet from A' then we obtain point B'. Now A'B' is refractive wavefront. whose angle with surface is r.



ω·K·T in $\triangle AA'B$ -

$$\sin i = \frac{P}{H}$$

$$\sin i = \frac{v_1 \Delta t}{A'B} \quad -①$$

in $\triangle A'B'B$ -

$$\sin \gamma = \frac{P}{H}$$

$$\sin \gamma = \frac{v_2 \Delta t}{A'B} \quad -②$$

eqⁿ① ÷ eqⁿ②

$$\frac{\sin i}{\sin \gamma} = \frac{v_1 \Delta t}{v_2 \Delta t}$$

$$\frac{\sin i}{\sin \gamma} = \frac{v_1}{v_2}$$

$$\boxed{\frac{\sin i}{\sin \gamma} = n_{21}}$$ (Snell's Law)

→ Incident Ray, normal & refracted rays all are in same plane in this construction.

→ Both laws of refraction is verified.

BOARD:- 2018

12. write malus law.

⇒ When unpolarized light is transmitted through both the polarizer and the analyzer, the intensity of the output light is directly proportional to the square of the cosine of angle b/w the polarizer & analyzer.

$$I \propto \cos^2\theta$$

$$I = I_0 \cos^2\theta$$

{I_0 = maximum intensity of output light}

13. write any two conditions necessary for interference of light.

⇒ 1. Both wave should be coherent.

2. Frequency of both wave should be same.
3. Amplitude of both wave should be approx equal.
4. Both wave should propogate in same direction.
5. Distance b/w both coherent source should be very small.

14. Draw the curve to intensity distribution of diffraction by a single slit.

BOARD:- 2019

15. Define diffraction of light.
16. write formula related to Malus Law.

⇒ $I = I_0 \cos^2\theta$

BOARD:- 2020

17. write any two difference b/w interference and diffraction of light.

⇒

Interference	Diffraction
1. This phenomenon occur due to superposition of 2 coherent wave.	1. This phenomenon occur due to superposition of many wavelets of same wave front.
2. width of dark & bright both fringes are same.	2. width of each fringe is not same.
3. Intensity of dark fringe is zero.	3. Intensity of dark fringe is not zero.

18. what is wave feont? Explain laws of refraction of light on the basis of Huygens wave theory. Draw necessary ray diagram.

BOARD:- 2021

19. what are coherent sources?

⇒ A source of wave that have a constant phase difference.

20. If ratio of amplitude of two light waves is 4:3 in interference, then calculate the ratio of max. & min intensities.

⇒ $\frac{a_1}{a_2} = \frac{4}{3}$

So $a_1 = 4x$ & $a_2 = 3x$

$$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{(4x+3x)^2}{(4x-3x)^2} = \frac{49x^2}{x^2}$$

$$\frac{I_{max}}{I_{min}} = \frac{49}{1} \quad \text{or } 49:1$$

18. What is diffraction? Explain laws of refraction of light on the basis of Huygens wave theory. Draw necessary ray diagram.

BOARD:- 2022

No question asked from this current syllabus

BOARD:- 2023

19. Path difference equal to phase difference 4π is -

⇒

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

$$\Delta x = \frac{\lambda}{2\pi} \times 4\pi \qquad \Delta x = 2\lambda$$

BOARD:- 2024

20. Natural light from the sun is -
A. polarised B. unpolarised
C. partial polarised D. linear polarised

⇒ unpolarised.

21. Bending of waves from their path by edges of an obstacle is called -

⇒ Diffraction.

23. What is coherent sources?

24. Derive Snell's Law for refraction of light from Huygen's wave theory.

25. Define interference of light & polarization of light.

Two topic - Law of reflection from hugen's principle
Polaroid (complete)