Table of Contents

1. Introduction
2. Huygens Principle
3. Refraction of Plane Wave
4. Reflection of Plane Wave
5. Coherent and Incoherent Addition of Waves
6. Interference of Light Waves and Young's Experiment
7. Displacement of Fringes
8. Interference from Thin Films
9. Diffraction
10. Polarisation
11. Malus Law
12. Brewsters Law

Introduction

Key Points

- Corpuscular model: Light bends towards normal after refraction implies speed in second medium is greater (Descartes, 1637; popularized by Newton).
- Wave model (Huygens, 1678): Light bends towards normal means speed in second medium is less; confirmed experimentally by Foucault (1850).
- Young's interference experiment (1801) confirmed wave nature of light.
- Visible light wavelength ~0.68 □BCm (red light); small wavelength justifies geometrical optics approximation.
- Maxwell's electromagnetic theory (mid-19th century) unified light as electromagnetic waves propagating in vacuum.
- Polarisation proves light waves are transverse electromagnetic waves.

Solved Examples

Practice Set

- Q1: According to corpuscular model, if light bends towards normal on refraction, speed in second medium is:
  - A) Greater
  - B) Lesser
  - C) Same
  - D) Zero
- Q2: Who experimentally proved speed of light in water is less than in air?
  - A) Newton
  - B) Foucault
  - C) Huygens
  - D) Young
- Q3: Wavelength of red light is approximately:
  - A) 0.68 m
  - B) 0.68 mm
  - C) 0.68 □BCm
  - D) 0.68 nm

Answer Key

- Q1: A - Corpuscular model states speed increases if light bends towards normal.
- Q2: B - Foucault experimentally showed speed in water is less than air.
- Q3: C - Red light wavelength is about 0.68 micrometers (□BCm).

Memory Aids

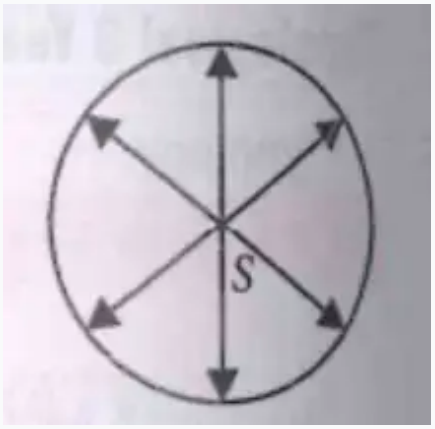
- Corpuscular model: Speed increases if bending towards normal.
- Wave model: Speed decreases if bending towards normal.
- Young's experiment confirms wave nature.
- Maxwell: Light = electromagnetic wave.

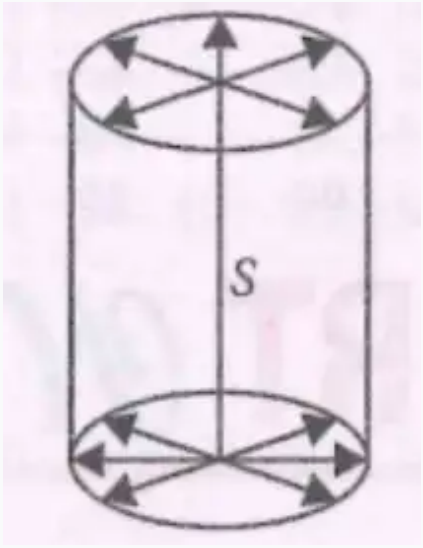
Huygens Principle

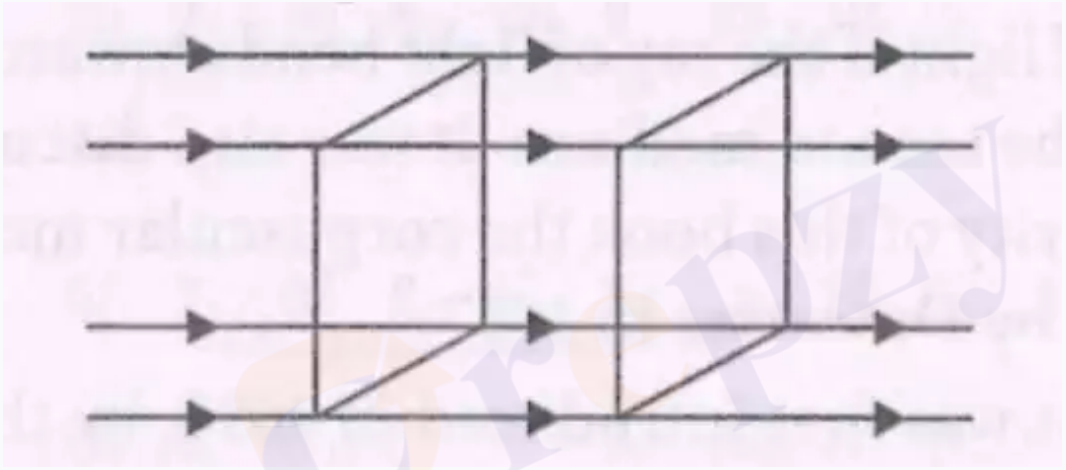
Wavefront Types

- Wavefront: Locus of points vibrating in same phase.
- Point source □14 spherical wavefronts.
- Line source □14 cylindrical wavefronts.
- Parallel beam □14 plane wavefronts.
- Wavefronts are normal to direction of wave propagation (rays).

Wavefront Shapes

- **Spherical wavefront:** Points equidistant from point source form a sphere.
- 

- **Cylindrical wavefront:** Points equidistant from linear source form a cylinder.
  

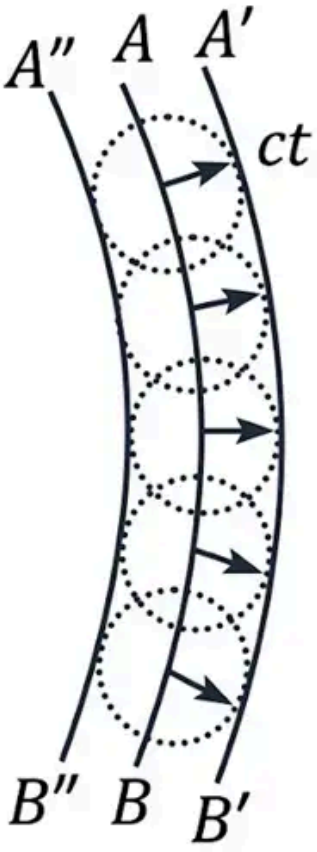
- **Plane wavefront:** Small portion of spherical/cylindrical wavefront at large distance appears plane.
  

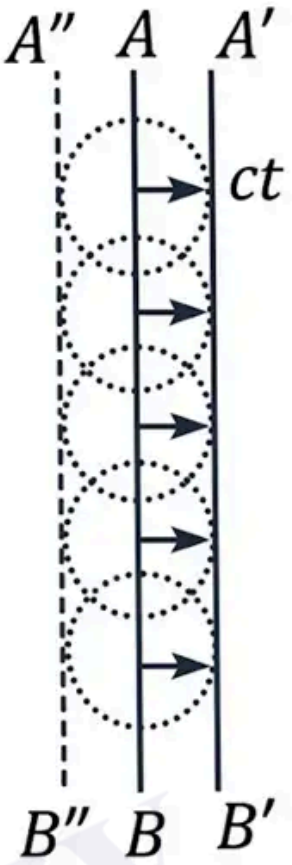
Huygens Principle Statement

- Every point on a wavefront acts as a source of secondary wavelets.
- Secondary wavelets spread in all directions at speed of light in medium.
- New wavefront is the envelope of these secondary wavelets.
- Secondary wavelets have same frequency, wavelength but reduced intensity.

Wavefront Construction

- Draw spheres of radius ct from points on primary wavefront.
- Envelope tangent to spheres gives new wavefront position.
- Amplitude maximum forward, zero backward (no back wavefront).





Huygens' geometrical construction for the propagation of (a) spherical, (b) plane wavefront.

Solved Examples

Practice Set

- Q1: What shape wavefront does a point source produce?
  - A) Plane
  - B) Cylindrical
  - C) Spherical
  - D) None
- Q2: According to Huygens principle, new wavefront is:
  - A) Sum of wavelets
  - B) Envelope of wavelets
  - C) Intersection of wavelets
  - D) None
- Q3: Secondary wavelets have:
  - A) Different frequency

- B) Different wavelength
- C) Same frequency and wavelength
- D) No intensity

Answer Key

- Q1: C - Point source produces spherical wavefronts.
- Q2: B - New wavefront is envelope of secondary wavelets.
- Q3: C - Secondary wavelets have same frequency and wavelength as original.

