

Wave Optics — Assignment 2

Class 12 Physics · Higher-difficulty challenge set + integrated problems · Answer key included · Narayan Gurukul Academy

Instructions: (1) Attempt all questions; start with the topic-wise challenge set, then attempt the integrated (multi-topic) problems.
(2) Give all answers with correct SI units. $g = 10 \text{ m/s}^2$ unless stated.
(3) A final answer key is provided at the end — try the full set before checking it.

Part A — Topic-wise challenge questions

Huygens' Principle

1. State Huygens' principle.
2. Use Huygens' principle to derive the laws of reflection.
3. Use Huygens' principle to derive Snell's law of refraction.

Interference of Light

1. What are coherent sources and why are they needed?
2. Write the conditions for a bright and a dark fringe.
3. Derive the expression for the fringe width.

Young's Double-Slit Experiment

1. Describe Young's double-slit experiment.
2. Derive the condition for constructive and destructive interference.
3. Derive the expression for the fringe width in YDSE.

Diffraction

1. Distinguish between interference and diffraction.
2. Derive the condition for the minima in single-slit diffraction.
3. A single slit of width 0.1 mm is illuminated by 500 nm light. Find the angular width of the central maximum.

Polarisation

1. What is polarisation and what does it show about light?
2. State Brewster's law and derive it.
3. Explain polarisation by scattering.

Part B — Integrated problems (multi-topic)

1. In Young's double-slit experiment, the slits are 0.5 mm apart and the screen is 1 m away. Light of wavelength 600 nm is used. Find the fringe width and the distance of the third bright fringe from the centre.
2. In a YDSE the fringe width in air is 0.4 mm. Find the fringe width when the whole apparatus is immersed in water ($n = \frac{4}{3}$).

3. A single slit of width 0.2 mm is illuminated by light of wavelength 600 nm. Find the angular width of the central maximum and the linear width on a screen 1.5 m away.
4. Light is incident on a medium at the polarising angle. If the refractive index of the medium is 1.5, find the polarising angle and the angle of refraction.
5. Two coherent sources of light of wavelength 500 nm produce interference. At a point on the screen the path difference is 1.5 μm . State whether a bright or a dark fringe is formed and justify your answer.

Answer Key

Huygens' Principle

Each point on a wavefront is a source of secondary wavelets; the forward envelope gives the new wavefront. It yields the laws of reflection and Snell's law.

Interference of Light

Coherent sources have a constant phase difference. Bright: path difference = $m\lambda$. Dark: path difference = $(2m-1)\lambda/2$. Fringe width $\beta = \lambda D/d$.

Young's Double-Slit Experiment

Path difference = $d \sin \theta \approx d x/D$. Bright: $d x/D = m\lambda$; dark: $d x/D = (2m-1)\lambda/2$; fringe width $\beta = \lambda D/d$. For $d = 2 \text{ mm}$, $D = 1 \text{ m}$, $\lambda = 600 \text{ nm}$: $\beta = 0.3 \text{ mm}$.

Diffraction

Minima: $a \sin \theta = m\lambda$; secondary maxima: $a \sin \theta = (2m+1)\lambda/2$; central maximum width = $2\lambda D/a$.

Polarisation

Polarisation restricts the electric field to one plane, showing light is transverse. Brewster: $\tan i_p = n$. Intensity through a polariser becomes half.

Integrated problems

1: $\beta = \lambda D/d = 1.2 \text{ mm}$; third bright fringe at $3\beta = 3.6 \text{ mm}$. 2: $\beta' = \beta/n = 0.3 \text{ mm}$. 3: $\theta = \lambda/a = 3 \times 10^{-3} \text{ rad}$; linear width = $2\lambda D/a = 9 \text{ mm}$. 4: $i_p = \tan^{-1} 1.5 \approx 56.3^\circ$; angle of refraction = $90^\circ - i_p \approx 33.7^\circ$. 5: path difference $1.5 \mu\text{m} = 3\lambda$ (since $\lambda = 0.5 \mu\text{m}$), an integer multiple, so a bright fringe.