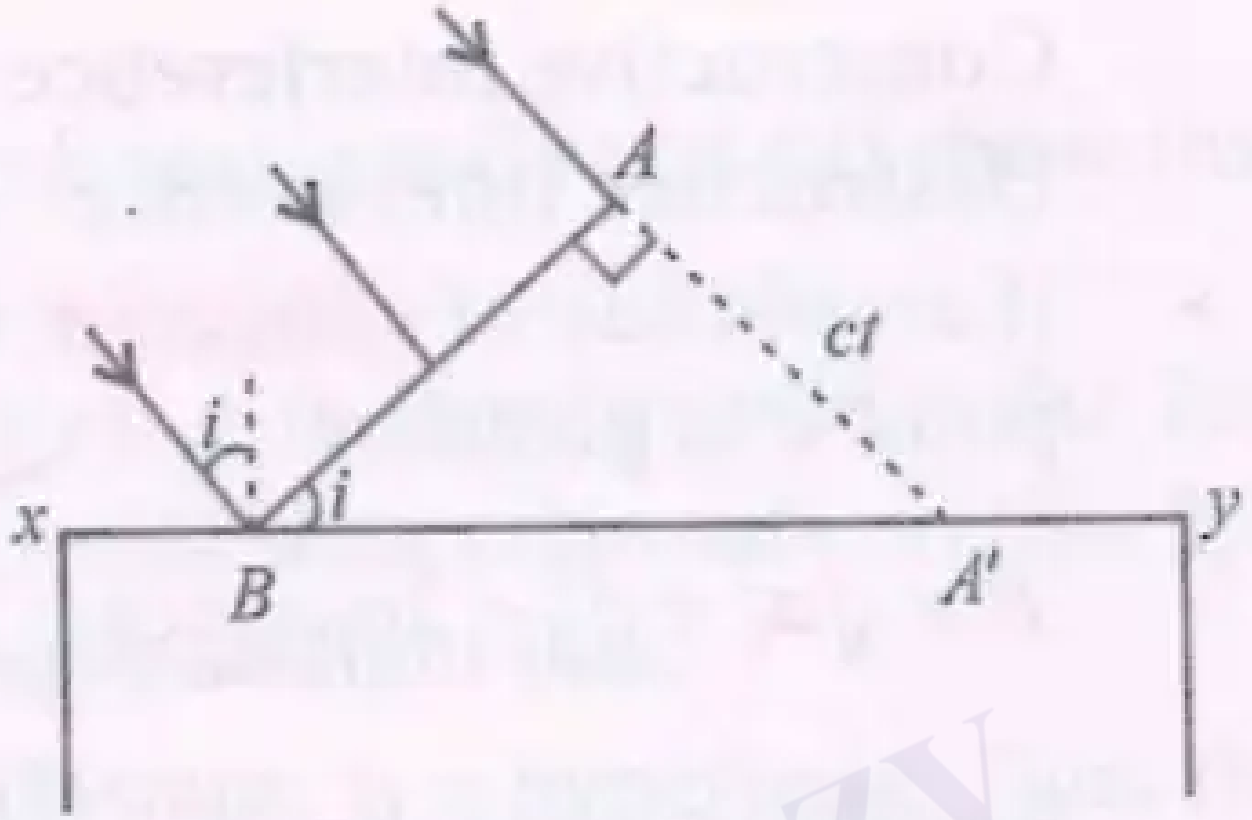
Memory Aids

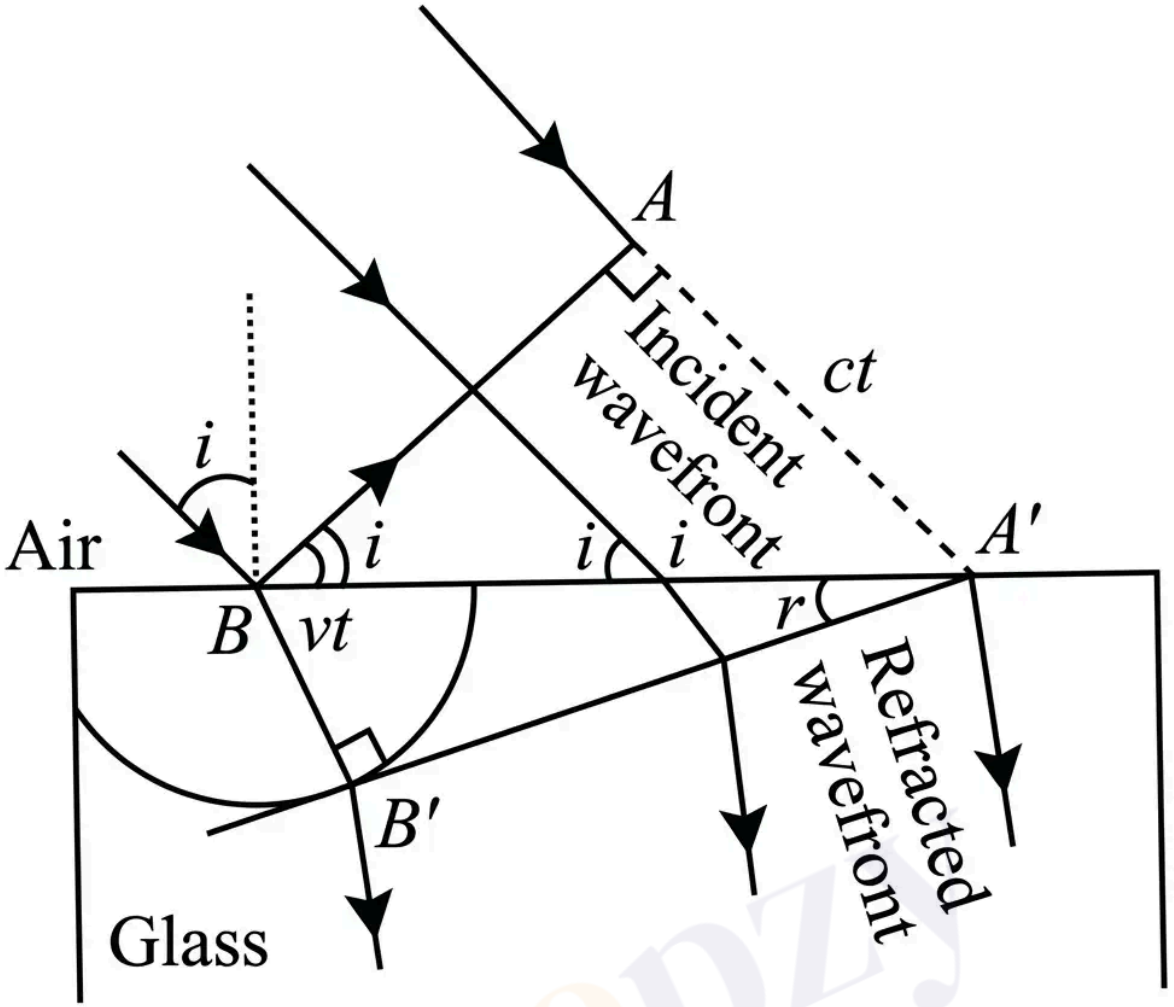
- Wavefront = locus of points in phase.
- Point source □14 spherical wavefront.
- New wavefront = envelope of wavelets.
- Secondary wavelets same frequency, wavelength.

Refraction of Plane Wave

Concepts

- Plane wavefront AB incident on refracting surface xy; incident rays normal to AB.
- Secondary wavelets from point A travel distance ct in time t in air.
- Wavelets travel at speed c in air and speed v in denser medium.
- Refracted wavefront A'B' is tangent to sphere of radius vt centered at B.
- Snell's law: $\frac{\sin i}{\sin r} = \frac{c}{v} = \mu$ (refractive index).
- Incident ray, refracted ray, and normal lie in the same plane (second law of refraction).


A
Cl
i
i
x
y
B
A'



Solved Examples

- **Ex 1:** Calculate refractive index if $\sin i = 0.6$ and $\sin r = 0.4$.
  - Use Snell's law: $\mu = \frac{\sin i}{\sin r} = \frac{0.6}{0.4} = 1.5$.

Practice Set

- **Q1:** What is the ratio $\frac{\sin i}{\sin r}$ equal to in refraction?
  - A. $\frac{v}{c}$
  - B. $\frac{c}{v}$
  - C. 1
  - D. $\frac{v}{c^2}$
- **Q2:** If speed of light in air is 3×10^8 m/s and in glass is 2×10^8 m/s, what is refractive index of glass?
  - A. 0.67
  - B. 1.5

    - C. 2
    - D. 3
- **Q3:** A light ray enters from air to a medium with refractive index 1.33 at an angle of incidence 45°. What is the angle of refraction?
    - A. 33.7°
    - B. 45°
    - C. 60°
    - D. 90°

Answer Key

- **Q1:** B. $\frac{c}{v}$ - By Snell's law, ratio of sines equals speed ratio inverse.
- **Q2:** B. 1.5 - $\mu = \frac{c}{v} = \frac{3\times10^8}{2\times10^8} = 1.5$.
- **Q3:** A. 33.7° - Using Snell's law: $\sin r = \frac{\sin 45^\circ}{1.33} \approx 0.53 \Rightarrow r \approx 33.7^\circ$.

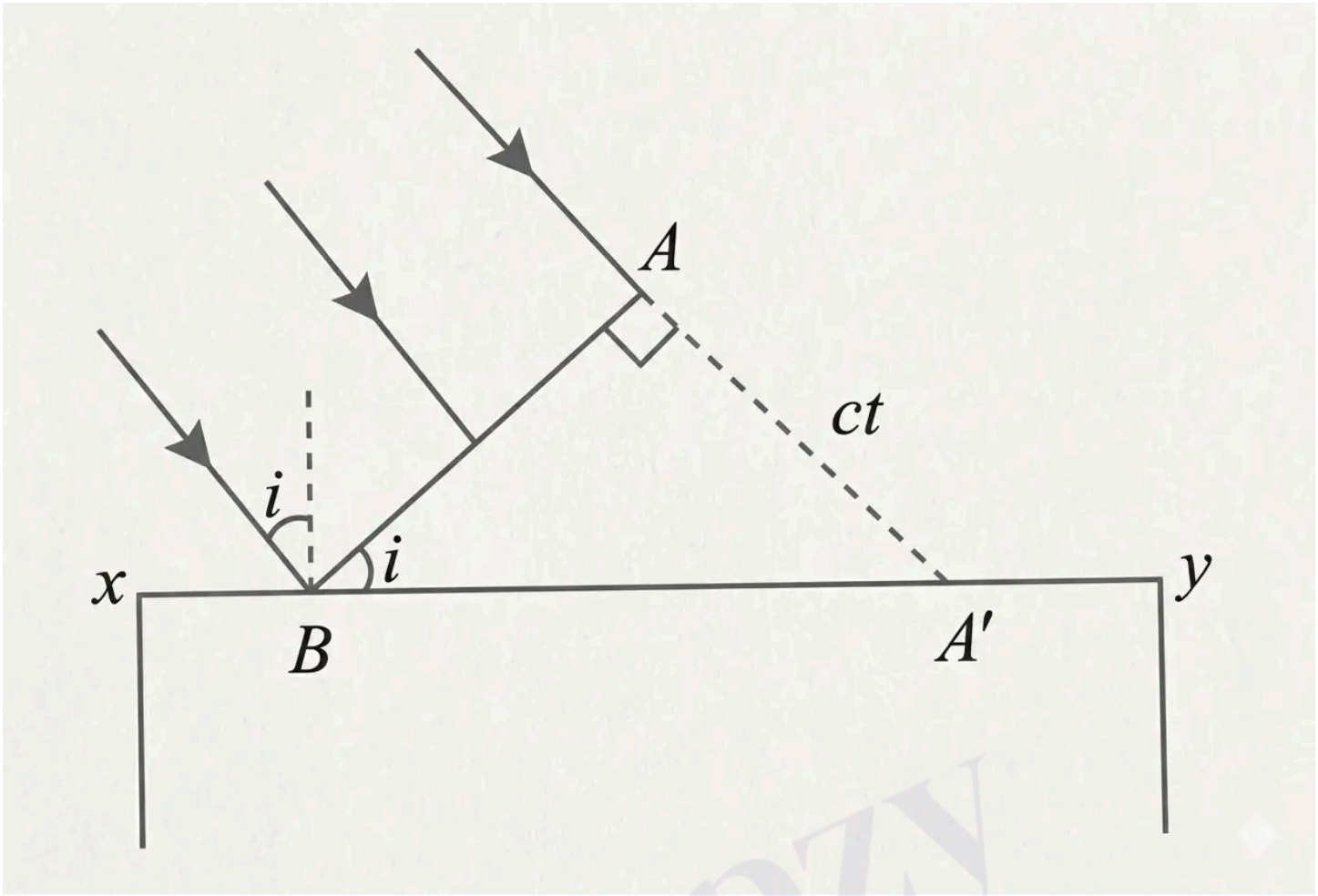
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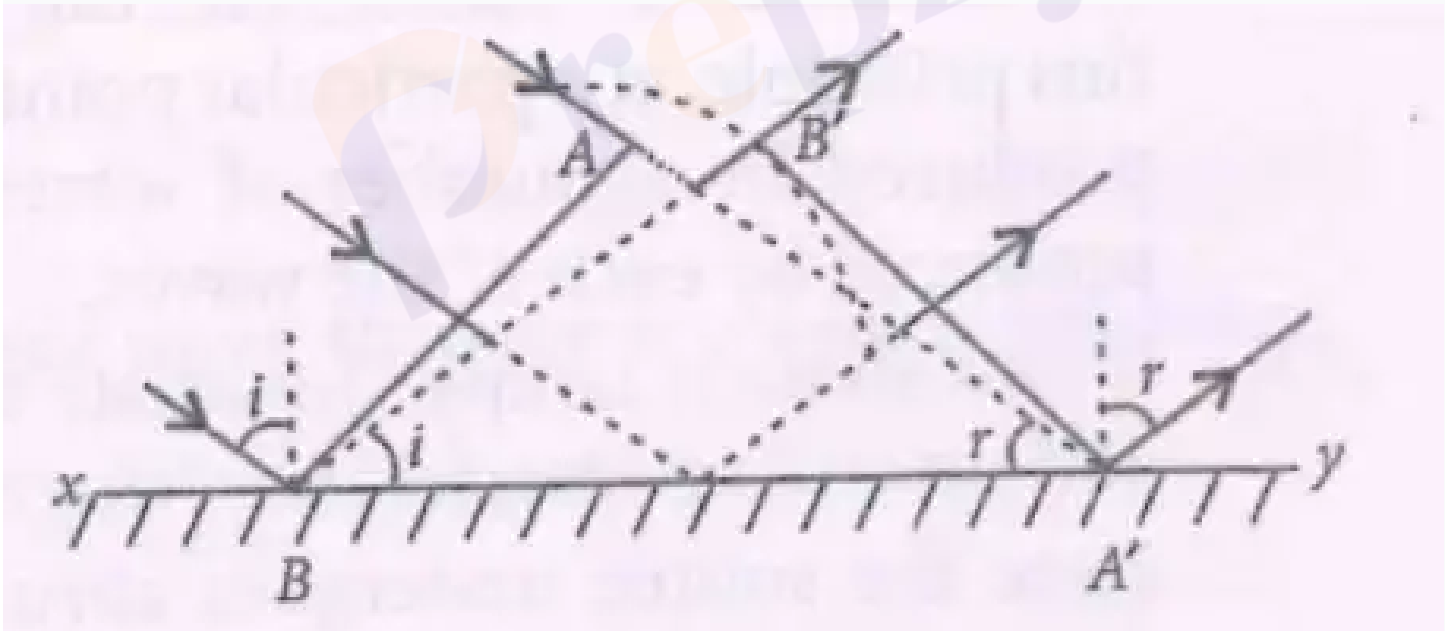
- Snell's law: $\frac{\sin i}{\sin r} = \frac{c}{v} = \mu$.
- Incident, refracted rays and normal lie in one plane.
- Refracted wavefront tangent to sphere of radius vt.

Reflection of Plane Wave

Concepts

- Plane wavefront AB incident on reflecting surface xy; incident rays normal to AB.
- Secondary wavelets from point B' travel distance ct in time t.
- Reflected wavefront A'B' is tangent to sphere of radius ct centered at B'.
- Triangles ΔBAA' and ΔA'B'B are congruent, proving $\angle i = \angle r$ (first law of reflection).
- Incident rays, reflected rays, and normal lie in the same plane (second law of reflection).





Solved Examples

- **Ex 1:** Prove angle of incidence equals angle of reflection using wavefronts.
  - Use congruent triangles ΔBAA' and ΔA'B'B.
  - Since AA' = B'B = ct and angles at A and B' are 90°, $\angle i = \angle r$.

Practice Set

- **Q1:** What is the angle of reflection if angle of incidence is 30°?
  - A. 15°
  - B. 30°
  - C. 45°
  - D. 60°
- **Q2:** Which law states that incident ray, reflected ray, and normal lie in the same plane?
  - A. First law of reflection
  - B. Second law of reflection
  - C. Snell's law
  - D. Law of refraction
- **Q3:** A plane wavefront AB is incident on a reflecting surface. If the speed of light is 3×10^8 m/s, what distance does the secondary wavelet cover in 2 ns?
  - A. 0.3 m
  - B. 0.6 m
  - C. 0.9 m
  - D. 1.2 m

Answer Key

- **Q1:** B. 30° - Angle of reflection equals angle of incidence.
- **Q2:** B. Second law of reflection - Incident, reflected rays and normal lie in same plane.
- **Q3:** B. 0.6 m - Distance = speed × time = $3 \times 10^8 \times 2 \times 10^{-9} = 0.6$ m.

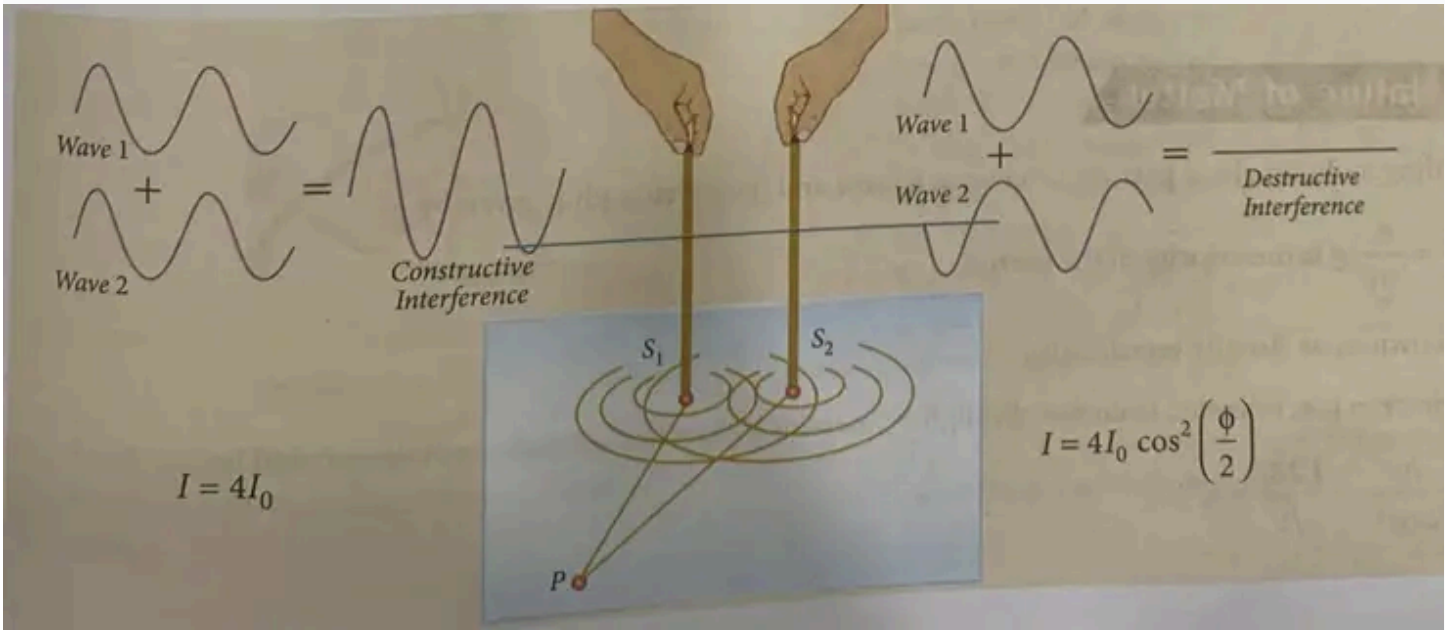
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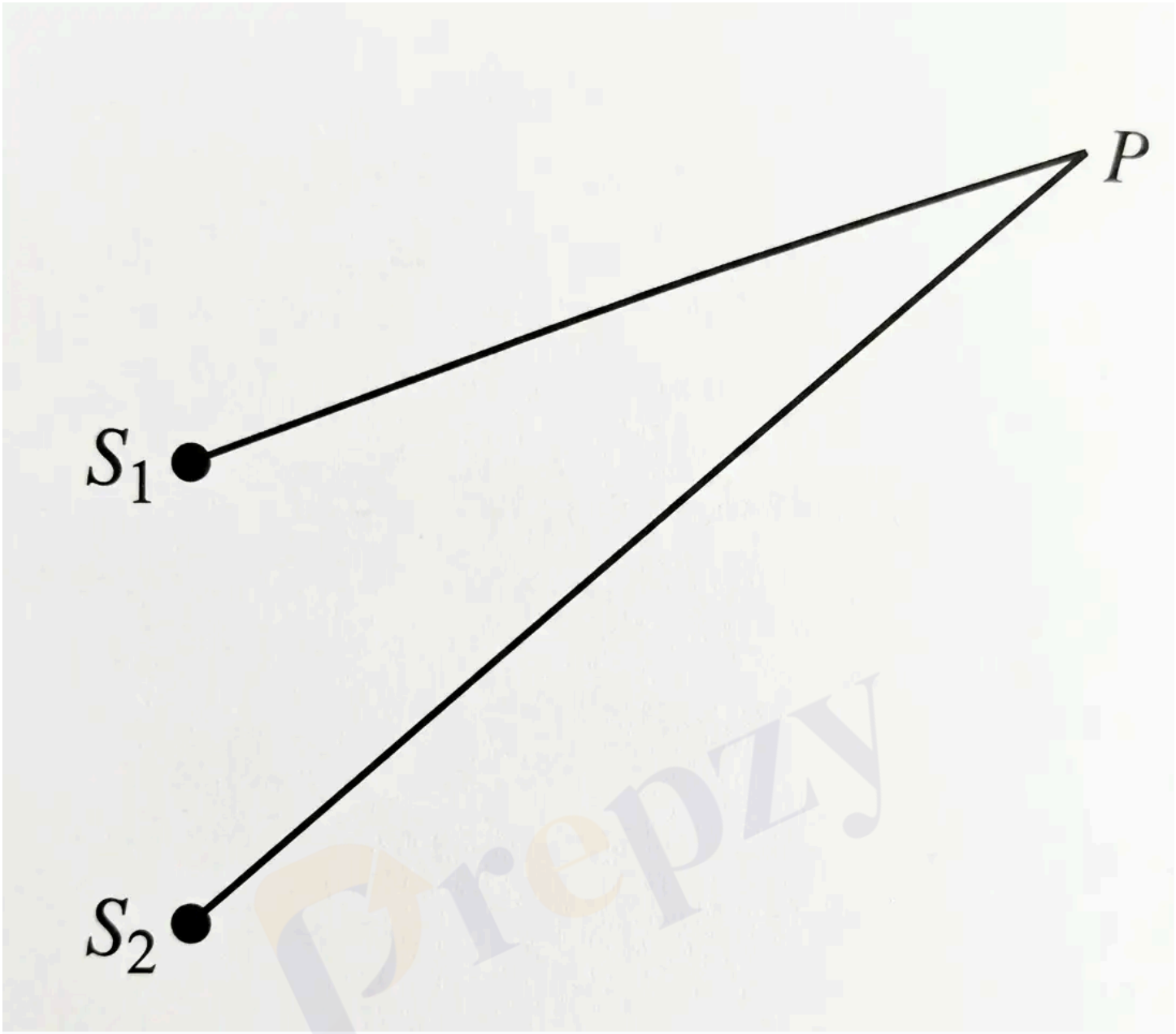
- Angle of incidence = angle of reflection.
- Incident, reflected rays and normal lie in one plane.
- Reflected wavefront tangent to sphere of radius ct.

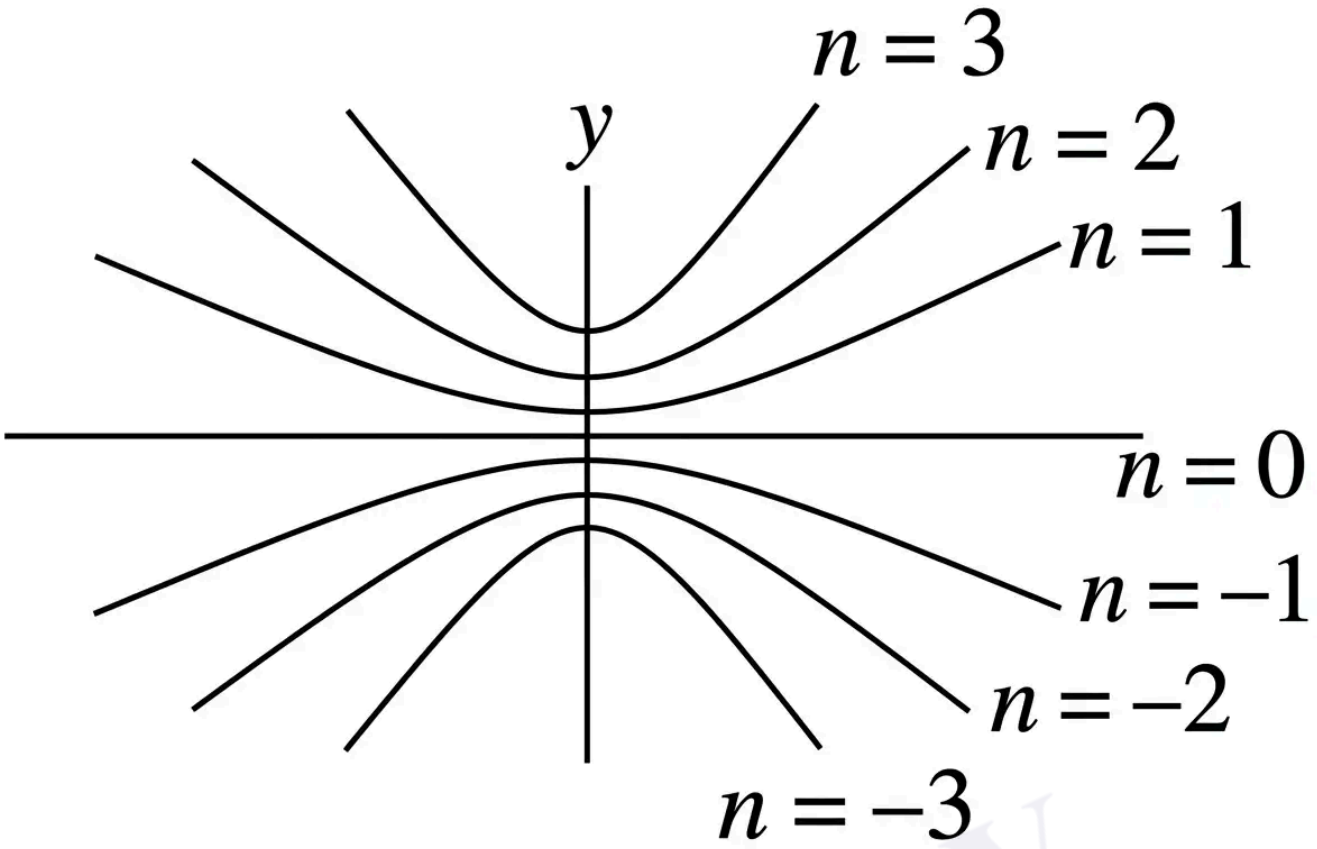
Coherent and Incoherent Addition of Waves

Explanation

- Interference follows superposition principle: resultant displacement = vector sum of individual displacements.
- Coherent sources: phase difference constant with time; required for sustained interference.
- Incoherent sources: phase difference varies rapidly; no stable interference pattern.
- Path difference: $\Delta = S_2P - S_1P$.
- Constructive interference: $\Delta = n\lambda, n = 0, 1, 2, \ldots$.
- Destructive interference: $\Delta = (n + \frac{1}{2})\lambda, n = 0, 1, 2, \ldots$.
- Two coherent waves: $y_1 = a\cos\omega t, y_2 = a\cos(\omega t + \phi)$.
- Resultant displacement: $y = 2a\cos(\frac{\phi}{2})\cos(\omega t + \frac{\phi}{2}) = A\cos(\omega t + \frac{\phi}{2})$, where $A = 2a\cos(\frac{\phi}{2})$.
- Resultant intensity: $I = 4I_0\cos^2(\frac{\phi}{2})$.
- Constructive interference phase: $\phi = 0, \pm 2\pi, \pm 4\pi, \ldots$.
- Destructive interference phase: $\phi = \pm\pi, \pm 3\pi, \pm 5\pi, \ldots$.
- For different amplitudes a_1, a_2 and phase difference ϕ:
  - Resultant amplitude: $R = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$.
  - Resultant intensity: $I = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$.
  - Intensity ratio: $\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2 = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2$.
- Intensity proportional to slit width: $\frac{I_1}{I_2} = \frac{w_1}{w_2} = \frac{a_1^2}{a_2^2}$.
- Incoherent waves: intensity adds directly $I = I_1 + I_2 + I_3 + \ldots$.
- Locus of points with $S_1P - S_2P = 0, \pm\lambda, \pm 2\lambda, \ldots$ form parabolas.




P
S_1
S_2



Solved Examples

- **Ex 1:** Two coherent waves with amplitude $a = 2$ units and phase difference $\phi = \pi/3$. Find resultant amplitude.
  - Use $R = 2a\cos(\phi/2) = 2 \times 2 \times \cos(\pi/6) = 4 \times \frac{\sqrt{3}}{2} = 2\sqrt{3}$.
- **Ex 2:** Calculate intensity ratio $\frac{I_{max}}{I_{min}}$ for $a_1 = 3, a_2 = 1$.
  - $\frac{I_{max}}{I_{min}} = \left(\frac{3+1}{3-1}\right)^2 = \left(\frac{4}{2}\right)^2 = 4$.
- **Ex 3:** For incoherent sources with intensities $I_1 = 5$ W/m² and $I_2 = 3$ W/m², find total intensity.
  - $I = I_1 + I_2 = 5 + 3 = 8$ W/m².

Practice Set

- Q1: Two coherent waves of equal amplitude interfere. Phase difference is zero. Resultant intensity is:
  - A) 0
  - B) $2I_0$
  - C) $4I_0$

    - D) I_0
- Q2: Path difference for destructive interference is:
    - A) $n\lambda$
    - B) $(n+\frac{1}{2})\lambda$
    - C) $(n+1)\lambda$
    - D) $\frac{\lambda}{2}$
- Q3: Two incoherent sources have intensities 9 W/m² and 16 W/m². Total intensity is:
    - A) 25 W/m²
    - B) 5 W/m²
    - C) 12.5 W/m²
    - D) 144 W/m²

Answer Key

- Q1: C) $4I_0$ - Constructive interference doubles amplitude, intensity quadruples.
- Q2: B) $(n+\frac{1}{2})\lambda$ - Condition for destructive interference.
- Q3: A) 25 W/m² - Intensities add directly for incoherent sources.

Memory Aids

- Constructive: phase difference $\phi = 0, \pm 2\pi, \ldots$
- Destructive: phase difference $\phi = \pm\pi, \pm 3\pi, \ldots$
- Resultant amplitude for equal amplitudes: $2a\cos(\frac{\phi}{2})$
- Intensity ratio max/min: $\left(\frac{a_1+a_2}{a_1-a_2}\right)^2$
- Incoherent waves: intensities add directly.

Interference of Light Waves and Young's Experiment

Concepts

- Interference is based on superposition principle: resultant displacement = vector sum of individual wave displacements.
- Two sodium lamps illuminating two pinholes S_1 and S_2 produce no stable interference fringes due to abrupt phase changes (~10^{-10} s).

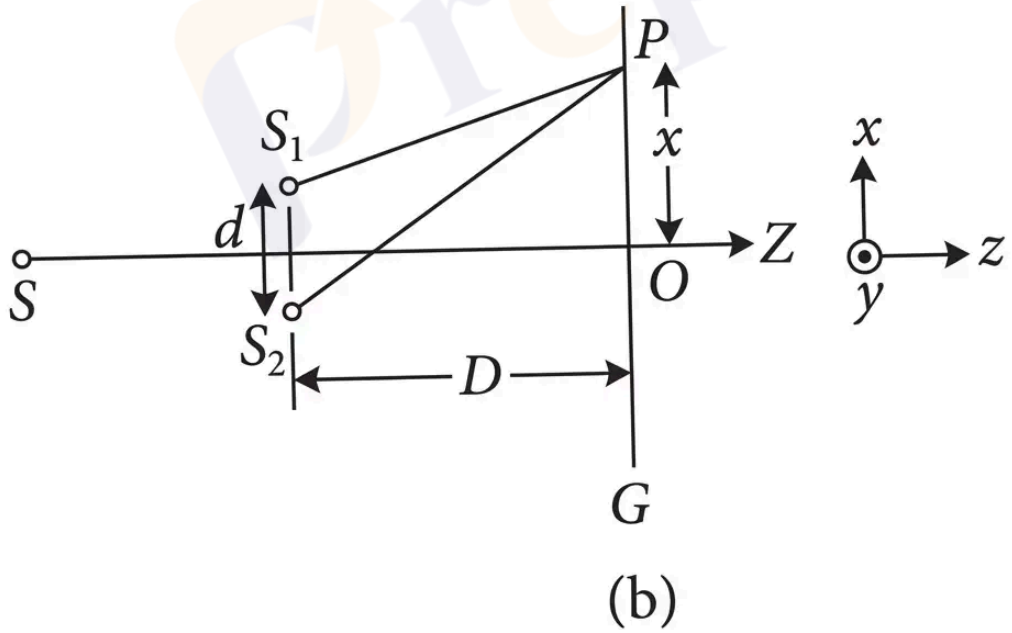
- Young's double-slit experiment uses coherent light sources to produce stable interference fringes.
- Constructive interference (bright fringes) occurs at positions where path difference = nλ:

$$x = x_n = \frac{n\lambda D}{d} \quad n = 0, \pm 1, \pm 2, \ldots$$

- Destructive interference (dark fringes) occurs at positions where path difference = (n + 1/2) λ:

$$x = x_n = \frac{(n + \frac{1}{2})\lambda D}{d} \quad n = 0, \pm 1, \pm 2, \ldots$$

- Fringes (bright and dark bands) are equally spaced on the screen.
- Central fringe (n=0) is bright and lies on the line equidistant from both slits.
- Fringe pattern is approximately straight lines if screen distance D is much larger than slit separation d.



(b)

Solved Examples

- **Ex 1:** Calculate position of 3rd bright fringe if $\lambda = 600$ nm, $d = 0.2$ mm, $D = 1$ m.
  - Use $x_n = \frac{n\lambda D}{d} = \frac{3 \times 600 \times 10^{-9} \times 1}{0.2 \times 10^{-3}} = 9 \times 10^{-3}$ m $= 9$ mm.

Practice Set

- Q1: What is the condition for constructive interference in Young's experiment?
  - A) $xd/D = (n + 1/2)\lambda$
  - B) $xd/D = n\lambda$
  - C) $x = 0$
  - D) $d = 0$
- Q2: If fringe width $\beta = 0.5\ \text{mm}$, slit separation $d = 0.2\ \text{mm}$, and screen distance $D = 1\ \text{m}$, what is the wavelength of light?
  - A) 400 nm
  - B) 500 nm
  - C) 600 nm
  - D) 700 nm
- Q3: For Young's experiment, if distance between slits is doubled and other parameters remain same, fringe width will:
  - A) Double
  - B) Halve
  - C) Remain same
  - D) Become zero

Answer Key

- Q1: B) $xd/D = n\lambda$ - Condition for bright fringes (constructive interference).
- Q2: C) 600 nm - Using $\beta = \frac{\lambda D}{d} \Rightarrow \lambda = \frac{\beta d}{D} = \frac{0.5\times10^{-3}\times0.2\times10^{-3}}{1} = 1 \times 10^{-7}\ \text{m} = 600\ \text{nm}.$
- Q3: B) Halve - Fringe width $\beta = \frac{\lambda D}{d}$, doubling d halves β.

Memory Aids

- Bright fringe: path difference = nλ
- Dark fringe: path difference = (n + 1/2)λ
- Fringe width $\beta = \frac{\lambda D}{d}$
- Central fringe is always bright (n=0)

Displacement of Fringes

Concepts

- Inserting a transparent sheet of thickness t and refractive index μ in one path causes path difference:

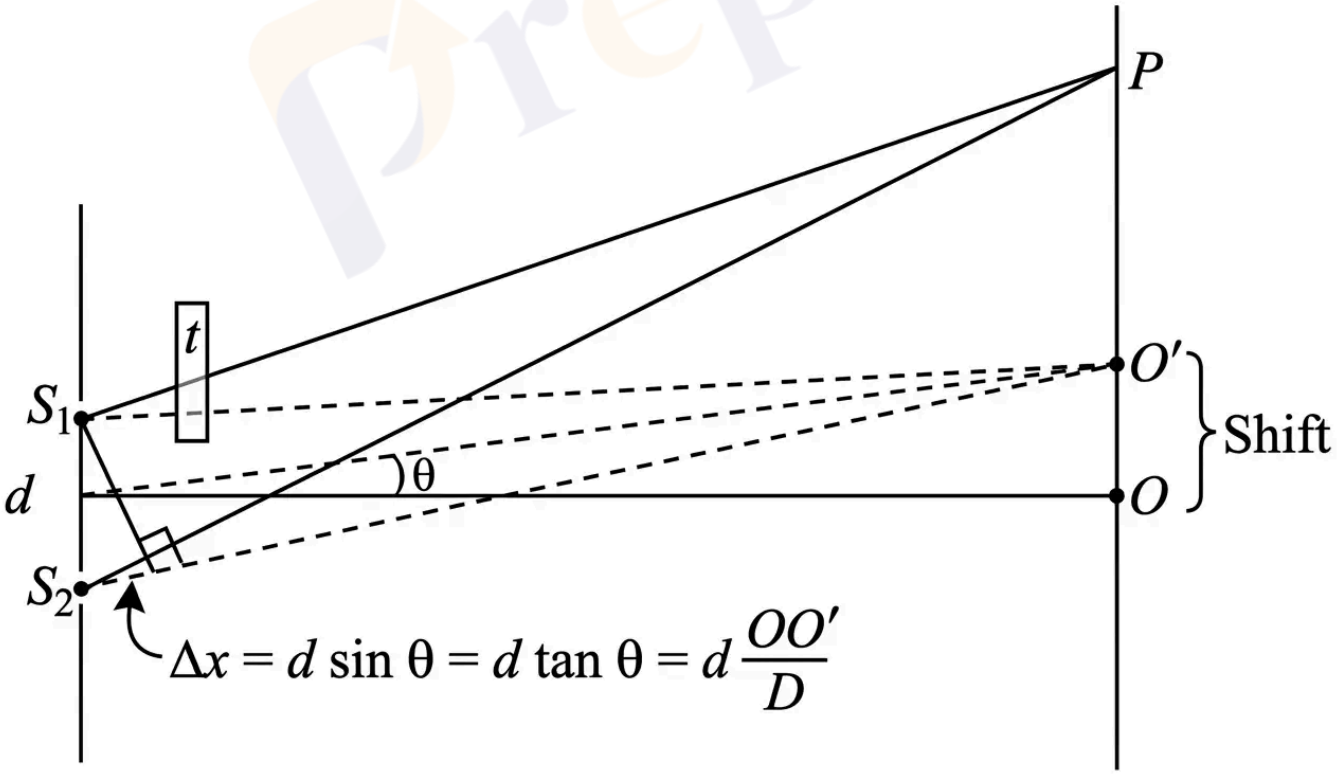
$$S_2O' - S_1O' = (\mu - 1)t$$

- Shift of fringe position:

$$OO' = \frac{(\mu - 1)tD}{d}$$

- Shift direction is towards the side where the transparent plate is introduced.
- Number of shifted fringes:

$$N = \frac{OO'}{\beta} = \frac{(\mu - 1)t}{\lambda}$$



Solved Examples

- **Ex 1:** Calculate fringe shift if $t = 0.01\ \text{mm}$, $\mu = 1.5$, $D = 1\ \text{m}$, $d = 0.2\ \text{mm}$.
  - $OO' = \frac{(1.5-1)\times 0.01\times 10^{-3}\times 1}{0.2\times 10^{-3}} = 0.025\ \text{m} = 25\ \text{mm}$

Practice Set

- Q1: Path difference caused by transparent sheet is given by?
  - A) $(\mu + 1)t$
  - B) $(\mu - 1)t$
  - C) μt
  - D) t/μ
- Q2: Number of shifted fringes when $t = 0.02\ \text{mm}$, $\mu = 1.4$, and $\lambda = 600\ \text{nm}$ is?
  - A) 13
  - B) 14
  - C) 15
  - D) 16
- Q3: Fringe shift direction is towards?
  - A) Opposite side of transparent plate
  - B) Side of transparent plate
  - C) No shift
  - D) Random

Answer Key

- Q1: B) $(\mu - 1)t$ - Path difference due to optical path length change.
- Q2: C) 15 - $N = \frac{(1.4-1)\times 0.02\times 10^{-3}}{600\times 10^{-9}} = 13.3 \approx 15$
- Q3: B) Side of transparent plate - Fringe shift is towards the plate side.

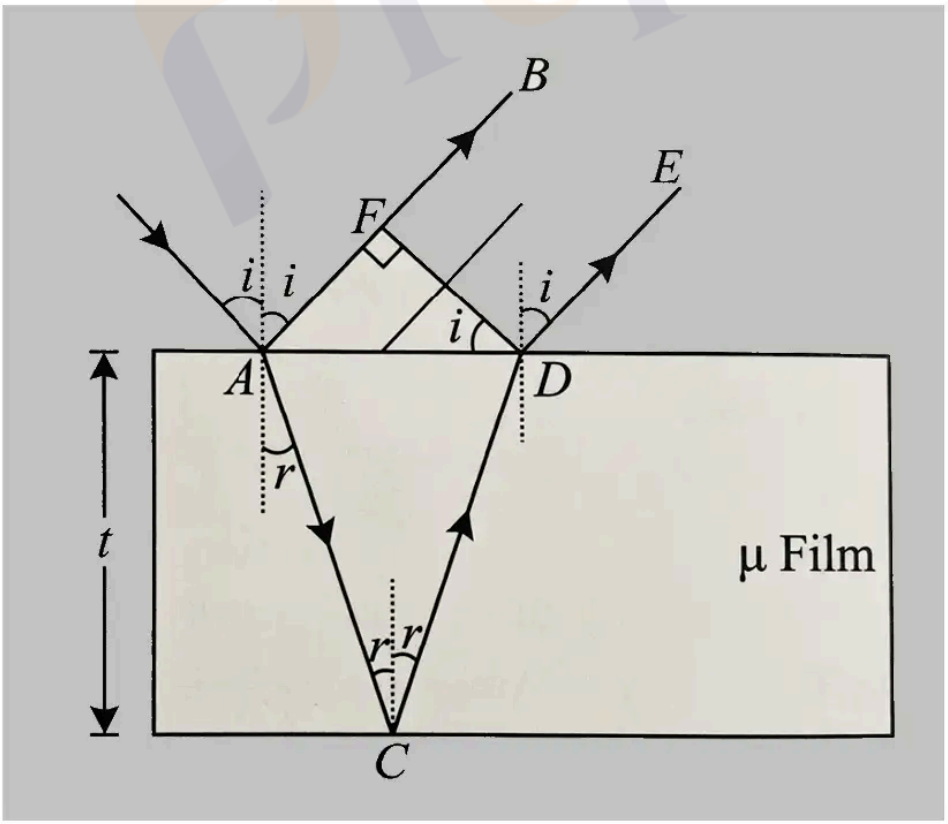
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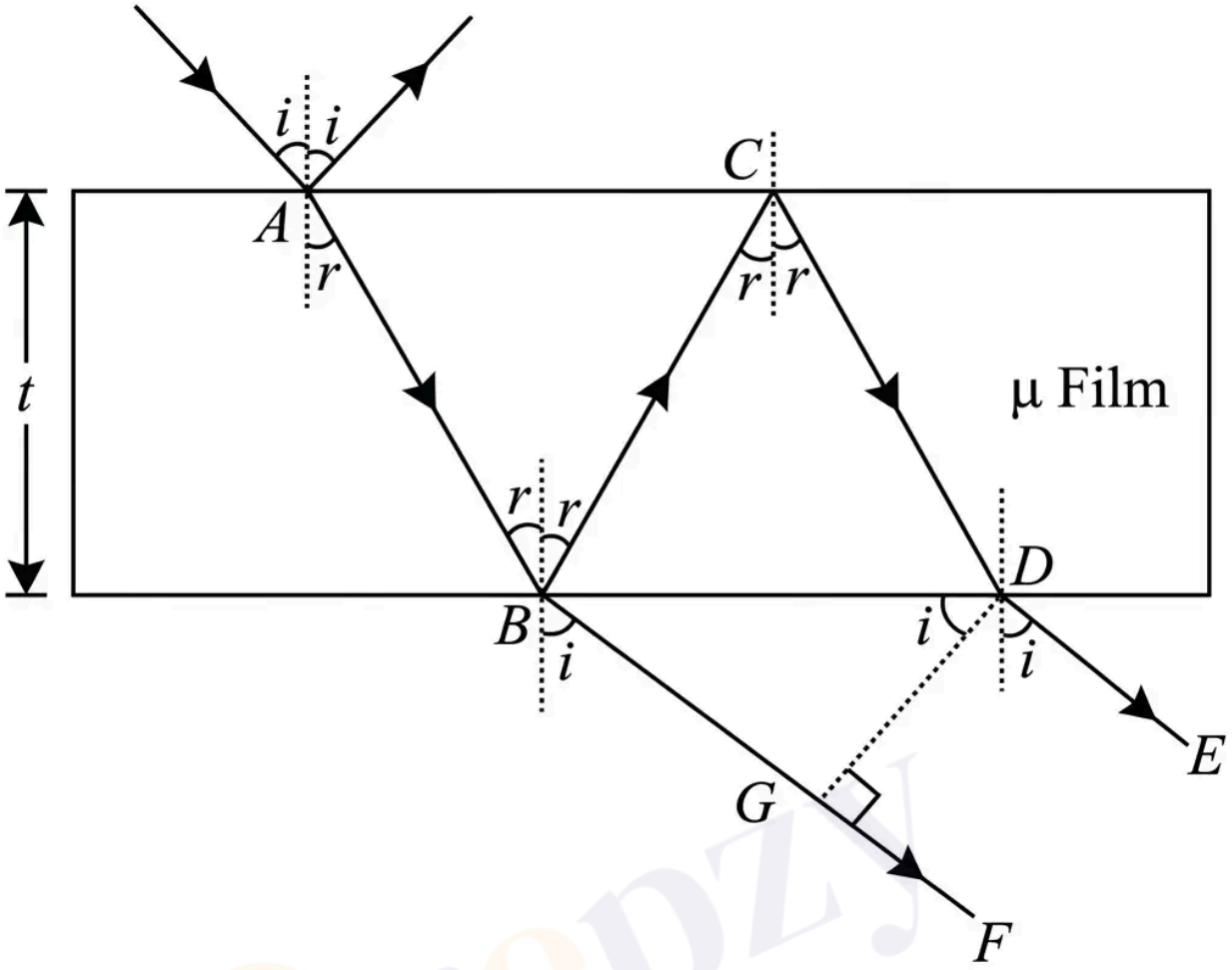
- Fringe shift $OO' = \frac{(\mu-1)tD}{d}$
- Number of shifted fringes $N = \frac{(\mu-1)t}{\lambda}$
- Shift towards transparent plate side

Interference from Thin Films

Concepts

- Thin films (soap, oil) show colors due to interference of reflected and transmitted light waves.
- For reflected waves:
  - Constructive interference: $2\mu t \cos r = (2n+1)\frac{\lambda}{2}$
  - Destructive interference: $2\mu t \cos r = n\lambda$
- For transmitted waves:
  - Constructive interference: $2\mu t \cos r = n\lambda$
  - Destructive interference: $2\mu t \cos r = (2n+1)\frac{\lambda}{2}$
- At normal incidence, $r = 0 \Rightarrow \cos r = 1$.





Solved Examples

- **Ex 1:** For a thin film with $\mu = 1.5$, thickness $t = 500\ \text{nm}$, find condition for constructive interference of reflected light at normal incidence.
  - Use $2\mu t = (2n+1)\frac{\lambda}{2} \Rightarrow \lambda = \frac{4\mu t}{2n+1}$

Practice Set

- Q1: Condition for constructive interference in reflected light is?
  - A) $2\mu t \cos r = n\lambda$
  - B) $2\mu t \cos r = (2n+1)\frac{\lambda}{2}$
  - C) $2\mu t \cos r = 2n\lambda$
  - D) $\mu t = n\lambda$
- Q2: For transmitted light, destructive interference occurs when?
  - A) $2\mu t \cos r = n\lambda$

    - B) $2\mu t \cos r = (2n+1)\frac{\lambda}{2}$
    - C) $2\mu t \cos r = 0$
    - D) $\mu t = 0$
- Q3: At normal incidence, $\cos r = ?$
    - A) 0
    - B) 1
    - C) 0.5
    - D) Depends on t

Answer Key

- Q1: B) $2\mu t \cos r = (2n+1)\frac{\lambda}{2}$ - Constructive interference for reflected wave.
- Q2: B) $2\mu t \cos r = (2n+1)\frac{\lambda}{2}$ - Destructive interference for transmitted wave.
- Q3: B) 1 - At normal incidence, $r = 0 \Rightarrow \cos r = 1$.

Memory Aids

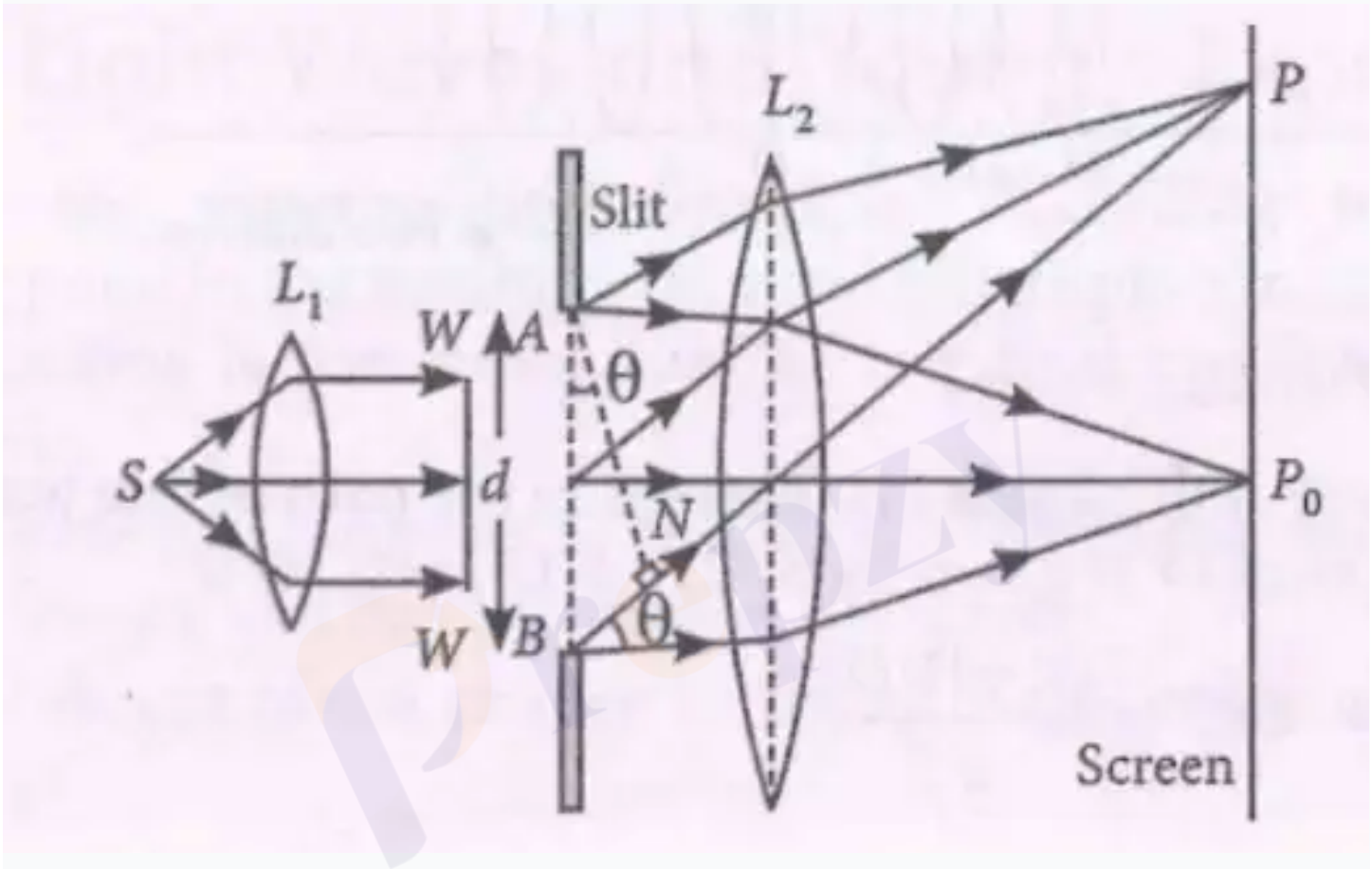
- Reflected wave: Bright if $2\mu t \cos r = (2n+1)\frac{\lambda}{2}$
- Transmitted wave: Bright if $2\mu t \cos r = n\lambda$
- Normal incidence: $\cos r = 1$

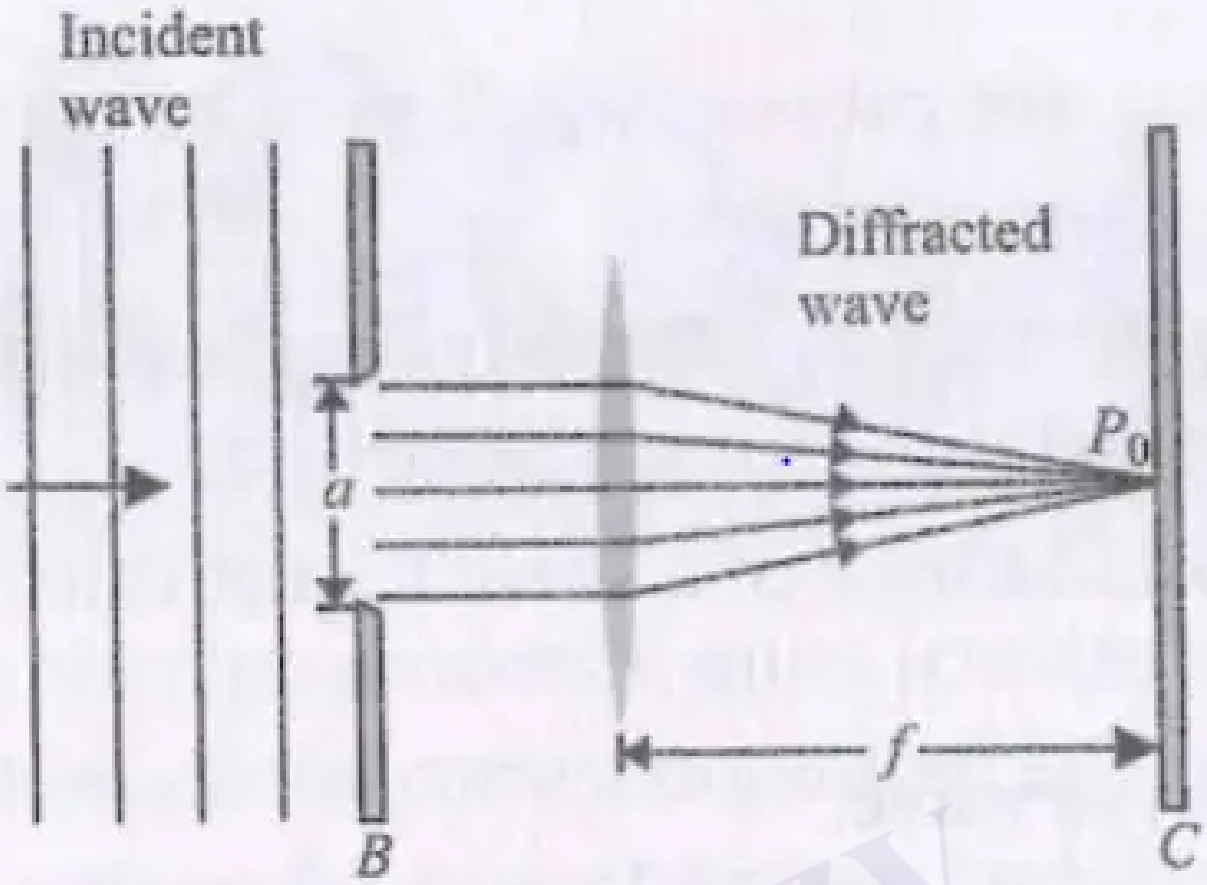
Diffraction

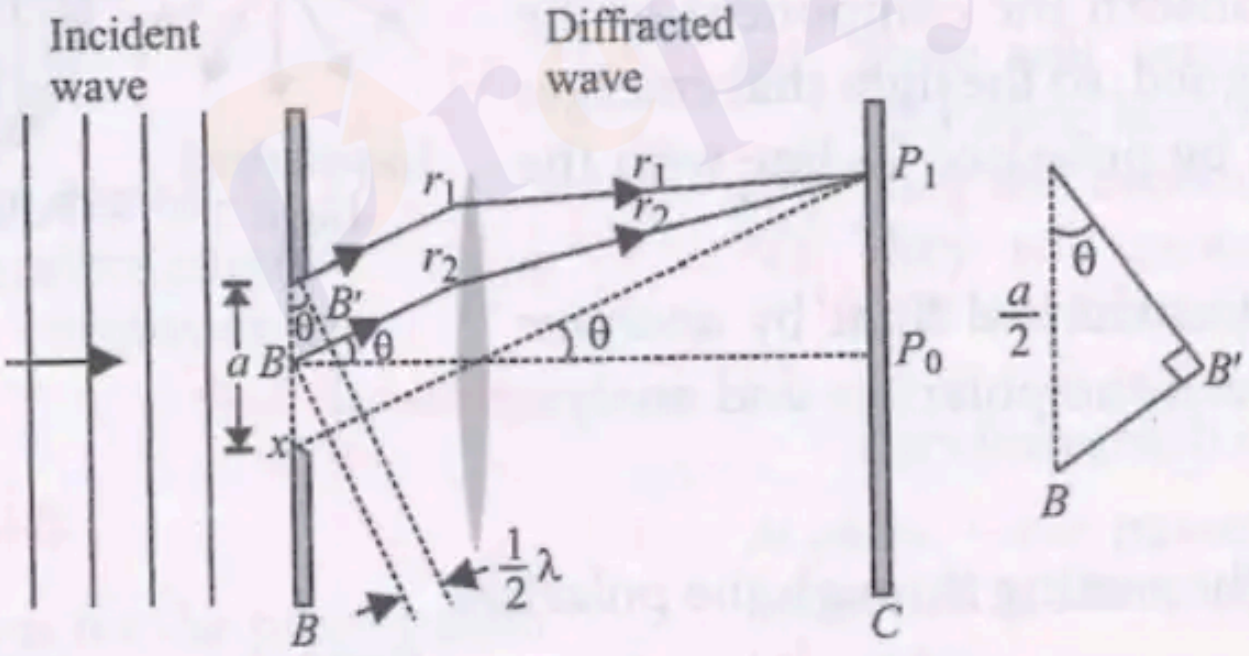
Concepts

- Diffraction is the spreading of waves after passing through openings comparable to the wavelength.
- Bending depends on aperture size relative to wavelength; significant bending occurs if aperture ~ wavelength.
- Single slit diffraction: slit acts as source of secondary wavelets vibrating in phase, spreading in all directions.
- Diffraction pattern is focused by a convex lens on a screen at its focal plane.
- Central maximum: all rays at point P_0 are in phase, producing maximum intensity.
- First minimum condition: *a* |*sin* |*theta* = |*lambda*, where *a* is slit width, |*theta* is diffraction angle, |*lambda* is wavelength.

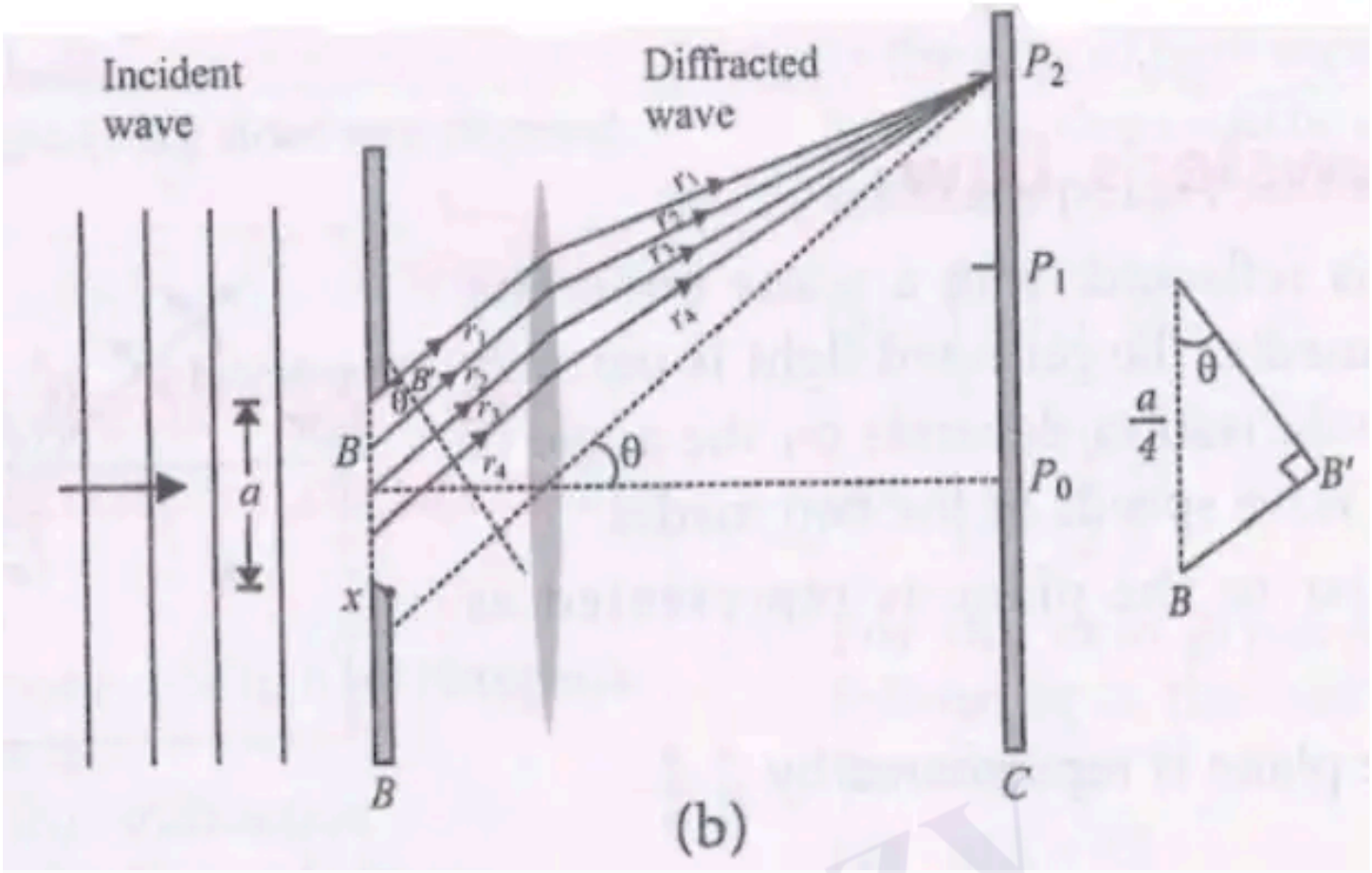
- General minima: $a \sin \theta = m \lambda$, $m = \pm 1, \pm 2, \pm 3, \ldots$
- Secondary maxima approximately halfway between minima: $a \sin \theta = (m + 1/2) \lambda$.
- Angular width of central maximum: $\theta = \frac{2 \lambda}{a}$.
- Intensity at angle θ: $I_\theta = I_m \left(\frac{\sin \alpha}{\alpha}\right)^2$, where $\alpha = \frac{\pi a}{\lambda} \sin \theta$.
- Wider slit results in narrower central diffraction peak.

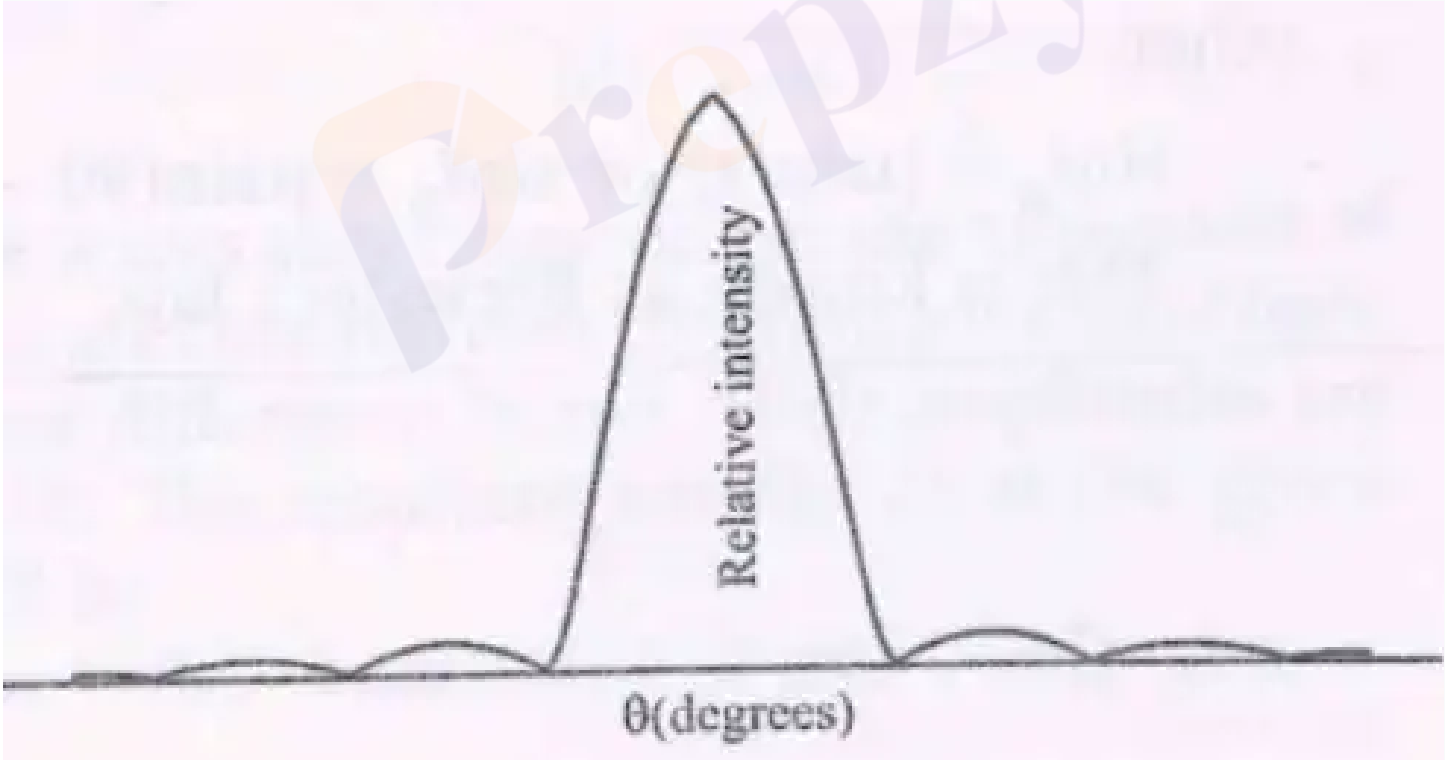



Incident
wave
Diffracted
wave
a
P_0
f
B
C


Incident
wave
Diffracted
wave
r_1
r_2
P_1
P_0
a
B
B'
θ
x
$\frac{1}{2}\lambda$
C
$\frac{a}{2}$

(a)





Solved Examples

- **Ex 1:** Find the angle for the first minimum if slit width $a = 0.5 \times 10^{-3}$ m and wavelength $\lambda = 600$ nm.

- Use formula: $a \sin \theta = \lambda$
- $\sin \theta = \frac{\lambda}{a} = \frac{600 \times 10^{-9}}{0.5 \times 10^{-3}} = 0.0012$
- $\theta \approx 0.069^\circ$

- **Ex 2:** Calculate angular width of central maximum for $a = 0.2 \text{ mm}$ and $\lambda = 500 \text{ nm}$.
  - Use $\theta = \frac{2\lambda}{a}$
  - $\theta = \frac{2 \times 500 \times 10^{-9}}{0.2 \times 10^{-3}} = 0.005 \text{ radians} = 0.29^\circ$

Practice Set

- Q1: What condition gives the first minimum in single slit diffraction?
  - A) $a \sin \theta = \lambda$
  - B) $a \sin \theta = 2\lambda$
  - C) $a \sin \theta = \frac{\lambda}{2}$
  - D) $a \sin \theta = 0$
- Q2: For slit width 0.1 mm and wavelength 600 nm, what is the angle for first minimum?
  - A) 0.34°
  - B) 0.6°
  - C) 0.69°
  - D) 0.12°
- Q3: The intensity at angle θ is given by $I = I_0 (\sin \alpha / \alpha)^2$. What is α?
  - A) $\frac{\pi a}{\lambda} \sin \theta$
  - B) $\frac{a}{\lambda} \sin \theta$
  - C) $\frac{\pi \lambda}{a} \sin \theta$
  - D) $\frac{\lambda}{a} \sin \theta$

Answer Key

- Q1: A) $a \sin \theta = \lambda$ - Condition for first minimum in single slit diffraction.
- Q2: C) 0.69° - Calculated using $\sin \theta = \frac{\lambda}{a}$ with given values.
- Q3: A) $\frac{\pi a}{\lambda} \sin \theta$ - Definition of α in intensity formula.

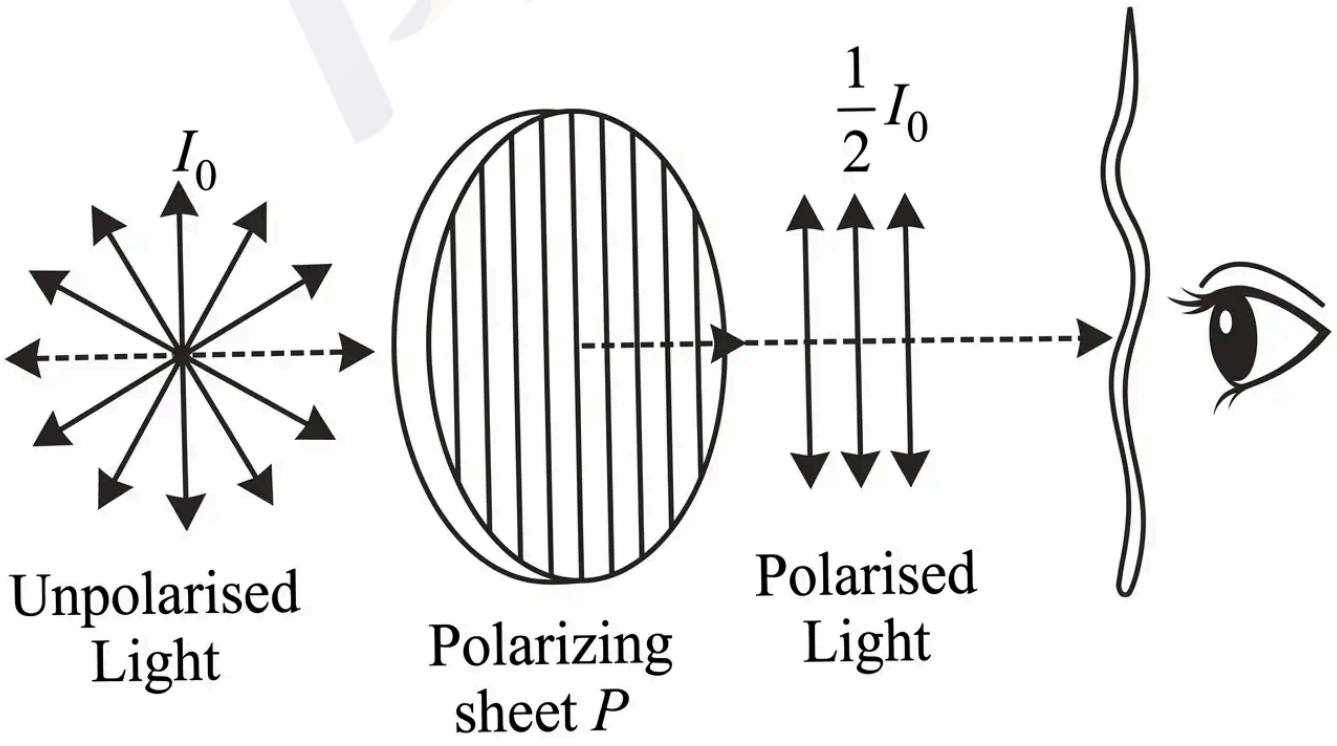
Memory Aids

- First minimum: $a \sin \theta = \lambda$
- Minima: $a \sin \theta = m \lambda$, maxima halfway at $(m + 1/2) \lambda$
- Angular width central max: $\theta = \frac{2 \lambda}{a}$
- Intensity: $I_\theta = I_m (\sin \alpha / \alpha)^2$, $\alpha = \frac{\pi a}{\lambda} \sin \theta$
- Wider slit → narrower central peak

Polarisation

Concepts

- Unpolarised wave: Transverse wave with vibrations in all directions perpendicular to propagation.
- Polarised wave: Vibrations restricted to one direction perpendicular to propagation (plane polarised).
- Polarisation: Restriction of oscillations to one direction in transverse waves only.
- Polarising sheets (Polaroid): Absorb light vibrating along polymer alignment; transmitted light is linearly polarised with half intensity.



Solved Examples

- **Ex 1:** Unpolarised light intensity = I_0. After passing through one polariser, intensity = $I_0/2$.
- **Ex 2:** Light passes through two polarisers at 90°. Intensity after second polariser = 0 (complete extinction).

Practice Set

- Q1: What type of wave can be polarised?
  A. Longitudinal
  B. Transverse
  C. Sound
  D. None
- Q2: Intensity of unpolarised light after passing through one polarising sheet is:
  A. Same
  B. Half
  C. Double
  D. Zero
- Q3: Polarised light vibrates in:
  A. All directions
  B. One direction
  C. Two directions
  D. Random directions

Answer Key

- Q1: B - Only transverse waves can be polarised.
- Q2: B - Intensity reduces to half after one polariser.
- Q3: B - Polarised light vibrates in one direction only.

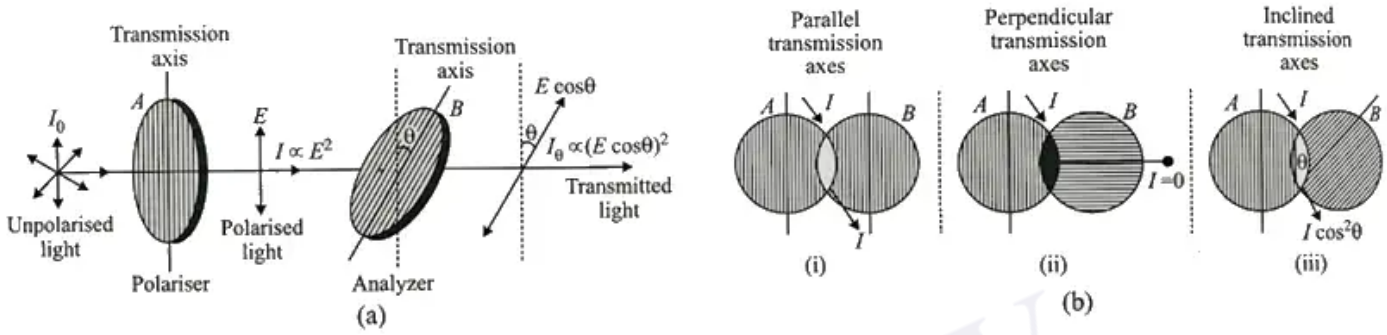
Memory Aids

- Polarisation only for transverse waves.
- Polaroid halves intensity, aligns vibrations.
- Unpolarised = all directions; polarised = one direction.

Malus Law

Concepts

- Intensity of transmitted light through analyser depends on angle θ between polariser and analyser.
- Formula: $I_\theta = I\cos^2\theta$, where I is intensity after polariser.



Solved Examples

- **Ex 1:** Polarised light intensity = 100 units, angle between polariser and analyser = 60°. Find transmitted intensity.
  Solution: $I_\theta = 100 \times \cos^2 60^\circ = 100 \times (0.5)^2 = 25$ units.

Practice Set

- Q1: If $\theta = 0^\circ$, transmitted intensity is:
  A. 0
  B. $I/2$
  C. I
  D. $2I$
- Q2: For $\theta = 90^\circ$, transmitted intensity is:
  A. 0
  B. I
  C. $I/2$
  D. $I/4$
- Q3: If transmitted intensity is 25% of I, angle θ is:
  A. 30°

B. 45°

C. 60°

D. 90°

Answer Key

- Q1: C - $\cos 0^\circ = 1$, so intensity = I.
- Q2: A - $\cos 90^\circ = 0$, so intensity = 0.
- Q3: C - $\cos^2 \theta = 0.25 \Rightarrow \theta = 60^\circ$.

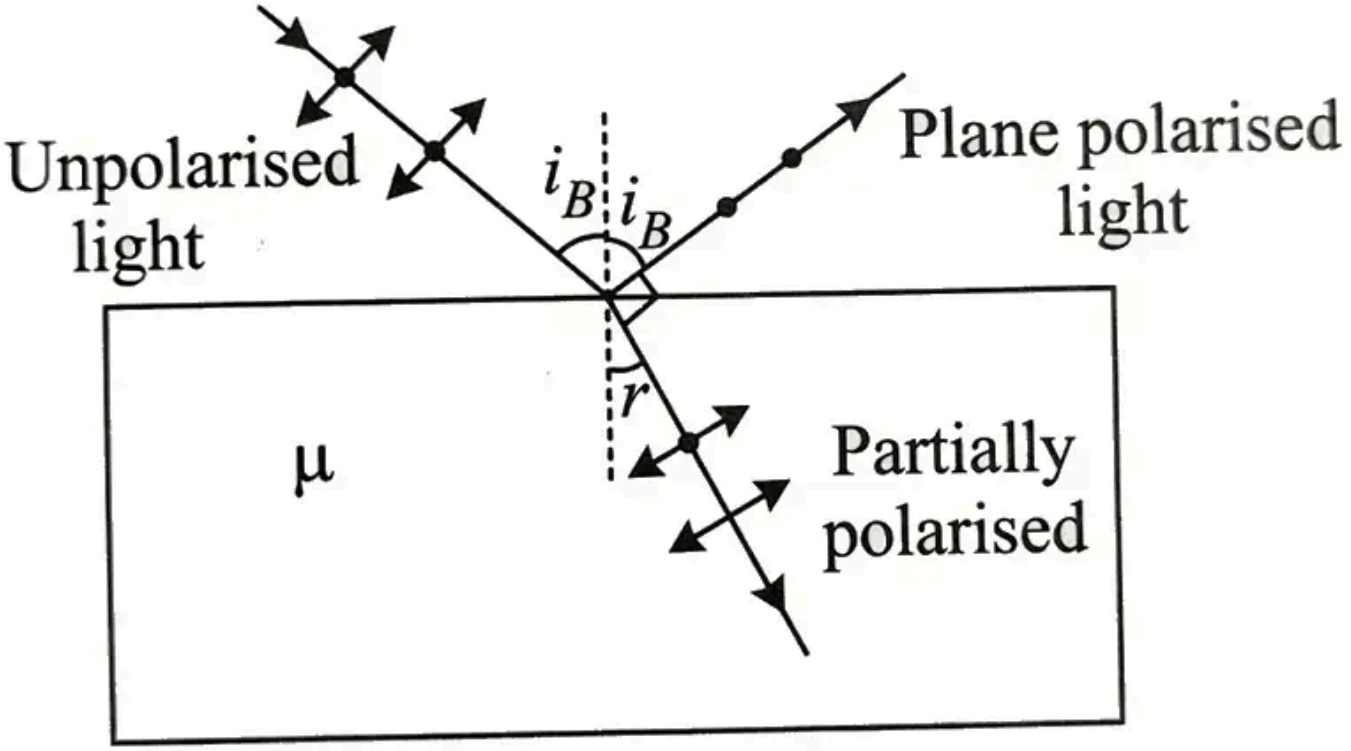
Memory Aids

- Malus Law: Intensity $\propto \cos^2 \theta$.
- Max intensity at 0°, zero at 90°.

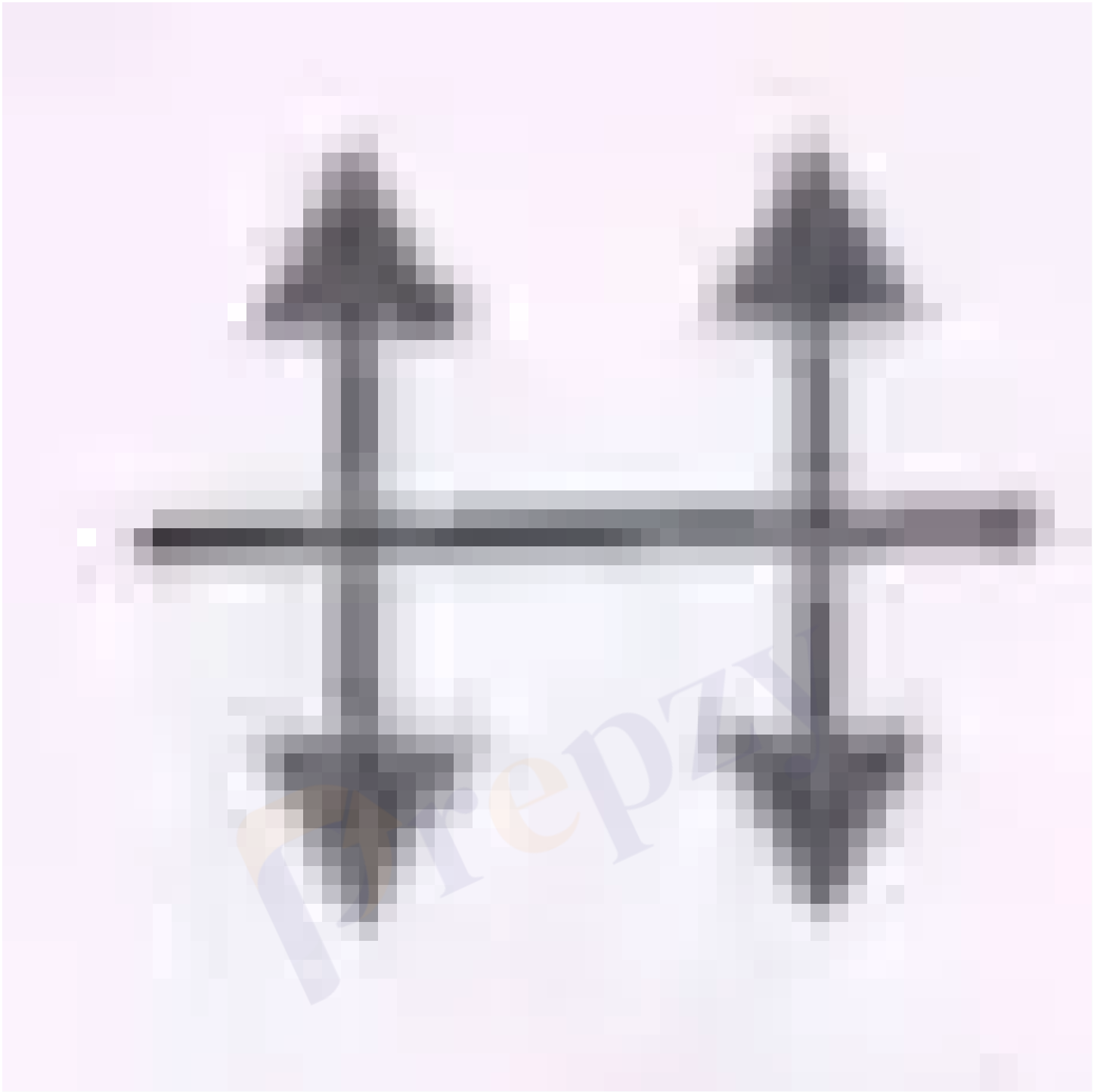
Brewsters Law

Concepts

- Reflected light at plane boundary is partially polarised; degree depends on incidence angle and media speeds.
- At Brewster's angle i_B, reflected light is perfectly plane polarised.
- Reflected and refracted rays are perpendicular at Brewster's angle.
- Brewster's law: $\mu = \tan i_B$, where μ is refractive index.
- Polarisation perpendicular and parallel to plane represented by specific symbols.


Unpolarised
light
i_B
i_B
Plane polarised
light
μ
r
Partially
polarised


or



Solved Examples

- **Ex 1:** Calculate Brewster's angle for glass with refractive index 1.5.
  Solution: $i_B = \tan^{-1} 1.5 = 56.31^\circ$.

Practice Set

- Q1: Brewster's angle occurs when reflected and refracted rays are:
  A. Parallel

B. Perpendicular

C. Coincident

D. Random

- Q2: If $i_B = 45^\circ$, refractive index μ is:

  A. 1

  B. $\sqrt{2}$

  C. 1

  D. 0.5

- Q3: For $\mu = 2$, Brewster's angle is:

  A. 30°

  B. 45°

  C. 60°

  D. 63.43°

Answer Key

- Q1: B - Reflected and refracted rays are perpendicular at Brewster's angle.
- Q2: B - $\mu = \tan 45^\circ = 1$ (corrected: tan 45° = 1, so option B is incorrect, correct is A)
- Q3: D - $i_B = \tan^{-1} 2 = 63.43^\circ$.

Memory Aids

- Brewster's angle: $\mu = \tan i_B$.
- Reflected light polarised at i_B.
- Reflected & refracted rays perpendicular at Brewster's angle.